FLORIDA POWER & LIGHT COMPANY
ST. LUCIE PLANT UNIT NO. 1
OFF-NORMAL OPERATING PROCEDURE NO. 0120037
REVISION 0

DRAFT

1.0 Title:

Reactor Coolant Gas Vent System Off-Normal Operation

2.0 Review and Approval:

Reviewed by Facility Review Group ______________________ 19__

Approved by ______________________ Plant Manager __________ 19__

Revision __ Reviewed by F R G ______________________ 19__

Approved by ______________________ Plant Manager __________ 19__

3.0 Purpose and Discussion:

3.1 The purpose of this procedure is to provide a method of venting non-condensible gases from the Reactor Coolant System (RCS) which may inhibit core cooling during natural circulation.

3.2 Guidance and precautions are also provided for use in determining the size of the non-condensible void formation, when to initiate venting, and termination of venting operations.

4.0 Symptoms:

4.1 Abnormal RCS conditions such as large variations in pressurizer level during normal charging and spraying operations have occurred.

4.2 If available, reactor vessel head temperatures equal to or greater than saturation temperature.

4.3 Plant events have occurred (such as safety injection tank [SIT] discharge, rapid RCS cooldown, or core uncovery events) that may result in the presence of a gaseous void in the vessel head.

4.4 Loss of pressurizer pressure control during normal pressurizer conditions (i.e., bubble established, normal heaters/spray capabilities).

4.5 Pressurizer indicates departure from saturated conditions i.e., for a given temperature, pressure is higher than saturation pressure.

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5.0 Instructions:

5.1 Immediate Automatic Actions:

. None

5.2 Immediate Operator Actions:

5.2.1 If any of the above listed symptoms have occurred or it is suspected that there is a non-condensible void formation present in the RCS by other detection means, then any changes being made to the primary system should be terminated and a steady state condition should be established.

5.3 Subsequent Operator Actions:

Note: Asterisked steps are not applicable if safety injection has been initiated.

* 5.3.1 Attempt to recombine any condensible gases by increasing RCS pressure through the use of pressurizer back-up heaters. If this step is successful in condensing the gas volume in the vessel head (as indicated by a return to normal readings in those parameters used to determine the presence of the gases) then return to the appropriate operating procedures.

5.3.2 Coordinate with appropriate on-site technical resources. (Technical Support Center [TSC] Supervisor if manned; Chemistry Department representative if TSC is not manned).

5.3.3 Determine the magnitude/size of the void formation per Appendix B, if possible.

5.3.4 Determine the recommended venting time required per Appendix C, if possible.

5.3.5 Increase the RCS sub-cooling to 50° F + inaccuracies by either pressurizing via pressurizer backup heaters or decreasing RCS temperature via dumping steam.

5.3.6 Terminate containment purge, if in progress. Start all available containment coolers.

5.3.7 Ensure that all available hydrogen recombiners are in service.

5.3.8 Verify that Chemistry Department is prepared for monitoring the containment atmosphere for hydrogen via the hydrogen analyzer and/or grab sample.

* 5.3.9 Increase pressurizer level to 80-85% in preparation for venting. This should provide inventory to displace approximately 900 $ft^3$ before reaching heater level.

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5.0 Instructions: (continued)

5.3 (continued)

* 5.3.10 If not already performed, manually block SIAS if the permissive is energized during the venting process.

5.3.11 Restore power to the RCGVS solenoid operated valves by inserting fuses 26F2 & 4 and 11F2 & 4.

| C.R.A.C. PANEL 1<br>11F2 & 4 | C.R.A.C. PANEL 2<br>26F2 & 4 |
|---|---|
| V-1442 | V-1441 |
| V-1444 | V-1443 |
| V-1445 | V-1446 |
| V-1449 | |

5.3.12 Monitor pressurizer pressure and level during the venting period and minimize the pressure and level decrease by selective use of charging pump combinations and letdown flow.

5.3.13 Observe the pressurizer level trend during the reactor vessel venting and, from the following conditions, determine the probable status of the reactor coolant system:

a. Controllable pressurizer level - gaseous voids exist in the RCS other than the reactor vessel head or pressurizer.

The orifice in the head vent is sized to limit water relief to within the make-up capability of one charging pump (44 GPM @ 2250 psia). Therefore, if no gases are present in the vessel head, then the pressurizer level should remain controlable.

b. Decreasing pressurizer level - gaseous voids exist in the reactor vessel head.

The venting of gases will result in a rapid decrease in pressurizer level due to the mass flow rate of the gases being greater than the mass input being provided by the charging system.

CAUTION: If pressurizer level decreases to less than 20%, then attempt to restore level by the CVCS System (isolate letdown, max. charging). If level cannot be restored, then manually initiate safety injection.

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5.0 Instructions: (continued)

5.3 (continued)

5.3.14 Commence venting the reactor vessel head. The flow path used is optional, and the decision as to which is used should be based on quantity of gas to be released. If recovery and processing in the waste gas system is desired then vent to the quench tank. If quantity is large, then vent to containment atmosphere.

5.3.15 Terminate venting when:

a. TIME PERIOD DETERMINED IN STEP 5.3.4 IS MET,

OR

b. PRESSURIZER PRESSURE DECREASES BY 200 PSI,

OR

c. PRESSURIZER LEVEL DECREASES BELOW 25% LEVEL,

OR

d. REACTOR COOLANT SUB COOLING LESS THAN 20°F + INACCURACIES,

OR

e. THE REACTOR VESSEL HEAD IS REFILLED AS INDICATED BY A DECREASE IN THE RATE OF CHANGE OF PRESSURE AND PRESSURIZER LEVEL.

