BALTIMORE GAS AND ELECTRIC

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VICE PRESIDENT
SUPPLY

August 11, 1981

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

Attn: Mr. D. G. Eisenhut, Director
Division of Licensing

Subject: Calvert Cliffs Nuclear Power Plant
Units Nos. 1 & 2, Dockets Nos. 50-317 & 50-318
Response to NUREG-0737 Item II.B.1

Gentlemen:

Enclosed are the guidelines which are being used to develop operating instructions for use of the reactor coolant system gas vent system (RCSVS).

The vent system is scheduled to be operational by January 1, 1982, by which time formal training will be completed and operating instructions issued.

If any additional information is required, we would be pleased to provide it to you.

Very truly yours,

Jon M. Files

for A. E. Lundvall, Jr.
Vice President-Supply

cc: J. A. Biddison, Esquire (w/o encl)
G. F. Trowbridge, Esquire (w/o encl)
Messrs. E. L. Conner, Jr. - NRC (w/ encl)
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Procedural Guidelines

For

Reactor Coolant Gas Vent System

For

Calvert Cliffs Units 1 & 2

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Procedural Guidelines

1. Purpose:

   To provide procedural guidelines for the Reactor Coolant Gas Vent System. This document does not provide detailed operating procedures, but is intended to be used as a guide when writing the detailed procedures.

2. Scope:

   The procedures have been divided into three basic sections: system status surveillance, normal operations, and emergency operation. In addition to presentation of the operational guidelines, the emergency operation includes a discussion of the plant response to the use of the RCGVS.

3. References:

   3.1 Bechtel Drawing FSK-M-201 sheets 4-7

   3.2 Bechtel Drawing FSK-MP-3137

   3.3 Bechtel Drawing FSK-MP-3348

   3.4 Bechtel Drawing FSK-MP-3410

   3.5 Bechtel Drawing FSK-MP-4202

   3.6 Bechtel Drawing FSK-MP-4459

   3.7 Bechtel Drawing SK-J-67 sheets 1-2

   3.8 Bechtel Drawing 62-460-E

Note: A simplified sketch of this system is provided on Figure 19 for reference when using this document.

4.0 System Status and Surveillance

4.1 RCGVS Standby Mode

1. Description of Operation

   During normal plant operations, the Reactor Coolant Gas Vent System is in a standby mode. All solenoid isolation valves (1-SV-103, 104, 105, 402, 106) are closed with appropriate administrative controls in force to prevent inadvertent system operation.

2. Initial Conditions

1) RCS fluid boundaries are intact.

2) The plant is in any mode of operation except refueling.

3) The following interfacing systems are available for use with the RCGVS should the system be required:

Electrical Power for the Valves
Quench Tank
Containment Recombiners and H_2 analyzers

4) The RCGVS temperature instrument (1-TI-102) is operational.

5) All RCGVS solenoid valves are closed with administrative controls imposed.

6) All manual valves in the vent path are locked open.

Operational Requirements

1. The leak tightness of the RCGVS isolation valves is verified by periodically monitoring the RCGVS temperature indicator (1-TI-102).

2. The standby status of the system is verified by assuring that the administrative controls remain in force.

4.2 Normal Plant Operations

4.2.1 RCGVS response to valve leakage during normal operations.

1. Description of Operation

While in standby, 1-TI-102 indicates that leakage has occurred past ~~one~~ two of the 4 solenoid valves. Operator response to the leakage includes verification that leakage is occurring, quantification of the leak rate, and eventual repair of the leaking valve. A flow chart to summarize operator response if provided as Figure 1.

2. Initial Conditions

1. Same as Status and Surveillance
2. 1-TI-102 indicates valve leakage by a temperature increase (and eventual alarm).

3. Operational Requirements

1. Conduct a RCS leak rate determination in accordance with established plant procedures and compare with a leak rate determination made prior to the temperature increase. No difference indicates that either the temperature indicator is faulty or that the leakage has been contained by the second isolation valve. An increase in the leak rate indicates that not only is leakage occuring, but it is also leaking past the second isolation valve.

2. If there is no change in RCS leak rate, then instrument malfunction is possible. No action is necessary other than to repair the instrument when plant conditions permit. Periodic leak rate determinations should be made to verify that leakage does not occur while the instrument is out of service.

3. If there is a change in RCS leak rate then one or both sets of isolation valves are leaking. If the leak rate is less than technical specification limits, then operation can continue, but the RCS leak rate determination should be monitored to assure that the rate does not increase. The leaking valves should be repaired at the earliest opportunity and if leakage reaches technical specification limits, the plant must be shutdown to repair the valves. Quench tank conditions should be monitored to assure proper temperature, pressure, and level are maintained in the tank. The tank level will provide an independent check of the leak rate.

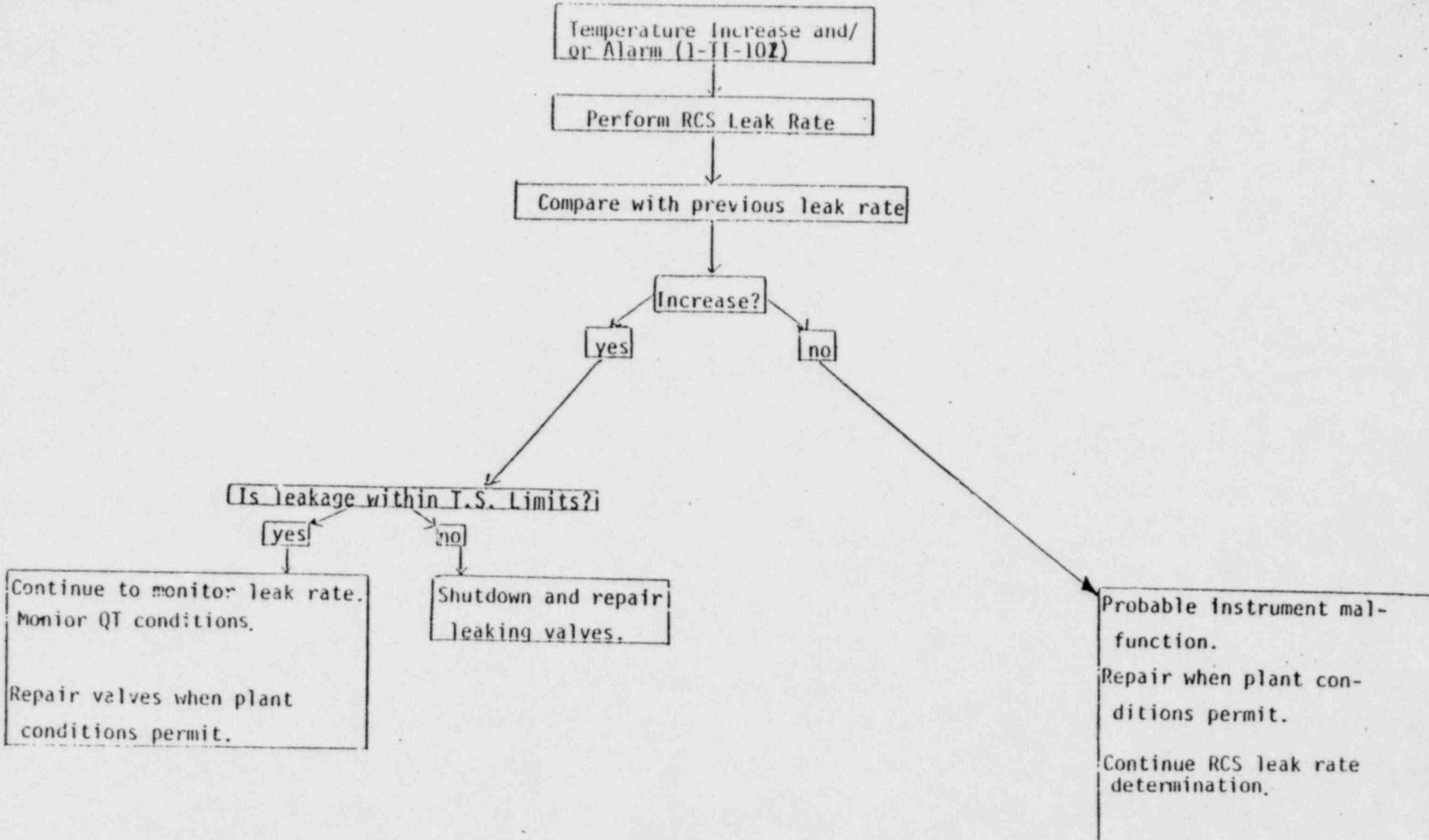

Figure 1

Response to System Valve Leakage

4.2.2 RCGVS Use in RCS Venting Prior to Refueling

BG&E refueling procedures were not available when these guidelines were written, but actual in plant use of the system should be compatible.

1. Description of Operation

   The RCGVS may be used to vent the RCS when the RCS is being pumped down to remove the reactor vessel head for refueling. This is done by aligning first the pressurizer vent and later the reactor vessel vent to the quench tank or atmosphere through the QT while the RCS fluid is being pumped out of the system.

2. Initial Conditions

   Same as Status and Surveillance except the reactor is in cold shutdown in preparation for head removal.

3. Operational Requirements

   1) Obtain administrative approval to operate the RCGVS valves.
   2) Initiate RCS draining and line up the pressurizer vent to either the quench tank, waste gas system, or atmosphere. Assure sufficient N_2 is supplied to the quench tank if the vent path does not include the waste gas system or containment atmosphere.
   3) When the pressurizer empties, open the reactor vessel vent to allow removal of fluid from the reactor vessel head.

4.2.3 RCGVS Use in RCS Venting Post-Refueling

1. Description of Operation

   The RCGVS may be used to vent the RCS when the RCS is being refilled following refueling. This is done by aligning the RCGVS to vent first the reactor vessel head and then the pressurizer to the quench tank. Vented gas is ultimately handled by the Waste Gas System.

2. Initial Conditions

   Same as Status and Surveillance except the RCS is partially drained from refueling, with the system ready to be refilled. Administrative controls of the solenoid valves may not be in force.

3) Operational Requirements

1. Obtain administrative approval (if required) to operate the RCGVS valves and repower the valves.
2. Align the system to vent the reactor vessel head to the quench tank and waste gas system and commence system fill.
3. When quench tank level indicates liquid flow (or, alternately, a vent system drain may be monitored for flow) close the reactor vessel isolation valves and open the pressurizer isolation valves.
4. When the pressurizer is full, close all RCGVS solenoids and establish administrative controls in preparation for startup.

