TASK CLOSE OUT DOCUMENT

Task Scope: Press and Temp Containment Conditions for greater than 30 days and possible causes of a change of state

To: M. Levenson
S. Levy
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Task No. 5 a & b   Date Complete 4/11/79

Reason felt task is complete:

Report with recommended state has been issued

Members of Committee

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[signature]
Signed
Committee Leader

-May 21 79

[redacted]

Reactor Simulation Tests Performed
By Billings Energy Corporation

Current as of April 10, 1979. All tests described below are performed or will be performed on the Reactor Simulator (Figure 1).

TEST - A April 6, 1979

The system was pressurized to 1000 psig (nominal) and heated to 280°F using a primary heating element simulating the core and a secondary heating element around the pipe leg. A band heater on the steam generator was also used.

During test, the secondary heater was disconnected. The primary heater was used to maintain 280°F. This heating element was controlled manually in an on/off fashion. The data plot shows pressure ripples that are coincident with the temperature variation associated with the heating cycle.

Water was drawn from the base of the reactor vessel in an amount that produced approximately 100 psi pressure drops. The water sample passed through a heat exchanger in an ice bath to cool prior to measurement. The mean temperature of the water existing in the heat exchanger was 86°F. The volume of water was measured directly with graduated glassware.

The plot of Test - A shows graphically that the water was not saturated with hydrogen until a pressure of approximately 300 psig was obtained. At this point a definite pressure rebound, characteristic of saturation, was observed. The fact that the solution was not saturated at 1000 psig was due to some procedural difficulties experienced in setting up for

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this first test. The data shows, however, that in accordance with the laboratory pressure drop tests, the pressure at which saturation occurs can be determined by watching for pressure rebound after an aliquot is extracted.

The hydrogen bubble volume to system water volume ratio corresponded to 0.4 per cent at 300 psig. By dropping the pressure further (to 100 psig) the bubble volume grew to 6.5%. (Note that hydrogen bubble volume is inferred from measurements of water removal. No correction has been made in the calculation for volume contraction of the pressure vessels as pressure is decreased. This effect will be examined in Test G.

Test - B April 8, 1979

Test B was performed similar to test A with the exception that the core simulation heater was controlled via a variable power transformer rather than an on-off switch. As a result, the pressure ripple due to heating variation was no longer in evidence.

Step changes in vessel pressure were again caused by taking incremental volumes of water from the base of the reactor.

The plot of Test B shows pressure rebound after the first increment of water was removed. This indicates that hydrogen saturation was achieved at a pressure in excess of 1000 psig. Accordingly, the fraction of bubble volume to water system volume was much greater than in test A. At 300 psig, for instance, the bubble volume comprised 9.55 % of the total system as compared with 0.4% at the same pressure in test A .

At the conclusion of the test, the size of the bubble in the steam generator was measured by exhausting the gas through a heat exchanger and measuring the volume by displacement of water. At room temperature and atmospheric pressure, reabsorption of hydrogen in the displacement water was assumed minimal. The bubble at the top of the steam generator was obtained by maintaining the final pressure with the pressurizer valve into the system. The valve at the top of the steam generator was then opened slightly and the fluid passed through the heat exchanger. When liquid was obtained, sampling was discontinued. The gas volume in the steam generator adjusted to 280°F and 300 psig, conditions existing at the end of the test, was very small compared to the hydrogen bubble contained in the total system. Of the total hydrogen bubble, 96% existed in the reactor and 4 % in the steam generator.

Although the steam generator is physically higher than the reactor, there are three effects that may contribute to the placement of the major portion of the bubble in the reactor. These effects are related to 1) localized pressure drop in the reactor, 2) preferential removal of hydrogen in the reactor due to heat effects at the core simulator heater, and 3) sweeping action of the water flow which convects hydrogen bubbles from the steam generator to the reactor where they collect in the upper half volume above the exit port.

Test - C

No test made

Test - D April 9, 1979

Test D was similar to test B with the exception that the water withdrawal rate was continuous instead of periodic. Although the water had been previously saturated with hydrogen, the hydrogen saturation pressure had decreased prior to start of test, as is evidenced by the data plot. Bubble growth was only 3% of the system water volume.

Test - E April 9, 1979

The continuous sample method of Test D was repeated in Test E after re-establishing hydrogen saturation at 1000 psig. The figure shows a much more dramatic growth of bubble size with pressure decrease.

As in all previous tests, the water temperature was held at 280°F during depressurization.

Test - F April 9, 1979

Test F was a repeat of test E with continuous water removal. The only change made was that the water was drawn from a tap at the base of the pressurizer instead of at the base of the reactor vessel. This change was made to more closely simulate the withdrawal of water from the pressurizer and also to see if a greater percentage of the hydrogen bubble would form in the steam generator.