5.3.16 Re-establish pressurizer level and evaluate the response of the pressurizer level trend to determine if a gas bubble existed in the head. If a gas bubble existed and the venting was terminated prior to the vessel being completely refilled, then return to Step 5.3.14.

Note: If multiple venting operations are required and the containment hydrogen concentration is equal to or greater than 3 volume percent, then provisions must be made to remove or reduce the volume of hydrogen from the containment prior to re-opening the reactor vessel head vent.

5.3.17 Return to the appropriate operating procedures following successful completion of the venting of the reactor vessel head.

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6.0 References:

6.1 C-E "Final Report on the Reactor Coolant Gas Vent System".

7.0 Records:

7.1 Completed Appendix B and C work sheets shall be retained in the plant file in accordance with QI-17/PSL-1.

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## APPENDIX A

## PRECAUTIONS

1. This venting procedure should not be used as the primary means to mitigate an inadequate core cooling event.

2. Venting operations should be performed prior to the initiation of safety injection flow throttling during a Post-Loca cooldown and depressurization. During venting "full flow" SI capabilities must be maintained if needed.

3. Do not trip any running or start any non-operating reactor coolant pumps during venting operations.

4. Containment purge should be isolated to prevent the release of any radioactive gases to the environment.

5. All available containment air circulation equipment should be started to prevent any hydrogen from forming a gas pocket and to ensure a representative hydrogen concentration is obtained during sampling.

6. Appendix C "Venting Time Period" determines the maximum allowable time period for venting which will limit the containment hydrogen concentration to less than 3 volume percent.

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## APPENDIX B

## NON-CONDENSIBLE VOID FORMATION SIZING

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1.0 The objective of this test is to inject a known volume of borated water into the RCS and then compare the expected results with the actual results.

2.0 If the safety injection system is in service, then the following steps are not applicable since normal pressurizer control will not be maintained.

3.0 Establish a constant pressurizer level and pressure condition.

3.1 Isolate all RCS sample points to minimize mass inventory loss.

3.2 Coordinate with the Technical Support Center (if appropriate) to insure that operations that could affect the test will not be performed until the conclusion of this test.

4.0 Record the following parameters:

4.1 RCS Pressure = __________ psia

4.2 Pressurizer Level = __________ %

4.3 Charging Rate = __________ GPM

4.4 RCP Seal Leakoff Flow = __________ GPM

4.5 Time = __________

5.0 Isolate the CVCS letdown system by closing the letdown isolation valves AOV-2515 and AOV-2516.

6.0 Turn off all pressurizer heaters, and terminate any pressurizer spray.

6.1 With RCPs on, place pressurizer pressure controller HIC-1100 in manual and zero the signal.

6.2 With RCPs off, secure auxiliary spray if being used.

7.0 Continue charging to the RCS until either:

7.1 PRESSURIZER PRESSURE INCREASES 100 PSI

<u>OR</u>

7.2 PRESSURIZER LEVEL INCREASES 5%.

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APPENDIX B



8.0 Record the following parameters:

8.1 RCS pressure = ________ psia

8.2 Pressurizer level= ________ %

8.3 Time = ________

9.0 Reinitiate CVCS letdown flow and restore normal perssurizer pressure and level control.

10.0 Calculate the initial and final pressurizer vapor space volumes. (express % level in decimal form)

10.1 Initial vapor volume=(1-PZR level %) X 1252 $ft^3$ + 134 $ft^3$ = ______ $ft^3$

10.2 Final vapor volume=(initial vol.) - (Delta PZR level % X 1252 $ft^3$) = ______ $ft^3$.

11.0 Calculate the total charged volume into the RCS.

11.1 Charged volume, $ft^3$ = (charging flow rate GPM-seal leakoff flow rate GPM) X

$$\frac{\text{Elapsed Time (min)}}{7.45\ \text{Gal/ft}^3}$$

12.0 Determmine the <u>expected</u> pressurizer level change

12.1 Expected Delta level = (charged volume $ft^3$) X .0667 = _____ %

13.0 Determine the <u>actual</u> pressurizer level change.

13.1 Actual Delta level - Step 8.2 - Step 4.2 = _____ %

14.0 If the <u>actual</u> pressurizer level change is less than the <u>expected</u> level change then a gaseous void exists in the reactor coolant system.

15.0 Perform the following steps to determine the volume of the RCS void:

15.1 Initial RCS Void $ft^3$=

$$\frac{\text{(Init. Vapor Vol.,Step 10.1)-(Final Vapor Vol.,Step 10.2)-(Charged Vol.,Step 11.1)}}{1-\frac{\text{Initial Pressure}}{\text{Final Pressure}}}$$

15.2 Final RCS Void $ft^3$=

$$\frac{\text{(Initial RCS Void, Step 15.1) X (Initial Pressure)}}{\text{(Final Pressure)}}$$

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APPENDIX B



16.0 Summary

16.1 Initial PZR vapor volume=__________ft$^3$

16.2 Final PZR vapor volume =__________ft$^3$ Difference=__________ft$^3$

16.3 Charged volume =__________ft$^3$

16.4 Expected Delta level =__________%

16.5 Actual Delta level =__________% Difference=__________%

16.6 Initial RCS void =__________ft$^3$

16.7 Final RCS void =__________ft$^3$

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## APPENDIX C

## VENTING TIME PERIOD

Page 1 of 3

1.0 During a core uncovery event, there exists the potential for a significant amount of hydrogen generated in the core which could be trapped in the reactor vessel and released to the containment atmosphere during the venting operation. The containment hydrogen concentration is limited to less than 4 volume percent to prevent a potential explosive mixture with oxygen, therefore, the amount of hydrogen that can be vented to the containment is restricted. A maximum allowable time period for venting is determined to limit the containment hydrogen concentration.