4.3 Emergency Plant Operations

This section describes the operation of the RCGVS in response to a plant accident which has created a non-condensible gas bubble in the reactor coolant system. The specific accident which caused the bubble to be formed will not be discussed; instead it will be assumed that a bubble exists regardless of the specific accident scenario. It is also assumed that means to detect the presence of the bubble exists.

4.3.1 Determination of Venting Path and Duration

1. Description of Operation

The first step in the use of the RCGVS under post-accident conditions is the establishment of the need to vent, the determination of the venting duration, and the choice of the venting path. Detection of the gas bubble establishes the need to vent, and the venting duration and path are determined based upon the bubble size and RCS parameters.

2. Initial Conditions

1) Same as Status and Surveillance except an accident has occurred which could lead to bubble formation.

2) The RCS fluid boundary may not be intact.

3. Operational Requirements

1. Establishing the need to vent:

a. For the reactor vessel, if a gas bubble, no matter how small, is detected in the reactor vessel by ΔP, heated-junction thermocouple, or some other suitable means, then there is a need to vent the reactor vessel.

b. The presence of a non-condensible gas in the pressurizer steam bubble can be indirectly ascertained by a departure from saturation conditions. For a given pressurizer temperature, the pressure will be higher than saturation by an amount dependent upon the steam/bubble volume and amount of gas present in the steam space. The effect is illustrated in Figure 16.

This method, however, is only useful for large gas volumes and provides an indirect indication of the volume of gas and how long the pressurizer should be vented to remove the gas. Further, since gas is present in the space even during normal plant operations, the objective of venting the pressurizer is not to remove all gas as is the case for the reactor vessel, but to remove enough of the gas so that the pressurizer can continue to function efficiently to maintain and control plant pressure. The procedural guidelines to accomplish this objective are as follows:

1. If a bubble is detected in the reactor vessel, it will be assumed that some hydrogen has collected in the pressurizer as well, even if the gas volume cannot be definitely measured in the pressurizer.

2. In this case, or if hydrogen is identified in the pressurizer independent of its presence in the reactor vessel by departing from saturation, sluggish pressure control, or sampling; then there is a need to vent the pressurizer.

c. For suspected volumes under 1000 SCF, to determine if the bubble is in the pressurizer:

1. Vent one pressurizer steam space.

2. Control all input and output from RCS and charge pressurizer with fluid. Observe level and pressure. If pressure increases and level does not, non-condensible gas is present.

2. Determination of Venting Duration

a) For the reactor vessel, the vent duration is selected to be long enough to remove the entire gas bubble from the vessel head. By reviewing the RCS temperature and pressure conditions, the venting duration is determined by referring to Figures 14 and 15.

b) For the pressurizer, the vent duration is selected as long enough to remove a sufficient amount of the gas from the pressurizer steam bubble to prevent the gas from interferring with RCS pressure control. This is done by venting the pressurizer long enough to remove the mass equivalent of the steam bubble. Steam bubble size is given by pressurizer level instrumentation and with this and the RCS temperature and pressure, the venting duration is determined by referring

to Figure 9. This vent duration is also sufficient to remove an equivalent volume of hydrogen, should the bubble be pure hydrogen. The venting times are based upon system vent flow rates illustrated in Figures 12 and 13.

c) The venting process will result in a pressure decrease within the RCS, the extent of which is influenced by the venting location, charging pump availability, and the initial pressure, level and temperature conditions. Figures 2 through 7 present the impact of a timed vent upon system pressure and pressurizer level for the venting process. Dependent upon initial conditions and the duration of venting required, it may be necessary to temporarily secure the venting process before the selected venting duration has elapsed to restore pressurizer level and plant pressure. However, as illustrated on the figures, the pressurizer pressure and level changes are slow enough to be controllable. Care must be taken during venting, that the vent process is not allowed to proceed long enough to produce steam bubbles in the main RCS due to reduction of pressure to saturation. Prior to venting, the operator must determine the minimum RCS pressure allowable (based upong RCS temperatures) and terminate venting prior to reaching that pressure. Similarily, when venting the reactor vessel or pressurizer, pressurizer level must not be allowed to decrease to below the heaters. The effect of this venting process on pressurizer pressure and level stability was determined by performing heat and mass balances upon the pressurizer. An initial pressurizer level of 800 ft^3 was assumed for these calculations. Although pressure and level changes will result from venting, the vent rate is slow enough that the changes are controllable.

3. Selection of Venting Path

The RCGVS removes gas from the RCS by venting the RCS to the quench tank The quench tank may be vented either to the waste gas system or to containment. The choice of which path to use is based upon the following guidelines:

1) With power and the quench tank rupture disc blown, vent to the quench tank. Then with water in the tank, it will provide cooling. With

no water in the tank, vent to atmosphere as this location should provide more complete mixing with the containment atmosphere and quicker access to the hydrogen recombiners.

2) With the quench tank rupture disc intact, small quantities of the gas may be vented to the waste gas system or remain in the QT and thus not enter the containment atmosphere. Larger quantities of gas are vented to containment from the quench tank.

3) Venting of hydrogen to containment will cause an increase of containment hydrogen concentration. Figure 17 illustrates the impact of the venting with and without hydrogen recombiners in operation. It is obvious that if large quantities of hydrogen must be vented, the recombiners must be in operation and even then hydrogen may approach combustible levels. If the concentration approaches combustible levels, the operator will have to make a decision to continue venting or to secure venting until containment hydrogen levels decrease. The decision should be based upon the following:

1. Venting the reactor vessel should take priority over containment hydrogen limits due to the potential for interruption of core cooling with hydrogen in the vessel.
2. Venting the pressurizer should not take priority over containment hydrogen limits unless the pressurizer bubble is interferring with the ability to maintain present pressure control.

4.3.2 Venting the Reactor Vessel to the Containment

This section and the following sections describe operator actions to vent the RCS via the various vent paths in the event of an accident. A summary flow path for the venting process is provided in Figure 18.

1. Description of Operation

The RCGVS is initially in standby and the need to operate the system to remove a gas bubble from the reactor vessel has been identified. After obtaining administrative approval to operate the system, the reactor vessel is vented to containment for a time period determined by system pressure, temperatures, and bubble size.

2. Initial Conditions

Same as Status and Surveillance except

- the RCS fluid boundary may not be intact
- an accident has occurred which has created a bubble in the reactor vessel
- the bubble size has been determined and the containment vent path chosen

3. Operational Requirements

1. Permission to use the RCGVS is obtained, and power restored to the system (if applicable).
2. Using the bubble size and RCS temperature and pressure, determine the vent duration to remove the bubble.
3. Assure that there is sufficient water in the pressurizer to conduct the vent without uncovering pressurizer heaters. It may be necessary to raise pressurizer level prior to venting or to secure venting temporarily and reestablish level if large bubbles are to be removed. Charging should be in operation during the vent to minimize pressurizer level changes. Pressure will also drop during the venting process. The effect of the vent on pressurizer pressure and level is illustrated in Figures 4 and 7. Pressurizer heaters should be energized during the vent to minimize the pressure drop.
4. Place the hydrogen recombiner(s) in operation and monitor containment H_2 concentrations if not already accomplished.
5. Vent to containment by opening the containment isolation valve and then one of the two reactor vessel isolation valves.
6. Secure venting after the predetermined time has elapsed by closing the reactor vessel isolation valve and then the containment isolation valve.
7. Evaluate the effectiveness of the vent on bubble removal and repeat if necessary after returning RCS pressure and pressurizer level to desired levels.

4.3.3 <u>Venting the Reactor Vessel to the Quench Tank</u>

1. Description of Operation

This operation is identical to the previous section except the vented gas is directed from the quench tank to the containment atmosphere or waste gas system. This path is used primarily for small bubble volumes unless the containment path is unavailable or the rupture disc has already been ruptured.

2. Initial Conditions

Same as vent to containment except for the vent path.

3. Operational Requirements

1. Same as the vent to containment except for the vent path.
2. During venting to the quench tank, monitor vent tank instrumentation and (assuming the containment vent path is available and with the rupture disc already ruptured) terminate venting to the quench tank by redirecting vent flow to containment if tank water level decreases to the point where it is no longer providing cooling for the vented gas.

4.3.4 Venting the Pressurizer to the Containment or Quench Tank

Description of Operation

This operation is identical to the previous operations except that the pressurizer is the source of vented gas.

4.3.5 Non-Condensible Gases in the Steam Generator

Another place in the RCS where non-condensible gases can collect is in the steam generator U-tubes. Since there are thousands of tubes in which the gases could collect, it would be impractical to install a vent on each tube. Non-condensible ses collecting in the tubes could affect natural circulation. Guidelines for starting and maintaining natural circulation for emergency conditions are presented in CEN-128, Vol. 1, "Response of Combustion Engineering Nuclear Steam Supply System to Transients and Accidents", April 1980.

