50-416
50-417

MISSISSIPPI POWER & LIGHT COMPANY
Helping Build Mississippi
P. O. BOX 1640, JACKSON, MISSISSIPPI 39205

NUCLEAR LICENSING & SAFETY DEPARTMENT

July 6, 1984

Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Attention: Mr. Harold R. Denton, Director

Dear Mr. Denton:

SUBJECT: Hydrogen Control Owners Group
Meeting Basis Submittal
HGN-018

The Hydrogen Control Owners Group (HCOG) has undertaken the 1/4 scale test program to define the thermal environment due to the combustion of hydrogen as a diffusion flame resulting from a postulated degraded core scenario. The attached information is provided to the NRC, prior to the planned meeting, for their review of the progress of the 1/4 scale test program. This submittal is to be the basis for the NRC to comment on the 1/4 scale test matrix so that HCOG and the NRC can reach concurrence on the test to be conducted in this facility. The HCOG-NRC meeting is scheduled for July 24-25, 1984 at Factory Mutual Research Corporation. An agenda for the meeting is included as Attachment 1, and the objectives for the meeting are included as Attachment 2.

The meeting will be held at the Factory Mutual Conference Center which is next to Factory Mutual Research Corporation in Norwood, Massachusetts. (See Attachment 3 for a map of the area.)

Significant progress has been made on construction of the test facility, including pressure testing of the vessel. The NRC staff members and their consultants attending this meeting will be invited to the test site to view the facility. (Appropriate clothing is recommended.) A bus will be provided to transport participants in the tour to and from the test site.

This submittal includes a summary of the HCOG program status (see Attachment 4) which will also be discussed at the proposed meeting. The instrumentation plan (see Attachment 5) is similar to that submitted in the HCOG response to the NRC requests for additional information (RAIs) previously transmitted to the staff on April 2, 1984. However, the current instrumentation plan now shows the location of the video cameras. The HCOG has proceeded with the 1/4 scale test program as described in previous submittals on facility design and HCOG's responses to RAIs.

Additional development of the BWR Core Heatup Code has occurred since initial discussions of the code with the NRC staff. The revised code is now being used to generate the postulated degraded core accident hydrogen release time histories which will be used for testing in the 1/4 scale facility. Conservative assumptions are being made both in scenario selection and code

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Y601 1/1 Add: Carl Stahle Charles Tinkler modeling to produce hydrogen release rates which are predominantly above the threshold for establishment of steady diffusion flames. This assures that the thermal environments obtained from the 1/4 scale facility will allow assessment of effects of steady diffusion flames. Equipment required to survive the thermal environment produced by deflagrations which occur with hydrogen release rates below the threshold have been demonstrated analytically to survive. These analyses were performed assuming a conservative constant hydrogen release rate duration corresponding to the total hydrogen production equivalent to oxidation of 75% of the active fuel cladding. As a result, the focus of the BWR Core Heatup Code evaluation and the 1/4 scale test program has been and remains the characterization of the thermal environment produced by diffusion flames resulting from postulated recoverable degraded core accident scenarios.

Some results from the BWR Core Heatup Code are summarized in this submittal and will be discussed in this meeting as it relates to the proposed test matrix. An additional submittal and meeting is planned for August to provide the NRC with the opportunity to review the details of the BWR Core Heatup Code.

Information is also provided in Attachment 4 concerning the 1/4 Scale Test Program. This includes the status of construction for the facility, the objectives for the test program and the development of the test matrices for the shakedown tests, scoping tests, and production tests. HCOG believes that the completion of the planned test program will provide sufficient data to demonstrate equipment survivability and resolve the diffusion flame issue. Once again, it is the purpose of this submittal and meeting to discuss and resolve NRC concerns regarding the 1/4 scale test program so that the overall HCOG program may proceed toward conclusion in an orderly and expeditious manner.

Should you have any questions, please do not hesitate to contact Mr. James R. Haley of Mississippi Power & Light Company.

Very truly yours,

James R Haley for

Sam H. Hobbs, Chairman
Hydrogen Control Owners Group

DBH/JRH:lm
cc: (See Next Page)

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cc: Mr. Carl R. Stahle (w/a) (12)
Hydrogen Control Program Manager
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Containment Systems Branch
Office of Nuclear Reactor Regulation
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Washington, D.C. 20555

Mr. John Cummings, Project Manager (w/a)
Hydrogen Studies, Division 4441
Sandia National Laboratory
Albuquerque, New Mexico 87185

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bcc: Mr. Erich Kant (IPC) (w/a)
Ms. Eileen Buzzelli (CEI) (w/a)
Mr. Erwin Zoch (GSU) (w/a)
Mr. John Hosler (EPRI) (w/a)
Mr. R. W. Evans (Enercon) (w/a)
Mr. M. Fuls (w/a)
Mr. B. Beasley (Bechtel) (w/a)
Mr. J. D. Richardson (TERA) (w/a)

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Attachment 1
HGN-018

HYDROGEN CONTROL OWNERS GROUP
NRC MEETING

JULY 24-25, 1984
FACTORY MUTUAL RESEARCH CORPORATION
NORWOOD, MASSACHUSETTS

AGENDA

July 24

8:00 - 8:15	Introduction and Meeting Objectives
8:15 - 8:30	Overview of HCOG Program Objectives
8:30 - 9:15	Review of 1/4 Scale Test Program Status
9:15 - 10:45	Travel to Test Site
10:45 - 12:00	Tour of Test Facility
12:00 - 2:30	Lunch and Return to Factory Mutual
2:30 - 3:30	Open Discussion on Test Facility
3:30 - 5:00	1/4 Scale Test Matrix Development

July 25

8:00 - 8:30	Summary of July 24 Discussion
8:30 - 10:00	NRC Comments on HCOG Responses to RAIs
10:00 - 10:30	Application of Test Data
10:30 - 11:30	Concurrence on Test Matrix Approach
11:30 - 1:00	Lunch/NRC Caucus
1:00 - 2:30	Open Discussion
2:30 - 3:00	Summary of Meeting
3:00	Adjourn

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HCOG-NRC MEETING OBJECTIVES

1. REVIEW THE ROLE OF THE 1/4TH SCALE TEST IN THE OVERALL HCOG PROGRAM.

2. REVIEW PROGRESS ON THE 1/4TH SCALE TEST PROGRAM.

3. REACH AGREEMENT AS TO THE ADEQUACY OF THE PRESENT TEST APPROACH TO PROVIDE THE NECESSARY INFORMATION ON DIFFUSION FLAMES.

4. DISCUSS THE DEVELOPMENT OF THE 1/4TH SCALE TEST MATRIX.

5. BRIEFLY REVIEW USE OF THE BWR CORE HEATUP CODE OUTPUT TO DEVELOP TIME HISTORIES TO BE INPUT TO THE 1/4TH SCALE TEST.

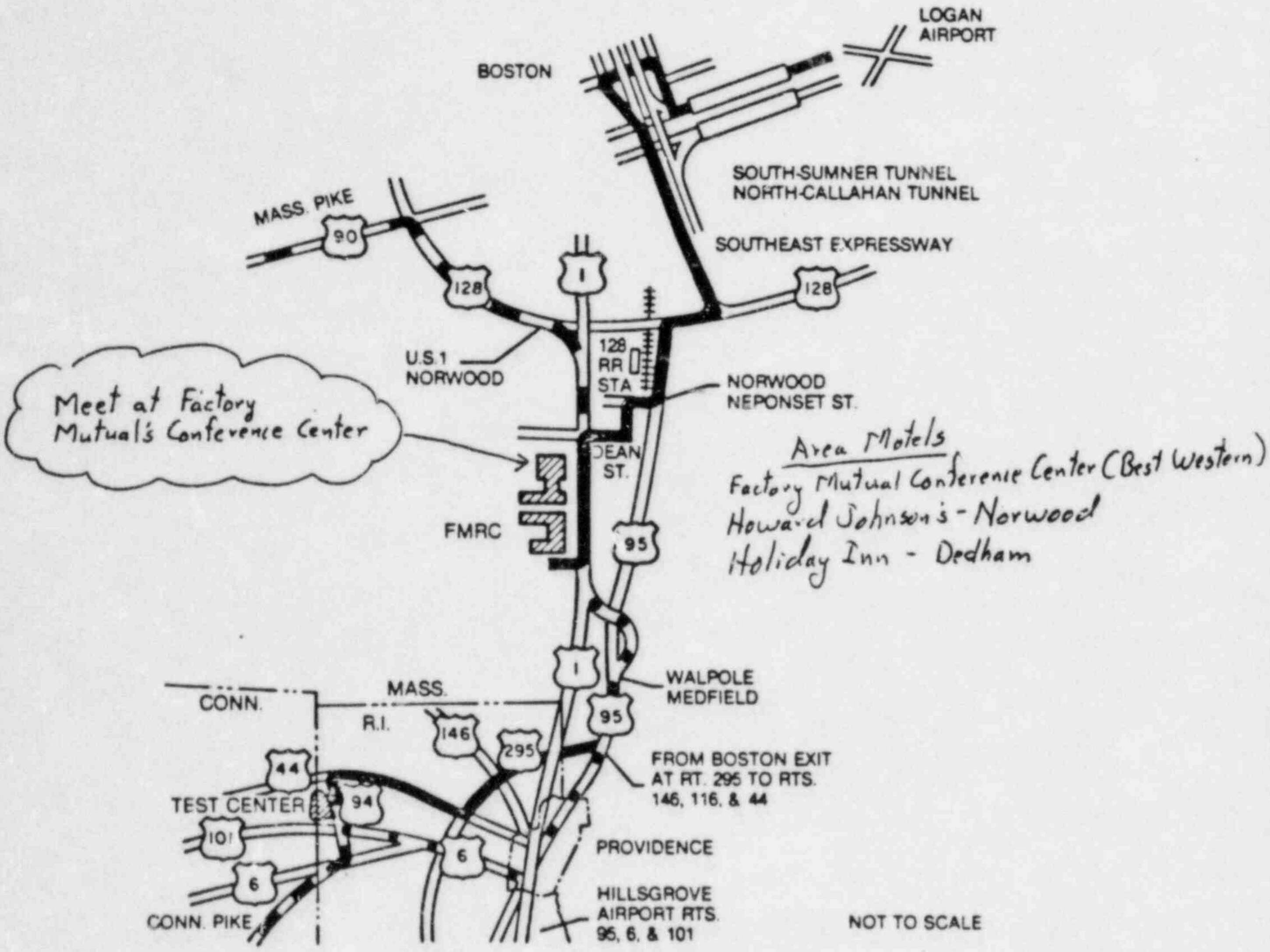
6. DISCUSS NRC COMMENTS ON THE HCOG RAI'S SUBMITTED ON APRIL 2, 1984.

7. DISCUSS APPLICATION OF THE TEST DATA.

8 REACH AGREEMENT ON TEST MATRIX APPROACH.

Attachment 3
HGN-018

How To Reach Factory Mutual Research Corporation Norwood, MA. and Factory Mutual Research Center West Glocester, R.I.



APPROXIMATE MILEAGE TO FMRC

BOSTON	18 MILES
PROVIDENCE, R.I.	32 MILES
ENTRANCE TO MASS. TURNPIKE	18 MILES

LEGEND

- FROM BOSTON, MASS.
- FROM PROVIDENCE, R.I.
- FROM NEW YORK AND POINTS WEST

APPROXIMATE MILEAGE TO TEST CENTER

NORWOOD	53 MILES
BOSTON	76 MILES
PROVIDENCE	27 MILES
NEW YORK	160 MILES

Factory Mutual System

Factory Mutual Research

Printed in USA (12-81)
P8102

MEETING BASIS SUBMITTAL

The Hydrogen Control Owners Group (HCOG) has undertaken the 1/4 scale test program to define the thermal environment due to the combustion of hydrogen as a diffusion flame resulting from a postulated degraded core scenario. The information contained in this attachment is provided to the NRC for review of the progress of the 1/4 scale test program, and to allow the NRC Staff an opportunity to comment on the 1/4 scale test matrix, so that HCOG and the NRC can reach concurrence on the tests to be conducted in the 1/4 scale test facility. HCOG believes that this test program will resolve the equipment survivability issues for steady diffusion flames.

1.0 1/4 Scale Test Program

The scaling basis used to design the 1/4 Scale Hydrogen Combustion Test Facility was described in Attachment 1 to Reference 1. Attachment 2 to Reference 1 provided a detailed report which summarized the design of the facility.

1.1 1/4 Scale Test Program Objectives

The goals and objectives for the 1/4 scale test program were delineated in Attachment 1 to Reference 2, which provided responses by HCOG to a number of NRC requests for additional information (RAIs).

The objectives of the test program are: (1) to obtain sufficient data to determine the full scale thermal environment (gas temperatures, gas velocities, and radiant heat fluxes) produced by diffusive burning of hydrogen which may be released during postulated recoverable degraded core accidents. The thermal environments will then be applied analytically to computer models of the equipment which is required to survive a burn to assess their thermal response, and (2) to assess the hydrogen mixing which occurs in the wetwell and upper containment prior to and during the hydrogen combustion transient.

Equipment survivability has already been demonstrated for the equipment required to survive a series of hydrogen deflagrations. These survivability calculations were completed for a hydrogen release corresponding to the reaction of 75% of the active fuel cladding with a hydrogen release rate of 1 lbm/sec. This evaluation is conservative since the results from the 1/20 and 1/5 scale tests, as documented in the attachment to Reference 3, showed that deflagrations will only occur for hydrogen release rates less than ~ 0.5 lbm/sec. This flow rate has been designated as the threshold for establishing continuous diffusion flames.

Therefore, only postulated recoverable degraded core scenarios which result in hydrogen release rates that are predominantly above the threshold for establishing continuous diffusion flames will be evaluated as part of the 1/4 scale test program.

1.2 1/4 Scale Test Facility Status

The primary enclosure for the test facility described in Reference 1 is nearing completion. This includes the outer tank, the inner tank and the major flow blockages. The exterior of the enclosure has not yet been painted. Installation of insulation on the interior surfaces of the facility is in progress. Major equipment including the data acquisition computer, the steam boiler, the air compressor, and other miscellaneous equipment has been received on site. The current schedule for the test program calls for initiation of the shakedown tests in September, 1984. Certain scoping tests which are described in Section 2.1 of this attachment are scheduled for October, 1984. The production testing is scheduled to follow in October and be completed by February, 1985.

1.3 1/4 Scale Facility Description

The capabilities of the 1/4 scale facility have been previously identified in Reference 1. Table 1-1 reiterates these capabilities and provides additional information on the capacities for the steam injection system and for the simulated containment unit coolers. Figures 1-1 through 1-4 show the actual configuration at each elevation for each of the containment designs. Figures 1-5 through 1-8 show the 1/4 scale facility simulation of each of the containment designs.

Figure 1-9 shows the structural design of the test facility. The test facility consists of a 31' diameter steel tank with a height of 49'. This tank contains a smaller tank which simulates the drywell volume. Airtight modules are installed in the outer test tank to simulate enclosed volumes in the containments. Floors in the test facility have been constructed in removable sections in order to test different plant configurations. The interior walls of the test facility have been covered with insulation. The lower portions of the external tank contains the simulated suppression pool. The test facility has been designed for the pressure range of -1.2 psig to 40 psig.

The major systems required for testing in the 1/4 scale facility include the simulated containment spray system, the simulated containment unit cooler system, the hydrogen injection system, the steam injection system, and the hydrogen ignition system. Each of these systems, with the exception of the simulated containment unit cooler system, is discussed in Reference 1. The simulated containment unit cooler system is discussed in Reference 2.

Hydrogen will be injected into the test facility through either simulated safety relief valve (SRV) discharge spargers or through both the simulated SRV discharge spargers and the simulated LOCA vents. The design of the simulated SRV discharge sparger was summarized in Reference 1. This design has been modified to ensure correct scaling for the injection of hydrogen or the simultaneous injection of steam and hydrogen.

Reference 1 states that the GMAC Model 7G glow plug will be used in the 1/4 scale test facility to initiate hydrogen combustion. A drawing which shows the mounting arrangement for the igniter in the test facility is included in Reference 1. The igniters are located in the test facility to correspond approximately with the igniter locations for Mississippi Power & Light Company's Grand Gulf Nuclear Station. The criteria used by Grand Gulf Nuclear Station for locating their igniters is representative of the criteria used by the other HCOG plants. Also, the 1/20th scale tests demonstrated that the exact igniter location was not a significant factor in determining diffussion flame environment. Therefore, the igniters in the facility are representative of all of the HCOG plants.

Figure 1-10 shows the test site layout. This figure shows the locations for the test facility, the steam boiler the hydrogen supply trailer, the control trailer, and access to the site.

2.0 Discussion of Test Plan

The testing will be conducted in three phases. Phase one will involve facility shakedown and check out. These tests will verify operation of facility systems and instruments. Phase two will be scoping tests which will confirm the threshold for establishing continuous diffusion flames and will evaluate parameters to be considered for production tests. Phase three will entail production tests to define the thermal environment produced by postulated degraded core accident scenarios.

2.1 Phase II - Scoping Tests

These tests will be used to confirm important parameters which affect definition of thermal environments from hydrogen release rate histories. Turndown tests will be performed to confirm the threshold for establishing continuous diffusion flames. Tests will also be performed to assess the effect of concurrent steam and hydrogen injection on the threshold for establishing continuous diffusion flames and the thermal environment at the HCU floor. Tests will also be performed to assess the effect of simultaneously discharging hydrogen through the LOCA vents and through the spargers on the thermal environment at the HCU floor. A test will be conducted to verify that the slight configuration difference between the Perry Nuclear Plant and the Grand Gulf Nuclear Station will have an insignificant effect on the thermal environment. (See

Figures 1-5 and 1-6.) These effects will be assessed by comparing the temperatures measured in this scoping test with the appropriate Grand Gulf Production tests.

2.2 Phase III - Production Tests

After the shakedown and scoping tests have been completed, the production tests will be conducted. They are listed in a tentative test matrix see Table 2-1, and will test the effect of using different hydrogen release histories, injecting the hydrogen through the simulated ADS valves as well as an additional stuck open relief valve, the effect of no containment sprays, and the different plant configurations. The development at the hydrogen release histories is discussed in Section 3.0.

The proposed production test matrix is based on the assumption that the following will be verified. If the scoping tests do not verify these assumptions, the production test matrix will be revised accordingly. Assumptions:

(1) Scoping tests confirm that the effects of hydrogen released through the spargers is limiting when compared to releasing the hydrogen through both the spargers and the LOCA vents.

(2) Scoping tests will confirm that the effects of injecting steam simultaneously with hydrogen will be negligible when compared with that of the injection of hydrogen alone.

(3) Scoping tests will confirm that the Perry configuration is similar enough to that of Grand Gulf such that the data obtained is applicable for both Grand Gulf and Perry.

(4) Scoping tests will confirm that with the igniters activated, there will be no pocketing of high concentrations of hydrogen.

As shown in Table 2-1, a set of tests has been included for the plant configurations which require simulation. The test configuration for each of the configurations will be as shown in Figures 1-5, 1-7, and 1-8. These figures show how the significant geometry differences will be accounted for. For each of the tested configurations, two basic sets of tests with three release histories will be run. Each set simulates the appropriate number of ADS spargers for the test configuration plus a stuck open relief valve sparger. This assumption is consistent with the Emergency Procedures Guidelines which instructs the operator to open the appropriate number of safety relief valves and depressurize the reactor for the scenario postulated. The difference between the two sets is in the location of the simulated stuck open relief valve (SORV) sparger. In each case the location is selected to represent what is anticipated to be the chimneys with the most severe thermal environments. Besides maximizing the thermal environment, such tests will provide results on the effect of the location of the stuck open relief valve. Tests 1 and 2 for the Grand Gulf configuration will be conducted in order to quantify the effect of sprays.

For each of the SORV sparger locations for a specific test configuration, three separate tests will be run with different hydrogen release histories. For the scenarios which produce hydrogen generation rates above the diffusion flame threshold, the hydrogen generation rate and the total amount of hydrogen produced are insensitive to the exact nature of the transient or accident which leads to conditions capable of producing hydrogen. The hydrogen production for a postulated degraded core accident scenario including rate, duration and total hydrogen production is maximized by the timing for initiation of reflood and the reflood rate. As the reflood flow rate increases, the peak hydrogen generation rate increases. However, both the duration of the hydrogen production and the total amount of hydrogen produced by the scenario decrease as the reflood flow rate is increased.

After evaluating various reflood cases, the HCOG will select three hydrogen release histories to be included in the 1/4 scale test matrix. The 1/4 scale test matrix identifies these three histories as Cases A, B and C. These three histories will be selected to be representative of the range of reflood rate cases with hydrogen generation rates above the diffusion flame threshold. The range of hydrogen generation rates is characterized by long duration with low peak hydrogen generation rates to short duration with high hydrogen generation rates. This will provide a range of release histories for analyzing the thermal response of small and large equipment.

The hydrogen release histories as generated by the BWR Heatup Code shows the hydrogen generation rates continuously varying with time. For the production tests these rates will be simulated in .032 kg/sec increments which have been mathematically calculated from the BWR Heatup Core Output. An example of this method is shown in Figure 3-1.

3.0 Development of the Hydrogen Release Time Histories

3.1 Background

The hydrogen release time histories are being developed for use in the 1/4 scale test matrix. The development of these time histories have considered postulated recoverable degraded core accident scenarios which result in hydrogen release rates predominantly above the continuous diffusion flame threshold. Due to the exothermic zirconium-steam reactions which produce these hydrogen release rates there is significant heating of the core. These scenarios cannot result in a total hydrogen production equivalent to oxidizing 75% of the active fuel cladding and still maintain a recoverable core.

Scenarios which could potentially result in oxidation equivalent to 75% of the active fuel cladding with a recoverable core would result in hydrogen release rates below the threshold for continuous diffusion flames. Therefore, these scenarios are outside the scope of the 1/4 scale test program.

The types of postulated scenarios which lead to hydrogen release rates above the threshold for continuous flames have a common sequence of events. The postulated scenarios begin with any transient or accident which results in relatively fast vessel depressurization, loss of significant vessel inventory, and inability to inject makeup to the vessel. Very little hydrogen would be produced during the initial depressurization of the vessel and not until the steam cooling becomes ineffective. The fuel is assumed to be 3/4 uncovered and would begin heatup before any appreciable oxide layer would be formed on the cladding surface. This type of scenario is conservative because formation of an oxide layer would reduce the amount of oxidation which could occur and therefore produces less hydrogen. This scenario is consistent with the emergency procedure guideline because if no injection flow is available to provide makeup to the vessel, the emergency procedure guideline requires that the vessel be depressurized. This will be accomplished by opening at least seven safety relief valves and would occur before any hydrogen is generated. This also assures that multiple hydrogen release points will be available.

No reflood is assumed to occur as core heatup progresses until hydrogen production in the vessel becomes limited by the availability of additional steam to feed the oxidation. This point in an unmitigated scenario represents the peak hydrogen generation rate. Reflood is then assumed to be initiated which produces a maximized hydrogen generation rate.

For such scenarios, the hydrogen generation rate and the total amount of hydrogen produced are insensitive to the exact nature of the transient or accident which leads to conditions capable of producing hydrogen. The hydrogen production for a postulated degraded core accident scenario including rate, duration and total hydrogen production is maximized by the timing for initiation of reflood and the reflood rate. As the reflood flow rate increases, the peak hydrogen generation rate increases. However, both the duration of the hydrogen production and the total amount of hydrogen produced by the scenario decrease as the reflood flow rate is increased.

3.2 BWR Core Heatup Code Modeling

Although the BWR Core Heatup Code has been utilized in calculating hydrogen release histories for degraded core accidents, the details of this code including modeling capability, assumptions and core nodalization will be presented to the Nuclear Regulatory Commission in a future submittal from HCOG. However, to provide a preliminary basis for assessing the hydrogen release histories predicted by the BWR Core Heatup Code, some details on code modeling are included in this submittal.

The BWR Core Heatup Code provides detailed modeling of the core components and geometry as well as the thermal hydraulic conditions in the reactor pressure vessel. The core geometry is assumed to remain intact during core heatup which maximizes the surface area available for oxidation. Zircaloy oxidation is modeled with the oxidation terminated at high temperature, in the oxidizing nodes. The oxidation is assumed to be terminated because in reality the cladding has melted and would relocate forming a geometry which would provide much less surface for oxidation. The code has been modified to account for oxidation of the exterior fuel channel walls and control blade oxidation which occurs due to steaming in the bypass region. A conservative assumption presently being used in the code is that the nodes above and below a melted node are still available for oxidation. In-fact, the flow of steam to these nodes would be restricted if not totally shutoff and would stop all hydrogen production in that fuel channel.

Termination of Zircaloy oxidation at high temperatures has been observed in numerous experimental investigations. Experiments conducted by Hagen at KFK included simulation of fuel rod oxidation and meltdown. These experiments showed that oxidation was terminated in the temperature range of 2200-2300 °K. The Power Burst Facility test included a test (SFD-1) which showed that the oxidation was terminated in the temperature range of 2300-2400 °K. Finally results from experiments performed by H. Chung at Argonne National Labs have been extrapolated and indicate that oxidation terminates at a temperature of approximately 2200 °K.

The apparent cause of oxidation termination is that the Zircaloy, which melts at a temperature of 2173 °K, interacts with the uranium oxide fuel. The liquid zirconium-uranuim oxide mixture slumps into a geometry which essentially eliminates the surface area available for oxidation. The physical state of the core is assumed to be altered when the oxidation cutoff temperature is reached. In the BWR Core Heatup Code, the oxidation termination point is assumed to be 2400 °K. When this temperature is reached in a given node, the oxidation from this node is terminated irreversably based upon the assumption that the geometry for the node is no longer intact and available for further oxidation.

Based upon the previous discussion, the scenarios evaluated with the BWR Core Heatup Code have several common elements. Therefore, the BWR Core Heatup Code has been modeled to reflect the following assumptions:

(1) The reactor pressure vessel is depressurized to two atmospheres.

(2) The vessel water level is assumed to be lowered until at least 3/4 of the core is uncovered.

(3) The fuel is free of any oxide buildup until after the core is 3/4 uncovered.

(4) The maximum hydrogen generation rate is reached before any additional water is injected.

(5) The injection occurs at constant reflood rates.

(6) The core geometry analytically remains intact which maximizes the surface area available for oxidation.

(7) The Zircaloy oxidation terminates at 2400 °K.

3.3 BWR Core Heatup Code Results

The BWR Core Heatup Code is being used to evaluate different reflood rates. Plots (See Figures 2-1 thru 2-20) are provided for reflood rate cases (0, 80, 150, 300, and 500 gpm) to show the core water inlet and steam outlet flows, the hydrogen generation rate, the Zircaloy oxidation fraction (MWR fraction) and the active core Zircaloy melt fraction. Reflood flow rates above 5000 gpm are more probable since more systems are available for recovery with flow rates in this region including all of the ECCS systems. Reflood transients with injection flow equal to 5000 gpm or above produce very little hydrogen because the core is rapidly quenched. Total hydrogen production is less than 200 pounds.

The 0 gpm reflood case produces peak hydrogen release rates at or just below the threshold for diffusion flames and therefore cannot be used for evaluating the effects of diffusion flames in the 1/4 scale test facility. However, it is used for determing the peak hydrogen generation rate for timing the start of reflood as described previously and for comparison against the reflood cases. The 80, 150, and 300 gpm reflood cases have hydrogen production rates above the diffusion flame threshold; however, these injection rates are inadequate to prevent excessive clad melt (greater than 50% melt) before the core is cooled.

4.0 Application of 1/4 Scale Test Data

As shown in the revised instrumentation plan included in Attachment 5, a significant amount of instrumentation has been included in the 1/4 scale test facility in order to measure gas velocities, temperatures, and radiant heat fluxes. From these measurements the thermal environment will be defined for the areas with equipment of concern. The test instrumentation has been strategically located based upon the experience gained in the 1/20th scale tests.

The convective heat transfer coefficient for a specific piece of equipment will be determined using standard methods with consideration of the flow Reynolds Number (based on the measured and appropriately scaled temperatures and flow velocities) and the geometric characteristics of the equipment. The radiative flux to equipment will be determined using Hottel charts with consideration of the view factor from the radiation source (flames and/or hot metal surfaces) to the equipment and a gas/metal source temperature based on measured data. The equipment thermal response will be determined by applying the thermal environment to the equipment computer models.