2.0 This guide assumes that the containment conditions are near normal.

3.0 Convert the containment free-volume to containment volume at standard temperature and pressure conditions.

3.1

$$\text{Cont.Volume(STP)},ft^3=(2.5 \times 10^6\ ft^3) \times \underset{\text{Note 1}}{\frac{\text{Cont. Press.}}{14.7}} \times \underset{\text{Note 2}}{\frac{492^{o}R}{\text{(Cont. Temp.)}}}$$

Note 1: Delete term unless containment pressure is greater than 2 PSIG.

Note 2: Temperature in degrees Rankine ($^{o}$ F + 460)

4.0 Determine containment hydrogen concentration in volume percent units.

4.1 Obtain value from Chemistry Department.

4.2 If there has been no leakage from the RCS to the containment, assume a value of zero.

4.3 Containment $H_2$ Concentration = __________%

5.0 Calculate the maximum hydrogen volume that can be vented to the containment which will result in a containment hydrogen concentration of less than or equal to 3 volume percent.

5.1 Max. $H_2$ Vol, $ft^3$= $\frac{(3.0\%-\text{Cont.}H_2\text{ Conc.,Step 4.3,\%}) \times (\text{Cont. Vol.[STP] Step 3.1})}{100\%}$

6.0 Obtain from Curve #1 the hydrogen flow rate which will result at the predicted RCS pressure at time of venting.

6.1 Predicted RCS pressure = __________psia

6.2 Hydrogen flow rate = __________SCFM

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APPENDIX C



7.0 The maximum allowable venting time period which will limit the containment hydrogen concentration to $\leq$ 3 volume percent is determined by:

7.1

$$\text{Venting period, mins.} = \frac{\text{Max. } H_2 \text{ Volume, Step 5.1}}{H_2 \text{ Flow rate, Step 6.2}}$$