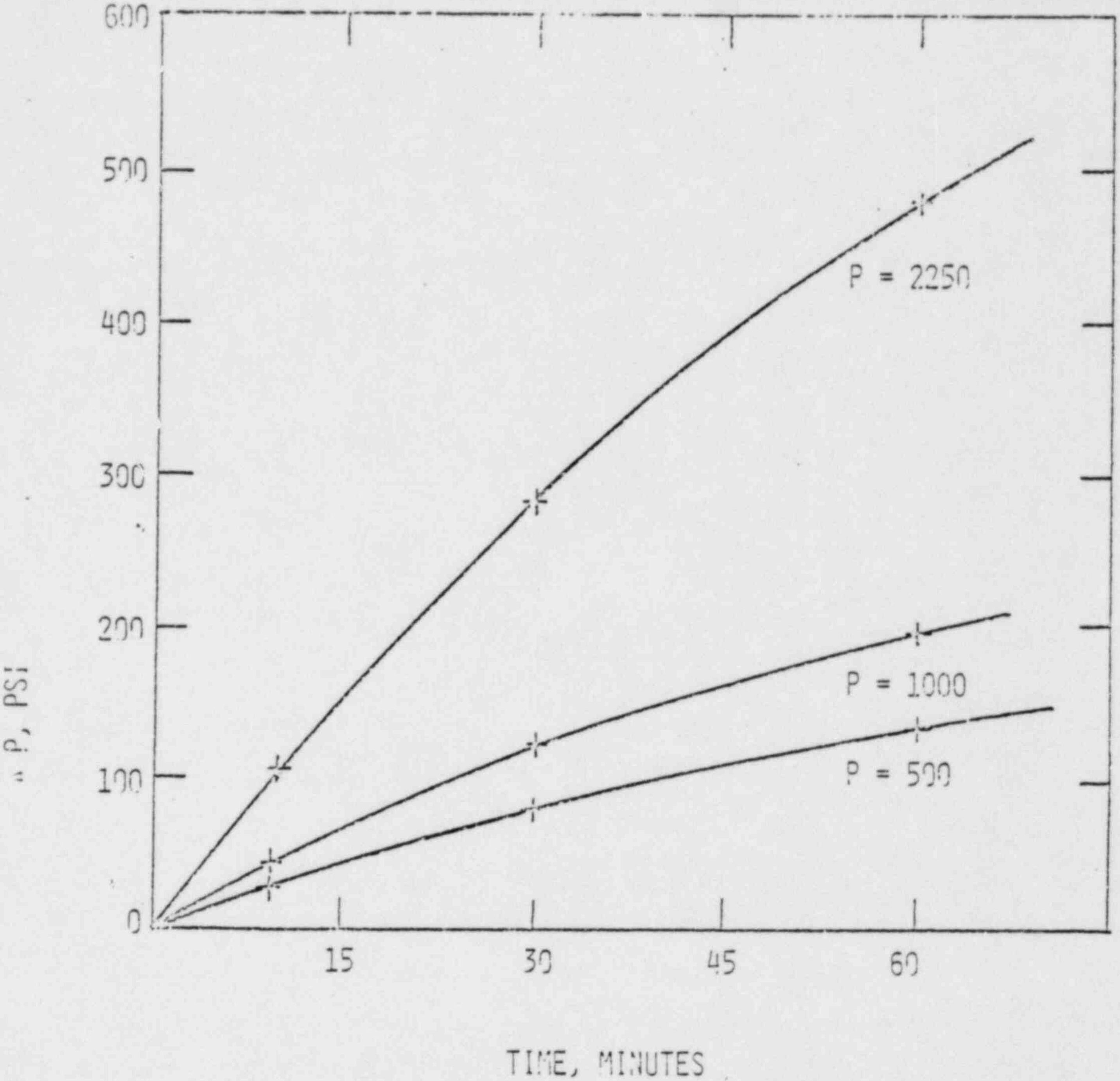

FIGURE 2

PRESSURIZER VENT - Δ P vs VENT TIME

(~~CCP~~ OFF)

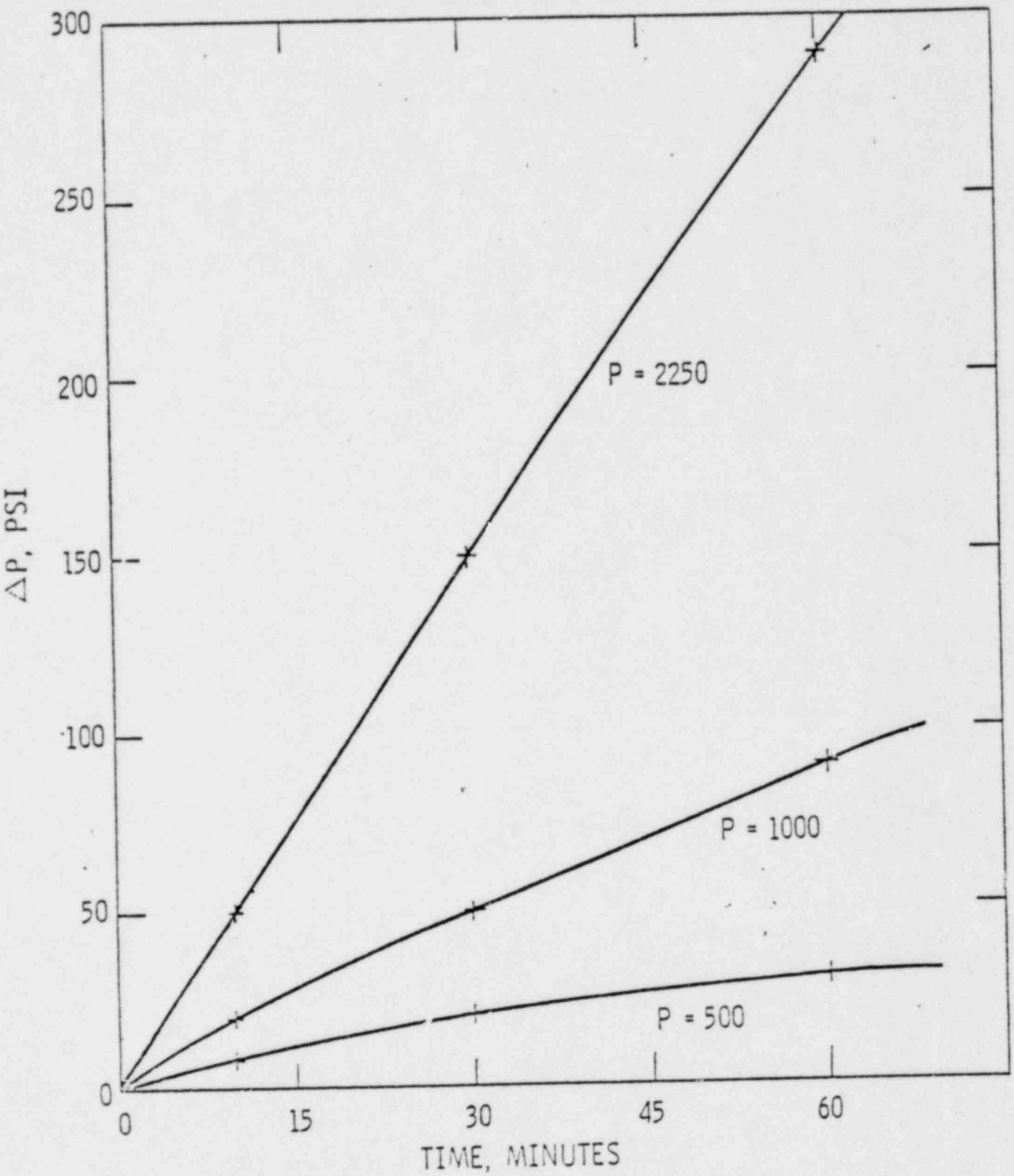

Figure 3
PRESSURIZER VENT - ΔP vs VENT TIME
(CCP OFF)

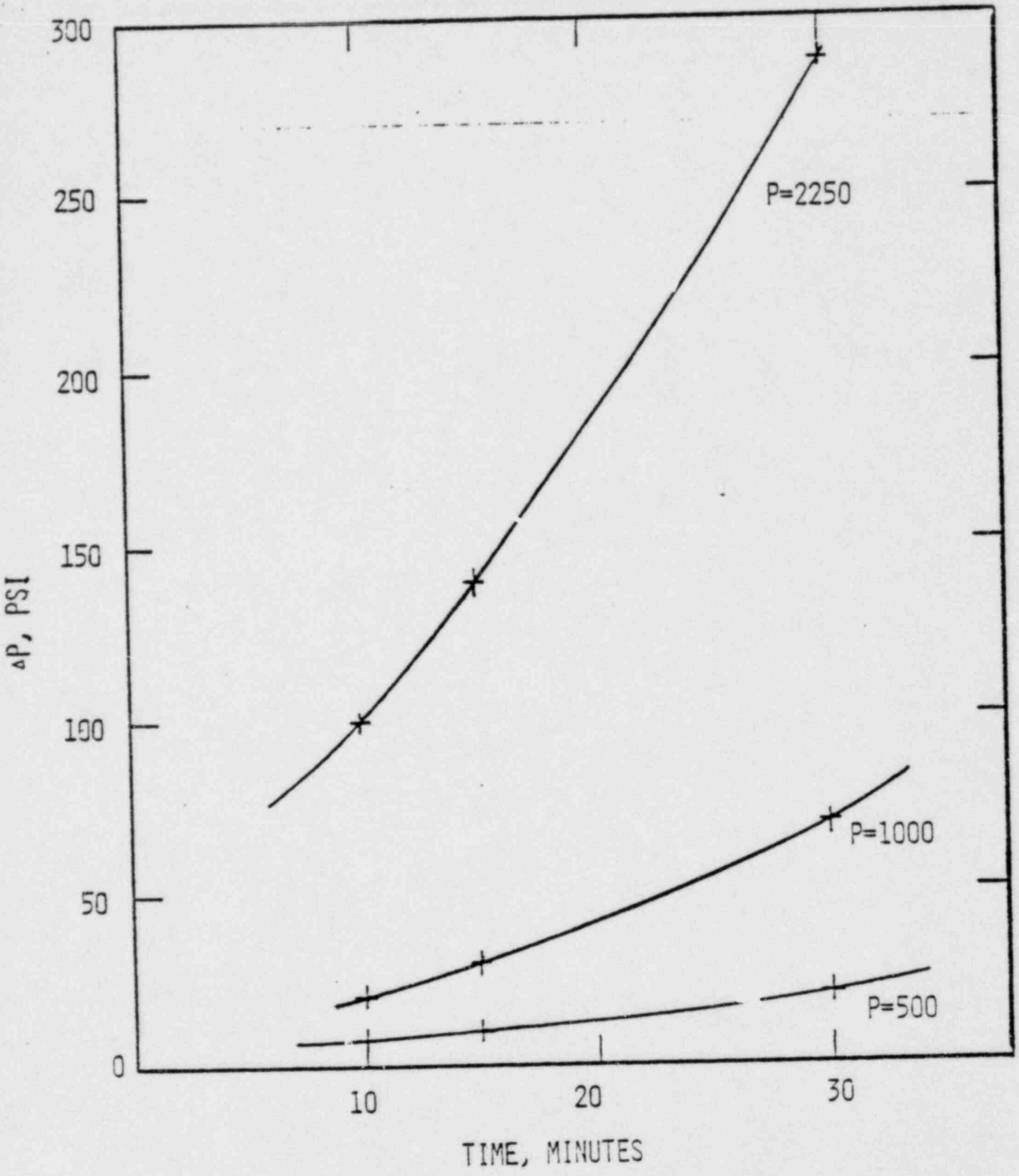

FIGURE 4

REACTOR VESSEL VENT-ΔP vs TIME

(CCP ON)