The approaches described above for determining convective and radiative heat loads will be used to predict the full-scale thermal environment from the 1/4 scale test data. This same method and thermal environment will be analytically applied to models of the sphere calorimeters included in the test instrumentation. The predicted thermal response of these calorimeters will be then compared with the observed response of the calorimeter. It is expected that this will demonstrate that the standard heat transfer methods are adequate for definition of a thermal enviroment based on measured data.

REFERENCES

1. Letter from HCOG to NRC, HGN-012, dated August 12, 1983.

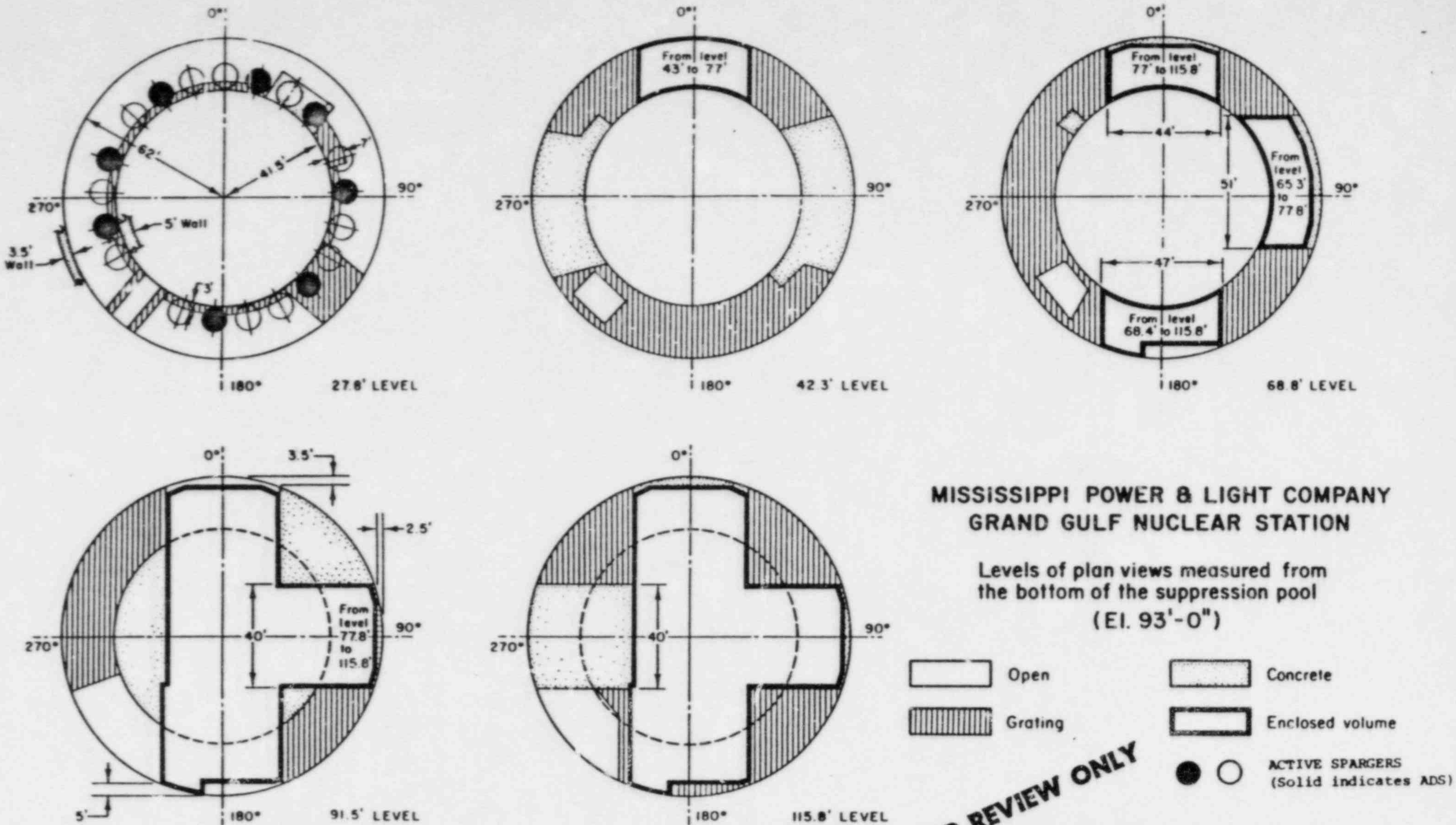
2. Letter from HCOG to NRC, HGN-016, dated April 2, 1984.

3. Letter from HCOG to NRC, HGN-014, date February 9, 1984.

Table 1 - 1

TEST FACILITY CAPABILITIES

- Simulation of plant geometry variations.
- Maximum/minimum pressure: 40/-1.2 psig.
- Controllable H_2 release rate: 0-4 lb/s (full-scale).
- Total H_2 release/test: 2500 lbs (full-scale).
- H_2 release through spargers and/or LOCA vents.
- Steam and air purging.
- Containment sprays at 3800 gpm (full-scale).
- Pool temperature range 70-185°F.
- Steam injection flow rate: 0-159 lbs/sec @ 100 psi (full-scale).
- Containment unit cooler heat removal rate: 23 M Btu/hr (full-scale).



DRAFT FOR REVIEW ONLY

FACTORY MUTUAL RESEARCH

GRAND GULF RENDITION
(Derived from FMRC Dwg Rev.1 Dated 11/20/83)

No. REVISION | By | Date | Appd | Date

TOLERANCES Linear, Angular: N/A

PRELIMINARY Not for fabrication. Date 6/18/84 By EAC

RELEASED FOR FABRICATION By, Approved: N/A Date, Date

Scale: As Marked
Date: 06/18/84

Desig EAC Date 6/4/84
Checked Date

Drawn by MVB
SHEET 1 OF 1
D840618-01

FIGURE 1-1

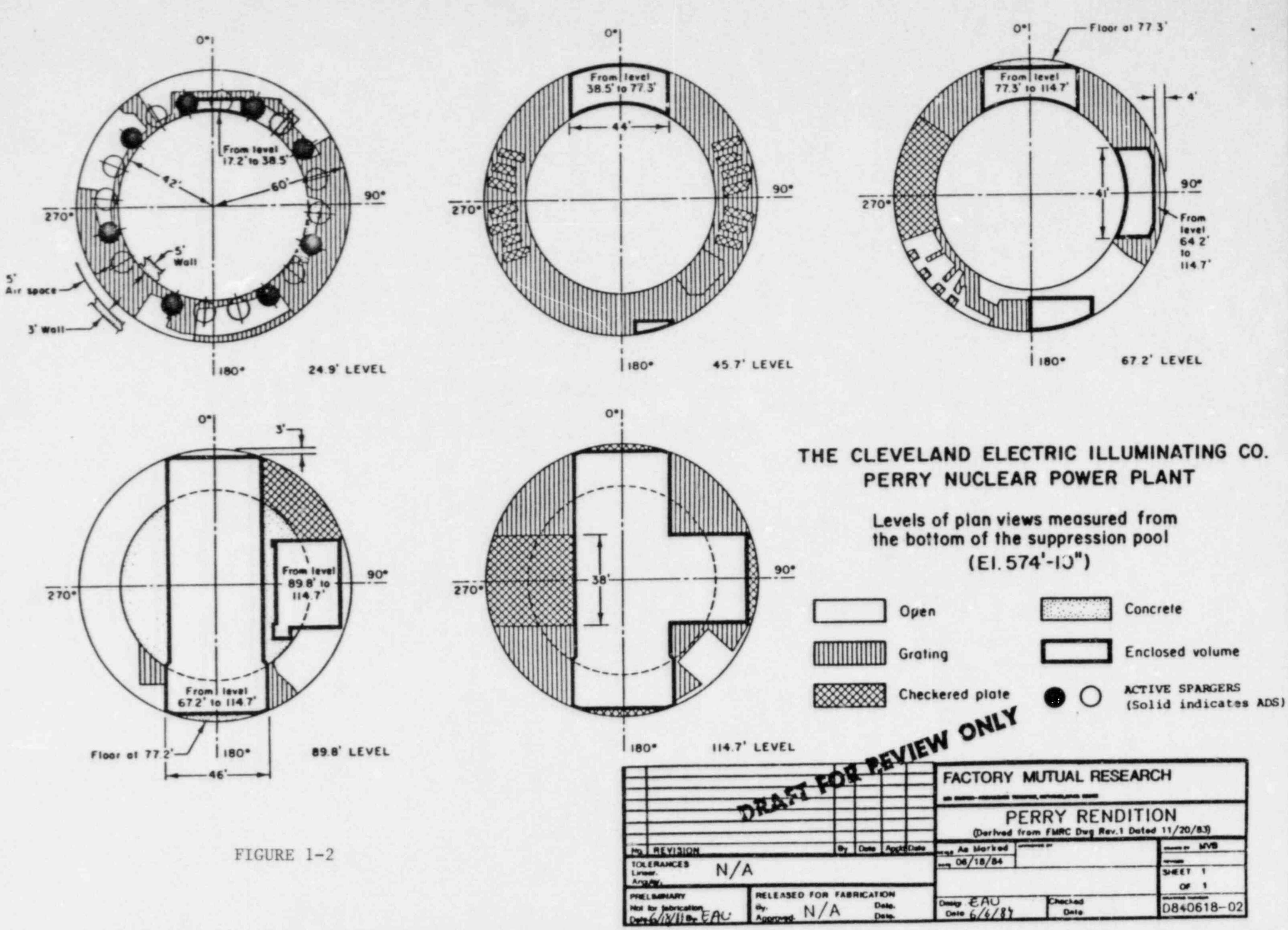
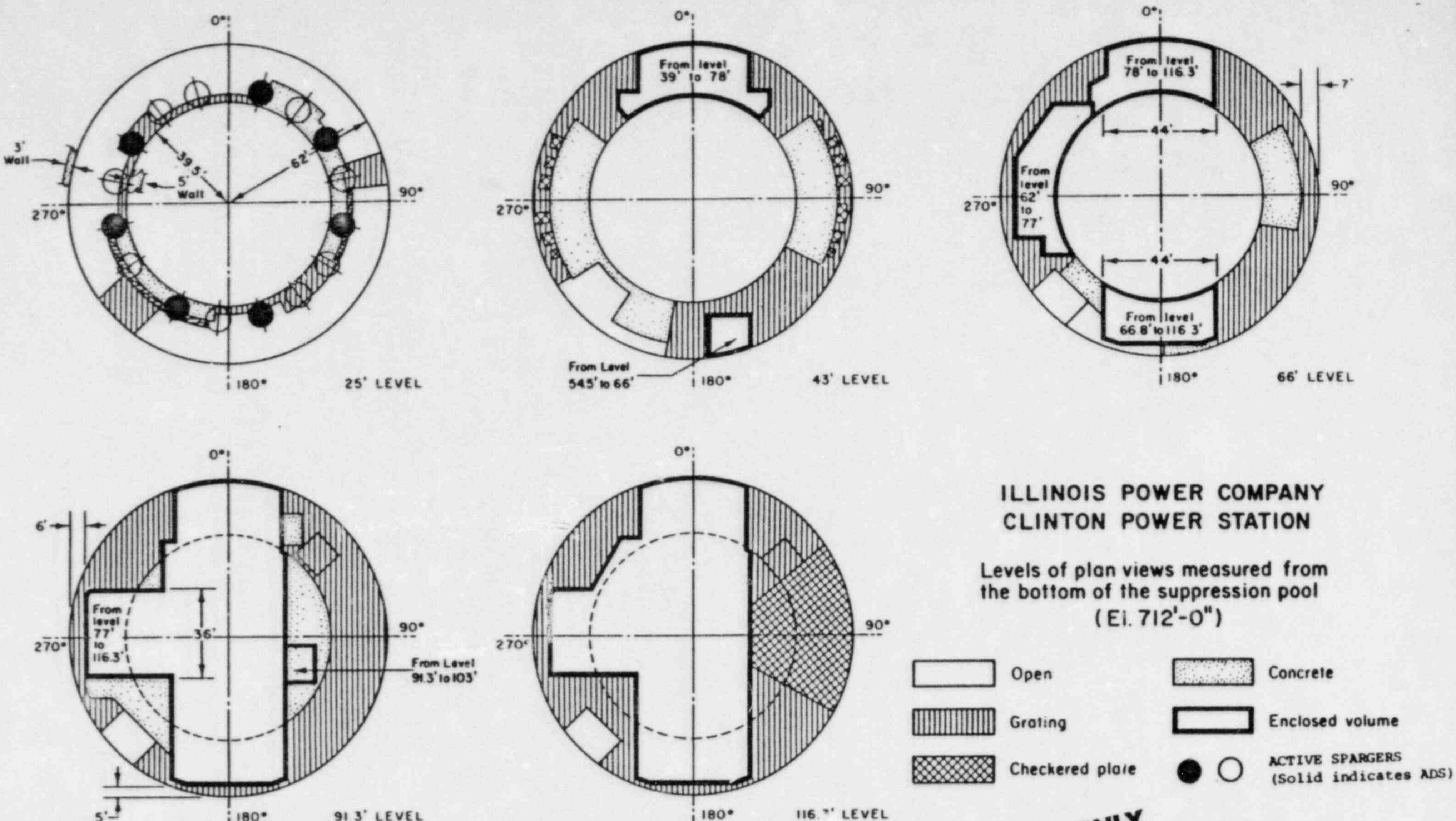
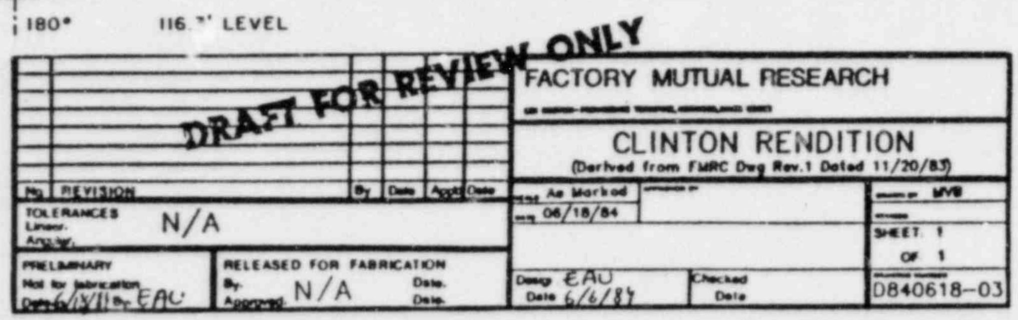

0°
From level 17.2' to 38.5'
42'
60'
90°
270°
5' Wall
5' Air space
3' Wall
180°
24.9' LEVEL
0°
From level 38.5' to 77.3'
44'
90°
270°
180°
45.7' LEVEL
0°
Floor at 77.3'
From level 77.3' to 114.7'
4'
41'
90°
270°
From level 64.2' to 114.7'
180°
67.2' LEVEL
0°
3'
From level 89.8' to 114.7'
90°
270°
From level 67.2' to 114.7'
Floor at 77.2'
180°
46'
89.8' LEVEL
0°
38'
90°
270°
180°
114.7' LEVEL
THE CLEVELAND ELECTRIC ILLUMINATING CO.
PERRY NUCLEAR POWER PLANT
Levels of plan views measured from the bottom of the suppression pool (El. 574'-10")
Open
Concrete
Grating
Enclosed volume
Checkered plate
ACTIVE SPARGERS (Solid indicates ADS)
DRAFT FOR REVIEW ONLY
FACTORY MUTUAL RESEARCH
PERRY RENDITION
(Derived from FMRC Dwg Rev.1 Dated 11/20/83)
No. REVISION
By Date Appd Date
TOLERANCES Linear. Angular.
N/A
PRELIMINARY Not for fabrication Date 6/18/84 By EAU
RELEASED FOR FABRICATION By. Date. Approved. N/A Date.
As Marked
06/18/84
Desig EAU Date 6/6/84
Checked Date
MVB
SHEET 1 OF 1
D840618-02

FIGURE 1-2

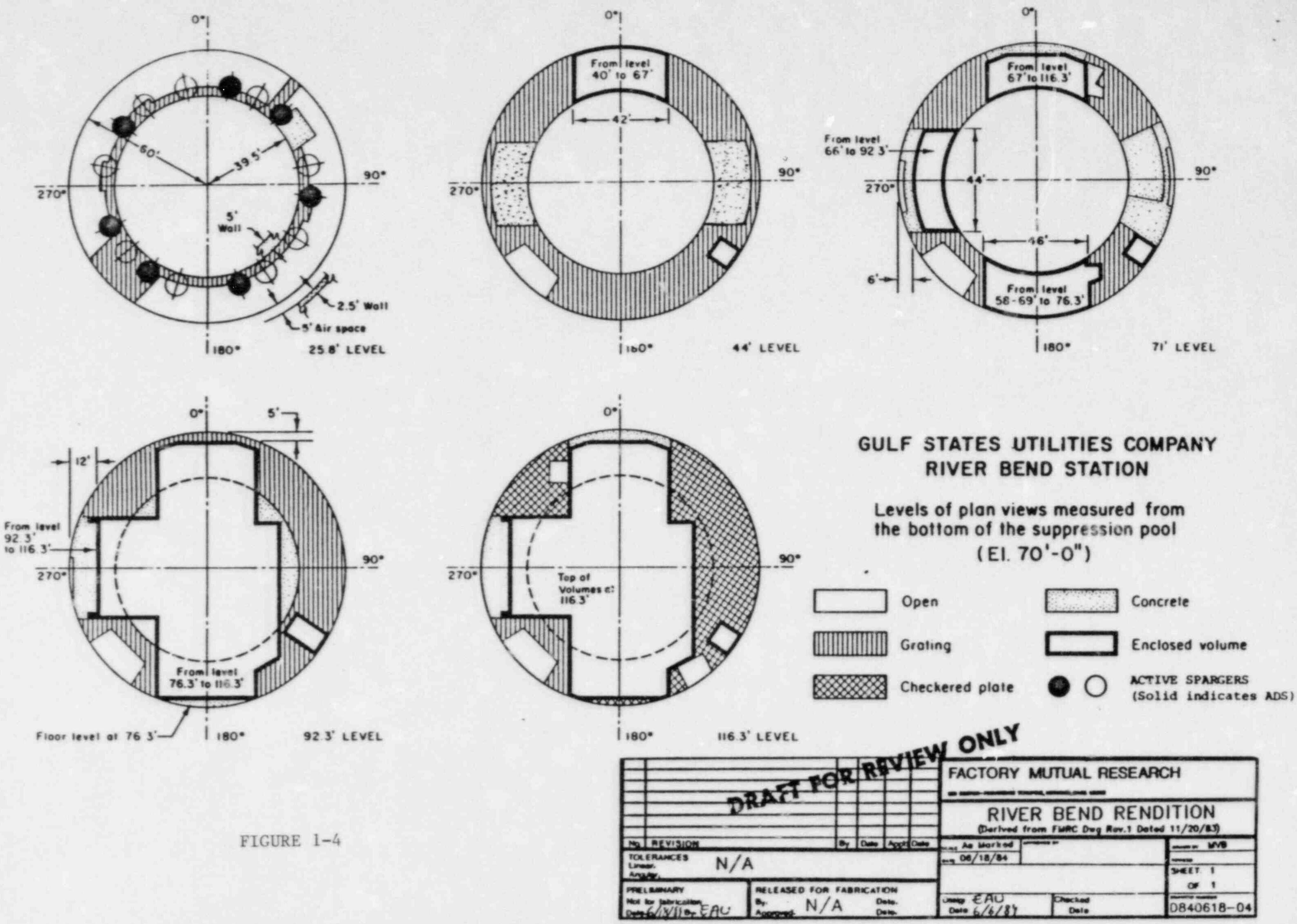


0°
3' Wall
5' Wall
39.3'
62'
90°
270°
180°
25' LEVEL
From level 39' to 78'
From Level 54.5' to 66'
43' LEVEL
From level 78' to 116.3'
7'
44'
From level 62' to 77'
From level 66.8' to 116.3'
66' LEVEL
6'
From level 77' to 116.3'
36'
From Level 91.3' to 103'
5'
91.3' LEVEL
116.3' LEVEL
ILLINOIS POWER COMPANY
CLINTON POWER STATION
Levels of plan views measured from the bottom of the suppression pool
(El. 712'-0")
Open
Concrete
Grating
Enclosed volume
Checkered plate
ACTIVE SPARGERS
(Solid indicates ADS)



DRAFT FOR REVIEW ONLY
FACTORY MUTUAL RESEARCH
CLINTON RENDITION
(Derived from FMRC Dwg Rev.1 Dated 11/20/83)
No. REVISION
By
Date
Appd
Date
TOLERANCES
Linear
Angular
N/A
PRELIMINARY
Not for fabrication
RELEASED FOR FABRICATION
N/A
As Marked
06/18/84
Design EAU
Date 6/6/84
Checked
Date
MVB
SHEET 1
OF 1
D840618-03

FIGURE 1-3



0°
90°
180°
270°
60'
39.5'
5' Wall
2.5' Wall
5' Air space
25.8' LEVEL
From level 40' to 67'
42'
44' LEVEL
From level 67' to 116.3'
From level 66' to 92.3'
44'
46'
6'
From level 58-69' to 76.3'
71' LEVEL
5'
12'
From level 92.3' to 116.3'
From level 76.3' to 116.3'
Floor level at 76.3'
92.3' LEVEL
Top of Volumes at: 116.3'
116.3' LEVEL
GULF STATES UTILITIES COMPANY
RIVER BEND STATION
Levels of plan views measured from the bottom of the suppression pool
(El. 70'-0")
Open
Concrete
Grating
Enclosed volume
Checkered plate
ACTIVE SPARGERS
(Solid indicates ADS)
DRAFT FOR REVIEW ONLY
FACTORY MUTUAL RESEARCH
RIVER BEND RENDITION
(Derived from FMRC Dwg Rev.1 Dated 11/20/83)
No. REVISION
By
Date
Appd
Date
As Marked
06/18/84
MVB
SHEET 1
OF 1
TOLERANCES
Linear
Angular
N/A
PRELIMINARY
Not for fabrication
6/18/84 By EAU
RELEASED FOR FABRICATION
By
Approved
N/A
Date
EAU
Date 6/6/84
Checked
Date
0840618-04

FIGURE 1-4

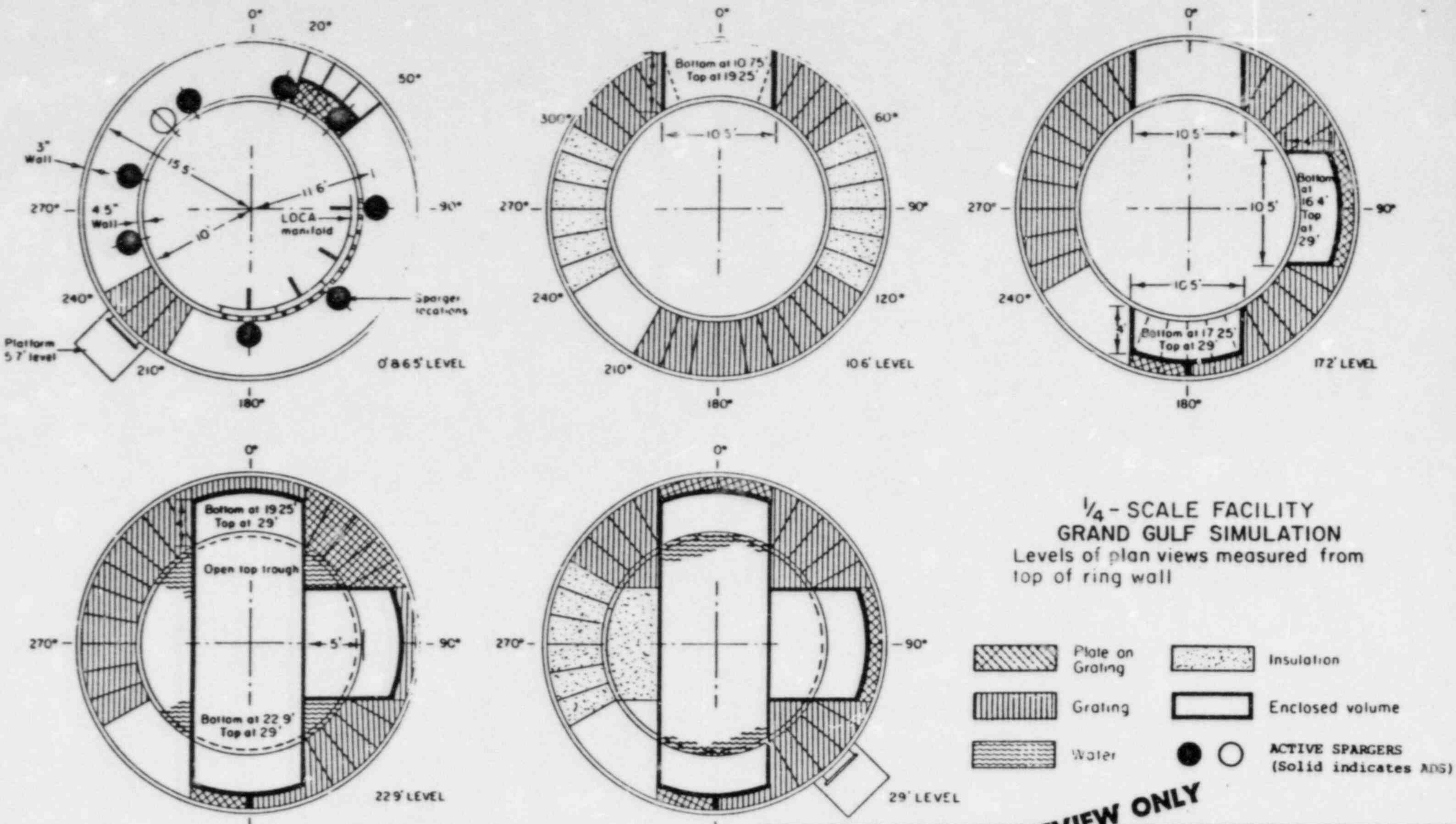


FIGURE 1-5

DRAFT FOR REVIEW ONLY

FACTORY MUTUAL RESEARCH

GRAND GULF SIMULATION
(Derived from FMRC Dwg Rev.3 Dated 12/7/83)

No.	REVISION	By	Date	Appd	Date

TOLERANCES Linear. Angular. N/A

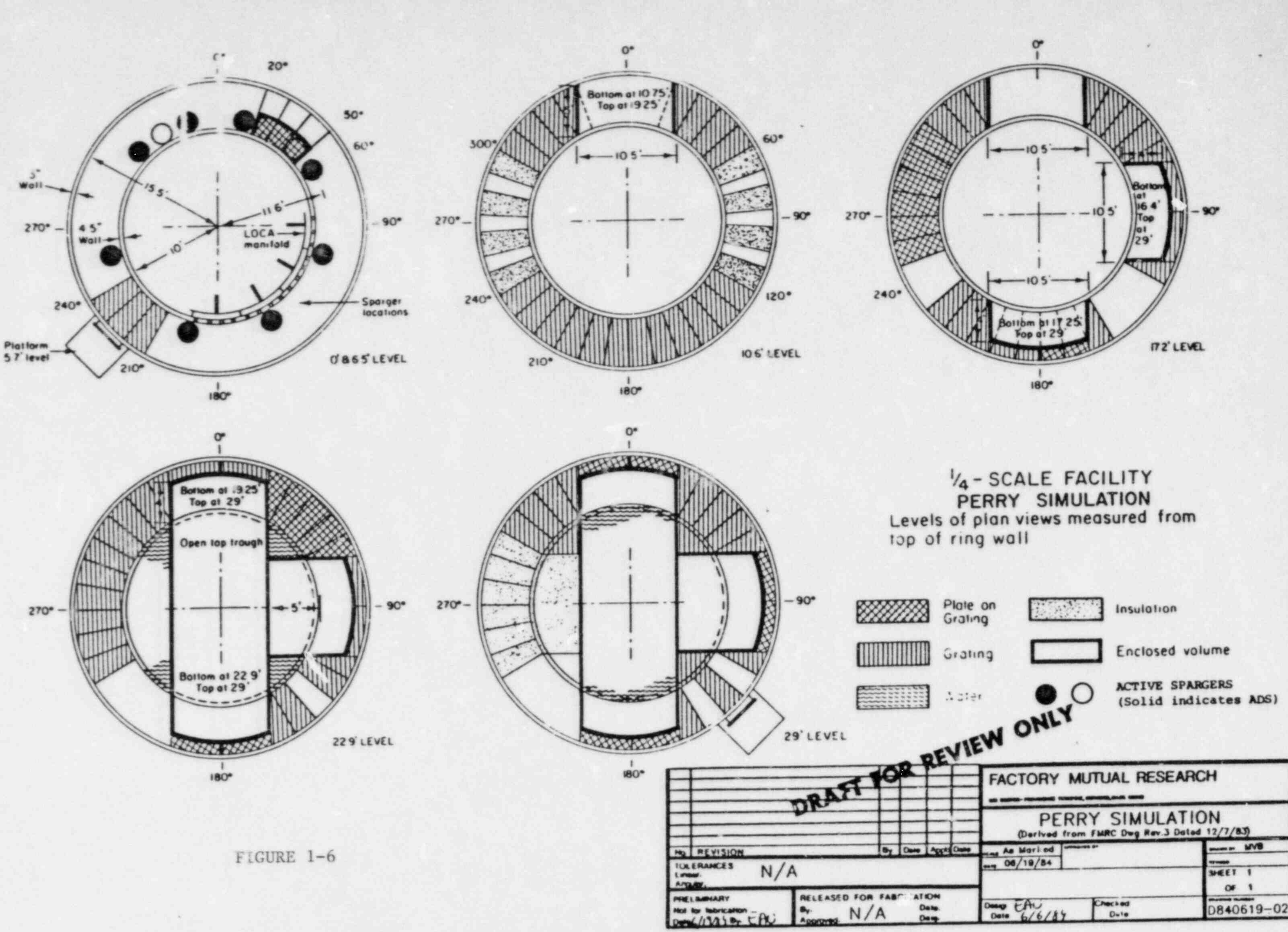
Scale As Marked — Dwg 06/19/84 — Drawn by MVB — SHEET 1 OF 1

PRELIMINARY Not for fabrication Date 6/19/84 By EAU

RELEASED FOR FABRICATION By. N/A Date. Approval. Date.