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APPENDIX C

CURVE #1
HYDROGEN FLOW RATE vs. PRESSURE

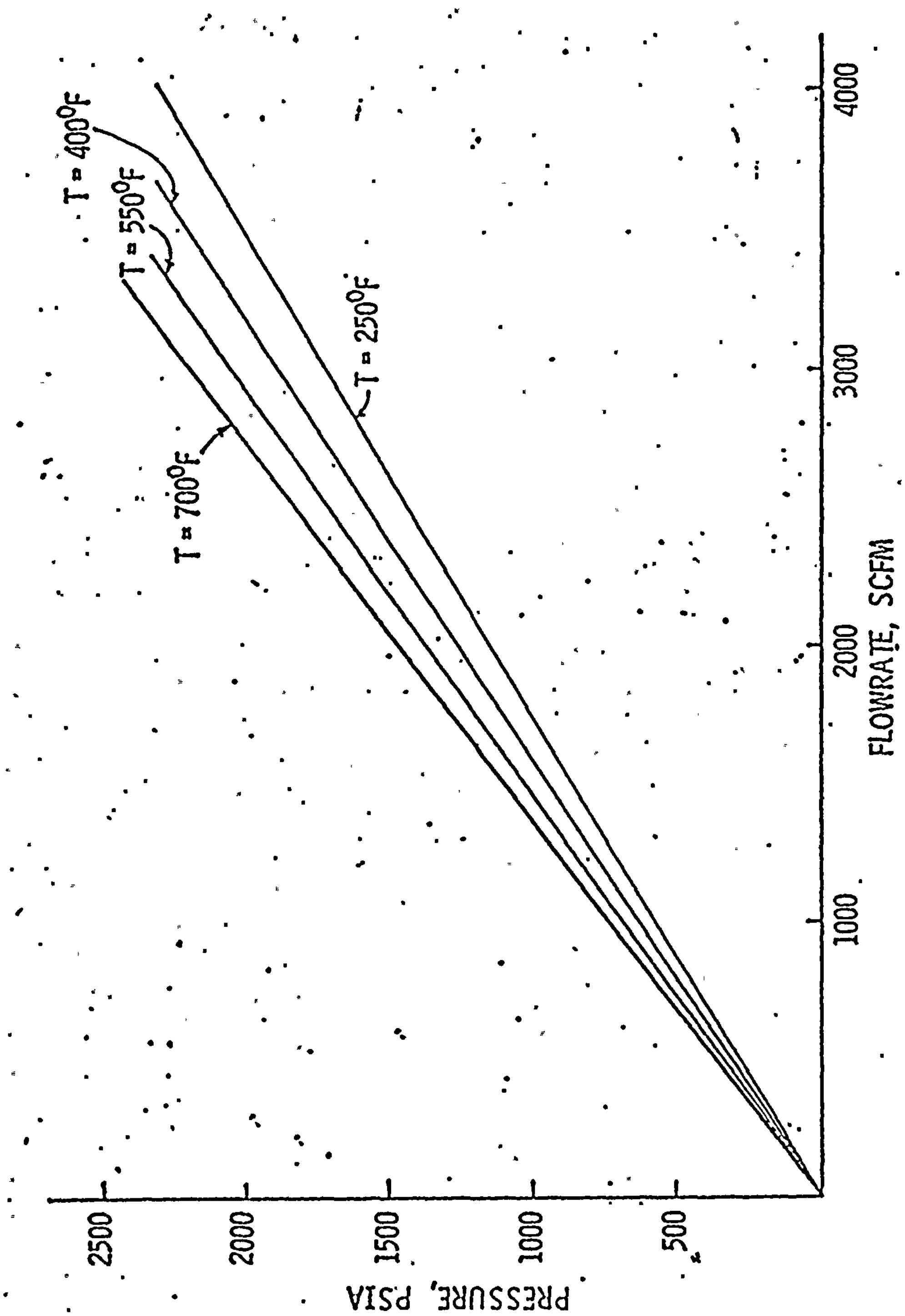

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FIGURE 1

PRESSURIZER VENT
HYDROGEN FLOW RATE vs. PRESSURE