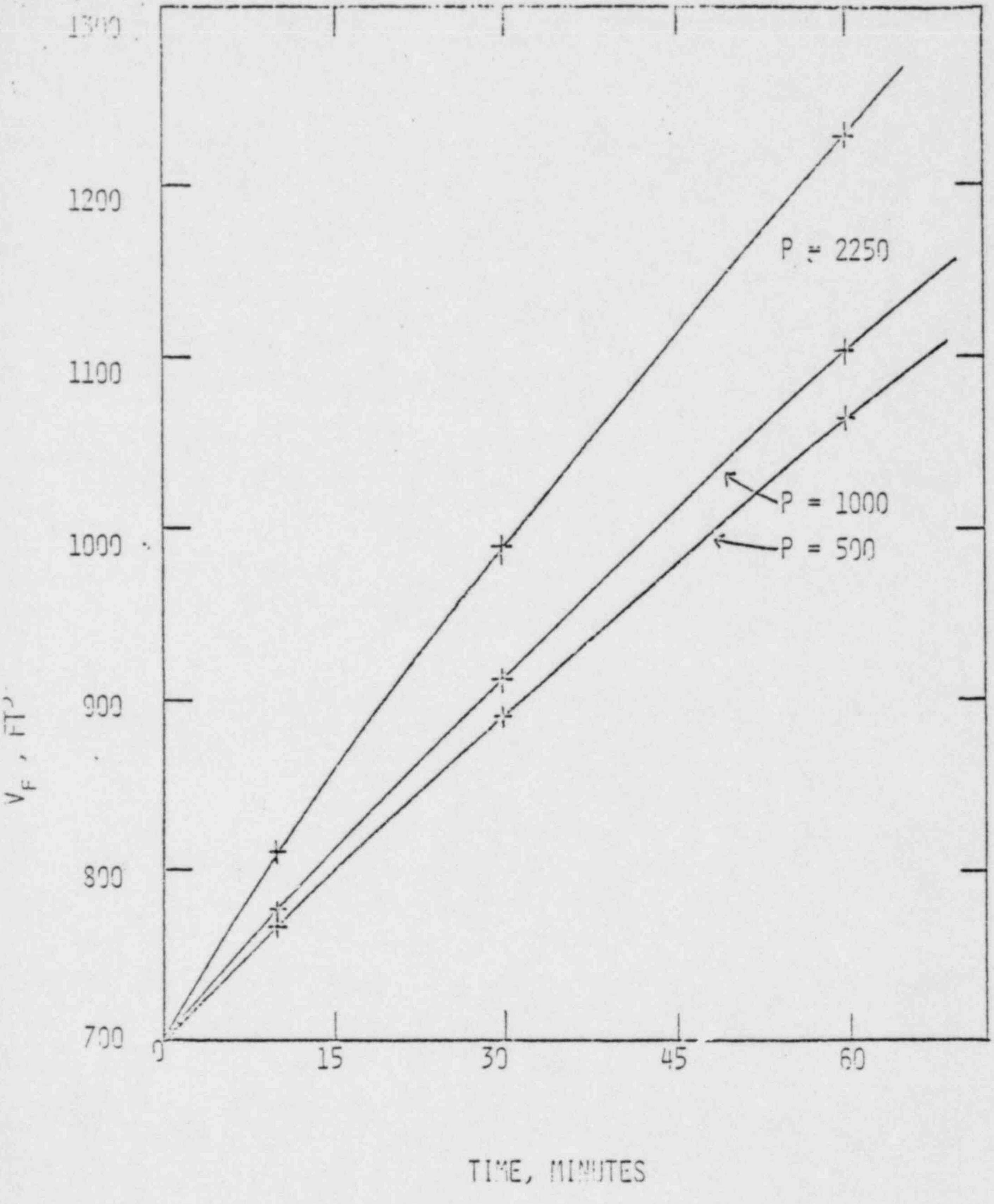

FIGURE 5

PRESSURIZER LEVEL vs TIME
PRESSURIZER VENT
(CCP ON)

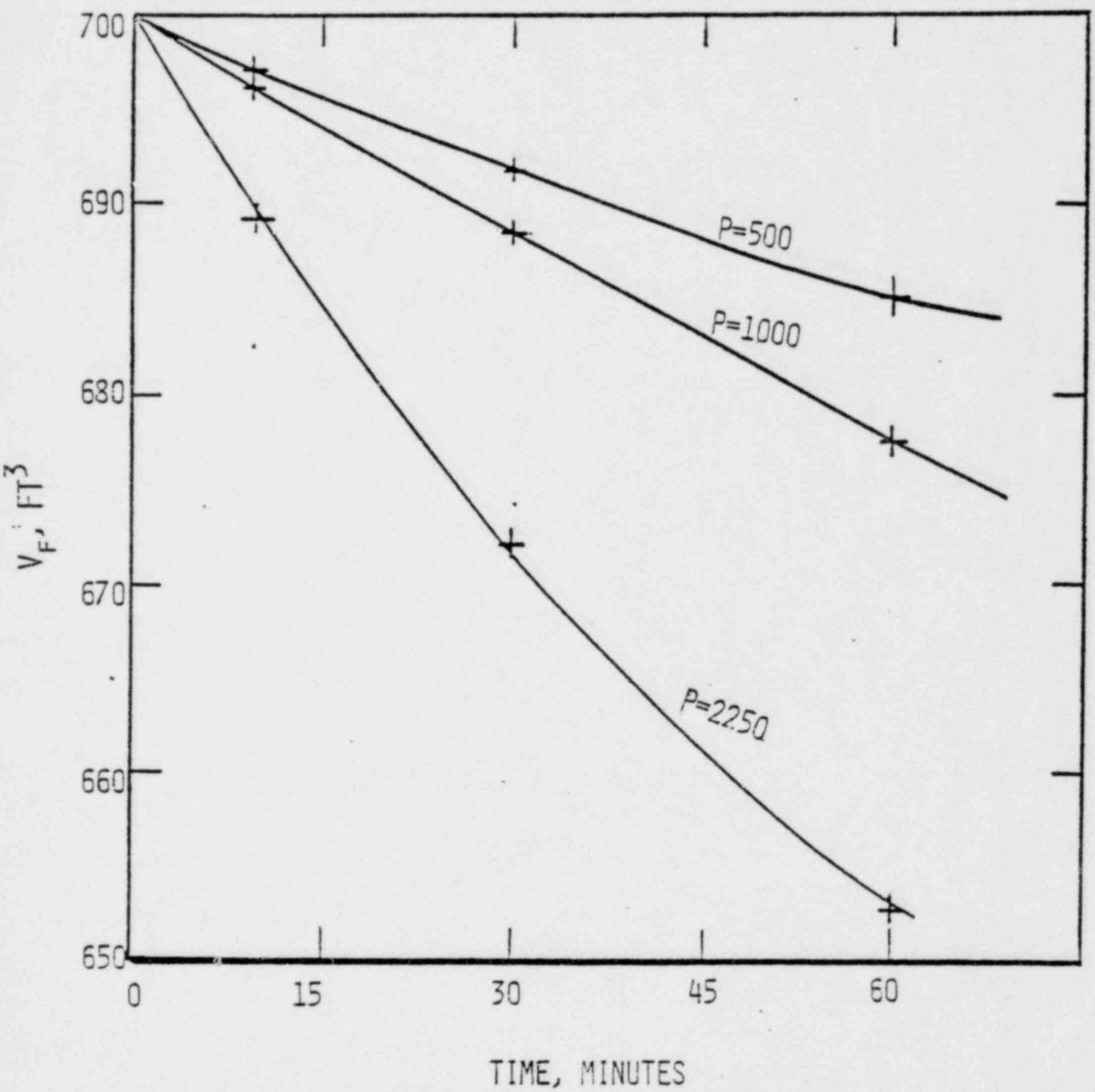

FIGURE 6

PRESSURIZER LEVEL vs TIME
PRESSURIZER VENT
(CCP OFF)