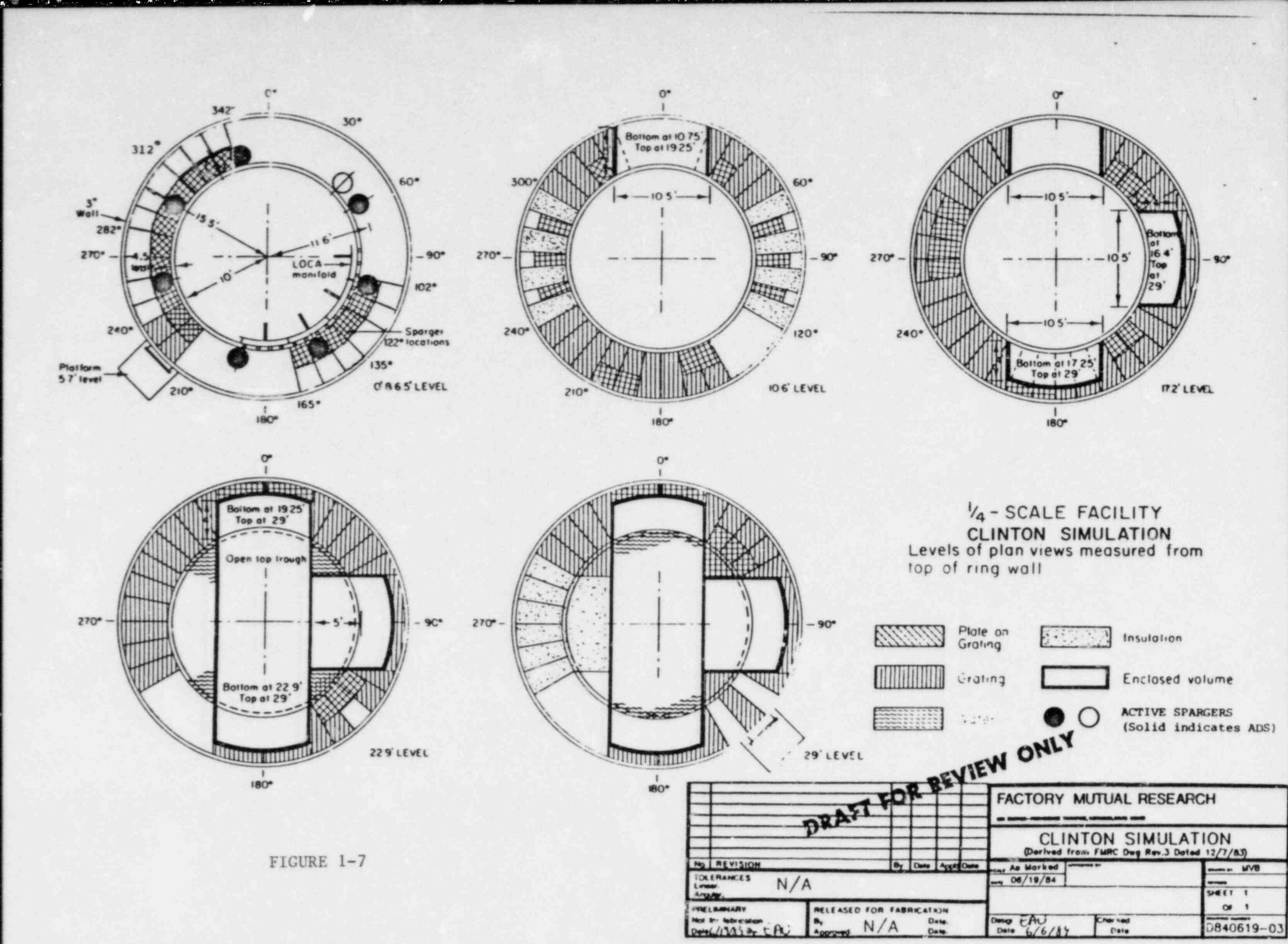
Design EAU Date 6/6/84 — Checked Date

D840619-01



0°
20°
50°
60°
5" Wall
15.5'
11.6'
270°
90°
4.5" Wall
LOCA manifold
10'
240°
Sparger locations
Platform 5.7' level
210°
0'-8.65' LEVEL
180°
Bottom at 10.75'
Top at 19.25'
300°
10.5'
120°
10.6' LEVEL
Bottom at 16.4'
Top at 29'
Bottom at 17.25'
Top at 29'
17.2' LEVEL
Bottom at 19.25'
Top at 29'
Open top trough
5'
Bottom at 22.9'
Top at 29'
22.9' LEVEL
29' LEVEL
1/4 - SCALE FACILITY
PERRY SIMULATION
Levels of plan views measured from top of ring wall
Plate on Grating
Insulation
Grating
Enclosed volume
ACTIVE SPARGERS
(Solid indicates ADS)
DRAFT FOR REVIEW ONLY
FACTORY MUTUAL RESEARCH
PERRY SIMULATION
(Derived from FMRC Dwg Rev.3 Dated 12/7/83)
REVISION
By
Date
TOLERANCES
Linear
Angular
N/A
As Marked
08/19/84
MVB
SHEET 1
OF 1
PRELIMINARY
Not for fabrication
RELEASED FOR FABRICATION
By
Approved
N/A
Date
EAC
6/6/84
Checked
D840619-02

FIGURE 1-6



¼ - SCALE FACILITY
CLINTON SIMULATION
Levels of plan views measured from top of ring wall
0' & 6.5' LEVEL
10.6' LEVEL
17.2' LEVEL
22.9' LEVEL
29' LEVEL
3" Wall
4.5" Wall
LOCA manifold
Sparger locations
Platform 5.7' level
Bottom at 10.75' Top at 19.25'
Bottom at 16.4' Top at 29'
Bottom at 17.25' Top at 29'
Bottom at 19.25' Top at 29'
Open top trough
Bottom at 22.9' Top at 29'
Plate on Grating
Grating
Insulation
Enclosed volume
ACTIVE SPARGERS
(Solid indicates ADS)
DRAFT FOR REVIEW ONLY
FACTORY MUTUAL RESEARCH
CLINTON SIMULATION
(Derived from FMRC Dwg Rev.3 Dated 12/7/83)
REVISION
TOLERANCES
N/A
PRELIMINARY
Not for fabrication
RELEASED FOR FABRICATION
N/A
As Marked
06/19/84
EAU
6/6/84
MVB
SHEET 1
OF 1
0840619-03

FIGURE 1-7

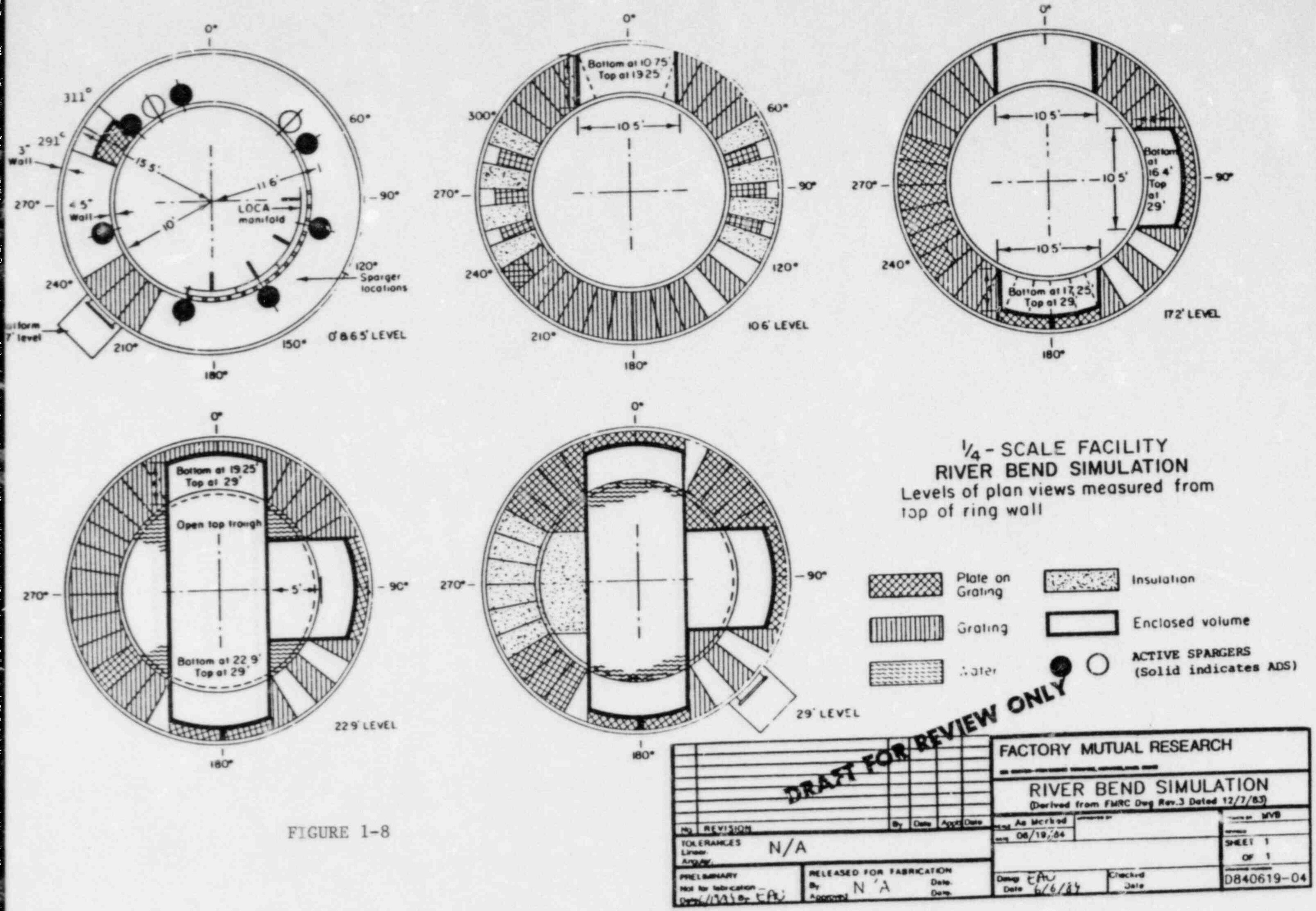
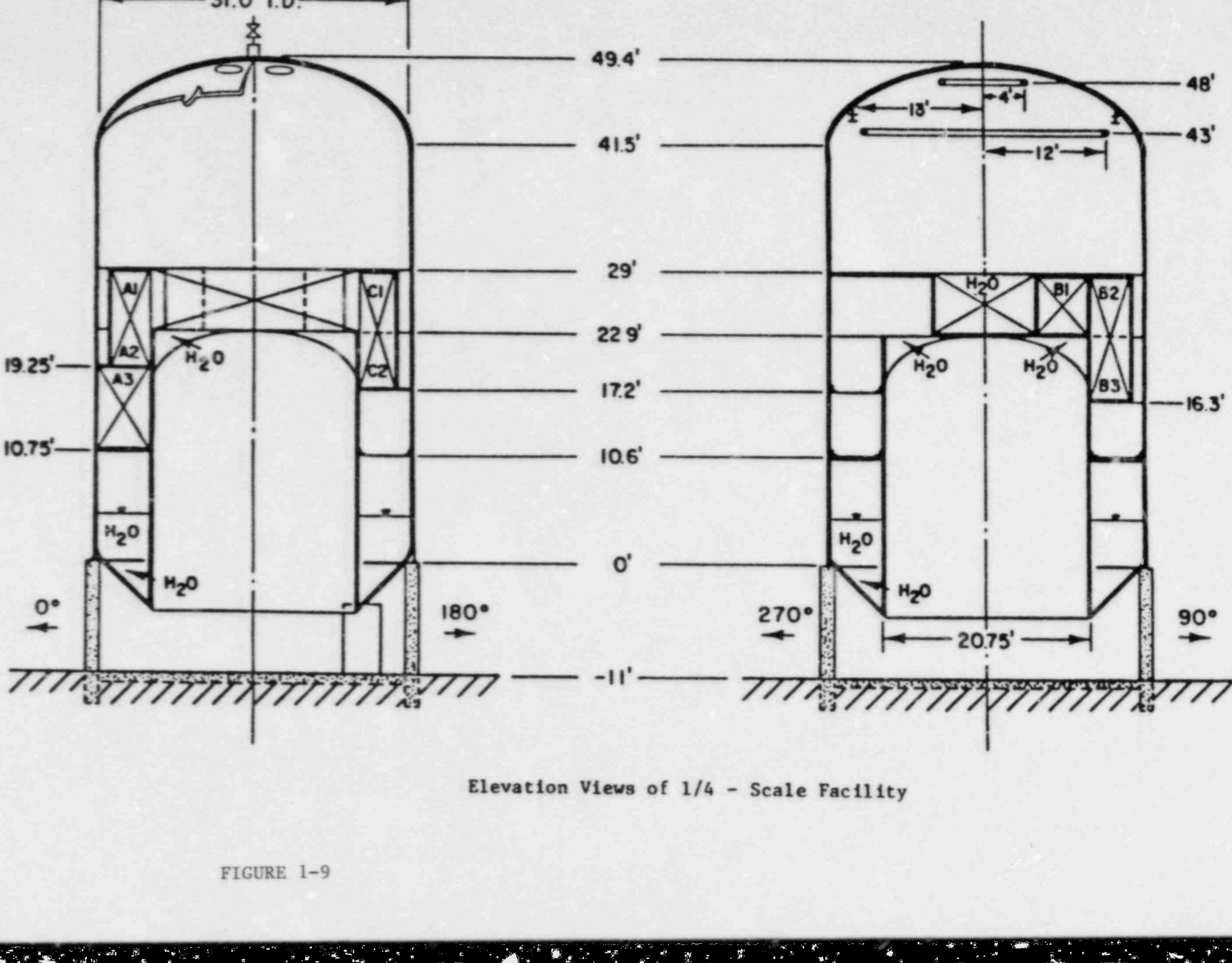
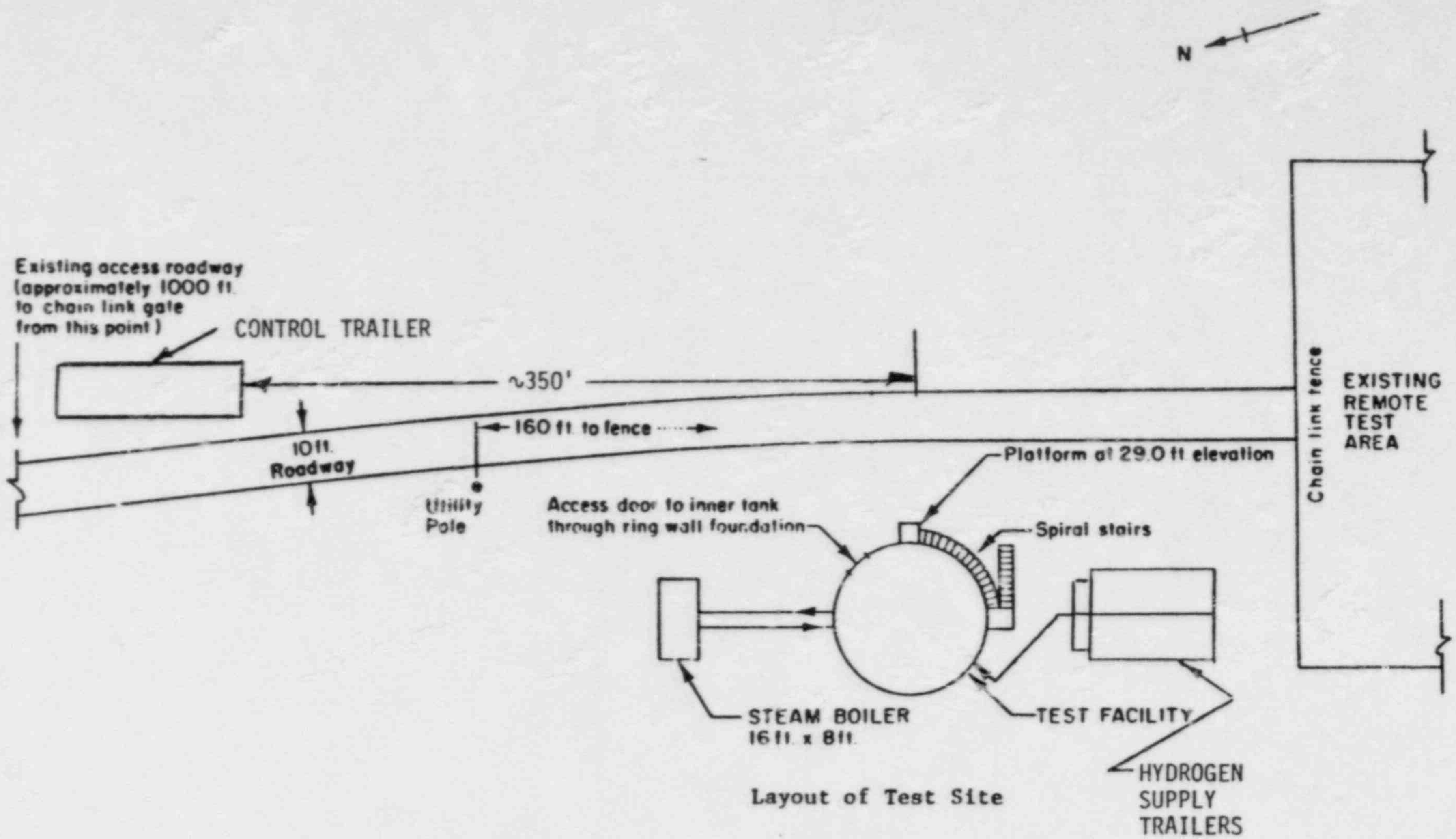

0°
311°
291°
3" Wall
15.5'
11.6'
LOCA manifold
270°
4.5" Wall
10'
90°
60°
240°
120°
Sparger locations
210°
150°
180°
0' & 6.5' LEVEL
Bottom at 10.75'
Top at 19.25'
300°
10.5'
10.6' LEVEL
Bottom at 16.4' Top at 29'
Bottom at 17.25' Top at 29'
17.2' LEVEL
Bottom at 19.25' Top at 29'
Open top trough
5'
Bottom at 22.9' Top at 29'
22.9' LEVEL
29' LEVEL
1/4 - SCALE FACILITY
RIVER BEND SIMULATION
Levels of plan views measured from top of ring wall
Plate on Grating
Insulation
Grating
Enclosed volume
Water
ACTIVE SPARGERS (Solid indicates ADS)
DRAFT FOR REVIEW ONLY
FACTORY MUTUAL RESEARCH
RIVER BEND SIMULATION
(Derived from FMRC Dwg Rev.3 Dated 12/7/83)
REVISION
By
Date
Appd
Date
TOLERANCES Linear Angular N/A
PRELIMINARY Not for fabrication
RELEASED FOR FABRICATION By N/A Approved Date
As Marked
06/19/84
Dsgn EAU Date 6/6/84
Checked Date
SHEET 1 OF 1
D840619-04

FIGURE 1-8



Elevation Views of 1/4 - Scale Facility

FIGURE 1-9



Layout of Test Site

FIGURE 1-10

TABLE 2-1
TENTATIVE PRODUCTION TEST MATRIX

TEST NO	H_2/STEAM RELEASE HSITORY (1)	NO./LOCATION OF ACTIVE SPARGERS (2)	SPRAYS OR COOLERS	CONFIGURATION SIMULATED
1	"A"	9 (8 ADS + 312°)	OFF	Grand Gulf/Perry (4)
2	"A"	↓	ON	↓
3	"B"		↓	
4	"C"	↓		
5	"A"	9 (8 ADS + 32°)		
6	"B"	↓		
7	"C"	↓		↓
8	"A"	8 (7 ADS + 36°) (3)		Clinton
9	"B"	↓		↓
10	"C"	↓		
11	"A"	8 (7 ADS + 323°) (3)		
12	"B"	↓		
13	"C"	↓		↓
14	"A"	8 (7 ADS + 28°) (3)		River Bend
15	"B"	↓		↓
16	"C"	↓		
17	"A"	8 (7 ADS + 323°) (3)		
18	"B"	↓	↓	↓
19	"C"			

*See the Following Page for Explanation Notes.

tBdb13

NOTES FOR TABLE 2-1

(1) THE HYDROGEN/STEAM RELEASE HISTORIES ("A," "B" AND "C") SHOWN IN THE ATTACHMENT ARE FOR GRAND GULF. THE CORRESPONDING RELEASE HISTORIES FOR THE OTHER PLANTS WILL BE DERIVED BY MULTIPLYING THOSE HISTORIES BY THE FOLLOWING RATIO:

$$\frac{\text{NO. OF FUEL BUNDLES IN THE OTHER PLANT CORE}}{\text{NO. OF FUEL BUNDLES IN GRAND GULF'S CORE}}$$

(2) THE SPARGER LOCATIONS IN THE TEST FACILITY ARE EVENLY SPACED AT 15° INTERVALS. THE TEST SPARGER CLOSEST TO THE ACTUAL LOCATION OF THE ACTIVE PLANT SPARGER WILL BE UTILIZED.

(3) SINCE THIS PLANT IS BEING SIMULATED AS A "MIRROR IMAGE" OF THE TEST FACILITY, THE TESTED LOCATIONS WILL BE IN "MIRROR IMAGE" POSITIONS TO THOSE SHOWN.

(4) A TEST WILL BE CONDUCTED AS PART OF THE SCOPING TESTS TO VERIFY THAT THE SLIGHT DIFFERENCE IN CONFIGURATION BETWEEN GRAND GULF AND PERRY WILL HAVE MINIMAL EFFECT ON THE THERMAL ENVIRONMENT AND THEREFORE, THESE PRODUCTION TESTS WILL BE APPLICABLE TO BOTH GRAND GULF AND PERRY.

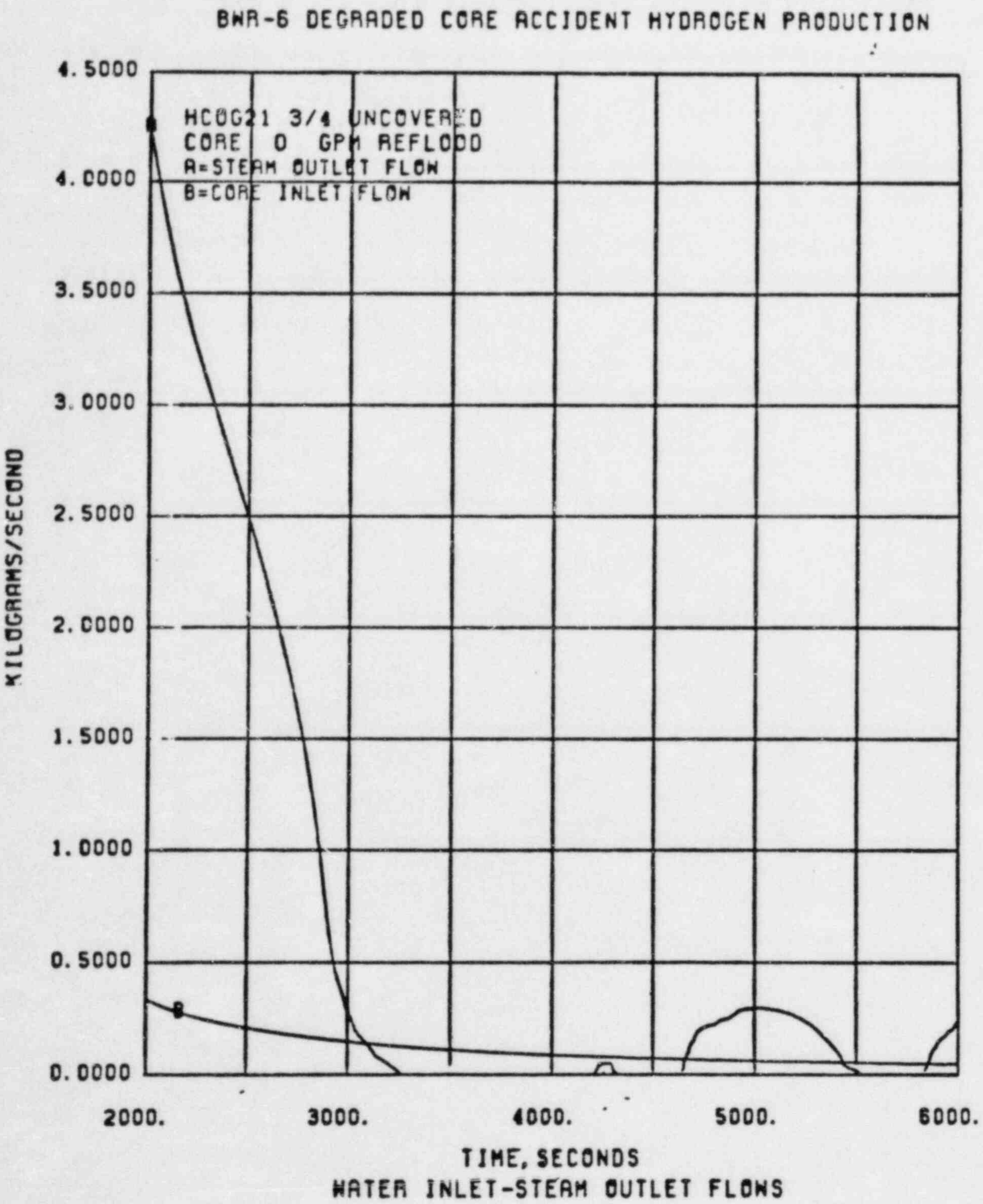
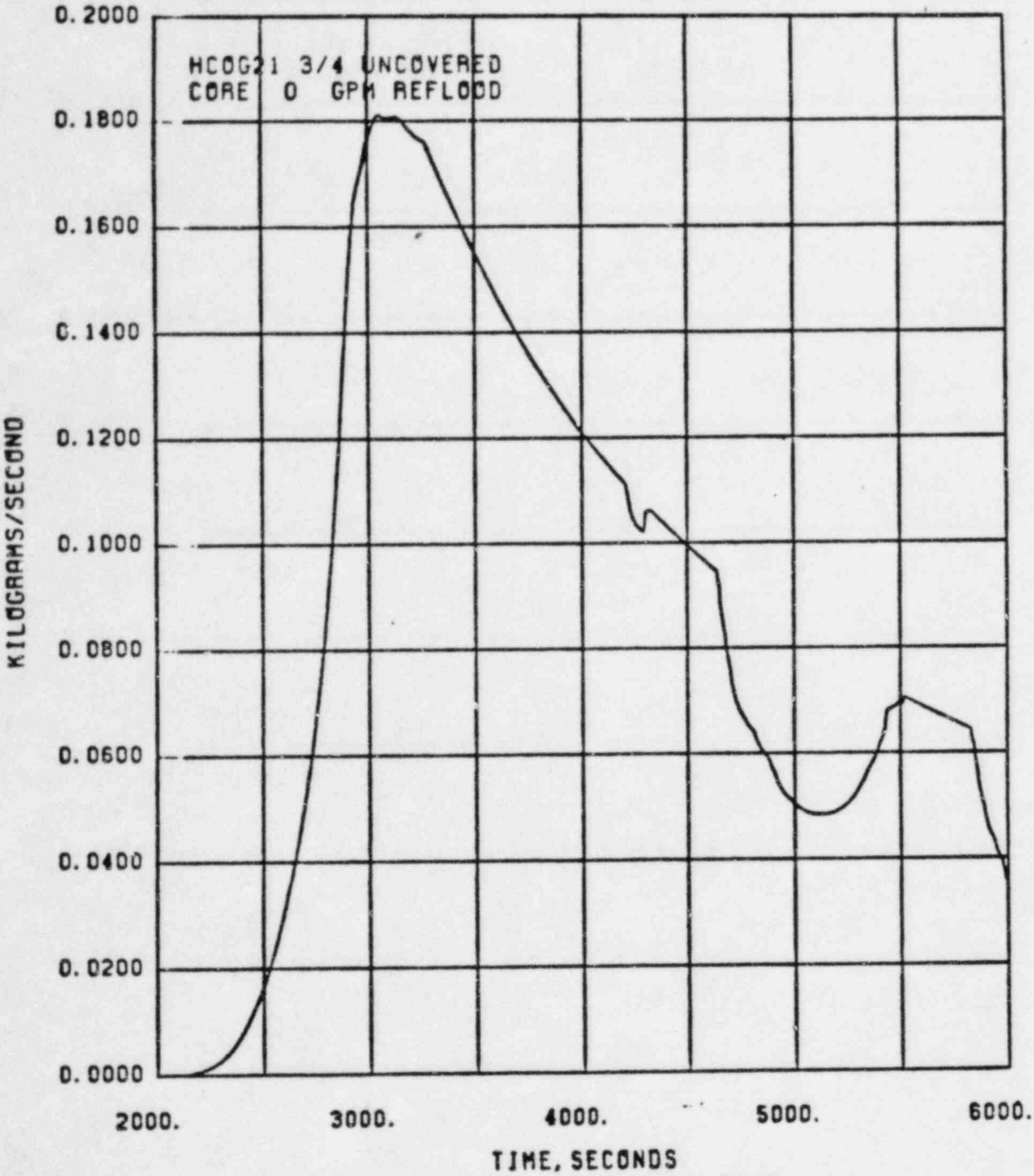