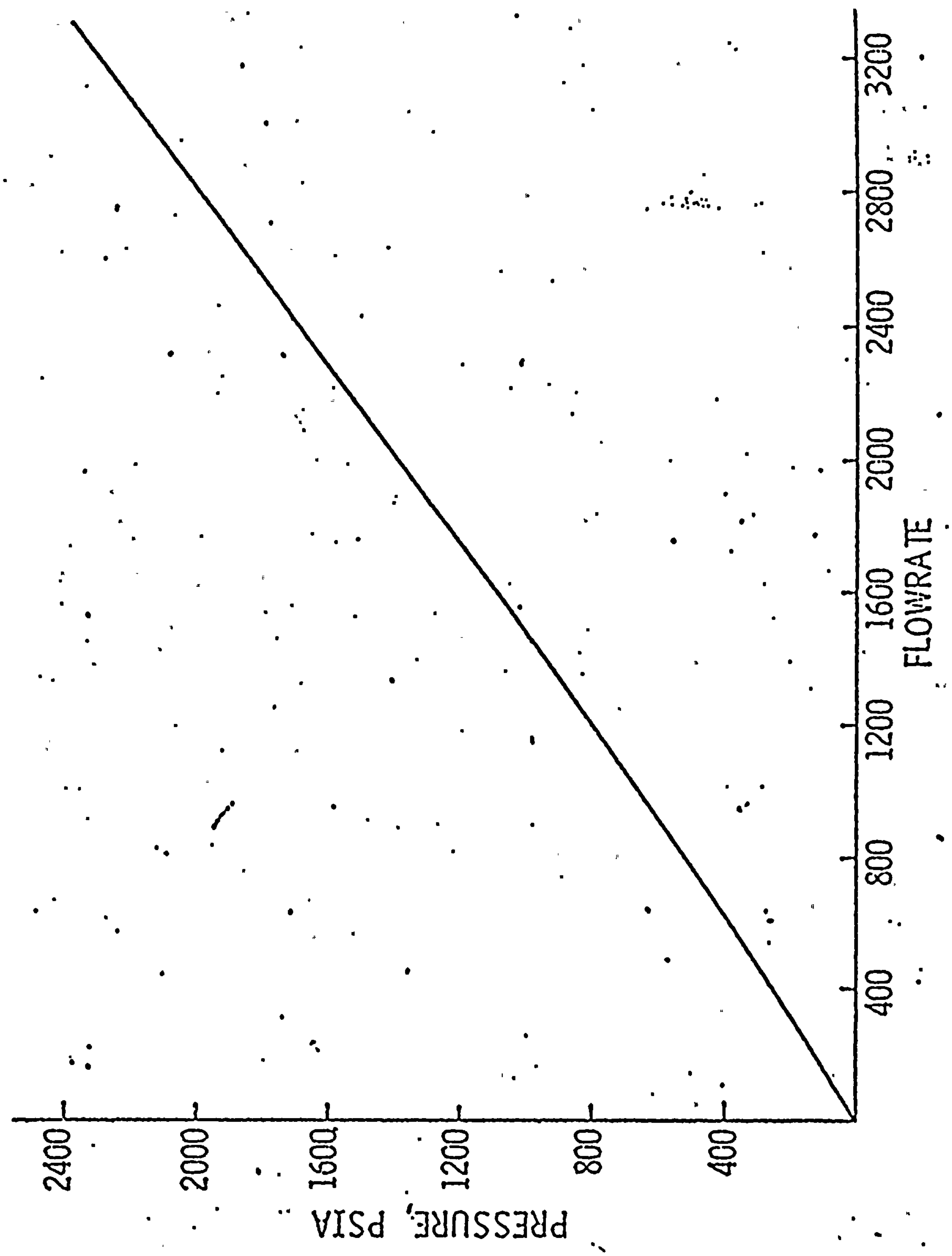

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FIGURE 2

REACTOR VENT
STEAM FLOW RATE vs. PRESSURE

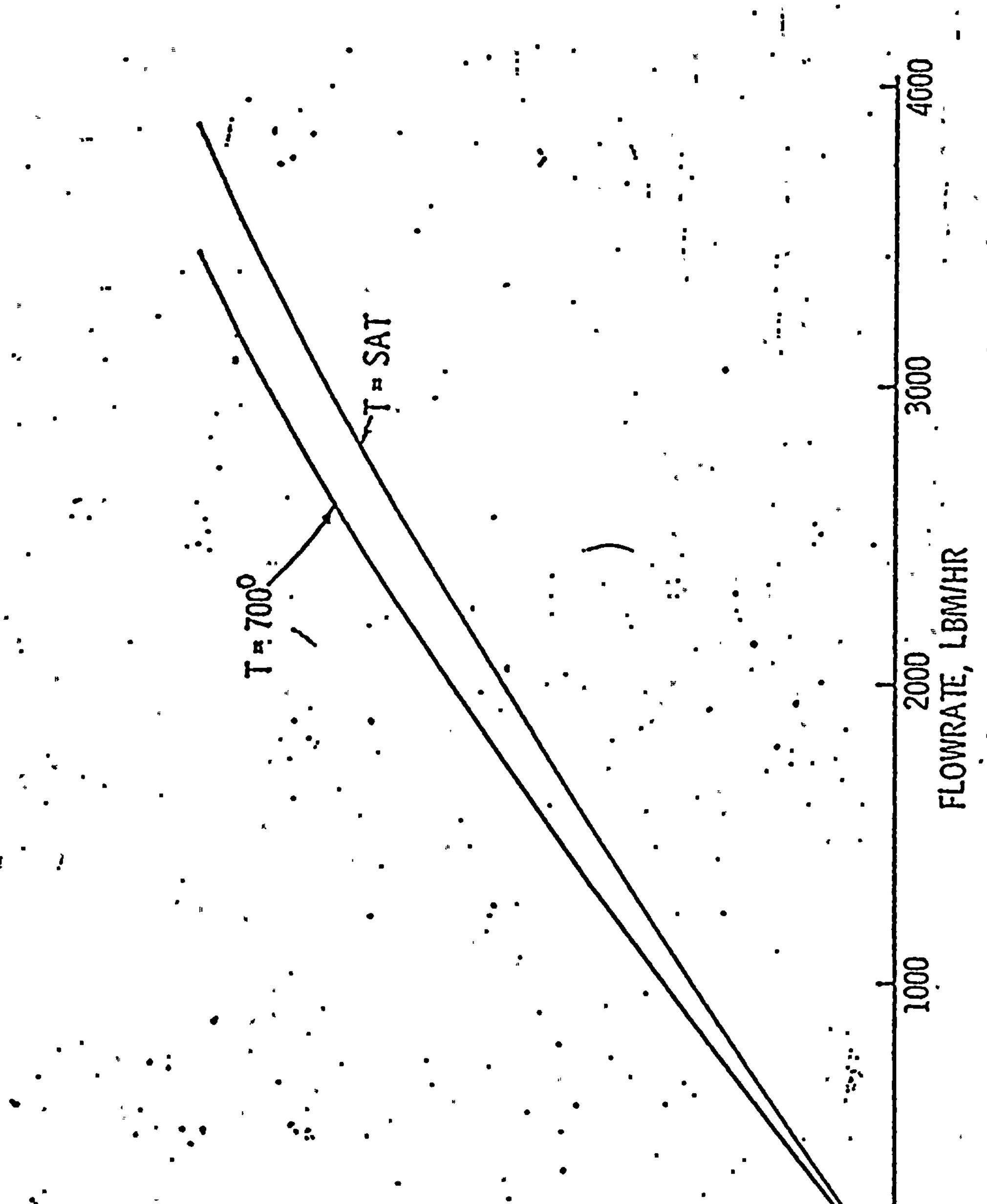

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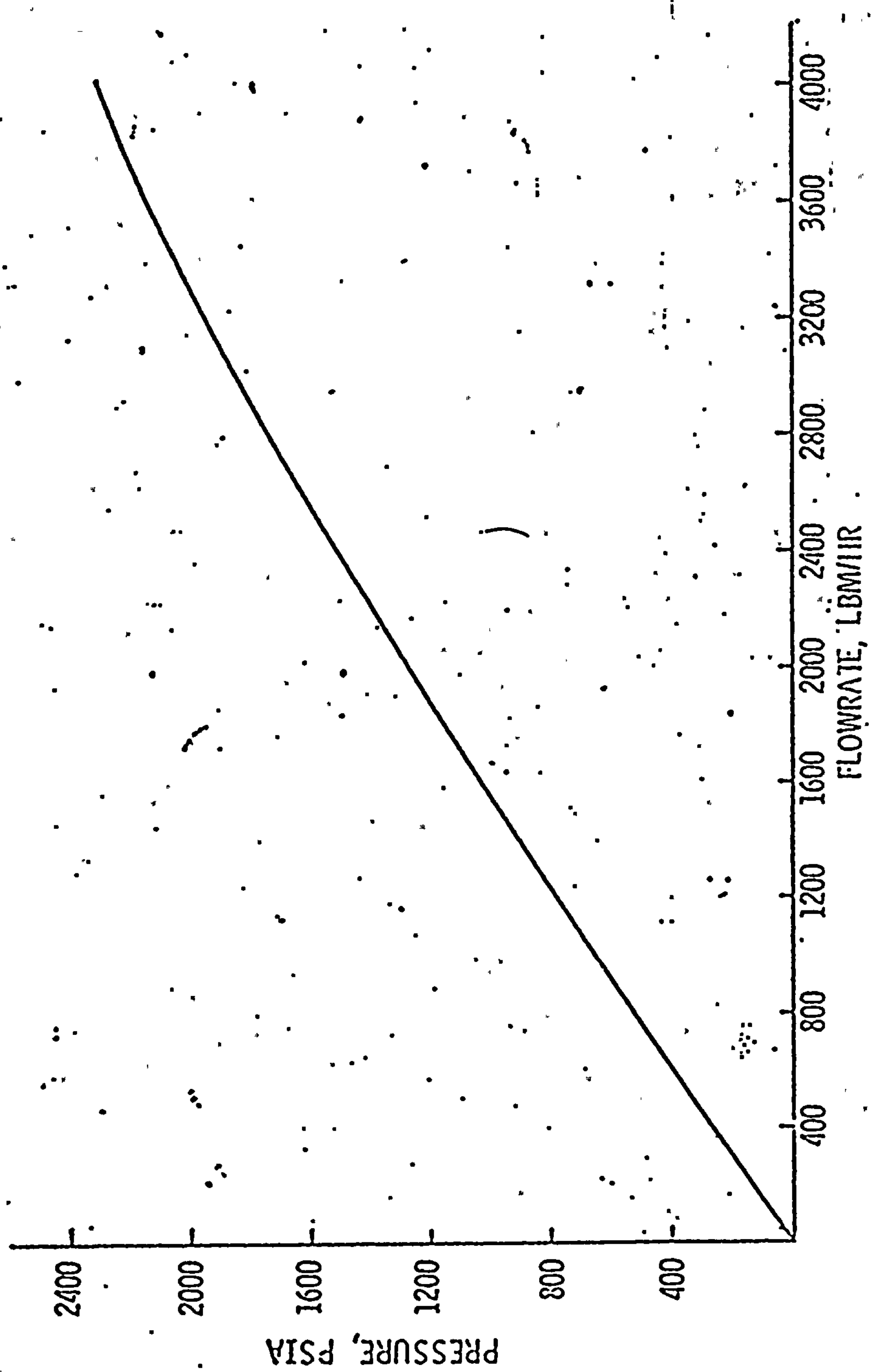
FIGURE 3.