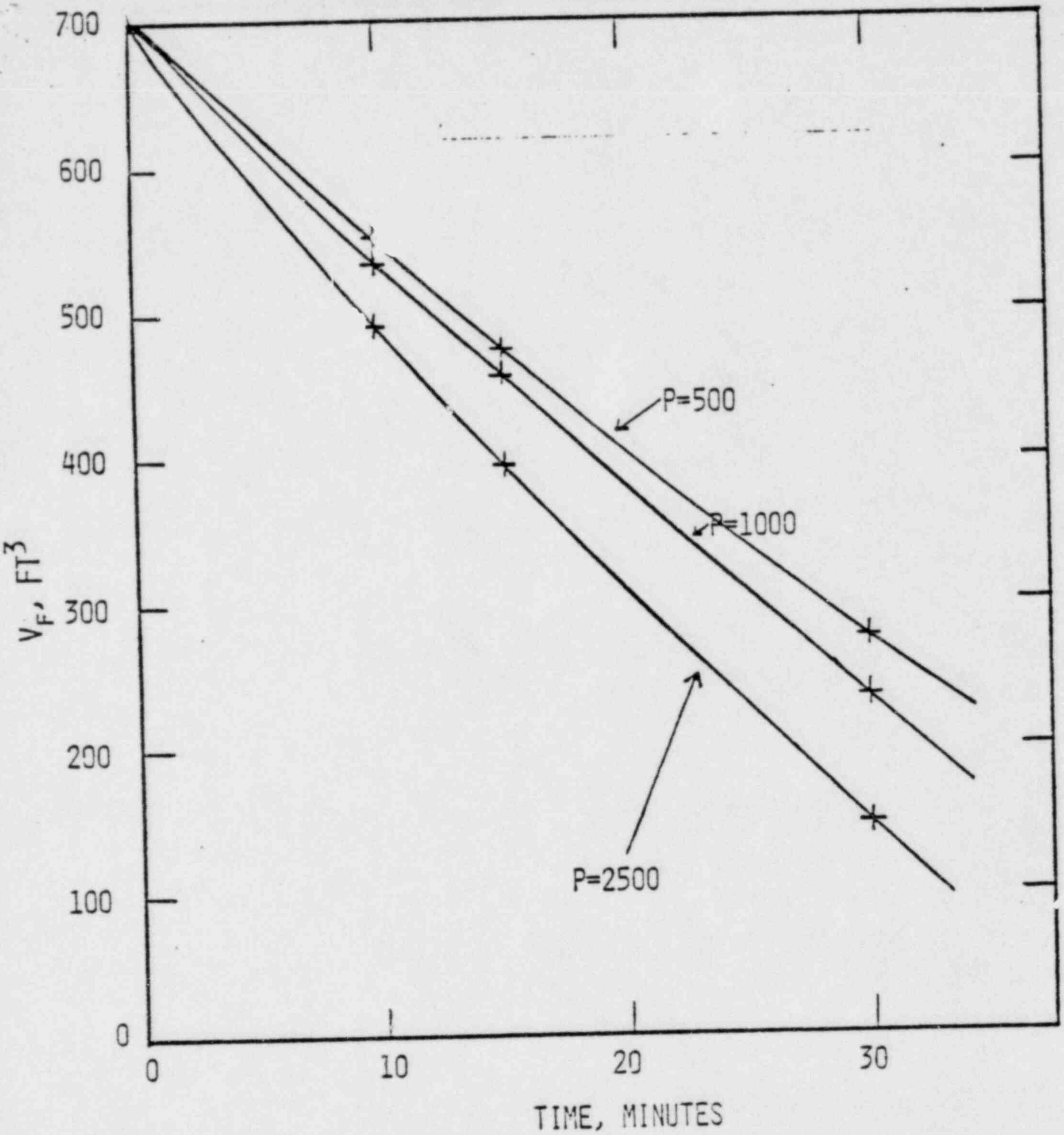

FIGURE 7

PRESSURIZER LEVEL vs TIME
REACTOR VESSEL VENT

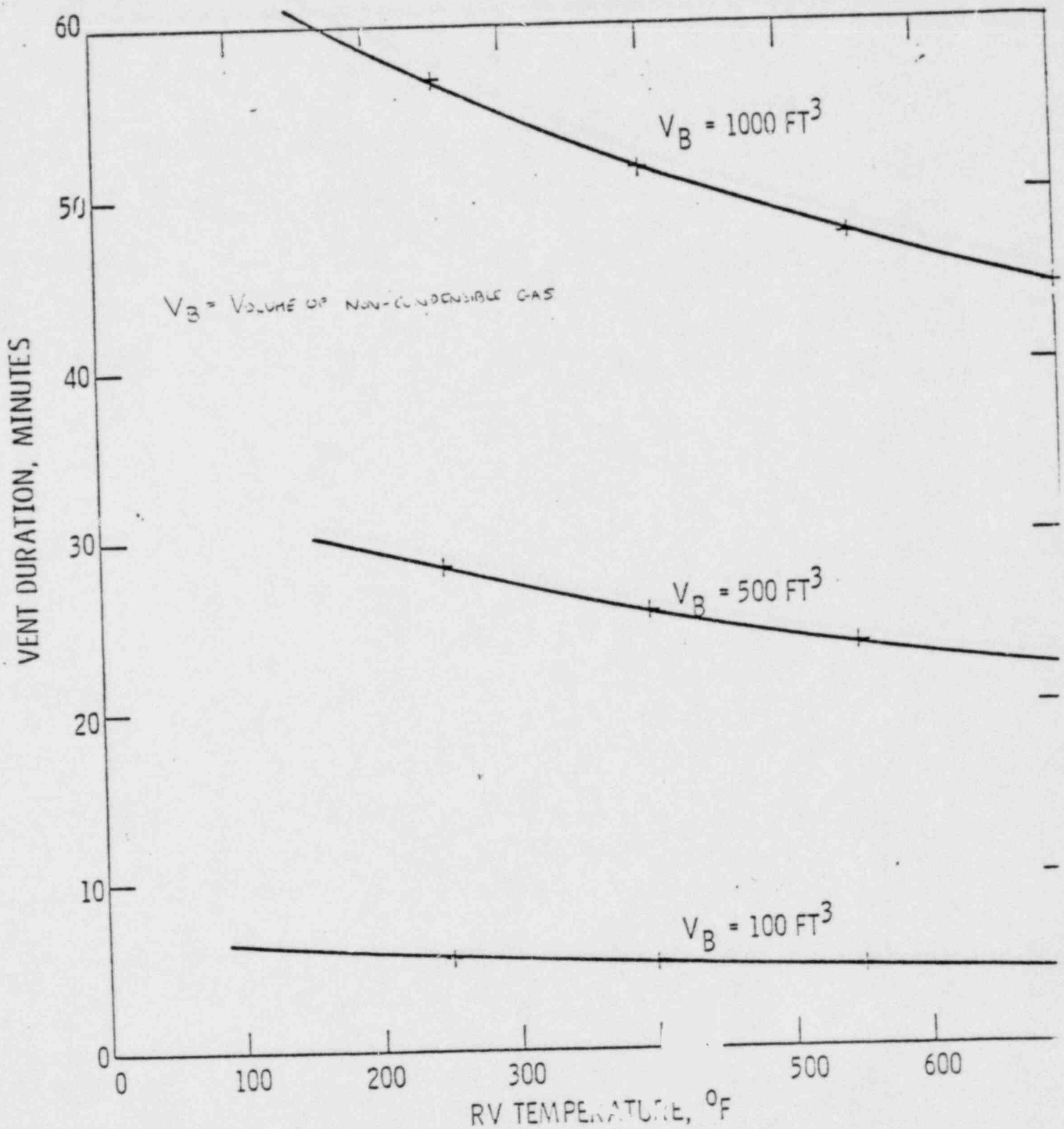

Figure 8
VENT DURATION OF HYDROGEN vs RV TEMPERATURE
P = 2250 PSIA

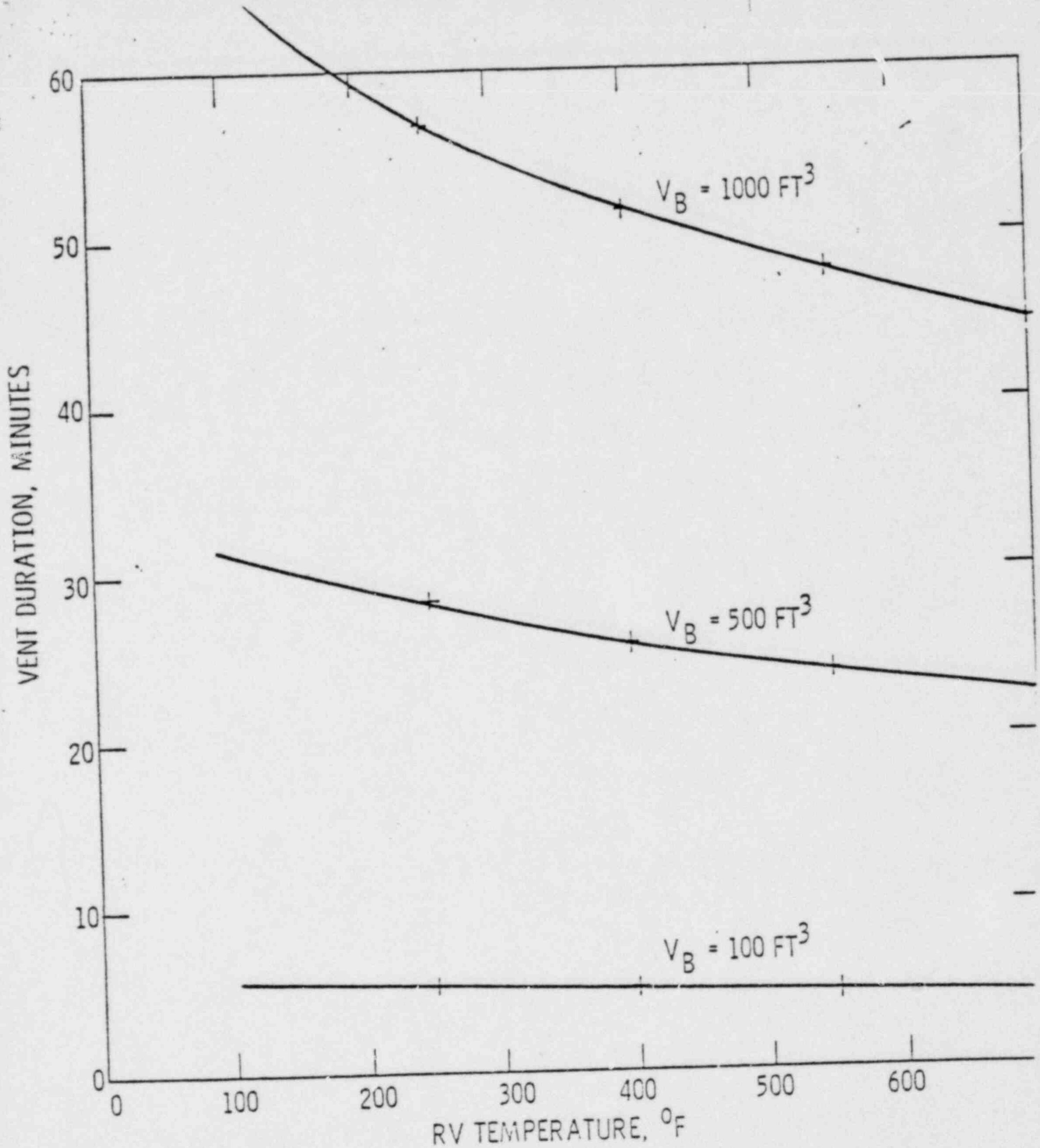

Figure 9
VENT DURATION OF HYDROGEN vs RV TEMPERATURE