BWR-6 DEGRADED CORE ACCIDENT HYDROGEN PRODUCTION
HCOG21 3/4 UNCOVERED
CORE 0 GPM REFLOOD
A=STEAM OUTLET FLOW
B=CORE INLET FLOW
4.5000
4.0000
3.5000
3.0000
2.5000
2.0000
1.5000
1.0000
0.5000
0.0000
KILOGRAMS/SECOND
2000.
3000.
4000.
5000.
6000.
TIME, SECONDS
WATER INLET-STEAM OUTLET FLOWS

FIGURE 2-1

BWR-6 DEGRADED CORE ACCIDENT HYDROGEN PRODUCTION



HYDROGEN GENERATION RATE

FIGURE 2-2

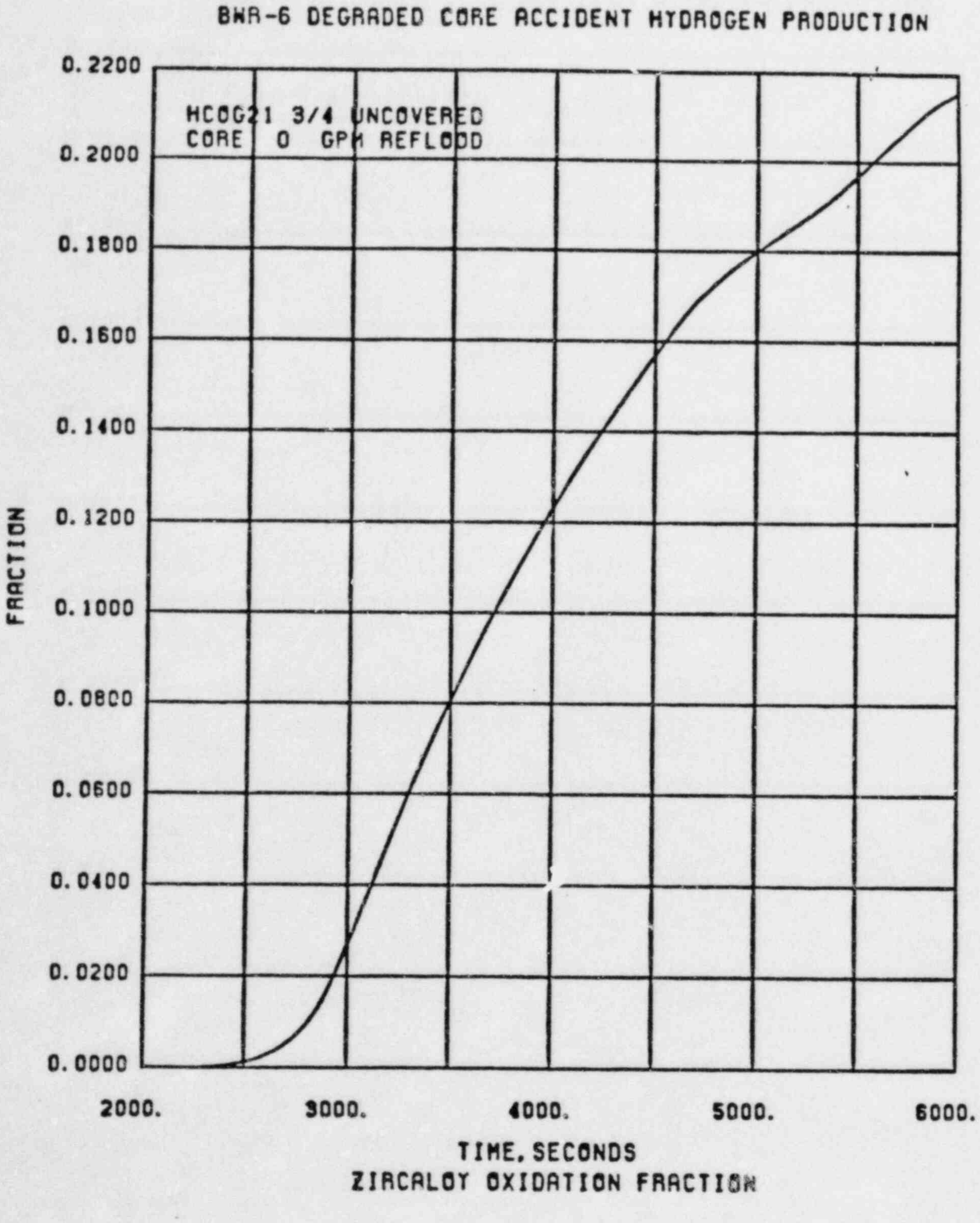

BWR-6 DEGRADED CORE ACCIDENT HYDROGEN PRODUCTION
HCOG21 3/4 UNCOVERED
CORE 0 GPM REFLOOD
FRACTION
0.2200
0.2000
0.1800
0.1600
0.1400
0.1200
0.1000
0.0800
0.0600
0.0400
0.0200
0.0000
2000.
3000.
4000.
5000.
6000.
TIME, SECONDS
ZIRCALOY OXIDATION FRACTION

FIGURE 2-3

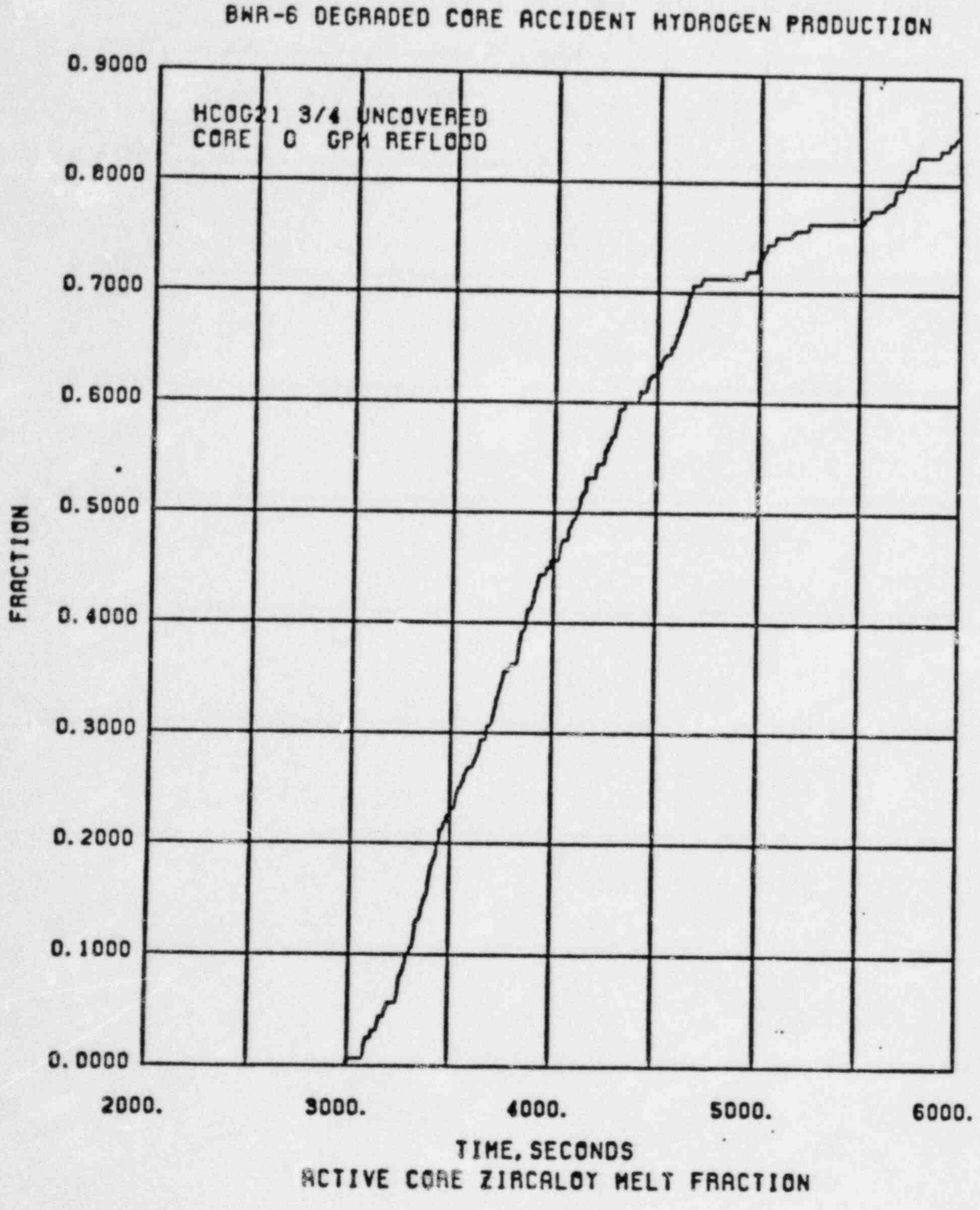
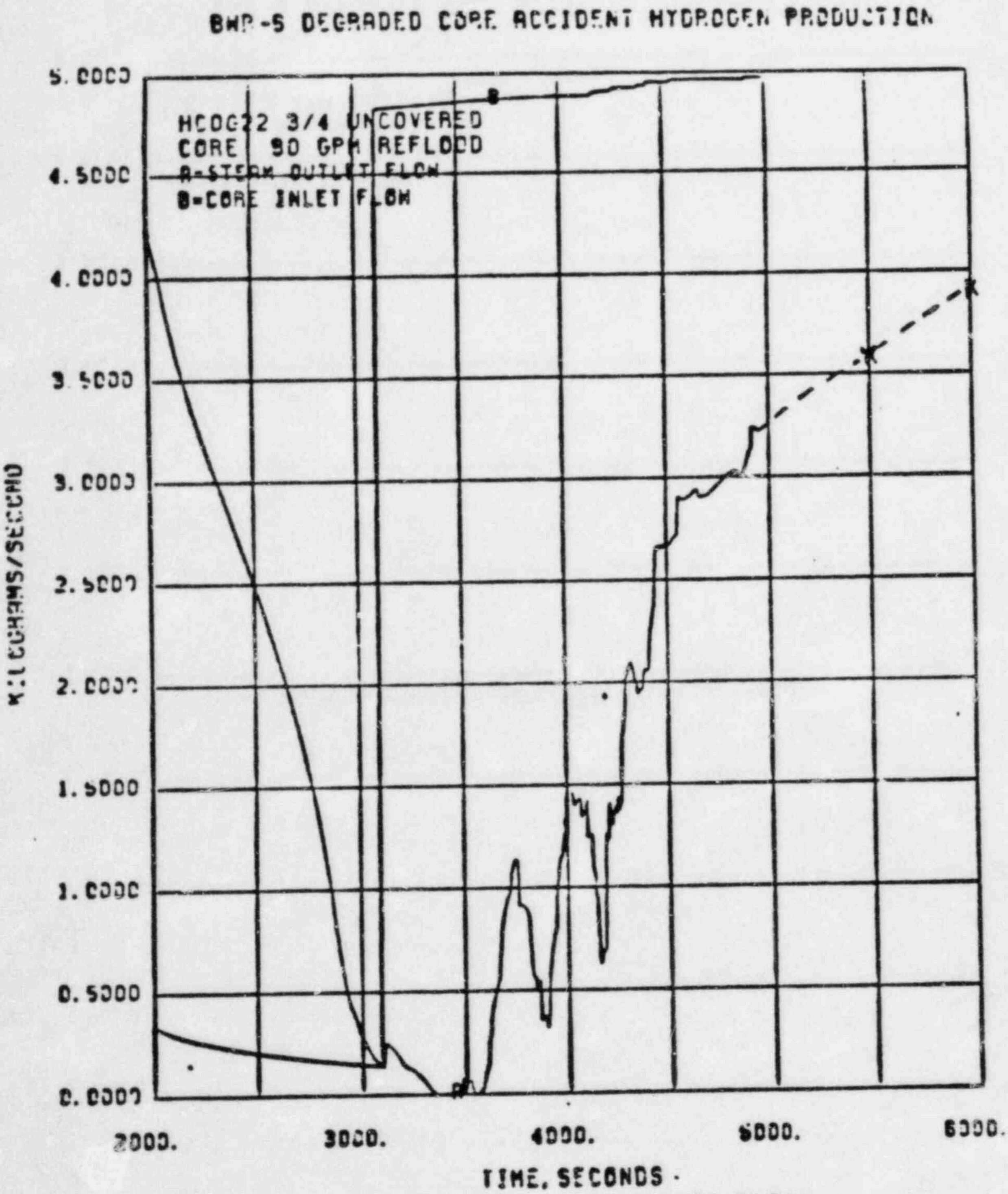
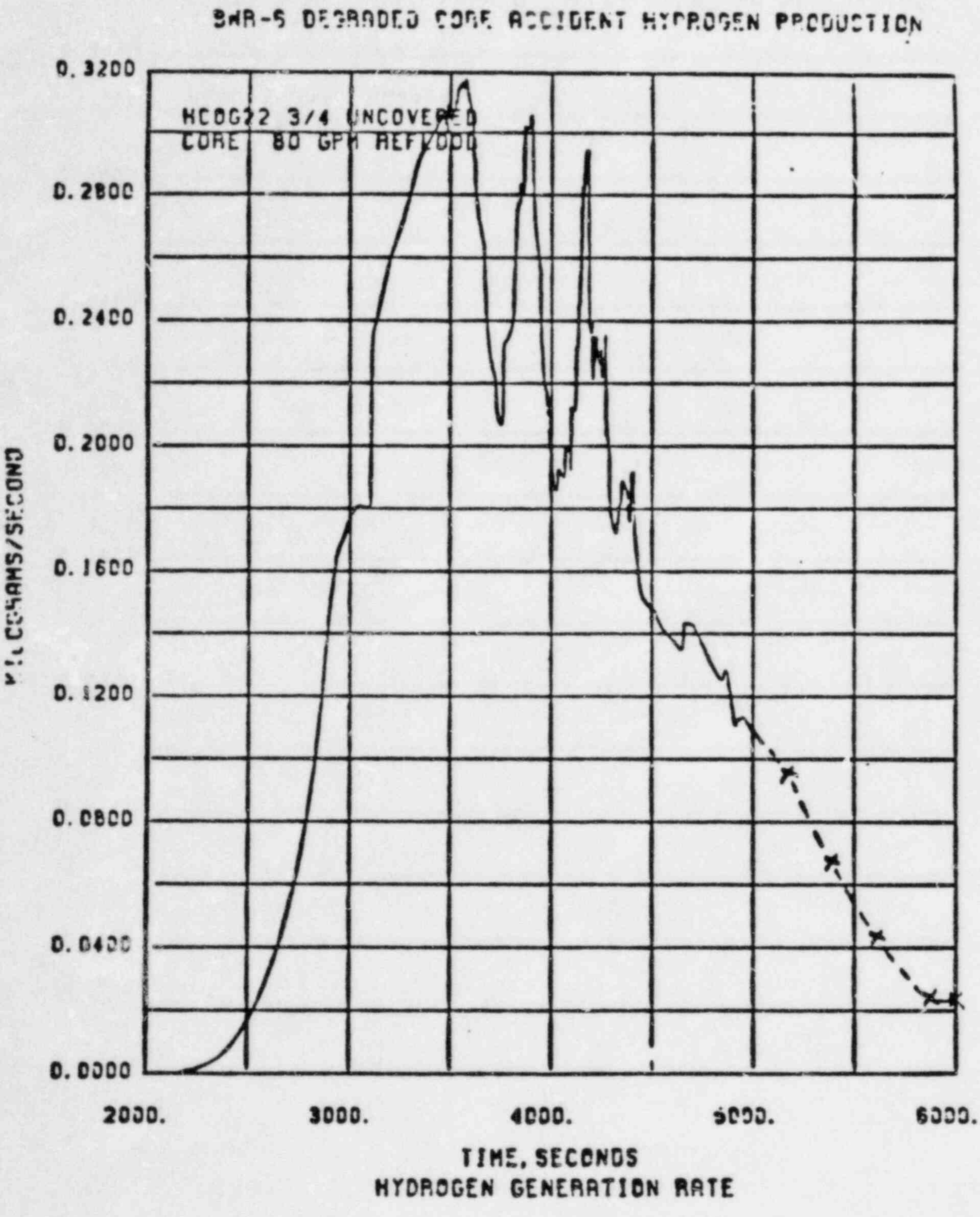

BWR-6 DEGRADED CORE ACCIDENT HYDROGEN PRODUCTION
HCOG21 3/4 UNCOVERED
CORE 0 GPM REFLOOD
0.9000
0.8000
0.7000
0.6000
0.5000
0.4000
0.3000
0.2000
0.1000
0.0000
FRACTION
2000.
3000.
4000.
5000.
6000.
TIME, SECONDS
ACTIVE CORE ZIRCALOY MELT FRACTION

FIGURE 2-4



BWR-5 DEGRADED CORE ACCIDENT HYDROGEN PRODUCTION
HCOG22 3/4 UNCOVERED
CORE 90 GPM REFLOOD
A-STEAM OUTLET FLOW
B-CORE INLET FLOW
5.0000
4.5000
4.0000
3.5000
3.0000
2.5000
2.0000
1.5000
1.0000
0.5000
0.0000
2000.
3000.
4000.
5000.
6000.
TIME, SECONDS
WATER INLET-STEAM OUTLET FLOWS

FIGURE 2-5



BWR-6 DEGRADED CORE ACCIDENT HYDROGEN PRODUCTION
HCOG22 3/4 UNCOVERED
CORE 80 GPM REFLOOD
0.3200
0.2800
0.2400
0.2000
0.1600
0.1200
0.0800
0.0400
0.0000
2000.
3000.
4000.
5000.
6000.
TIME, SECONDS
HYDROGEN GENERATION RATE

FIGURE 2-6

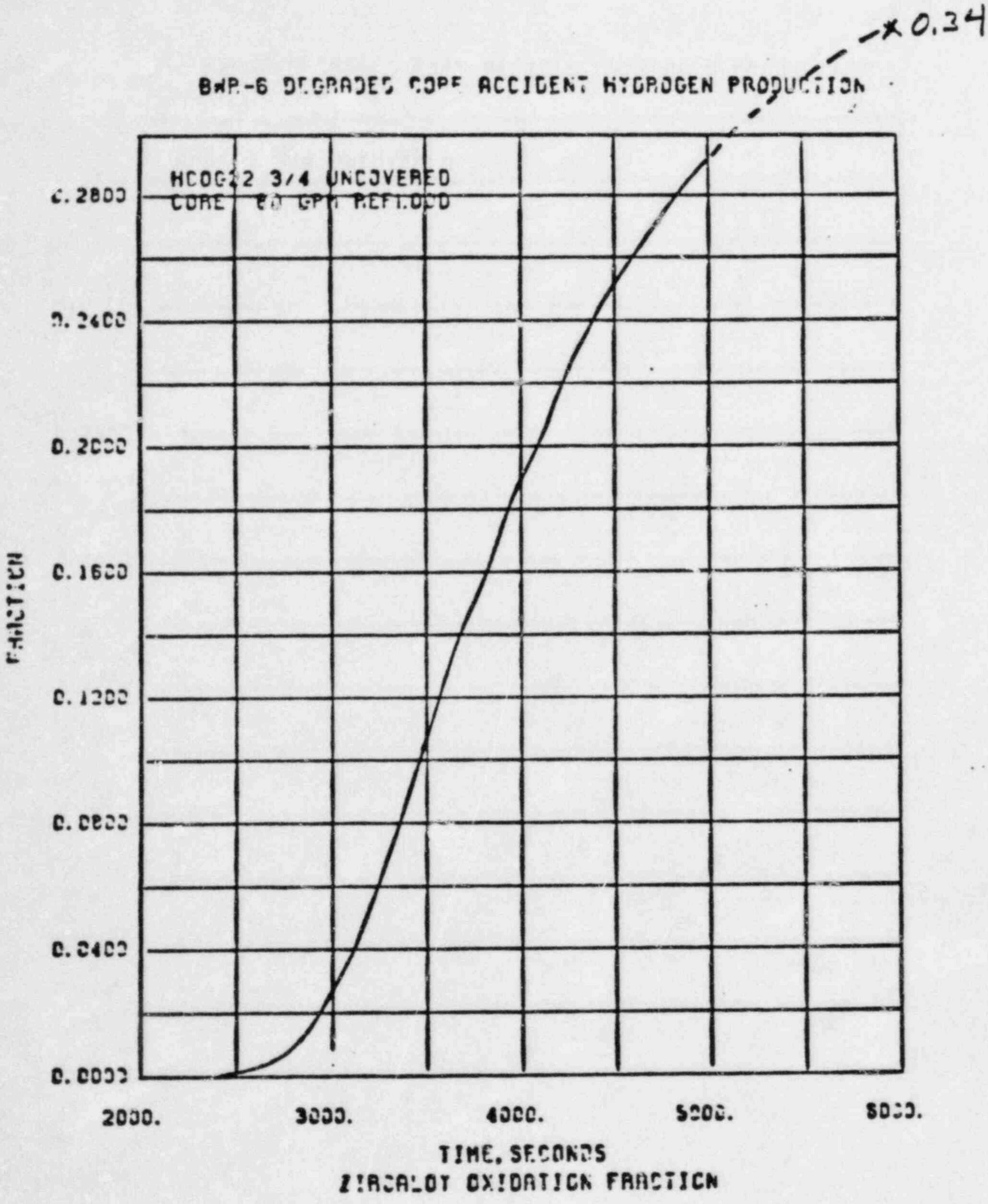

BWR-6 DEGRADED CORE ACCIDENT HYDROGEN PRODUCTION
HCOG22 3/4 UNCOVERED
CORE 60 GPM REFLOOD
*0.34
0.2800
0.2400
0.2000
0.1600
0.1200
0.0800
0.0400
0.0000
FRACTION
2000.
3000.
4000.
5000.
6000.
TIME, SECONDS
ZIRCALOY OXIDATION FRACTION

FIGURE 2-7

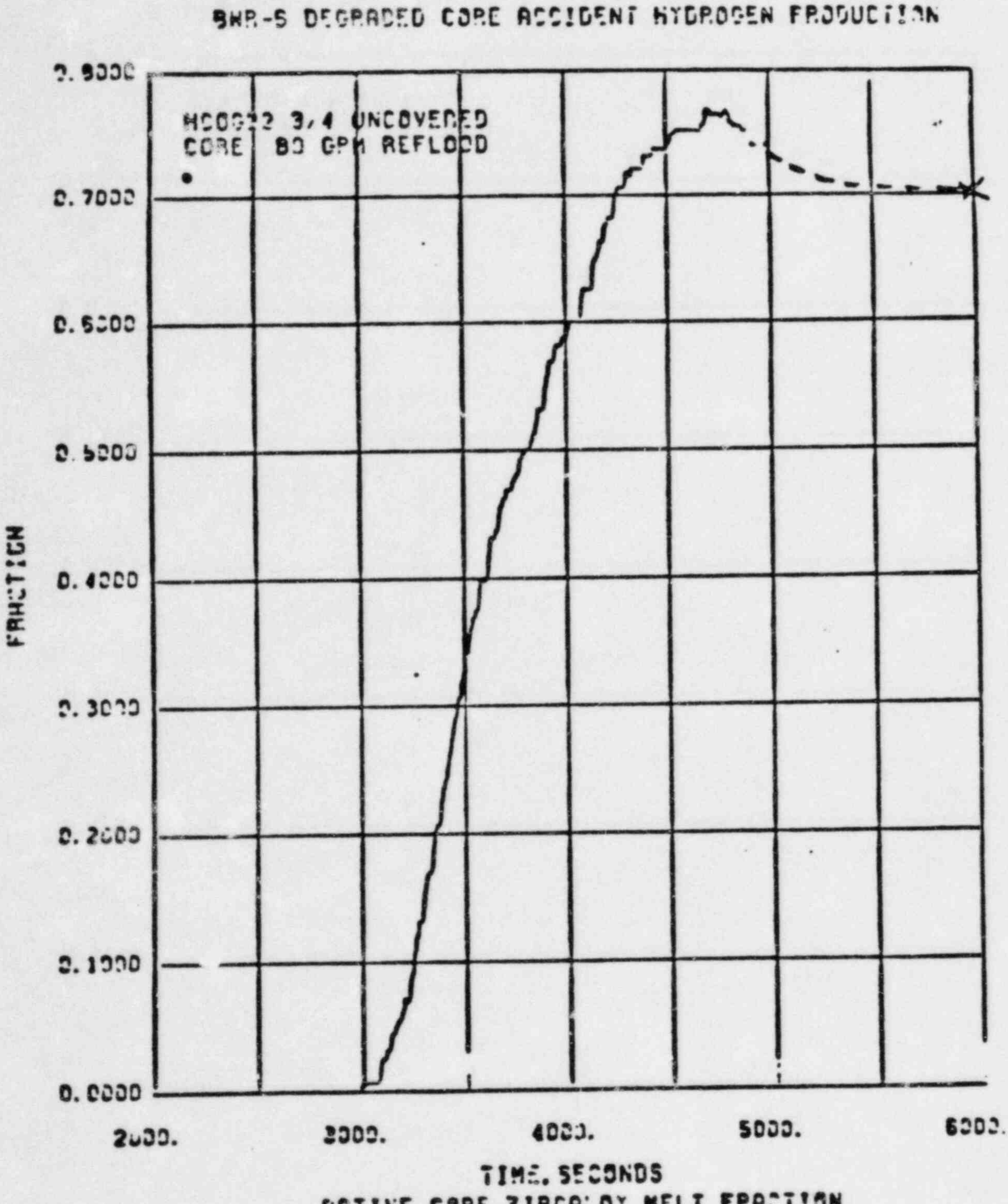
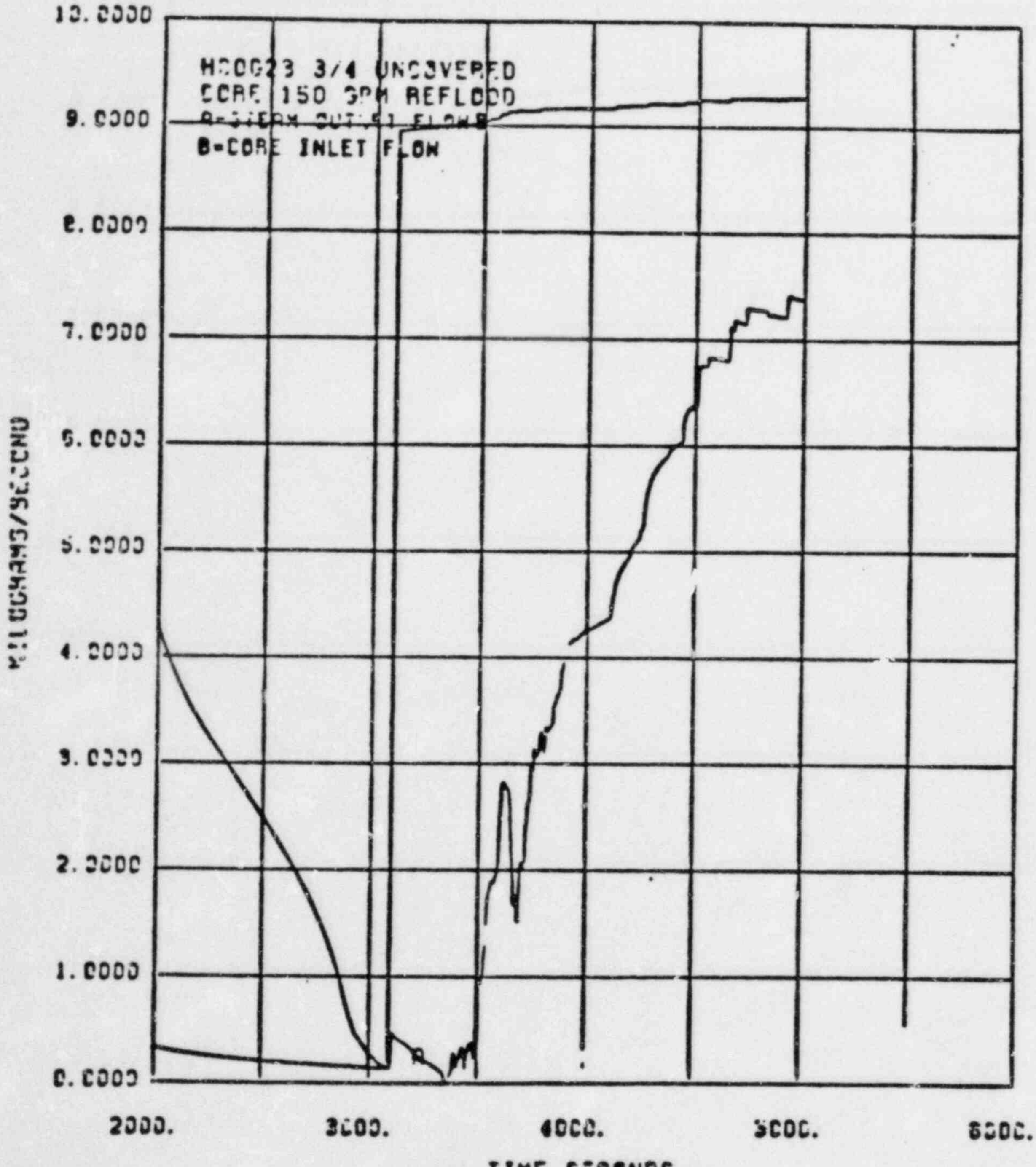