PRESSURIZER VENT
STEAM FLOW RATE vs. PRESSURE



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## FACT SHEET

### SOURCES OF NON-CONDENSIBLES

| Source | Volume (STP) | Mass |
|---|---|---|
| 1. Complete oxidation of clad (hydrogen) | 448000 $ft^3$ | 2514.8 lbs[a] |
| 2. Fuel rod fill gas (helium) | 1140 $ft^3$ | 12.7 lbs[a] |
| 3. Fission gases (Xe, Kr, $I_2$) | 26 $ft^3$ | 9.0 lbs[a] |
| 4. Safety injection tanks (nitrogen) | | |
| a. Cover gas | 51820 $ft^3$ | 4042.2 lbs[b] |
| b. Dissolved gas | 690 $ft^3$ | 53.8 lbs[b] |
| 5. Dissolved in refueling water tank (air) | 1360 $ft^3$ | 109.7 lbs[c] |
| 6. Dissolved in primary coolant (hydrogen) | 384 $ft^3$ | 2.2 lbs |
| 7. Pressurizer vapor space (hydrogen) | 793 $ft^3$ | 4.6 lbs |

NOTES

a. For breaks requiring the return to natural circulation no fuel rod rupture or oxidation is predicted. Numbers are based on 36924 fuel rods.

b. For breaks requiring the return to natural circulation the SIT's do not inject water.

c. The largest amount of liquid injected from the refueling water tank (RWT) during the boiling phase for breaks that return to natural circulation is approximately 40% of the RWT volume.

**Pressurizer**

| | |
|---|---|
| Volume of Top Spherical Head | ≈134 $ft^3$ |
| Volume of Bottom Spherical Head | ≈114 $ft^3$ |
| Volume of Cylinder Section | ≈1252 $ft^3$ |
| Level Span | ≈350 inches |
| Volume vs. % Span | ≈15 $ft^3$ per % |
| Inches vs. % | ≈3.6" per % |
| Volume Required to Cover Heaters | ≈266 $ft^3$ |
| Pressurizer O.D. | ≈106.5 inches |
| Pressurizer I.D. | ≈96 inches |
| Pressurizer Cross Sectional Area | ≈50.27 $ft^2$ |

**Steam Generators**

| | |
|---|---|
| Total Volume of U-Tubes | ≈1147 $ft^3$ |
| Volume of S/G Cold Plenum | ≈250 $ft^3$ |
| Volume of S/G Hot Plenum | ≈258 $ft^3$ |