P = 1000 PSIA

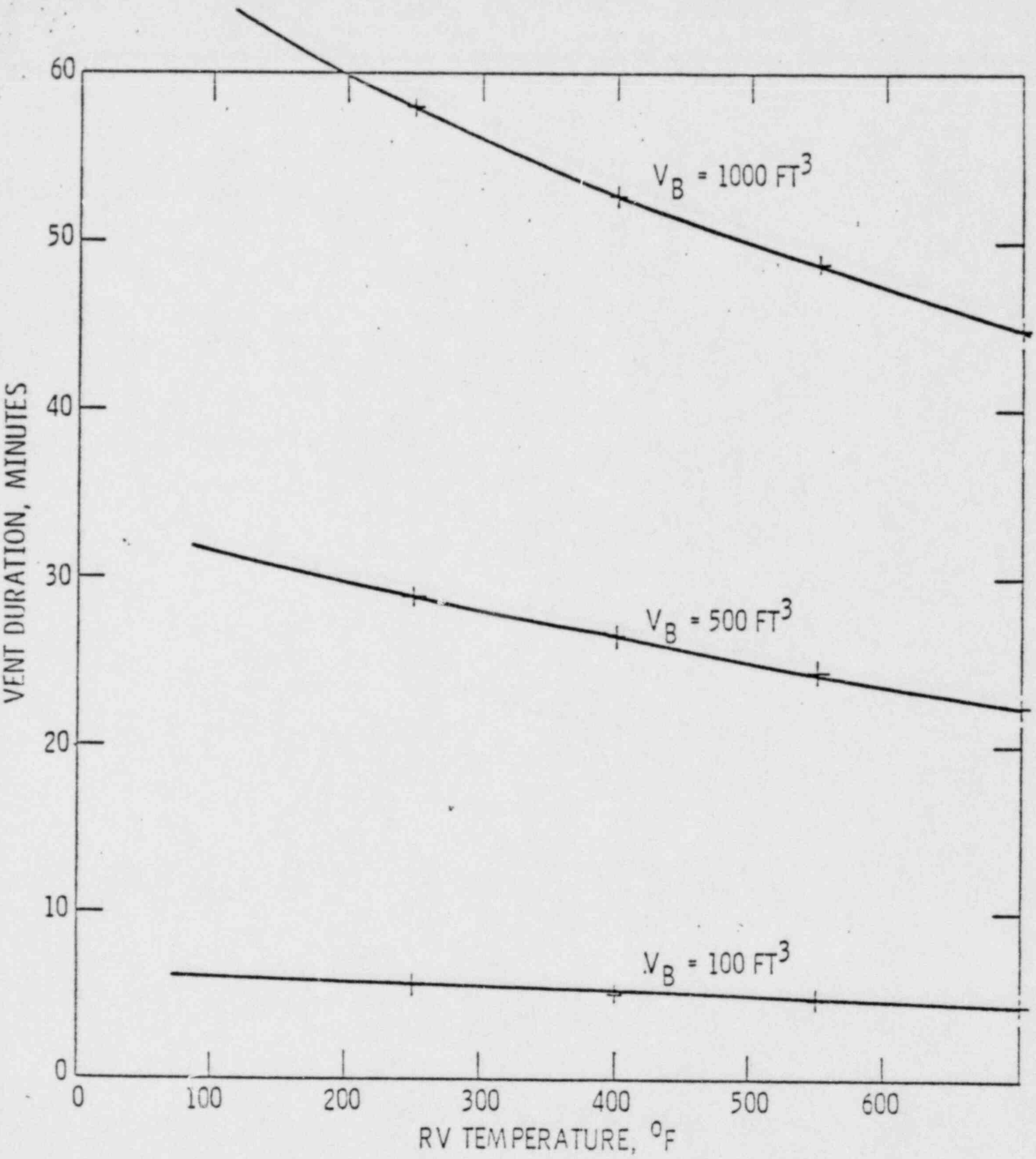

Figure 10
VENT DURATION OF HYDROGEN vs RV TEMPERATURE
P = 250 PSIA

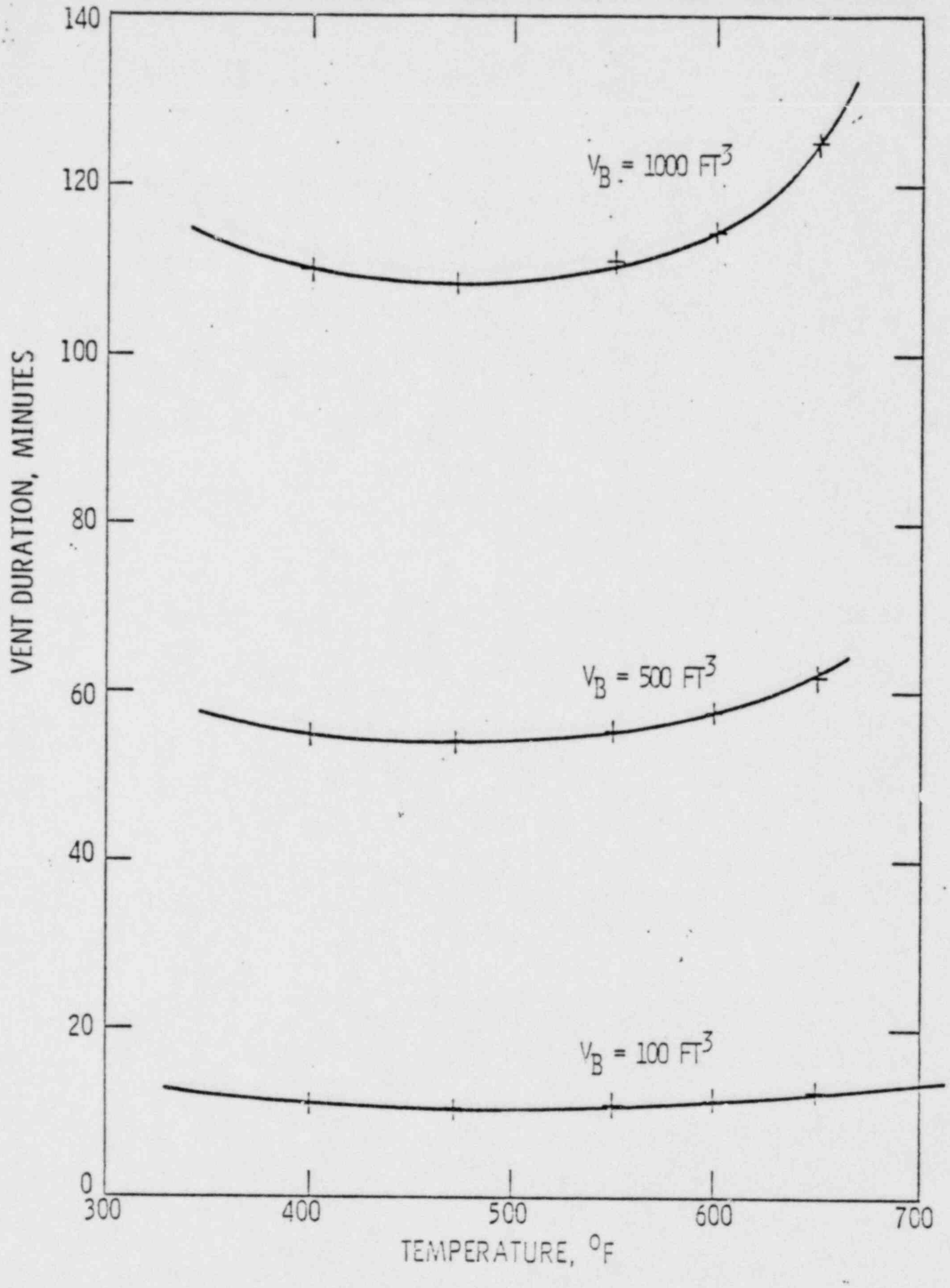

Figure 11
STEAM VENTING DURATION FROM PZR AT $P=P_{SAT}$

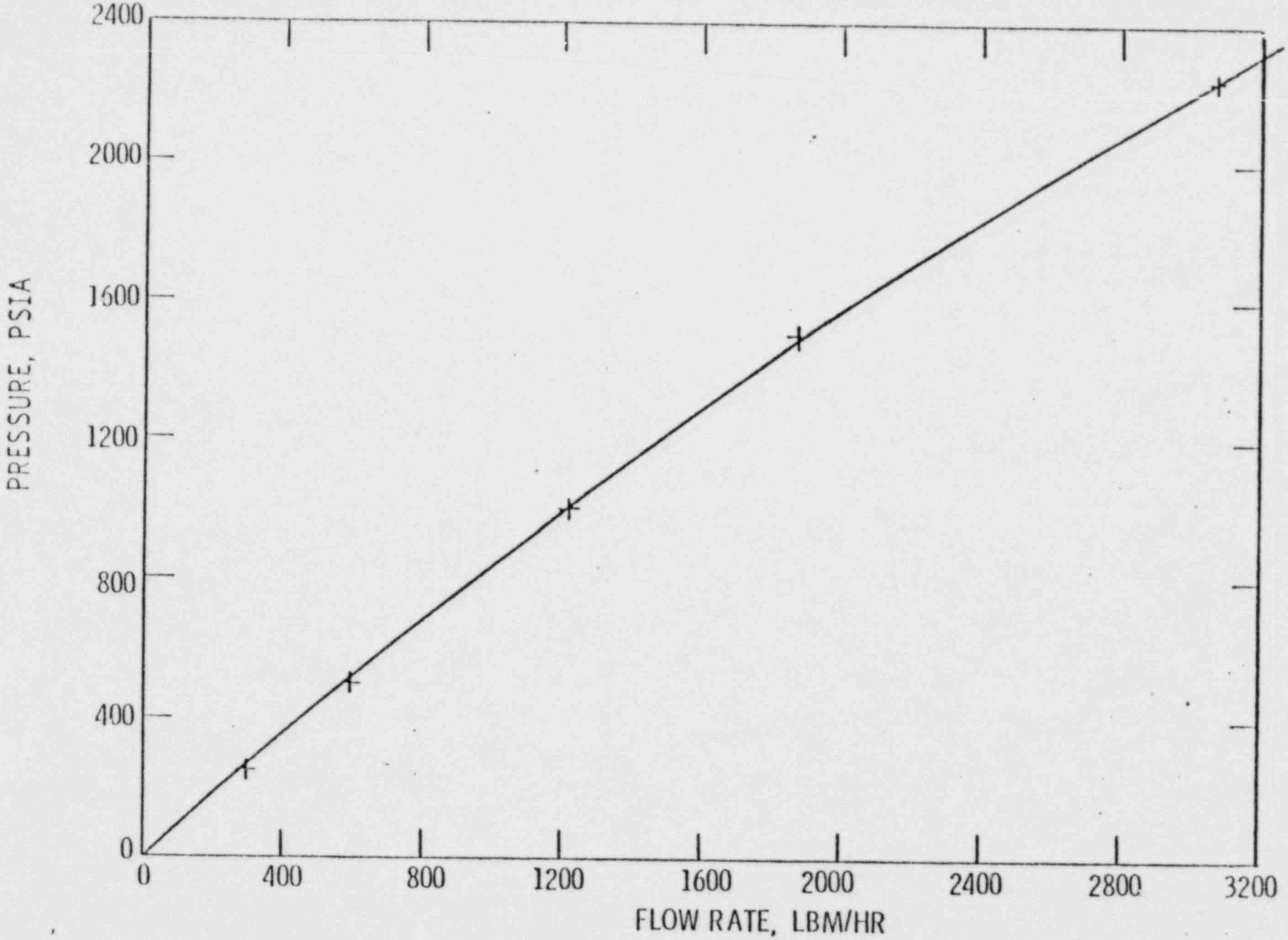

Figure 12
STEAM (PZR)