BWR-5 DEGRADED CORE ACCIDENT HYDROGEN PRODUCTION
0.8000
0.7000
0.6000
0.5000
0.4000
0.3000
0.2000
0.1000
0.0000
FRACTION
2000.
3000.
4000.
5000.
6000.
TIME, SECONDS
ACTIVE CORE ZIRCALOY MELT FRACTION

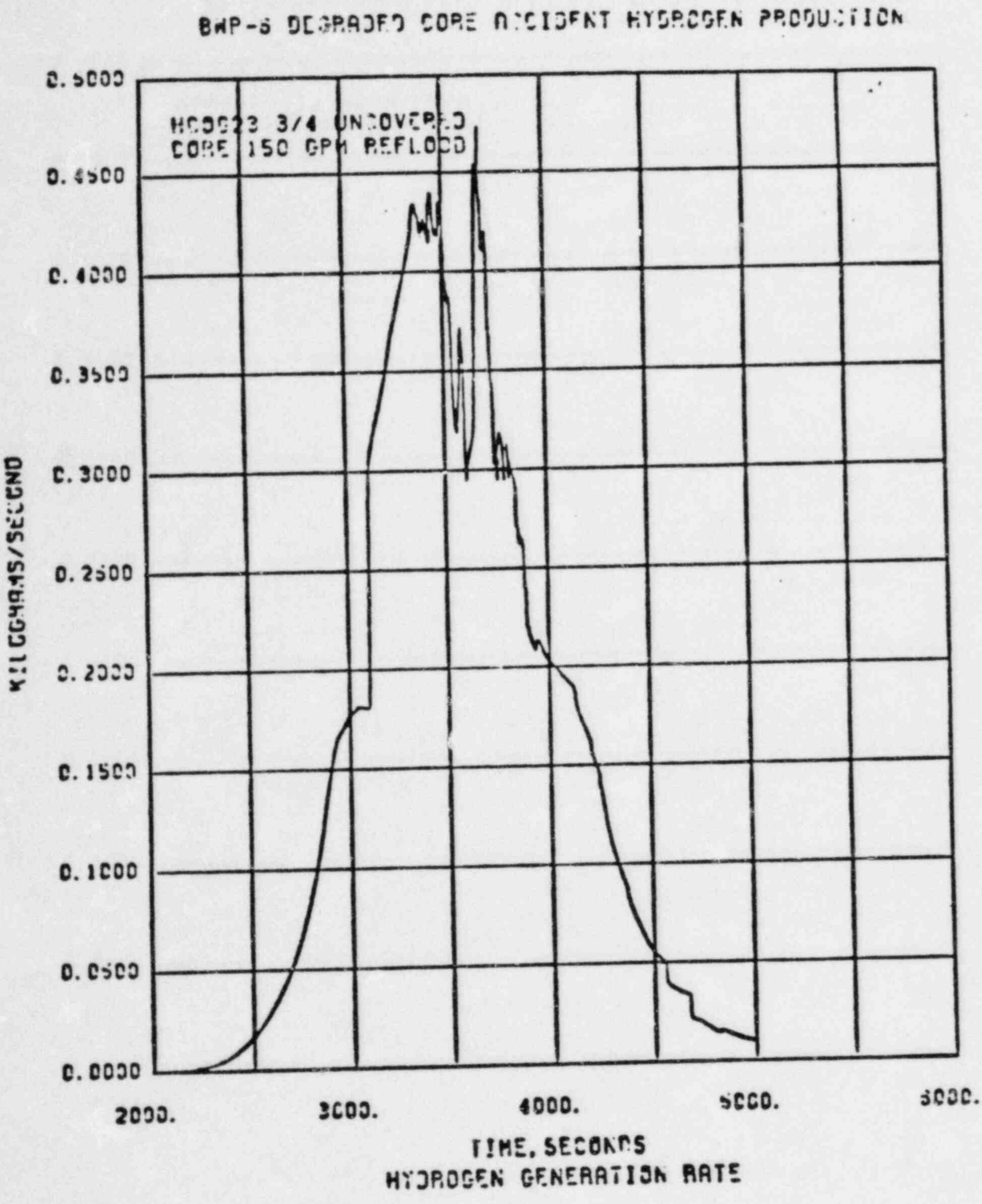
FIGURE 2-8

BWR-5 DEGRADED CORE ACCIDENT HYDROGEN PRODUCTION



WATER INLET-STEAM OUTLET FLOWS

FIGURE 2-9



BWP-6 DEGRADED CORE ACCIDENT HYDROGEN PRODUCTION
HC0023 3/4 UNCOVERED
CORE 150 GPM REFLOOD
0.5000
0.4500
0.4000
0.3500
0.3000
0.2500
0.2000
0.1500
0.1000
0.0500
0.0000
KILOGRAMS/SECOND
2000.
3000.
4000.
5000.
6000.
TIME, SECONDS
HYDROGEN GENERATION RATE

FIGURE 2-10

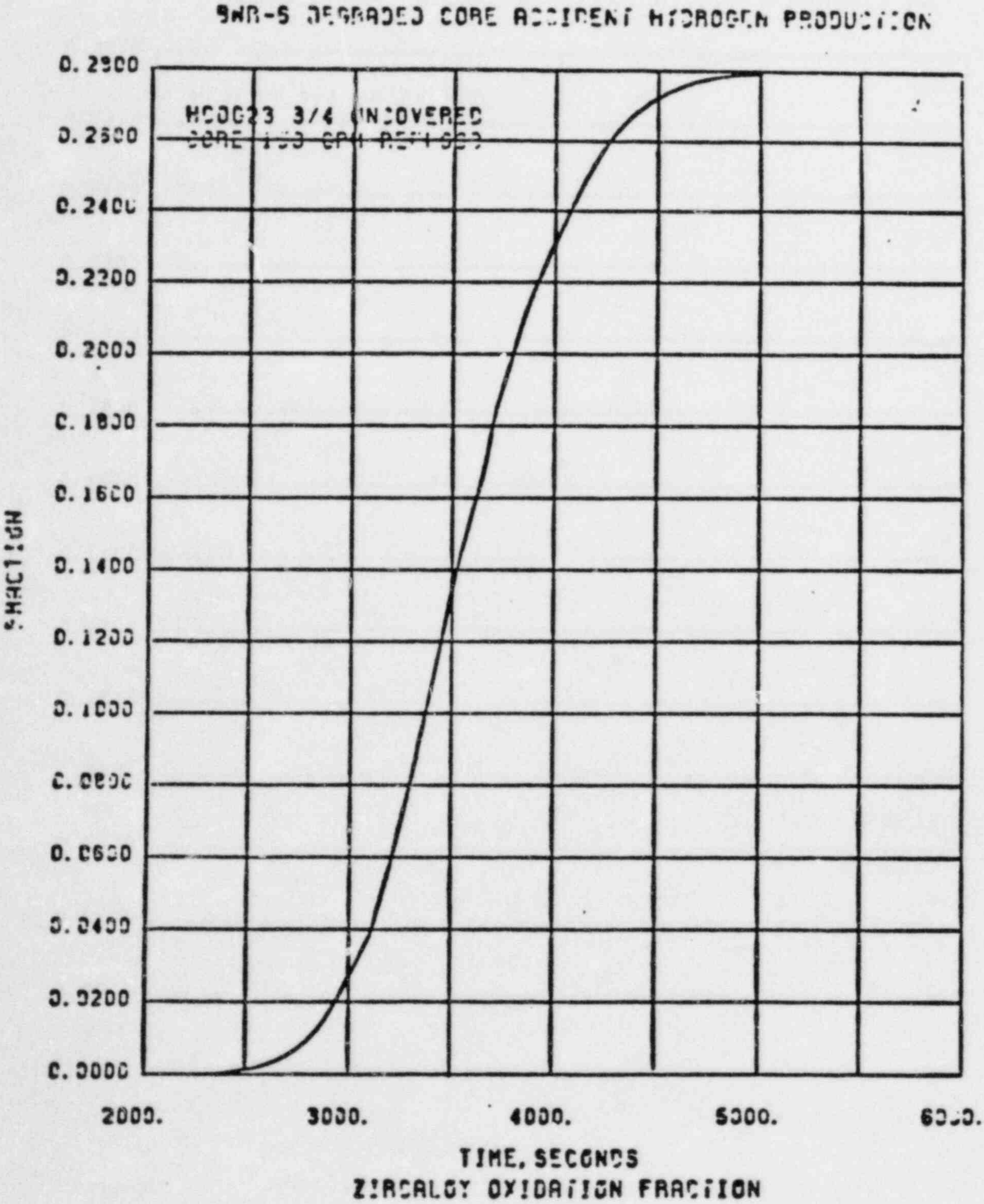

BWR-6 DEGRADED CORE ACCIDENT HYDROGEN PRODUCTION
HC0023 3/4 UNCOVERED
0.2800
0.2600
0.2400
0.2200
0.2000
0.1800
0.1600
0.1400
0.1200
0.1000
0.0800
0.0600
0.0400
0.0200
0.0000
FRACTION
2000.
3000.
4000.
5000.
6000.
TIME, SECONDS
ZIRCALOY OXIDATION FRACTION

FIGURE 2-11

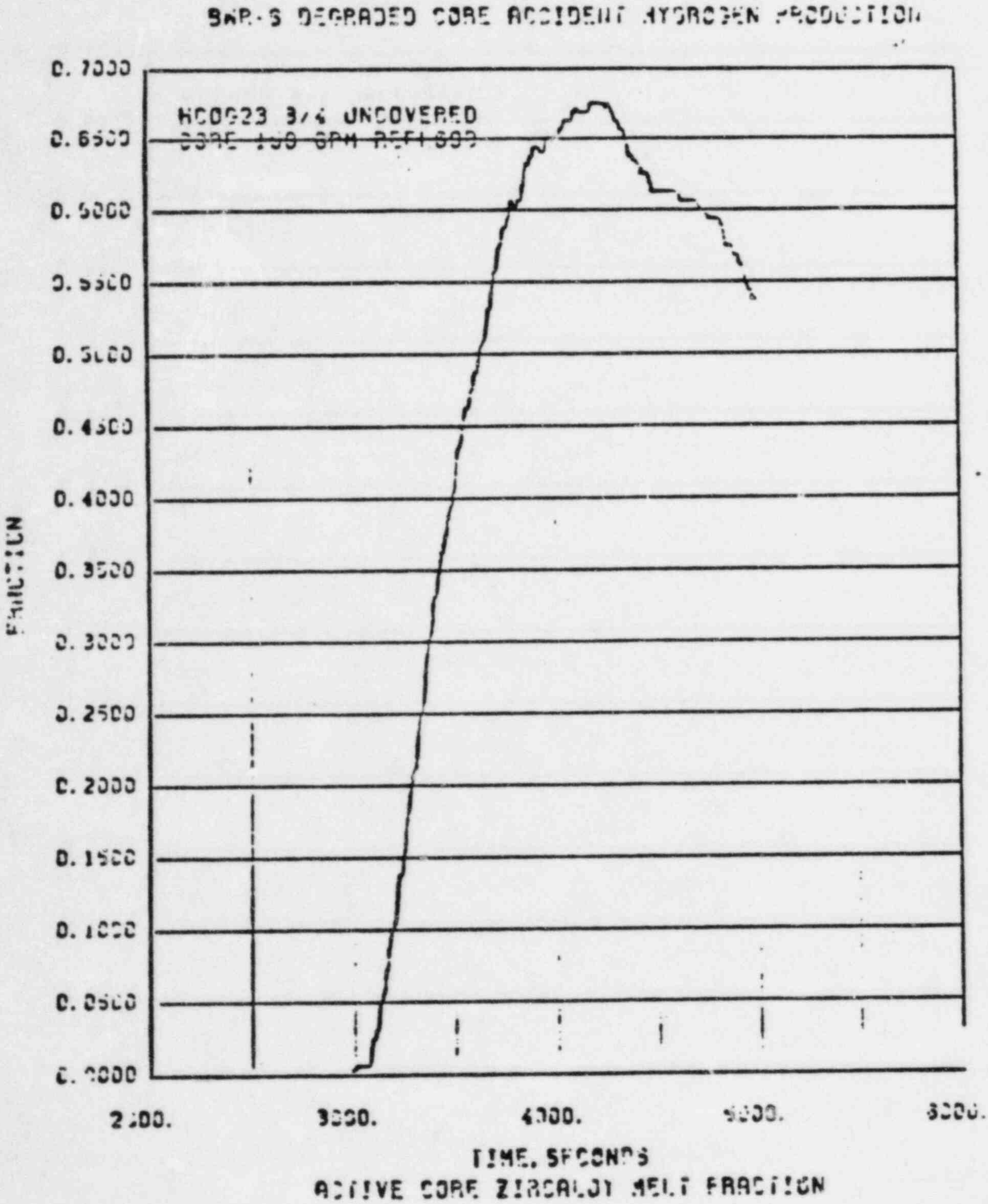

BWR-5 DEGRADED CORE ACCIDENT HYDROGEN PRODUCTION
HC0923 3/4 UNCOVERED
0.7000
0.6500
0.6000
0.5500
0.5000
0.4500
0.4000
0.3500
0.3000
0.2500
0.2000
0.1500
0.1000
0.0500
0.0000
FRACTION
2500.
3000.
4000.
5000.
6000.
TIME, SECONDS
ACTIVE CORE ZIRCALOY MELT FRACTION

FIGURE 2-12

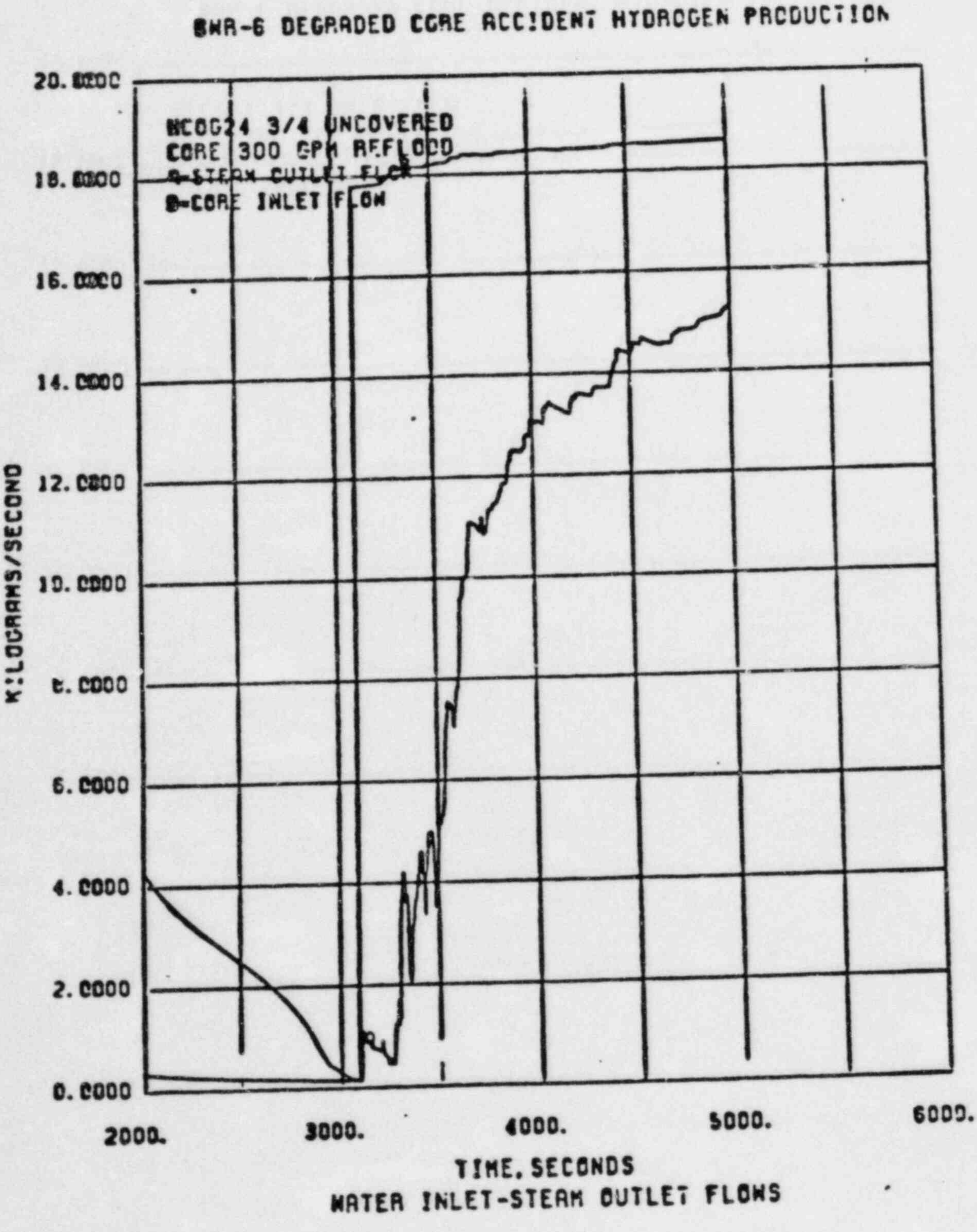

BWR-6 DEGRADED CORE ACCIDENT HYDROGEN PRODUCTION
MCOG24 3/4 UNCOVERED
CORE 300 GPM REFLOOD
CORE INLET FLOW
20.0000
18.0000
16.0000
14.0000
12.0000
10.0000
6.0000
4.0000
2.0000
0.0000
KILOGRAMS/SECOND
2000.
3000.
4000.
5000.
6000.
TIME, SECONDS
WATER INLET-STEAM OUTLET FLOWS

FIGURE 2-13

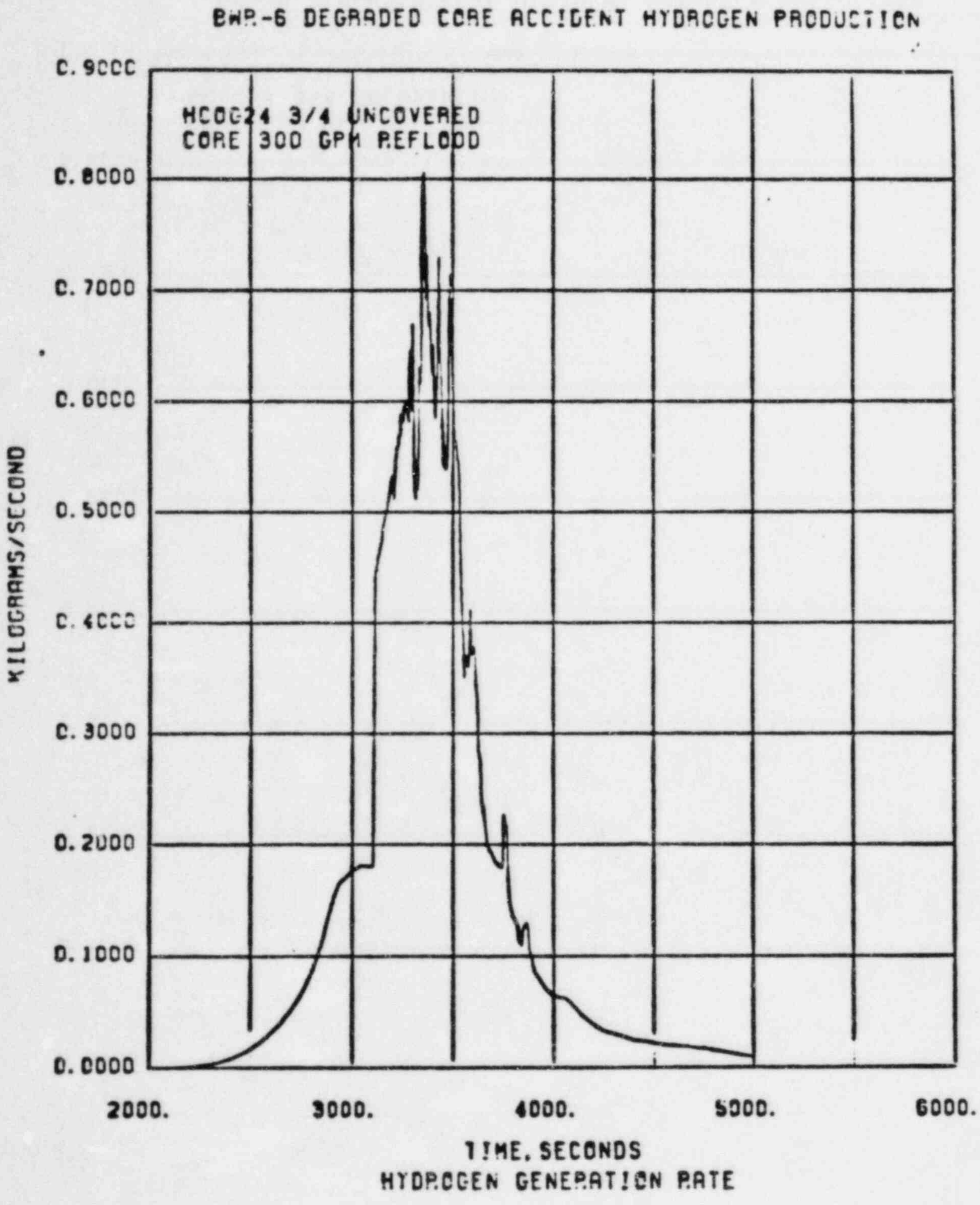

BWR-6 DEGRADED CORE ACCIDENT HYDROGEN PRODUCTION
HCOG24 3/4 UNCOVERED
CORE 300 GPM REFLOOD
0.9000
0.8000
0.7000
0.6000
0.5000
0.4000
0.3000
0.2000
0.1000
0.0000
KILOGRAMS/SECOND
2000.
3000.
4000.
5000.
6000.
TIME, SECONDS
HYDROGEN GENERATION RATE