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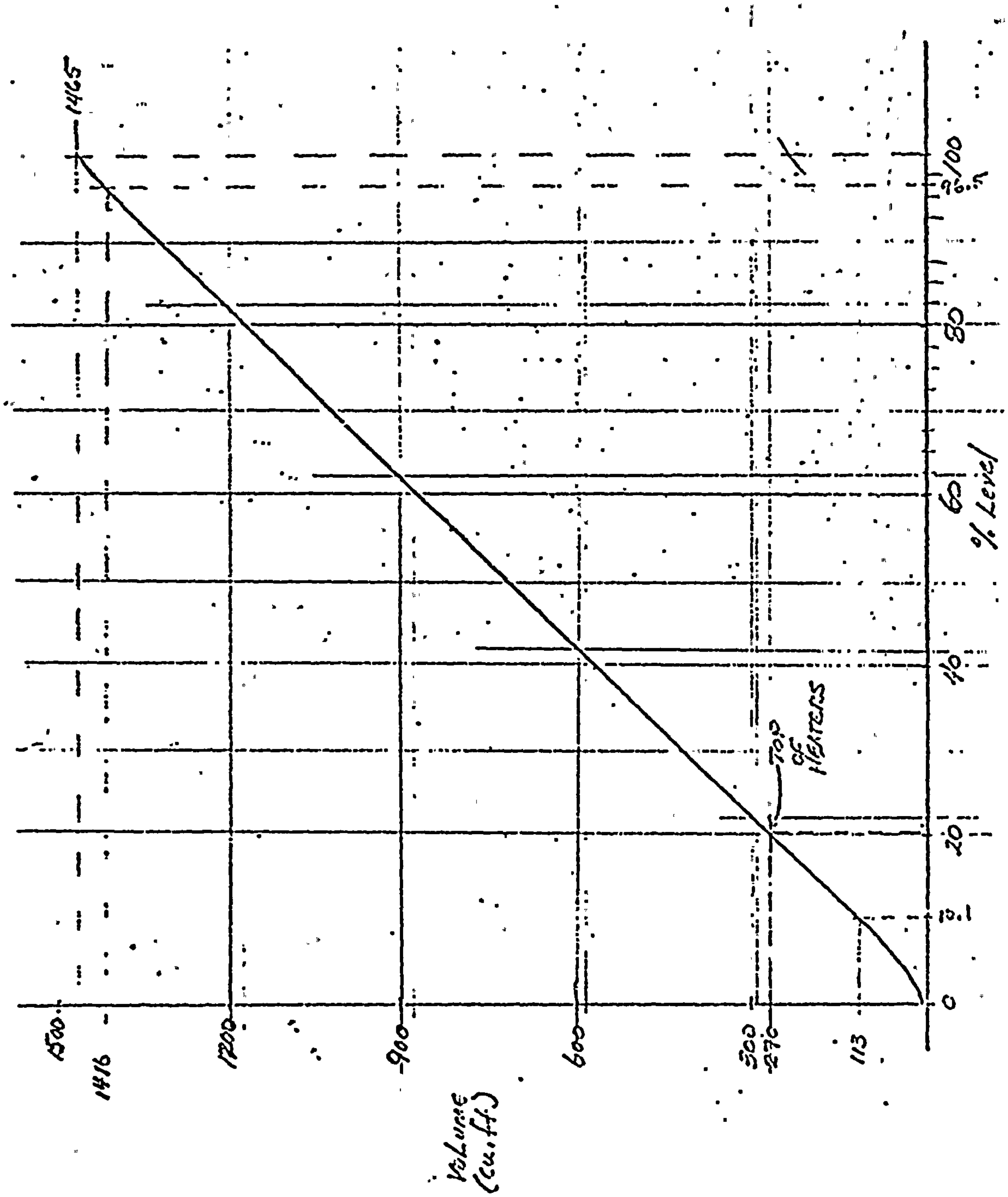
PRESSURIZER LEVEL (%) VS. VOLUME (Cu Ft)
PRESSURIZER at 2250 psia/653° F.



OFF-NORMAL OPERATING PROCEDURE NO. 0120037, REVISION 0
REACTOR COOLANT GAS VENT SYSTEM OFF-NORMAL OPERATION

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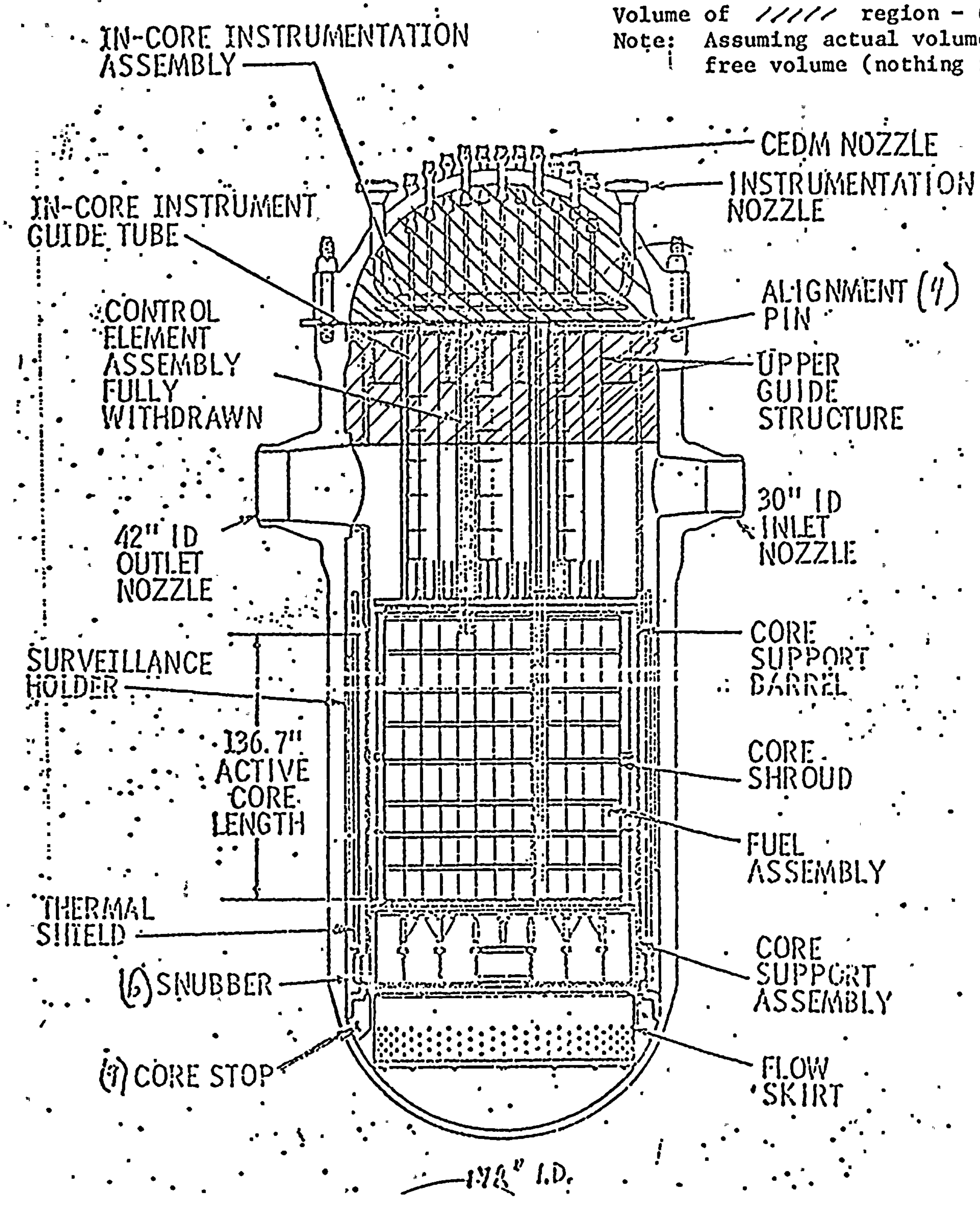
REACTOR ARRANGEMENT - VERITCAL SECTION