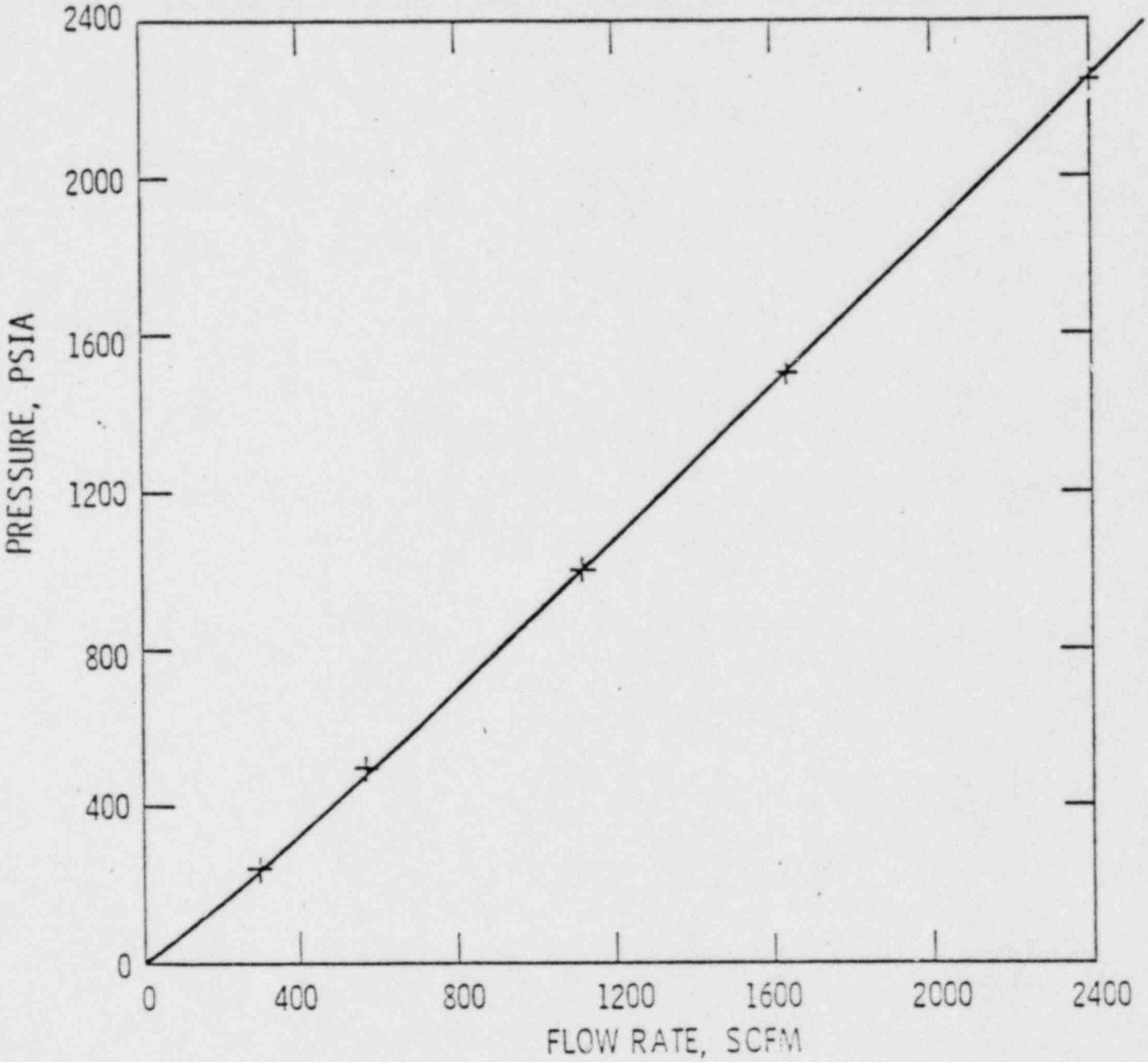

Figure 13
HYDROGEN (PZR)

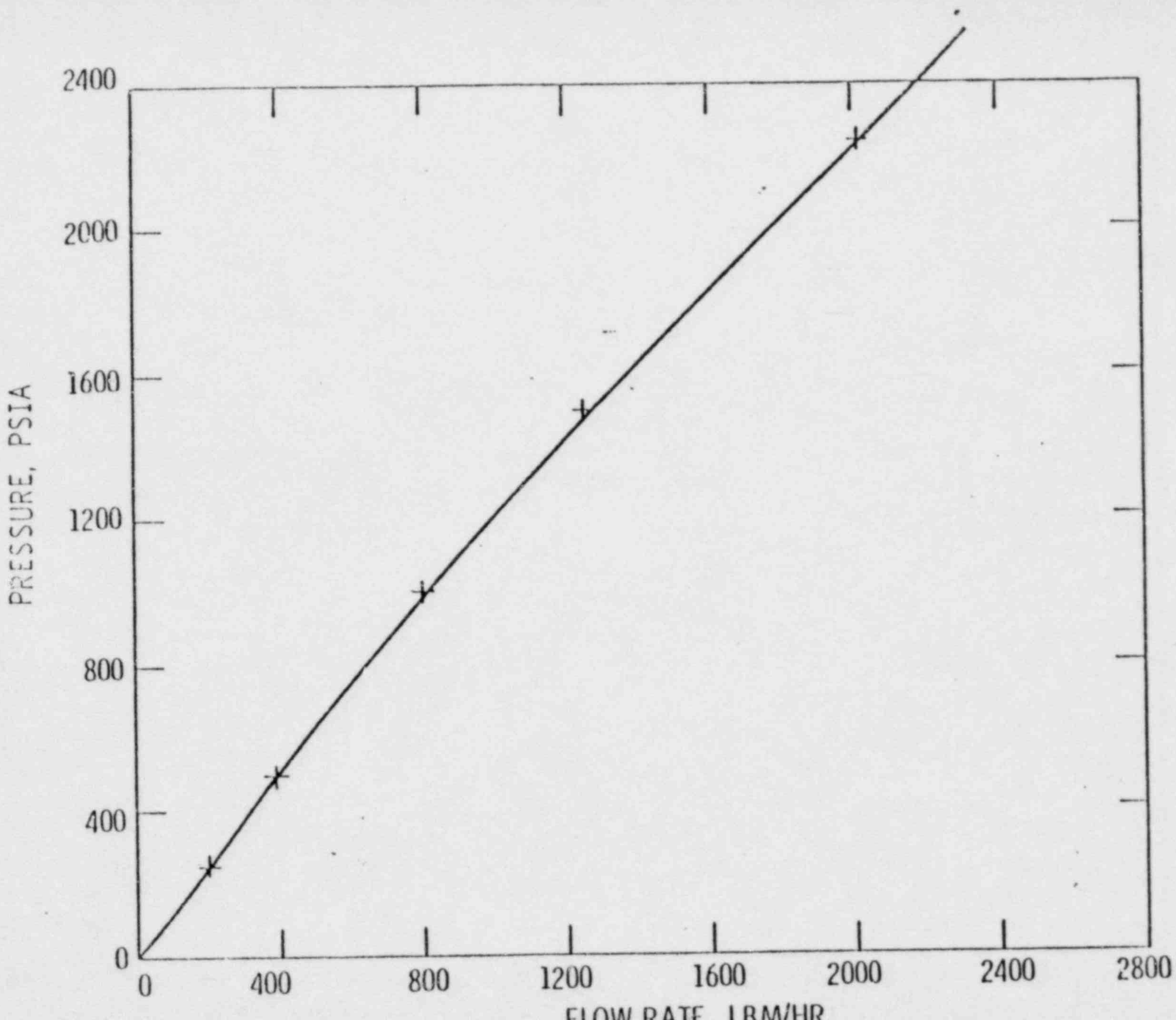

Figure 14
STEAM (REACTOR)
(SATURATED)

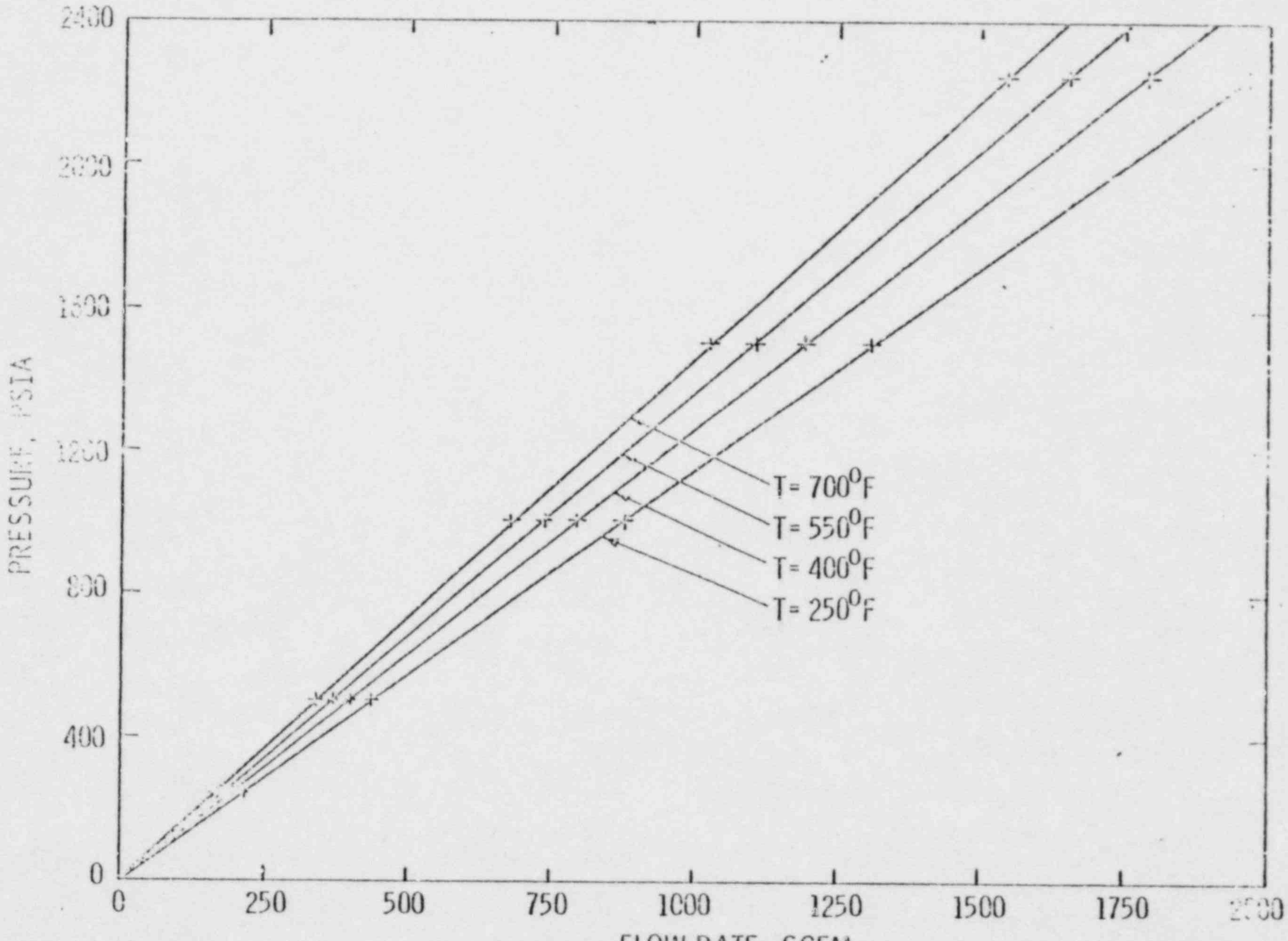

Figure 15
HYDROGEN (REACTOR)