FIGURE 2-14

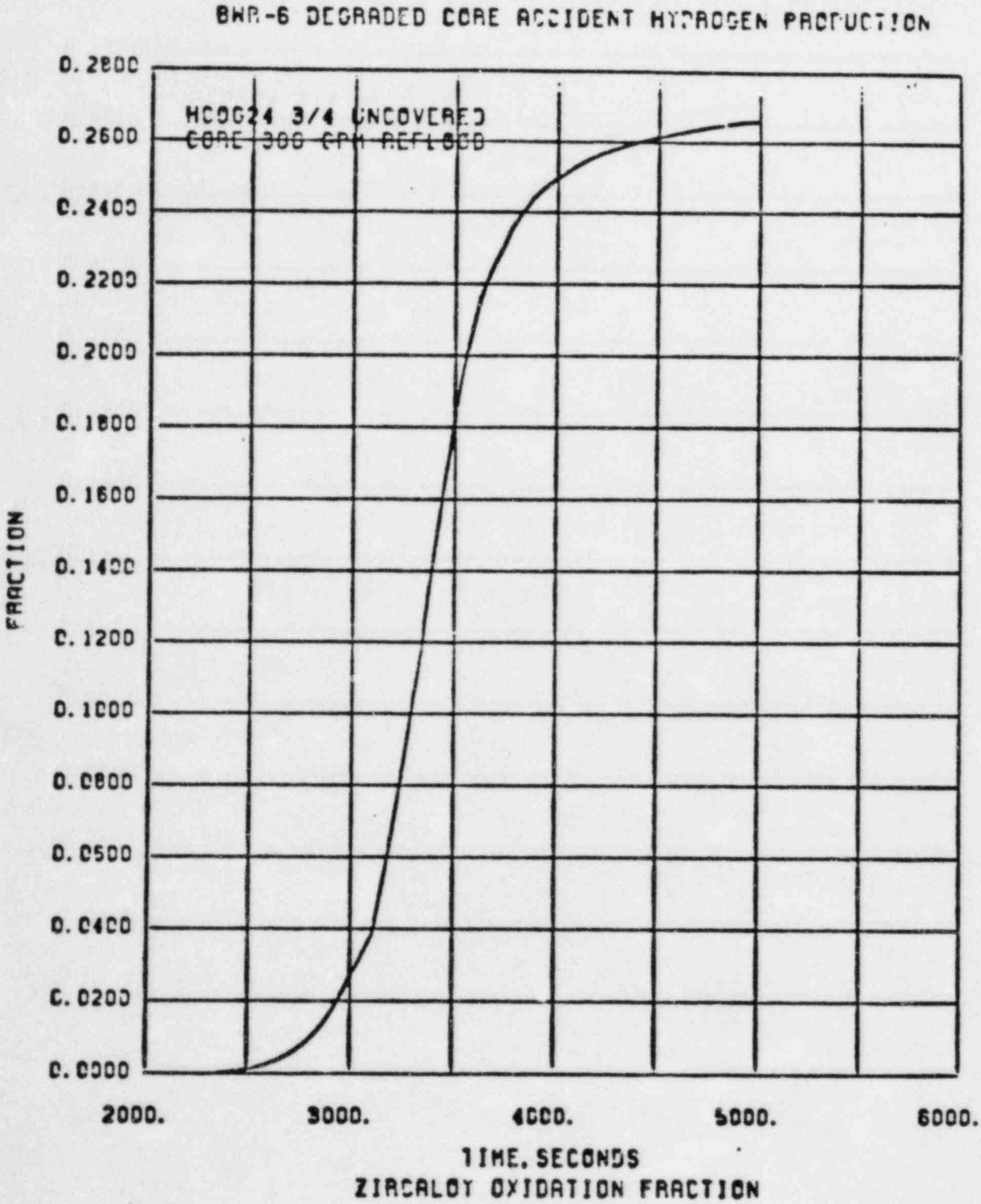
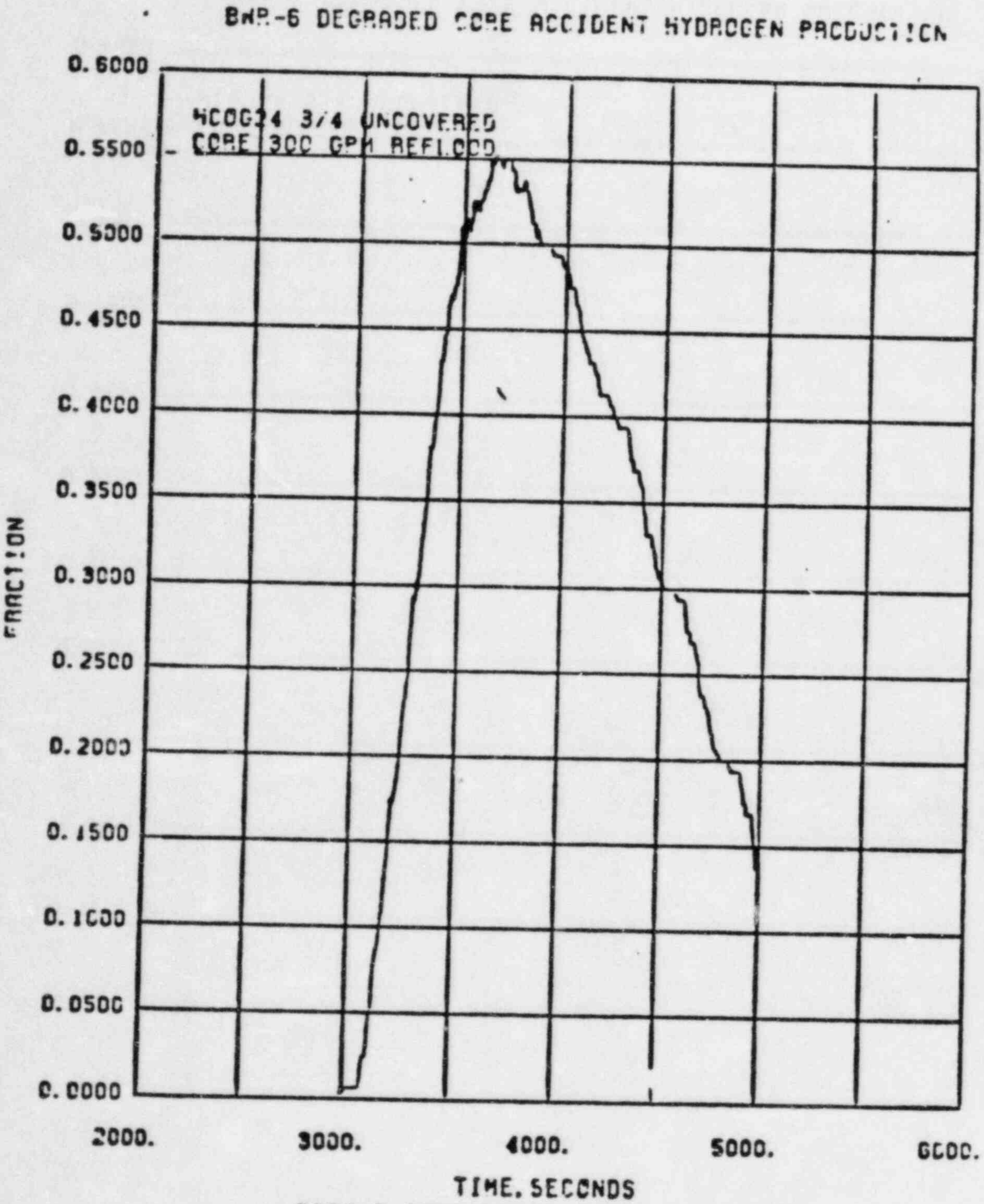

BWR-6 DEGRADED CORE ACCIDENT HYDROGEN PRODUCTION
HCOG24 3/4 UNCOVERED
CORE 300 GPM REFLOOD
FRACTION
0.2800
0.2600
0.2400
0.2200
0.2000
0.1800
0.1600
0.1400
0.1200
0.1000
0.0800
0.0600
0.0400
0.0200
0.0000
2000.
3000.
4000.
5000.
6000.
TIME, SECONDS
ZIRCALOY OXIDATION FRACTION

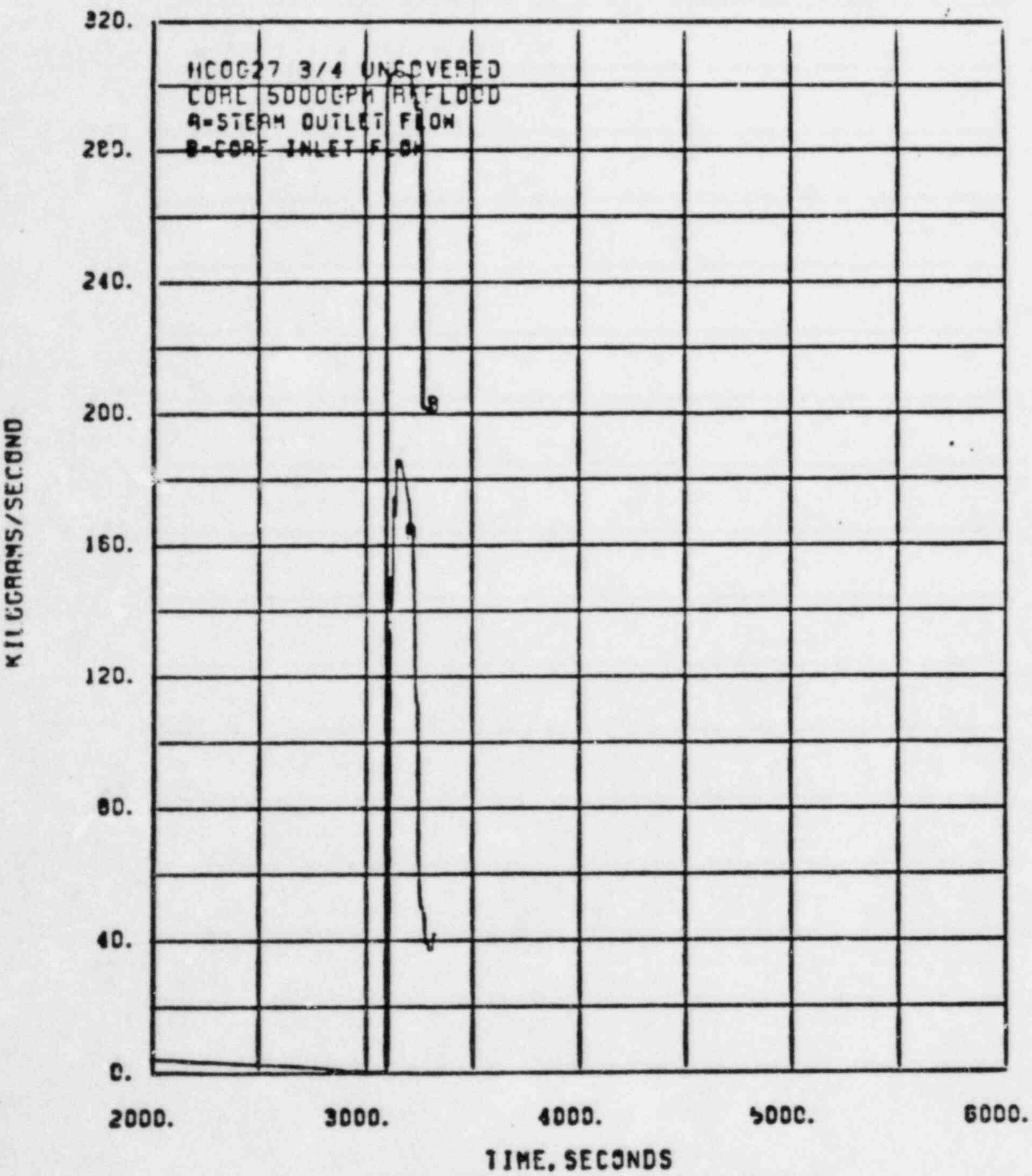
FIGURE 2-15



ACTIVE CORE ZIRCALOY MELT FRACTION

FIGURE 2-16

BWR-6 DEGRADED CORE ACCIDENT HYDROGEN PRODUCTION



WATER INLET-STEAM OUTLET FLOWS

FIGURE 2-17

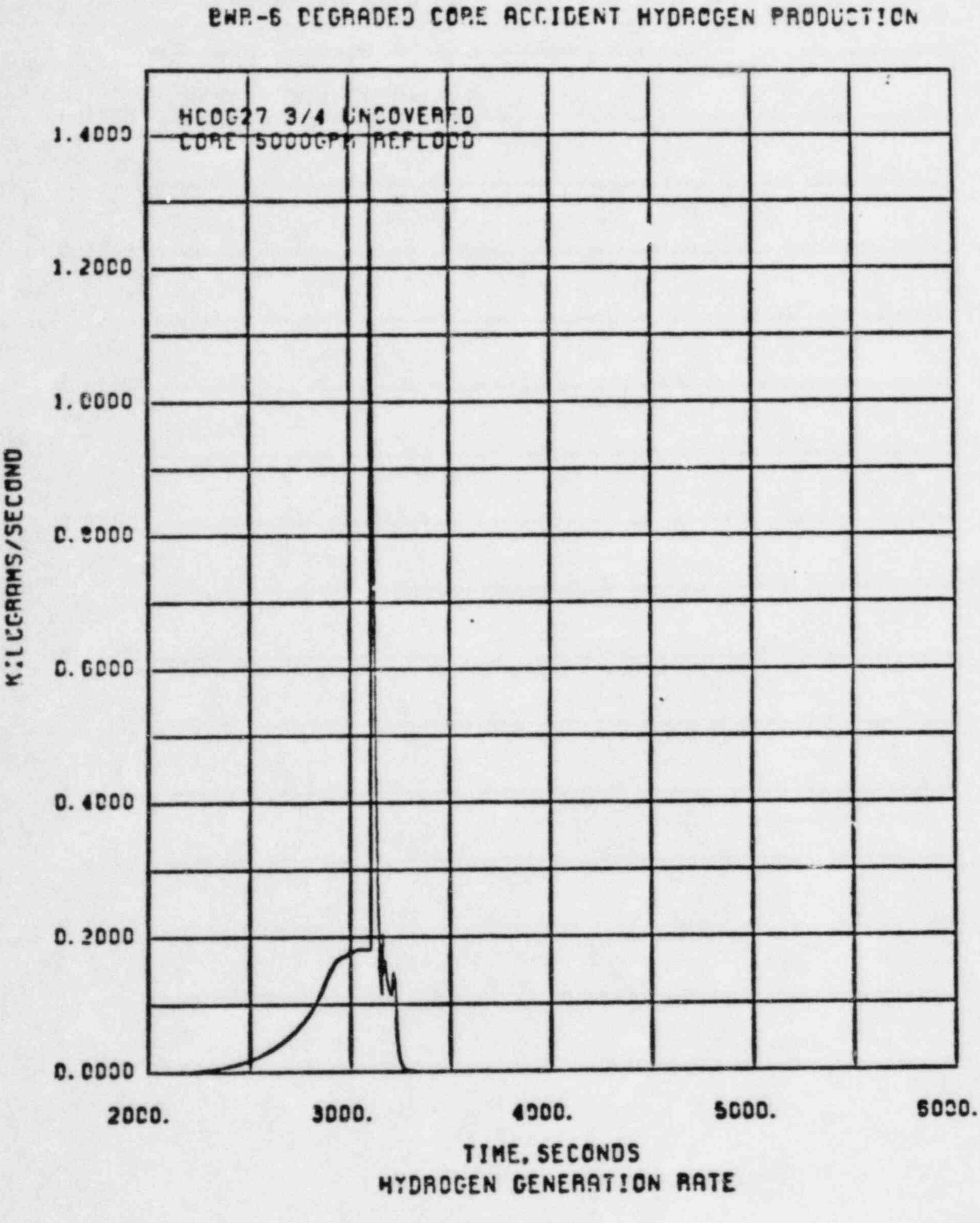

BWR-6 DEGRADED CORE ACCIDENT HYDROGEN PRODUCTION
HCOG27 3/4 UNCOVERED
CORE 5000GPM REFLOOD
KILOGRAMS/SECOND
1.4000
1.2000
1.0000
0.8000
0.6000
0.4000
0.2000
0.0000
2000.
3000.
4000.
5000.
6000.
TIME, SECONDS
HYDROGEN GENERATION RATE

FIGURE 2-18

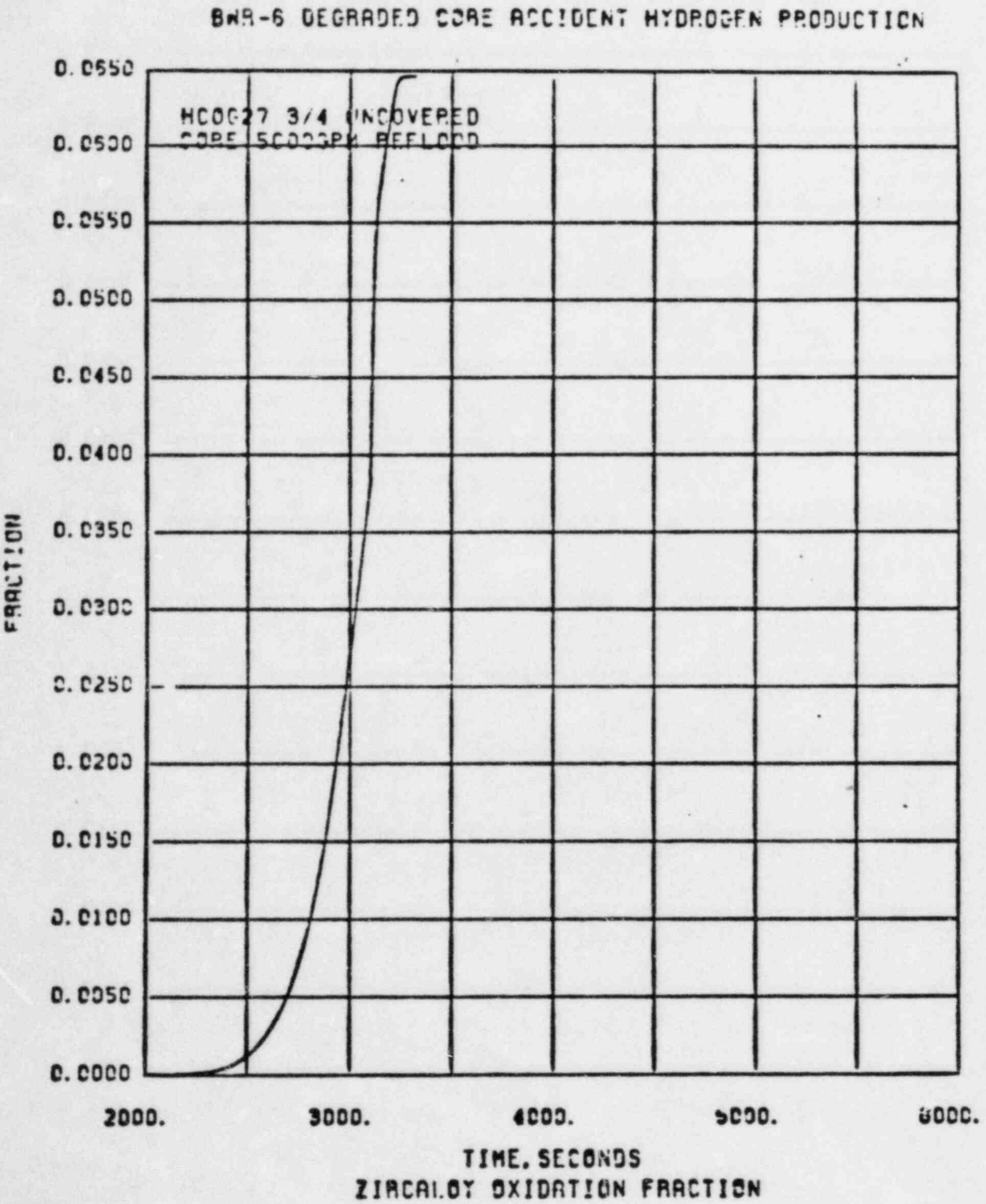

BWR-6 DEGRADED CORE ACCIDENT HYDROGEN PRODUCTION
HCOG27 3/4 UNCOVERED
CORE 5000GPM REFLOOD
FRACTION
2000.
3000.
4000.
5000.
6000.
TIME, SECONDS
ZIRCALOY OXIDATION FRACTION

FIGURE 2-19

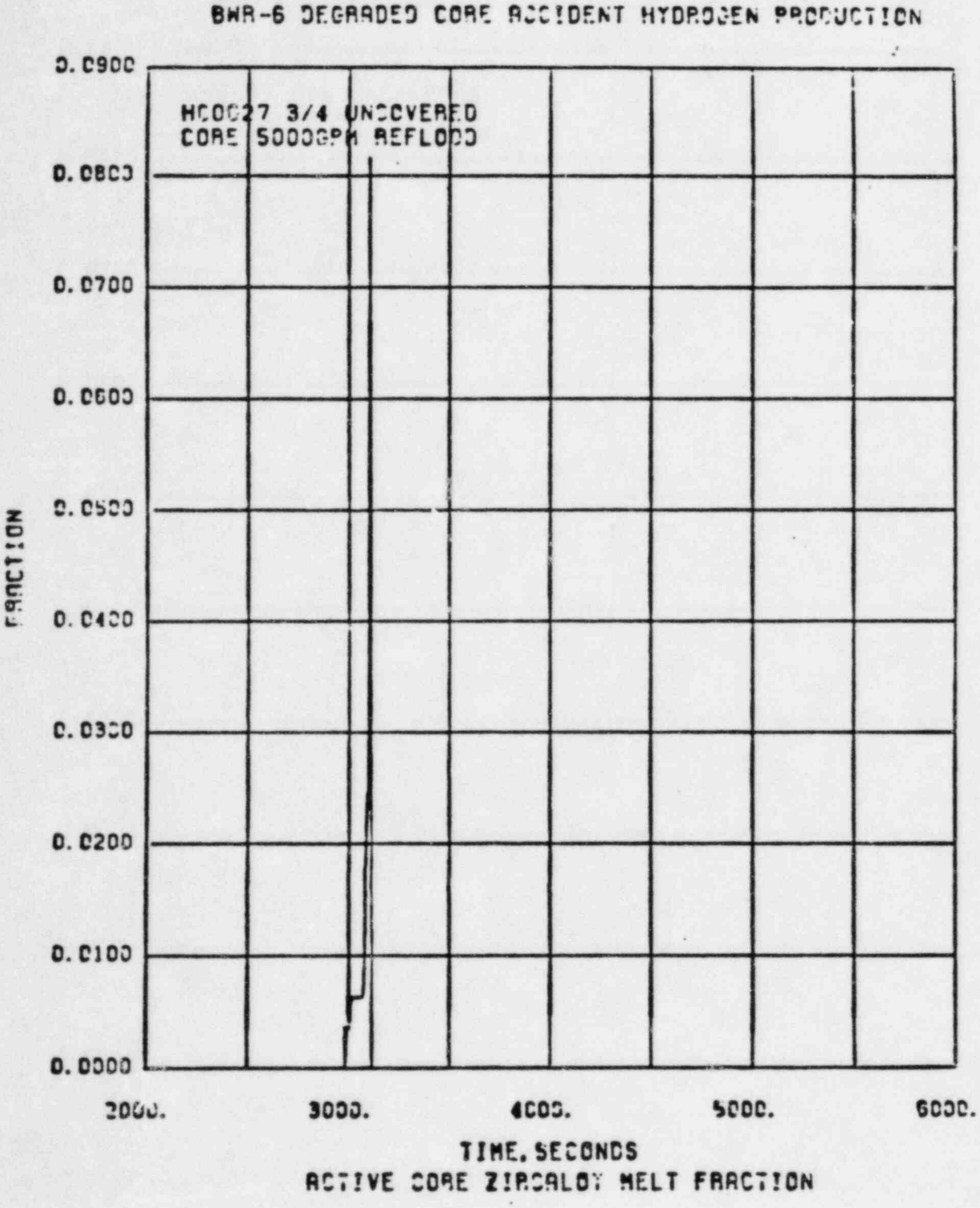

BWR-6 DEGRADED CORE ACCIDENT HYDROGEN PRODUCTION
HC0027 3/4 UNCOVERED
CORE 5000GPM REFLOOD
0.0900
0.0800
0.0700
0.0600
0.0500
0.0400
0.0300
0.0200
0.0100
0.0000
FRACTION
2000.
3000.
4000.
5000.
6000.
TIME, SECONDS
ACTIVE CORE ZIRCALOY MELT FRACTION

FIGURE 2-20

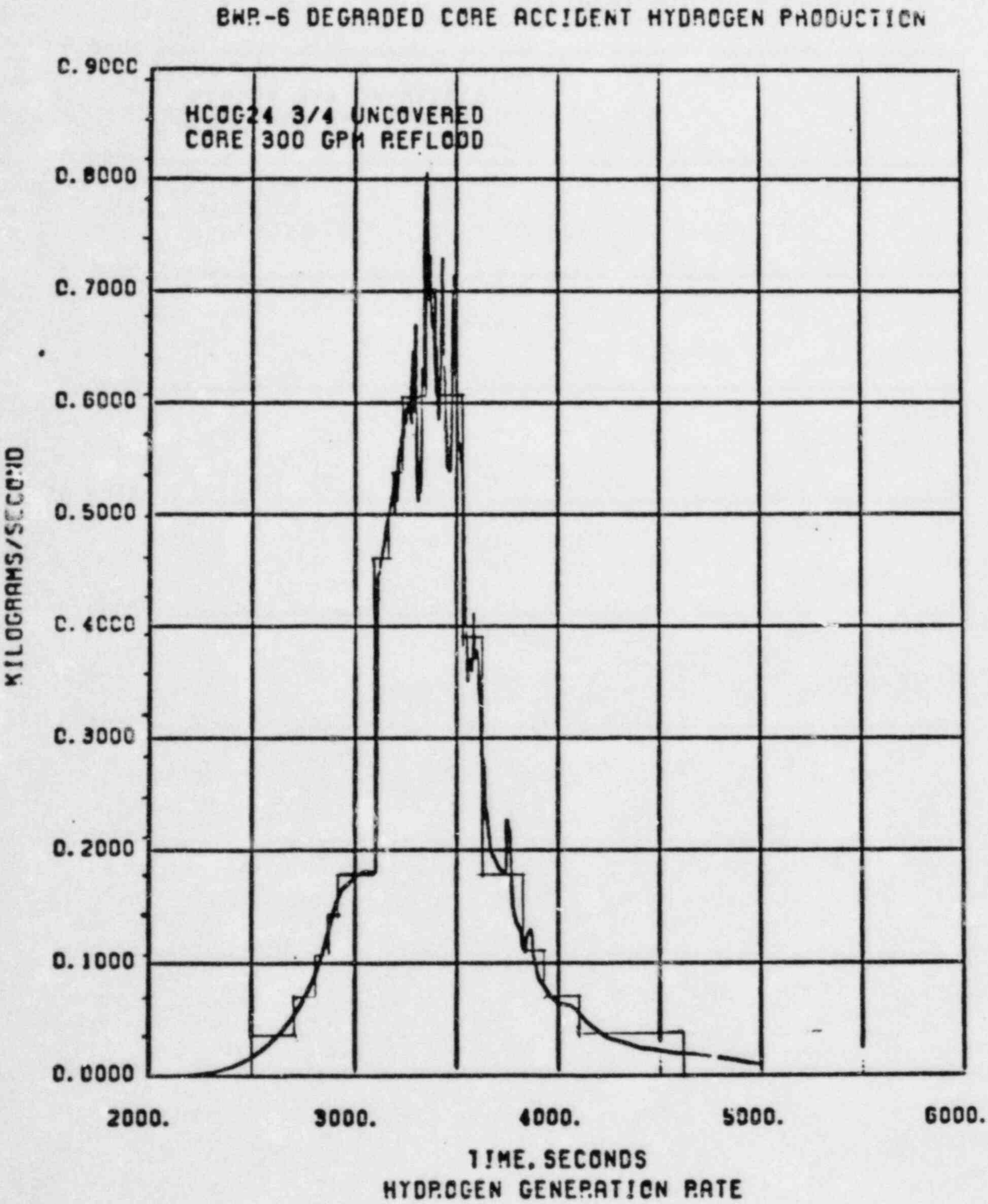


FIGURE 3-1

NOTE: Example of how the hydrogen generation rate will be simulated in the test facility.