Volume of \\\\\ region - 691 $ft^3$
Volume of ///// region - 662 $ft^3$
Note: Assuming actual volume as free volume (nothing inside)



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REACTOR COOLANT GAS VENT SYSTEM OFF-NORMAL OPERATION

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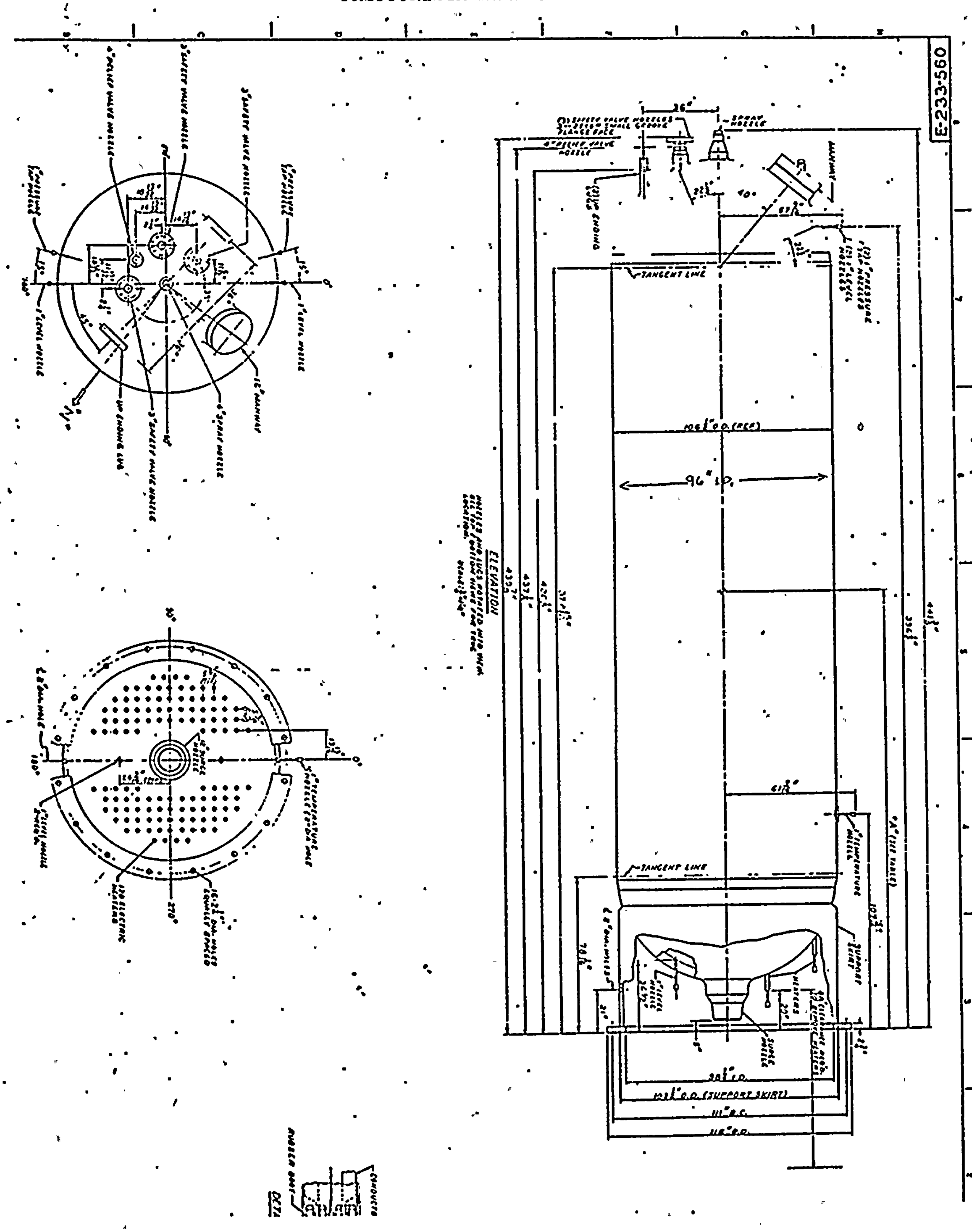
PRESSURIZER ARRANGEMENT



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SYSTEM FLOW DIAGRAM