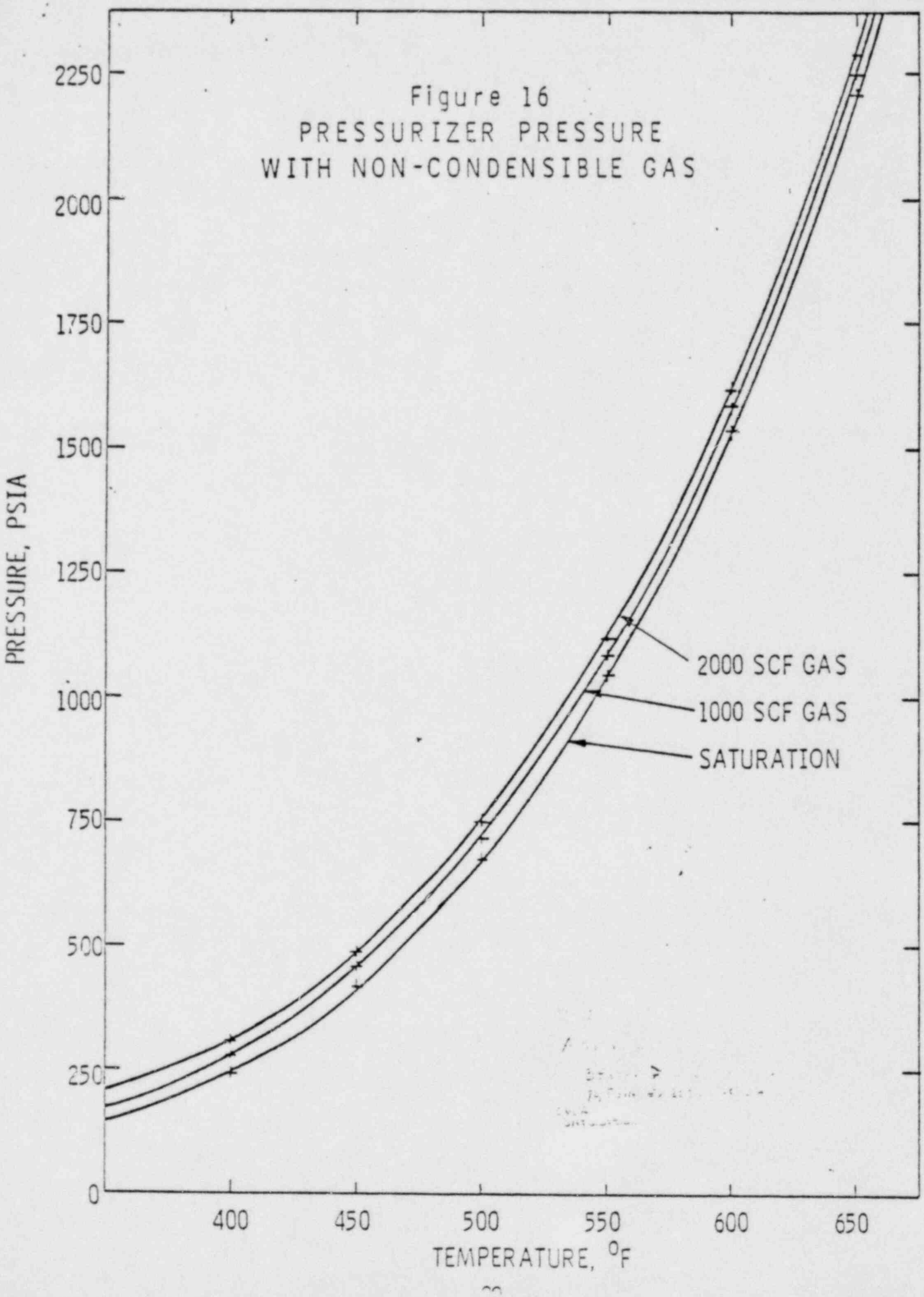

Figure 16
PRESSURIZER PRESSURE
WITH NON-CONDENSIBLE GAS

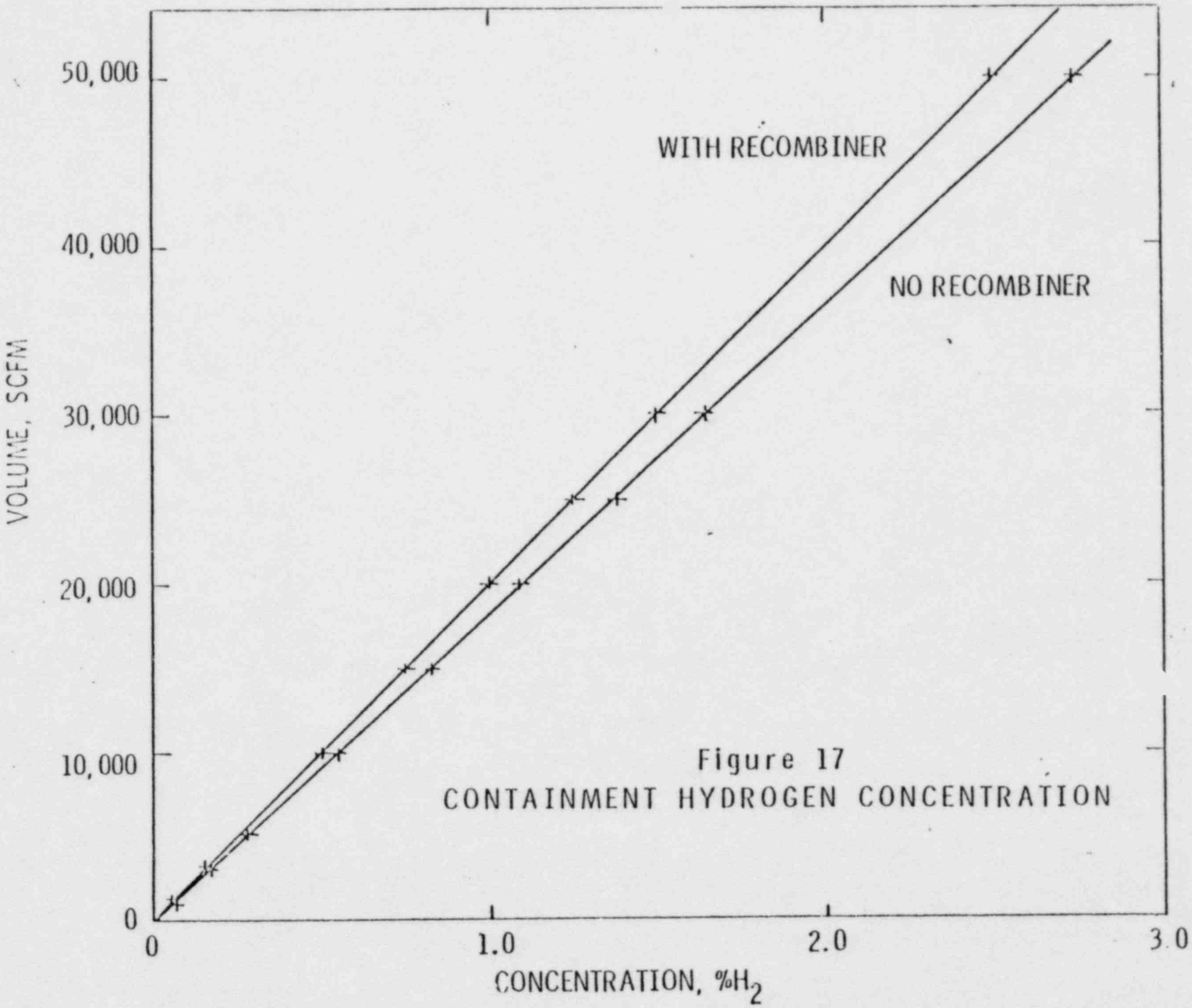

Figure 17
CONTAINMENT HYDROGEN CONCENTRATION

Figure 18 - RCGVS Accident Response

Accident Occurs

↓

Monitor For Bubble Formation

↓

Bubble in Reactor Vessel? (Recheck Bubble Status as Necessary)

Yes:

Determine bubble size and vent duration

↓

Determine vent sink

↓

Energize pressurizer heaters, establish charging flow, verify pressurizer level

↓

Obtain administrative approval to vent

↓

Energize H_2 recombiner

↓

Proceed with vent

(next page)

No:

Either non-condensibles in pressurizer or previous vent of RV?

- **Yes:**

  Determine vent duration

  ↓

  Determine vent size

  ↓

  Energize pressurizer heaters, verify pressurizer level, charge if necessary

  ↓

  Obtain administrative approval to vent

  ↓

  Energize H_2 recombiner and monitor H_2 concentration

  ↓

  At explosive limits?

  - **No:** Proceed with Vent (next page)
  - **Yes:**
    1. With adequate RCS pressure control, Do not vent until H_2 concentration is acceptable, or;
    2. with inadequate RCS pressure control or if vent path is to intact QT, proceed with vent.

    (next page)

- **No:** No need to vent → Recheck Bubble Status as Necessary

Vent to QT for timed interval

Vent to containment for timed interval

Monitor QT Conditions

Near rupture disc setpoint?

No

Continue Vent

Yes

(Operator Option)

1. Switch to containment vent, waste gas vent, or

2. Continue vent through ruptured rupture disc. [illegible]

Secure vent after timed interval

Bubble Status as necessary