Attachment 5
HGN-018

Rev: D2

Date: 12, Mar, 84

PROPOSED INSTRUMENTATION LAYOUT FOR EPRI 1/4-SCALE FACILITY

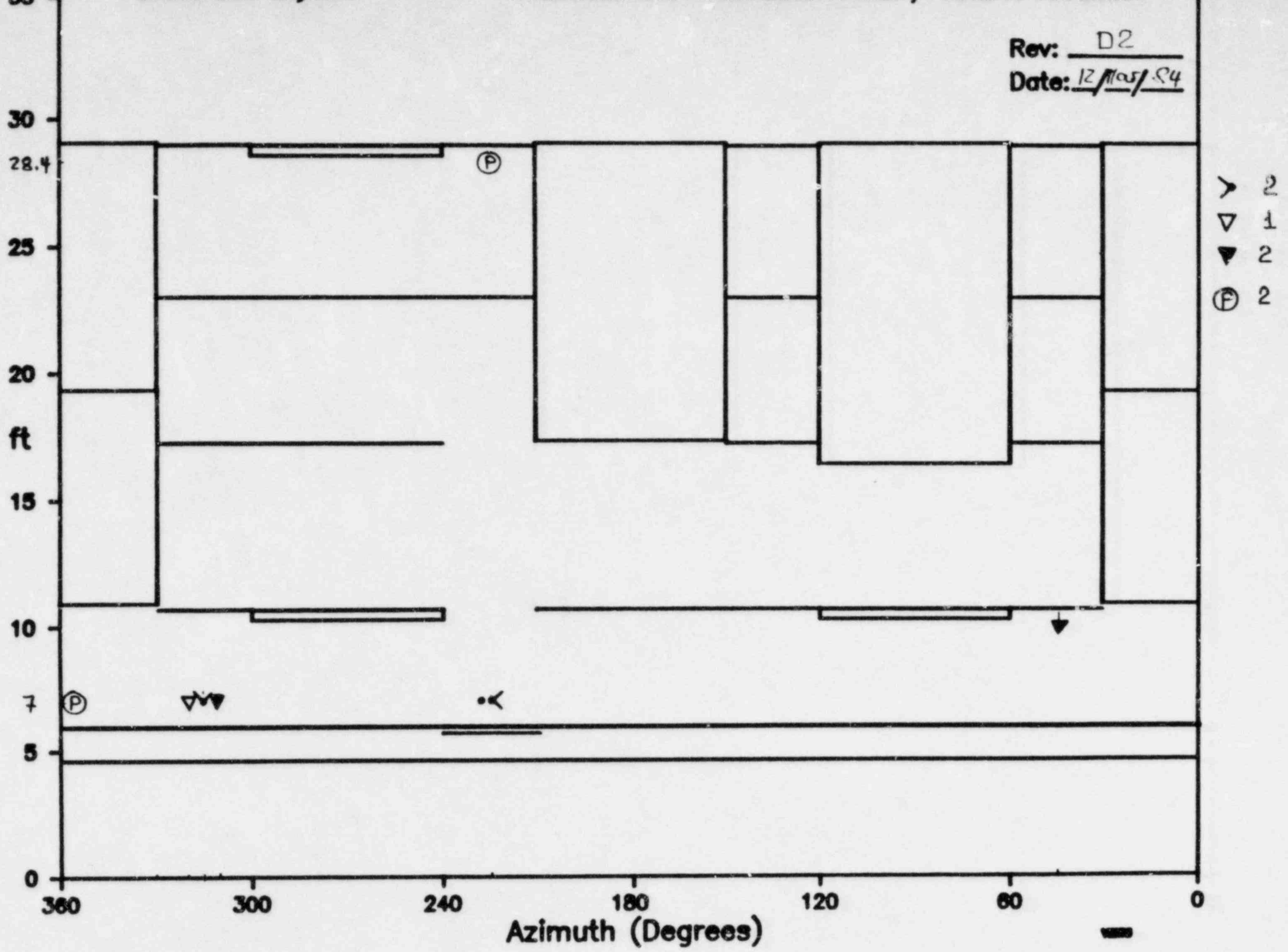
SUMMARY

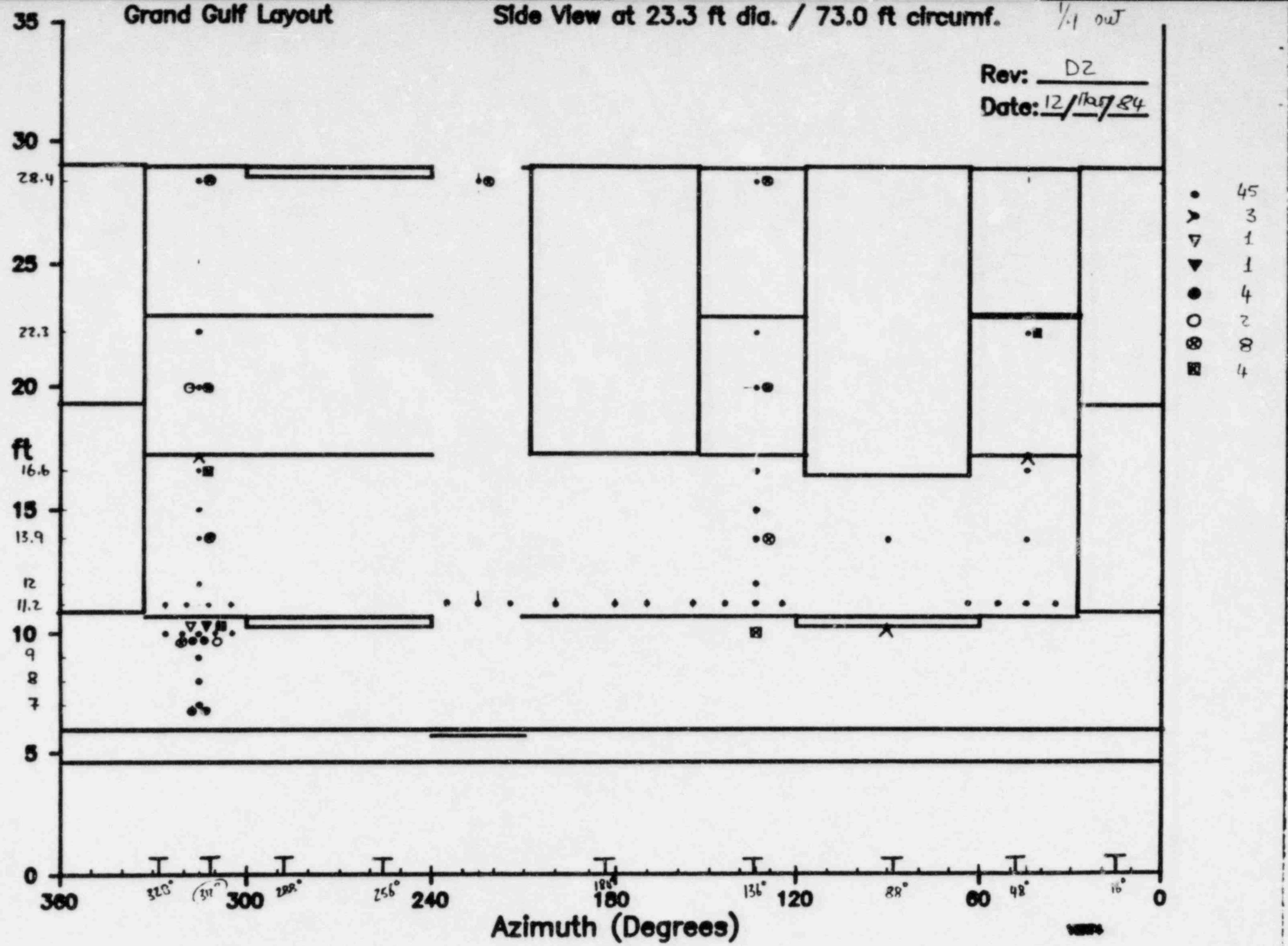
SYMBOL	EXTENDED DESCRIPTION	# OF LOCATIONS
■◀	VIDEO CAMERAS	5
•	Gas Thermocouples. Type K, mostly 3-5 mil Wire.	118
<	Surface Thermocouples (on Insulation or Grating). Type K, mostly 32 mil Wire.	12
▼	Total-Energy, Wide-Angle Radiometers.	5
▽	Gardon-Type Total Heat Flux Gages.	4
●	Sphere Calorimeters.	10
○	Bidirectional Velocity Probes, Mounted Horizontally. (8 multiplexed, 2 continuous).	10
⊗	Bidirectional Velocity Probes, Mounted Vertically. (all multiplexed)	16
□	Continuous Gas Analysis (Hydrogen and Oxygen).	3
☒	Multiplexed Gas Analysis Lines (Hydrogen, Oxygen and Water Vapor).	18
Ⓟ	Total Pressure.	2
	Other Temperatures (pool water [2], hydrogen [1], steam [1], water spray [1], ignitor [1], instrumentation area [1])	7
	Flow Rates (steam [2], water spray [1]).	3
	TOTALS	213

NOTES:
1) Location of active spargers indicated in plan view (X) and in elevation (T).
2) Event lines used for control purposes not shown in the list.

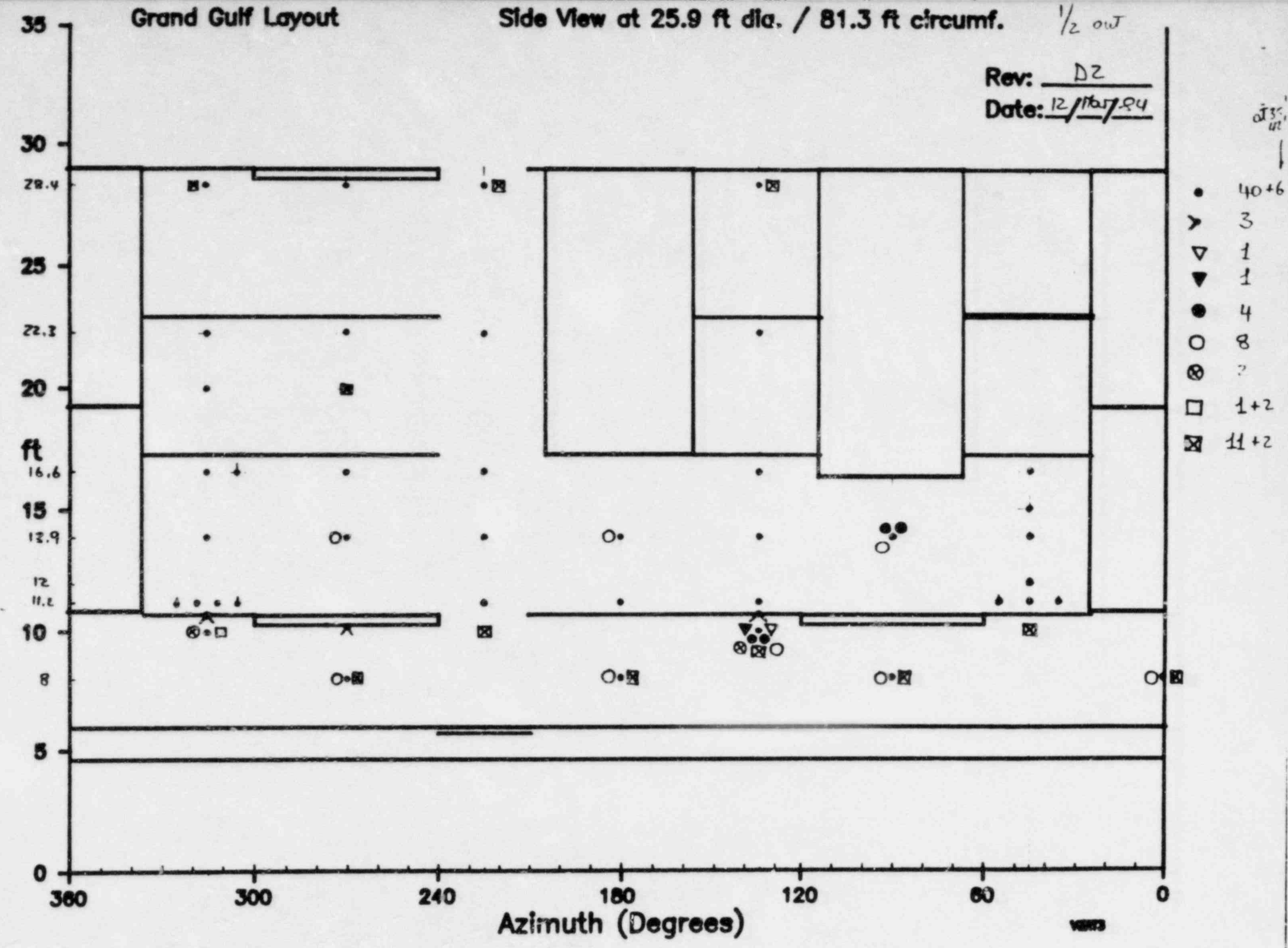
[File in INSTR3.TXT by FT]

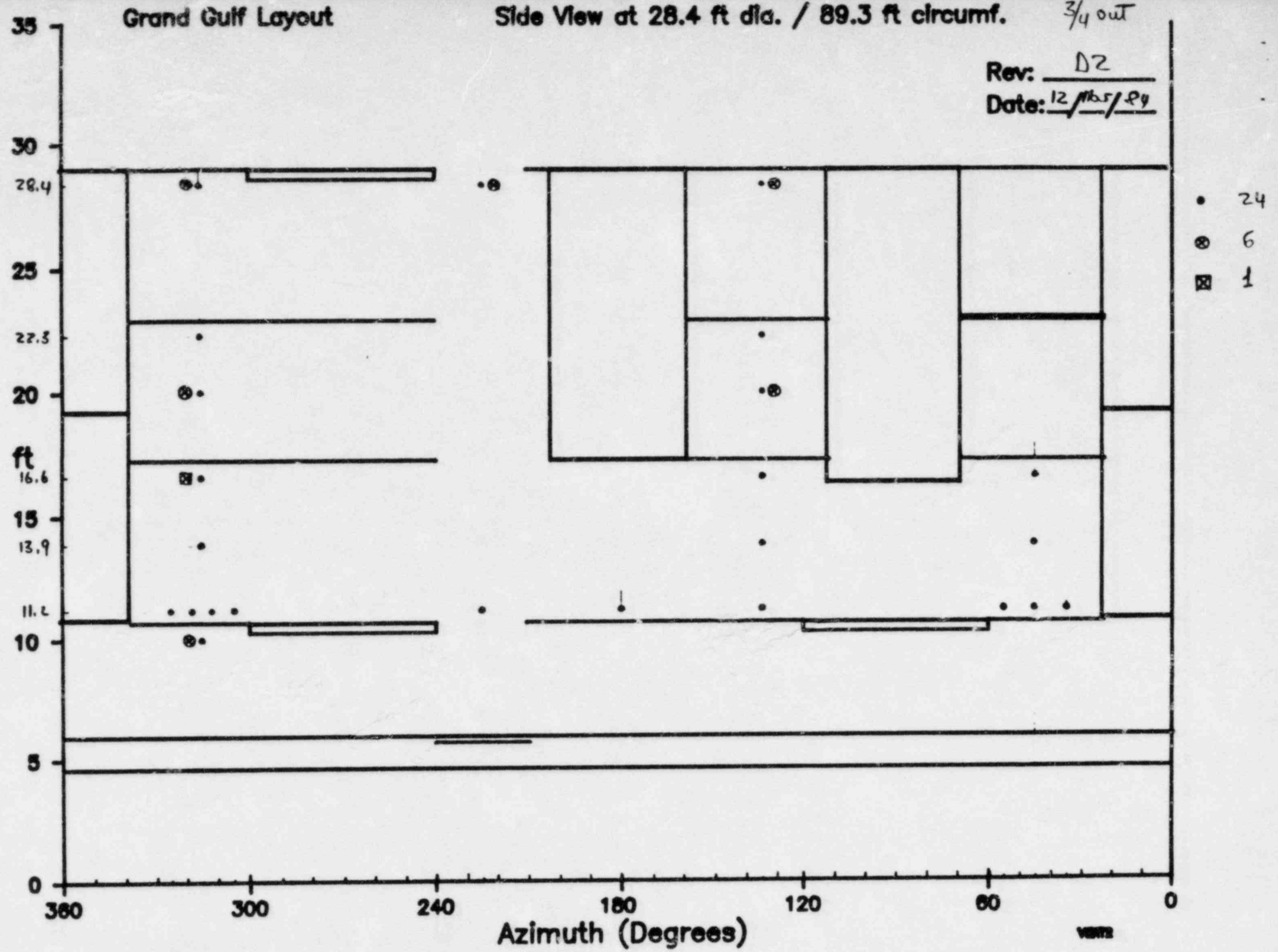
Grand Gulf Layout Innermost Side View: 20.8 ft dia. / 65.2 ft circumf.



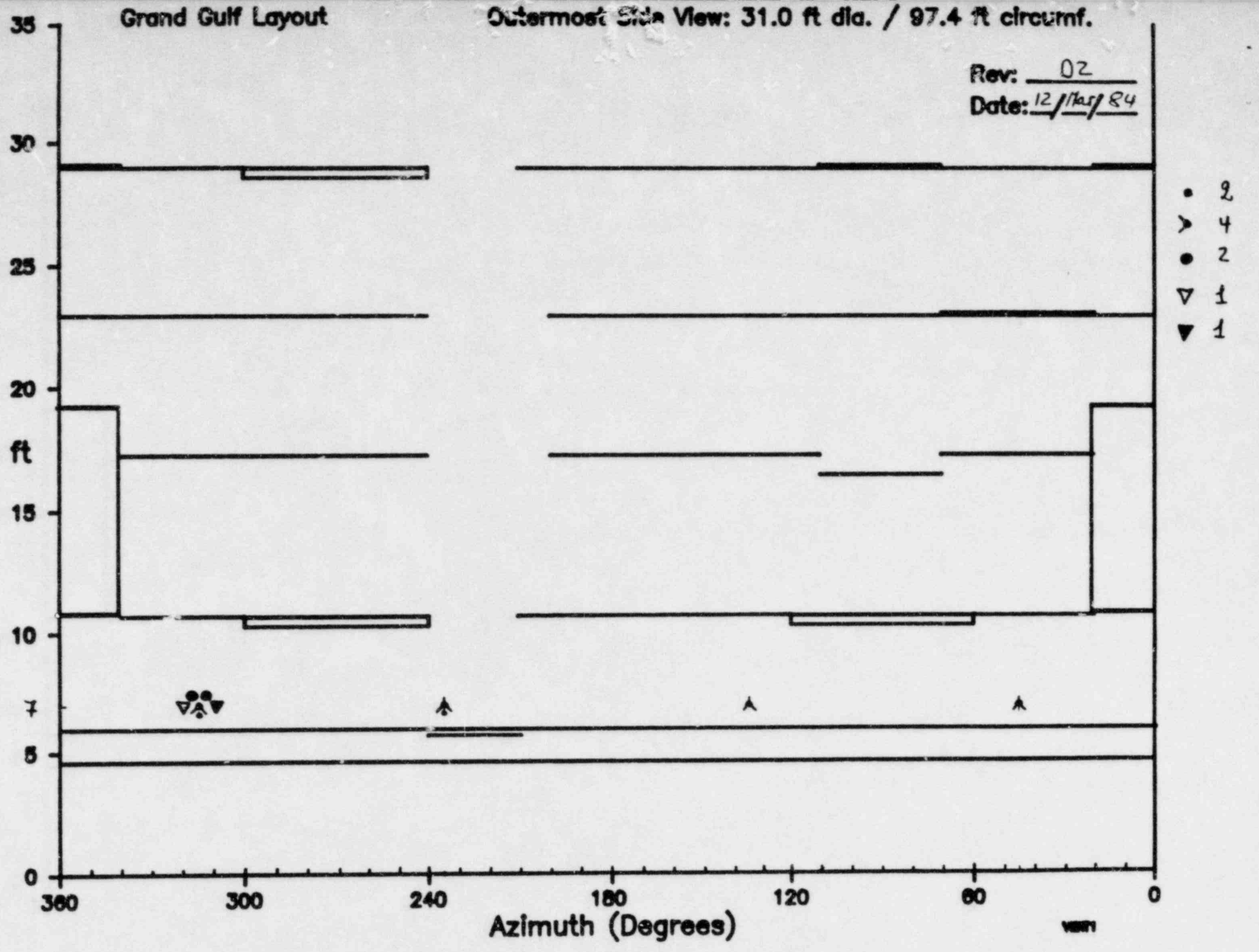


Grand Gulf Layout
Side View at 23.3 ft dia. / 73.0 ft circumf.
1/1 ow
Rev: DZ
Date: 12/11/84
ft
35
30
28.4
25
22.3
20
16.6
15
13.9
12
11.2
10
9
8
7
5
0
45
3
1
1
4
2
8
4
360
328°
311°
300
288°
256°
240
184°
180
136°
120
88°
60
48°
16°
0
Azimuth (Degrees)


Grand Gulf Layout
Side View at 25.9 ft dia. / 81.3 ft circumf.
1/2 owT
Rev: DZ
Date: 12/Mar/84
ft
35
30
28.4
25
22.3
20
16.6
15
13.9
12
11.2
10
8
5
0
360
300
240
180
120
60
0
Azimuth (Degrees)
40+6
3
1
1
4
8
?
1+2
11+2



Grand Gulf Layout
Side View at 28.4 ft dia. / 89.3 ft circumf.
3/4 out
Rev: D2
Date: 12/Nov/84
24
6
1
35
30
28.4
25
22.3
20
ft
16.6
15
13.9
11.2
10
5
0
360
300
240
180
120
60
0
Azimuth (Degrees)

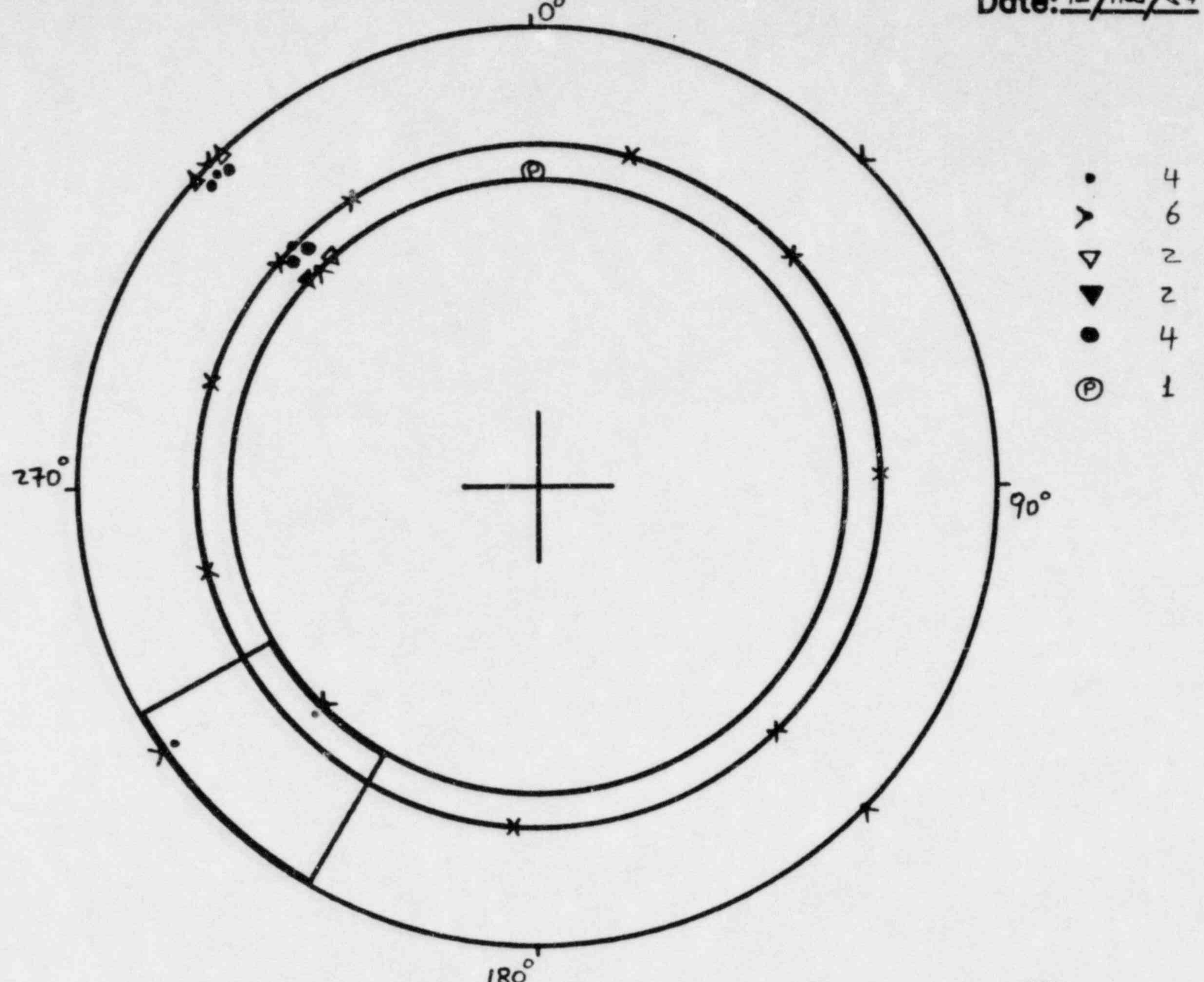


Grand Gulf Layout
Outermost Side View: 31.0 ft dia. / 97.4 ft circumf.
Rev: 02
Date: 12/Mar/84
35
30
25
20
ft
15
10
7
5
0
2
4
2
1
1
360
300
240
180
120
60
0
Azimuth (Degrees)

Grand Gulf Layout Elevation 7.0 ft

Rev: Δ2

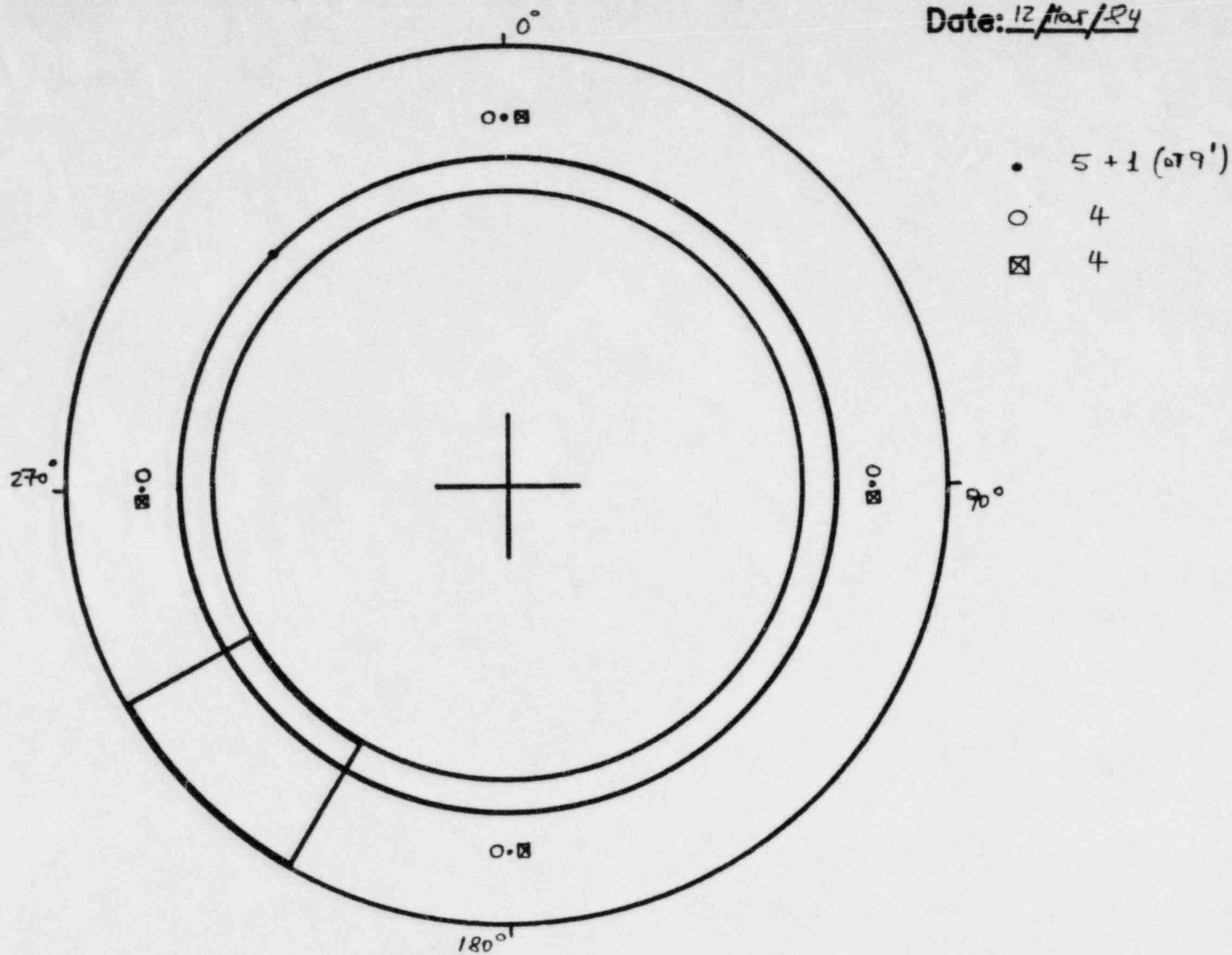
Date: 12/Mar/84



Grand Gulf Layout   Elevation 8.0 ft

Rev: D2

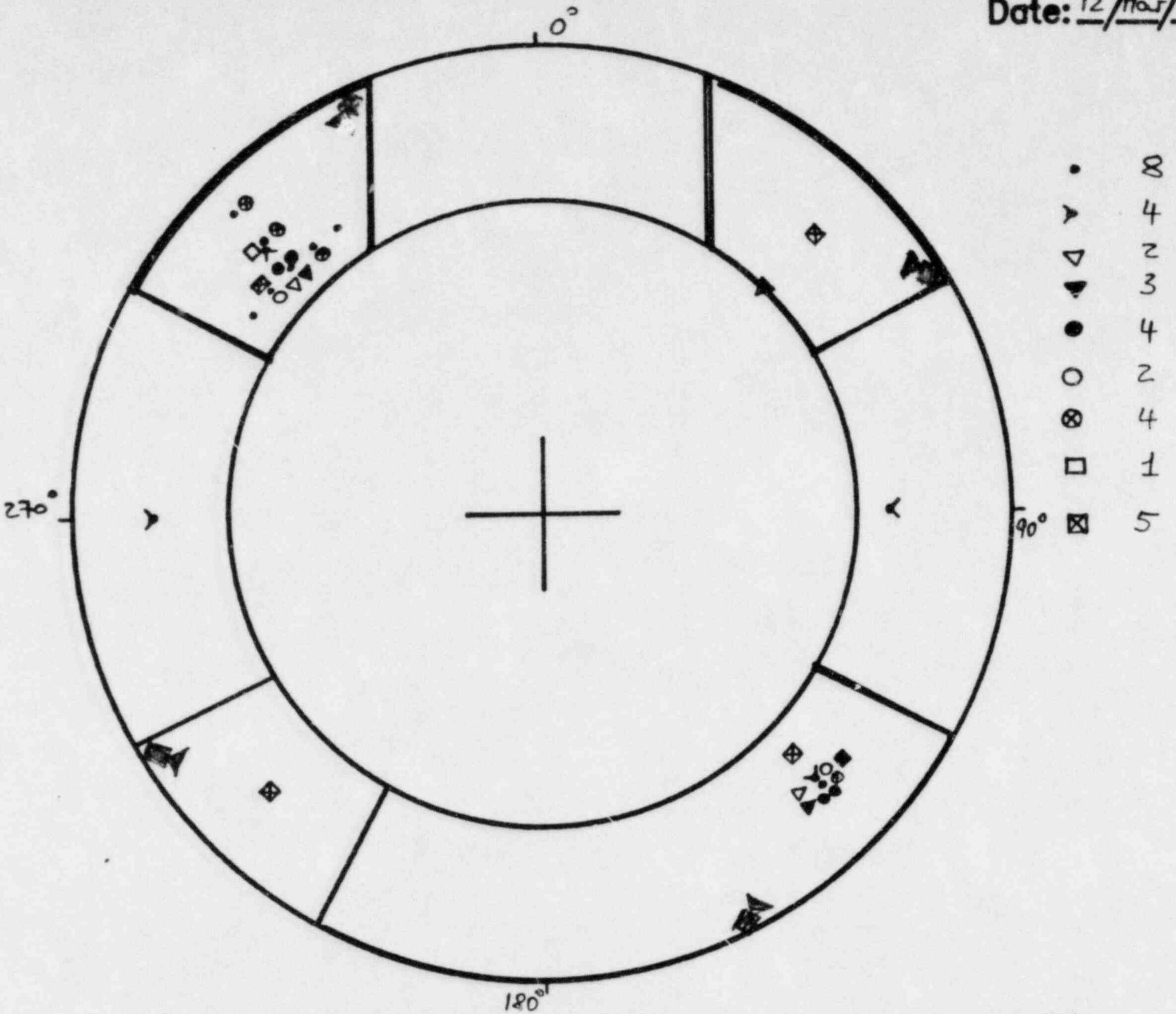
Date: 12/Mar/84



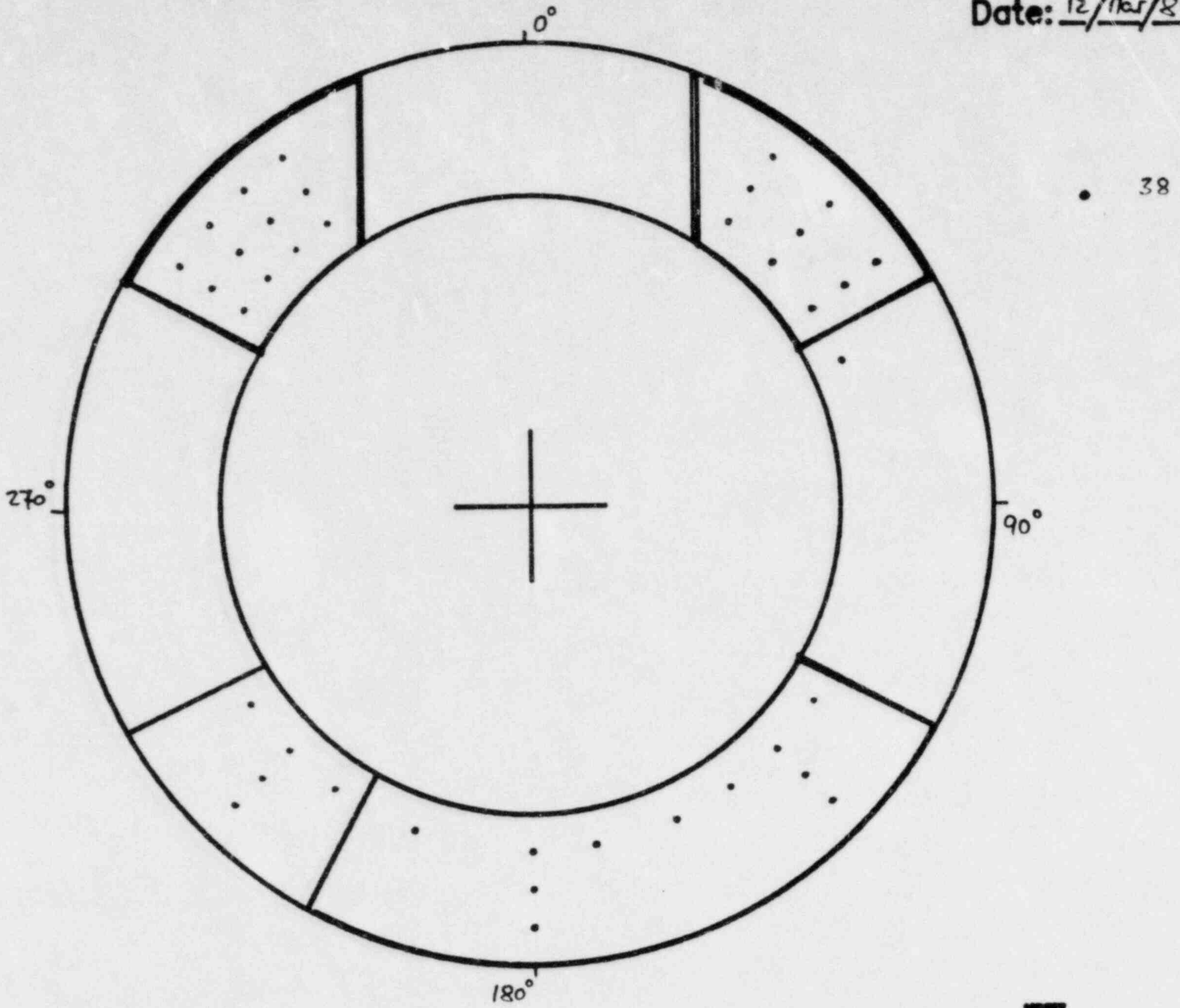
Grand Gulf Layout Elevation 10.0 ft

Rev: DZ

Date: 12/Mar/84

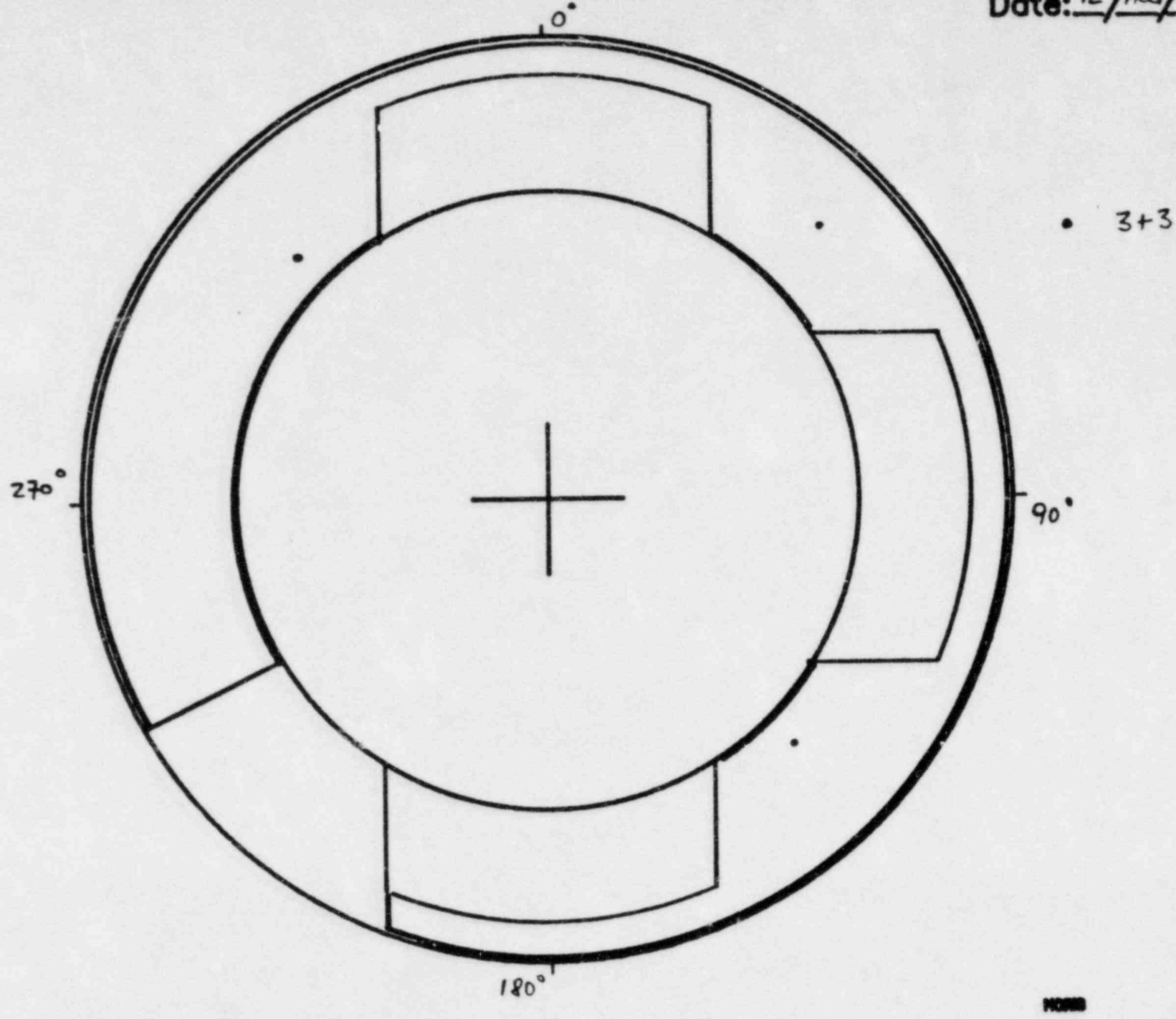


Grand Gulf Layout **Elevation 11.2 ft** Rev: D2 Date: 12/Mar/84

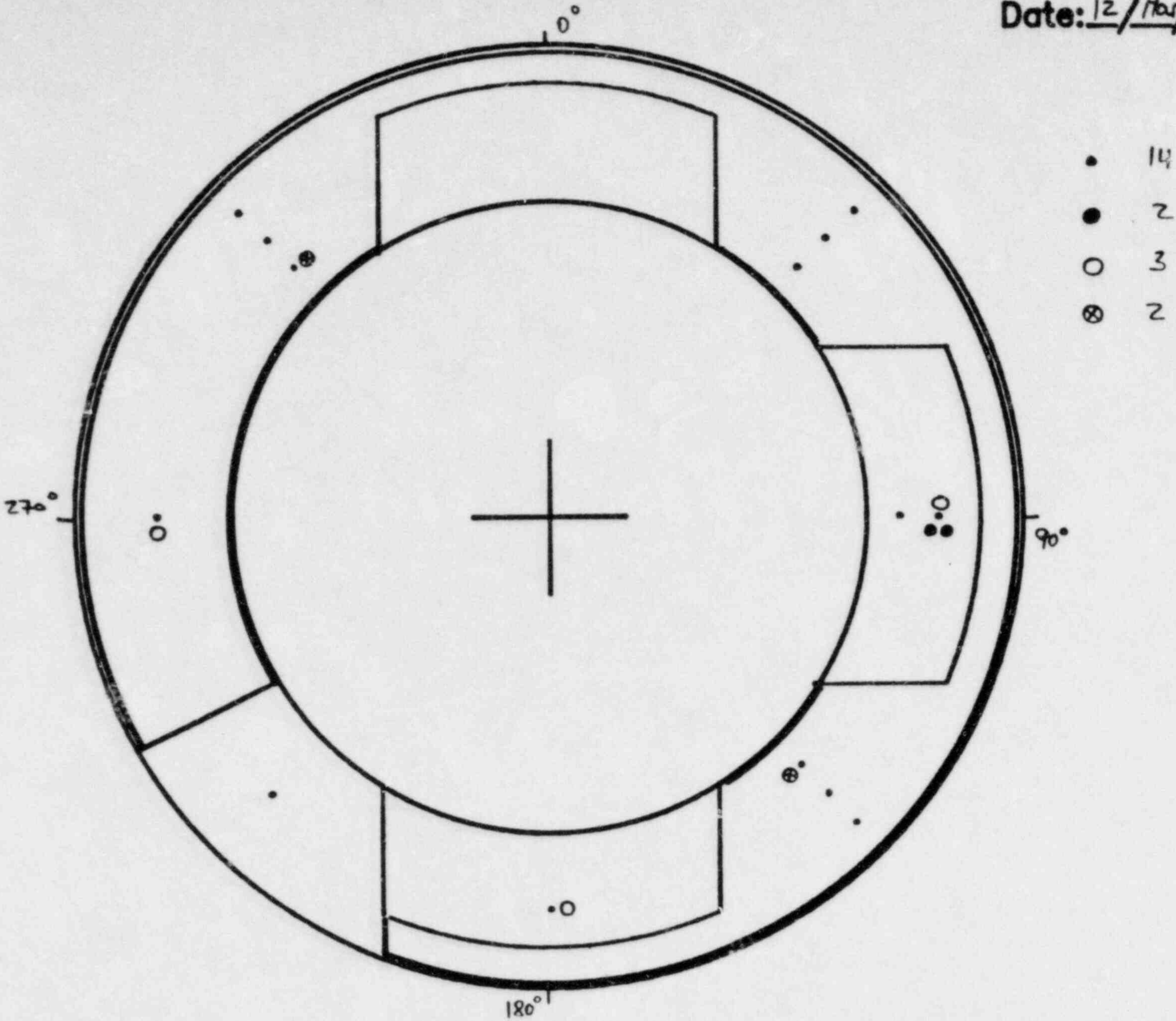


MO907

Grand Gulf Layout   Elevation 12 & 15 ft.   Rev: D2
Date: 12/11/84



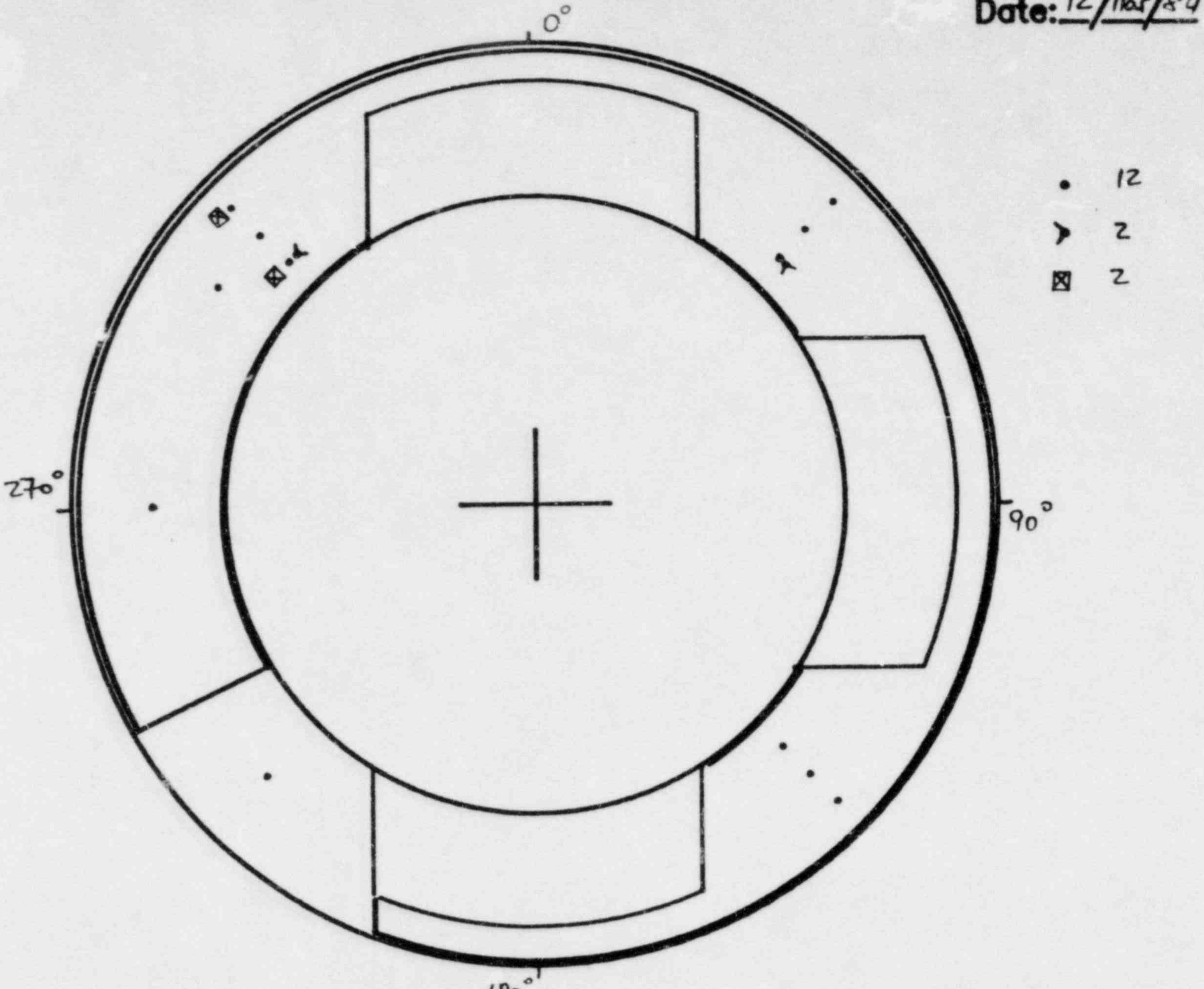
Grand Gulf Layout **Elevation 13.9 ft** **Rev:** D2
Date: 12/Mar/84



Grand Gulf Layout Elevation 16.6 ft.

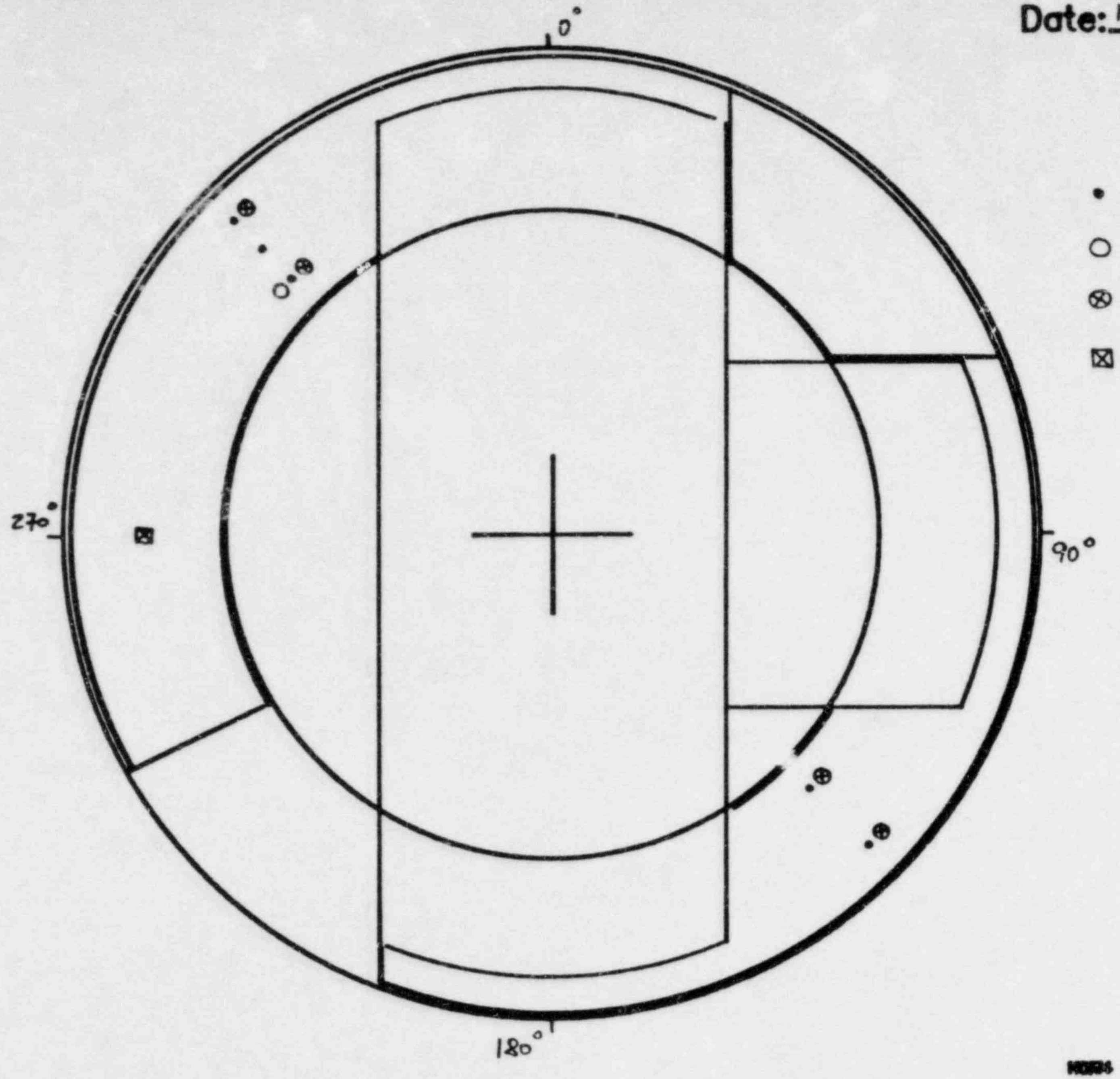
Rev: D2

Date: 12/Mar/84



Grand Gulf Layout   Elevation 20.0 ft

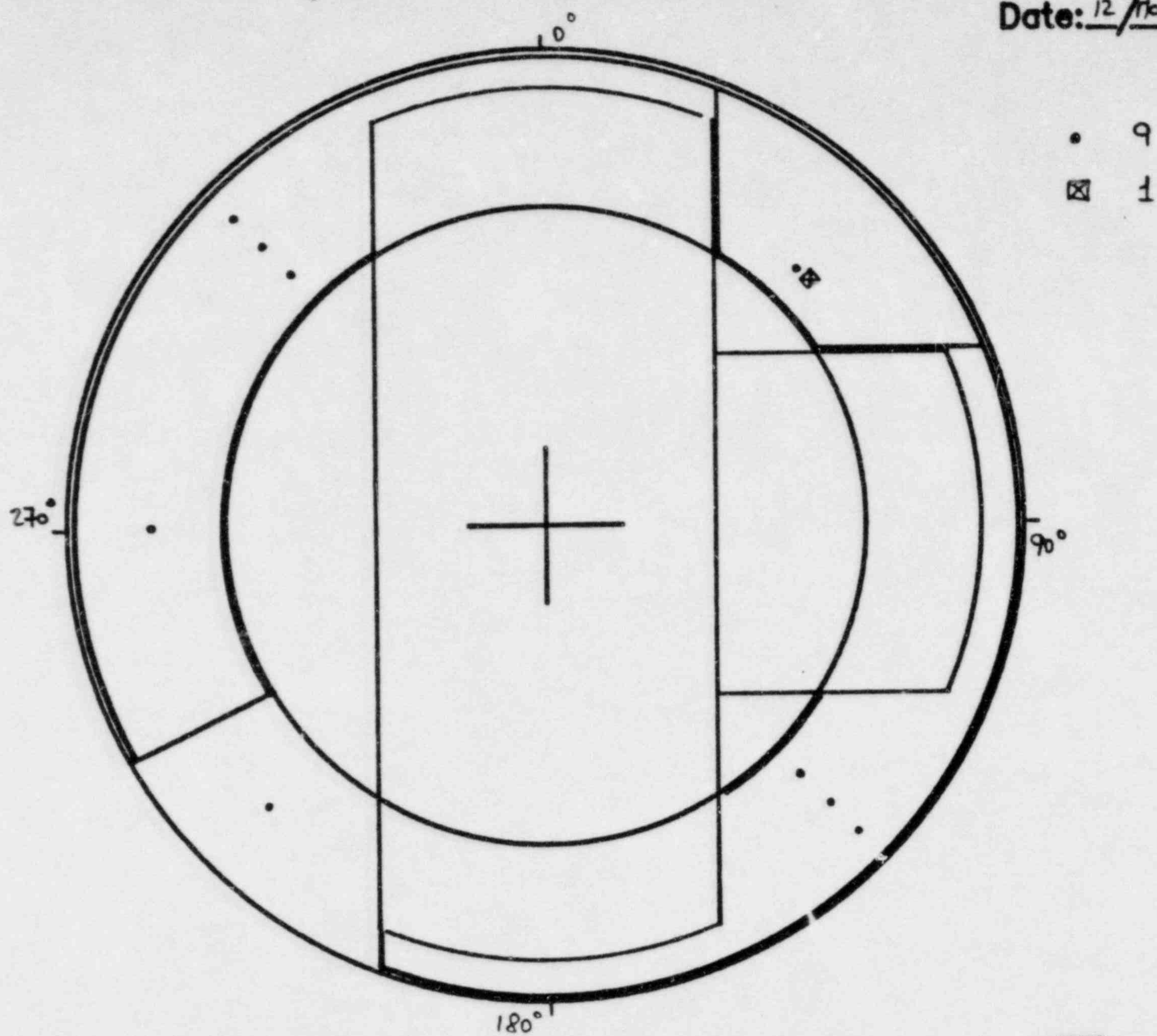
Rev: D2
Date: 12/Mar/84



•	5
○	1
⊗	4
⊠	1

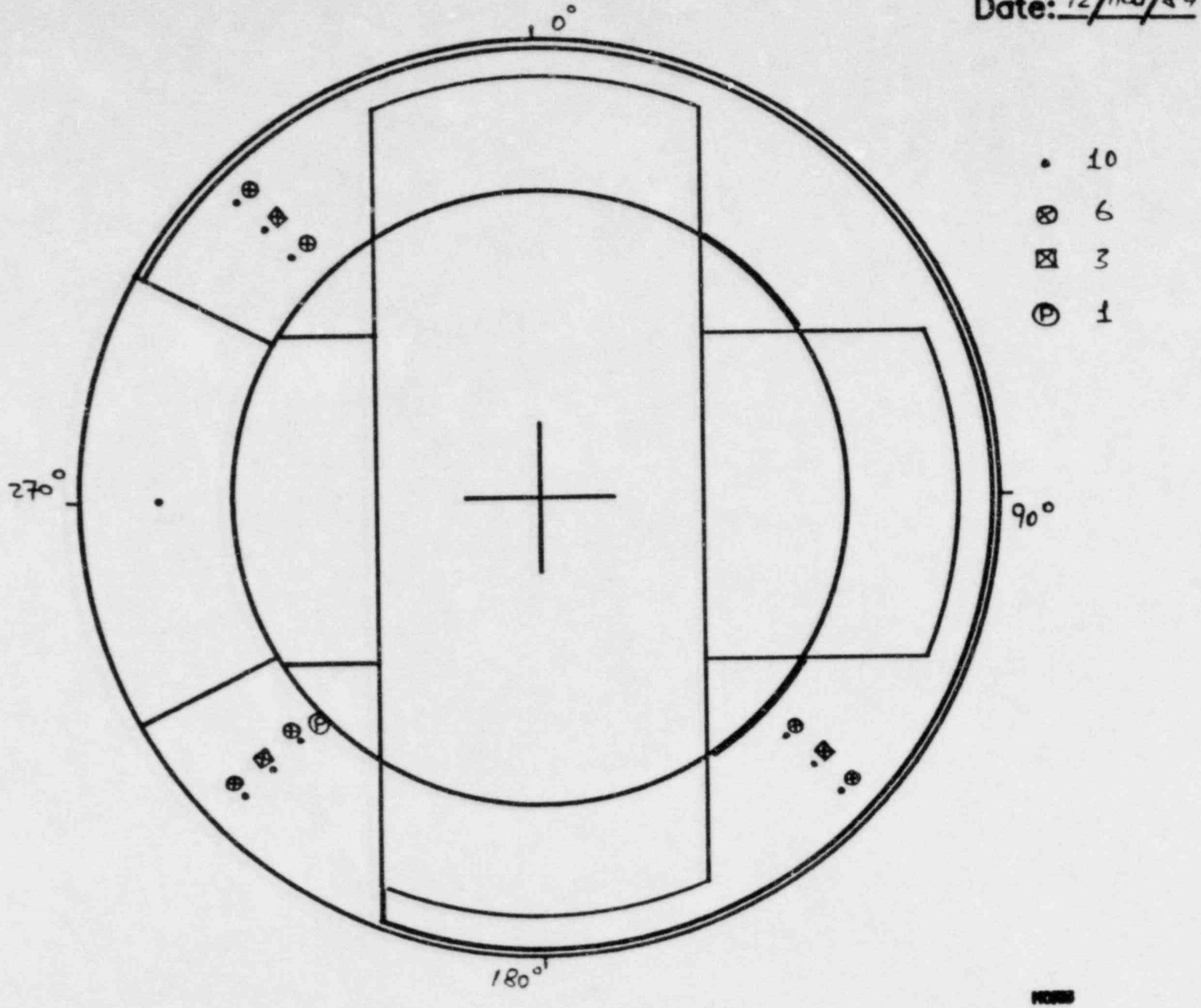
Grand Gulf Layout Elevation 22.3 ft

Rev: D2
Date: 12/Mar/84



Grand Gulf Layout Elevation 28.4 ft Rev: DZ

Date: 12/Mar/84



Grand Gulf Layout **Elevation 35 & 42 ft** **Rev:** D2
Date: 12/Mar/84