Results were very similar to test E. A slightly greater hydrogen bubble was created in the system at 300 psig in test E than in test F. The amount of hydrogen volume present in the steam generator was still small in comparison to the total bubble size indicating that the location of the water withdrawal tap was not a significant factor.

A cross plot of bubble volume vs system pressure is given for runs A, B, D, E, and F.

Test - G (~~Yet to be performed~~ Completed)

Part 1: Using unsaturated water the system will be brought up to temperature while measuring delta p. Pressurization above the boiling point will be accomplished by applying hydrogen to the pressurizer. It is assumed that the surface area of contact will be sufficiently small and the pressure sufficiently low that the amount of hydrogen going into solution will be slight.

Part 2: The system will be depressurized as in Tests D, E, and F. This run will establish the system volume decrease with pressure reduction as the vessels contract.

Measurement of delta p will also be made to establish a reference signal for the condition of unsaturated water.

Test - H (Yet to be performed)

In test H the amount of hydrogen that enters the system will be measured as pressure is increased at constant temperature of 280°F. Hydrogen will be withdrawn from a hydrogen cylinder of known volume and temperature. Mass of hydrogen removed from the cylinder will be calculated from the pressure decrease of the cylinder as it empties.

Saturated water will be obtained at several pressures by pressurizing and observing pressure stability.

Measurement of delta p will be made at each saturation step to see if a change in either flow dynamics, water density, or noise can be observed.

Test - I ~~(Yet to be performed)~~ Completed

After achieving a saturated solution at 1000 psig and 280°F, the system will be dropped in temperature and pressure in separate steps.

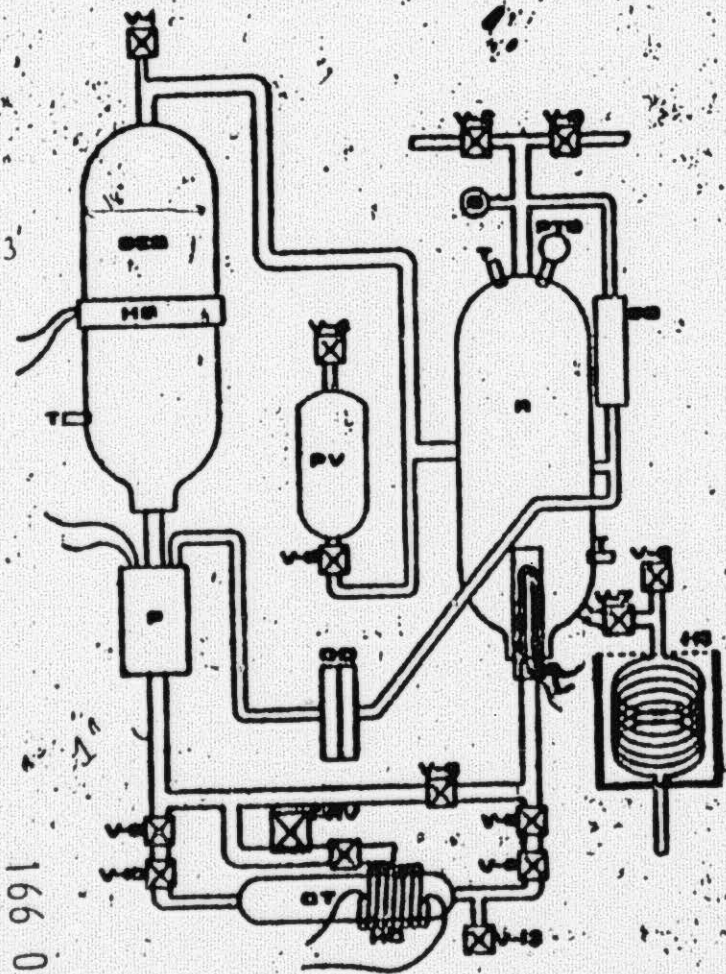
Part 1 will be a drop in temperature from 280 °F to 130°F at constant pressure of 100 psig. Pressure will be maintained constant through use of the pressurizer as needed. The volume of water in the pressurizer before and after test will be obtained.

Part 2 will be a continuous pressure drop from 1000 psig to 300 psig by water removal from the system. Temperature will be held constant at ~~300~~ 130°F.

Measurement of delta p will be taken in both parts. The peak to peak noise level of the delta p signal will be noted on a strip chart recorder.

Deleted ~~Test - J~~ (proposed repeat of Test H in order to perform Test K)

Deleted ~~Test - K~~ (proposed repeat of Test I with reversal of the order; constant temperature pressure reduction followed by constant pressure temperature reduction.)



SGS - Steam Generator Simulator

HB - Heat Band

P - Pump

PV - Pressurizer Vessel

OD - Oil Diaphram

PRV - Pressure Relief Valve

CT - Charging Tank

HC - Heating Coil

G - Gauge

PTG - Pressure Transducer Gauge

T - Thermocouple

SG - Sight Glass

R - Reactor

HE - Heat Exchanger

V - Valves

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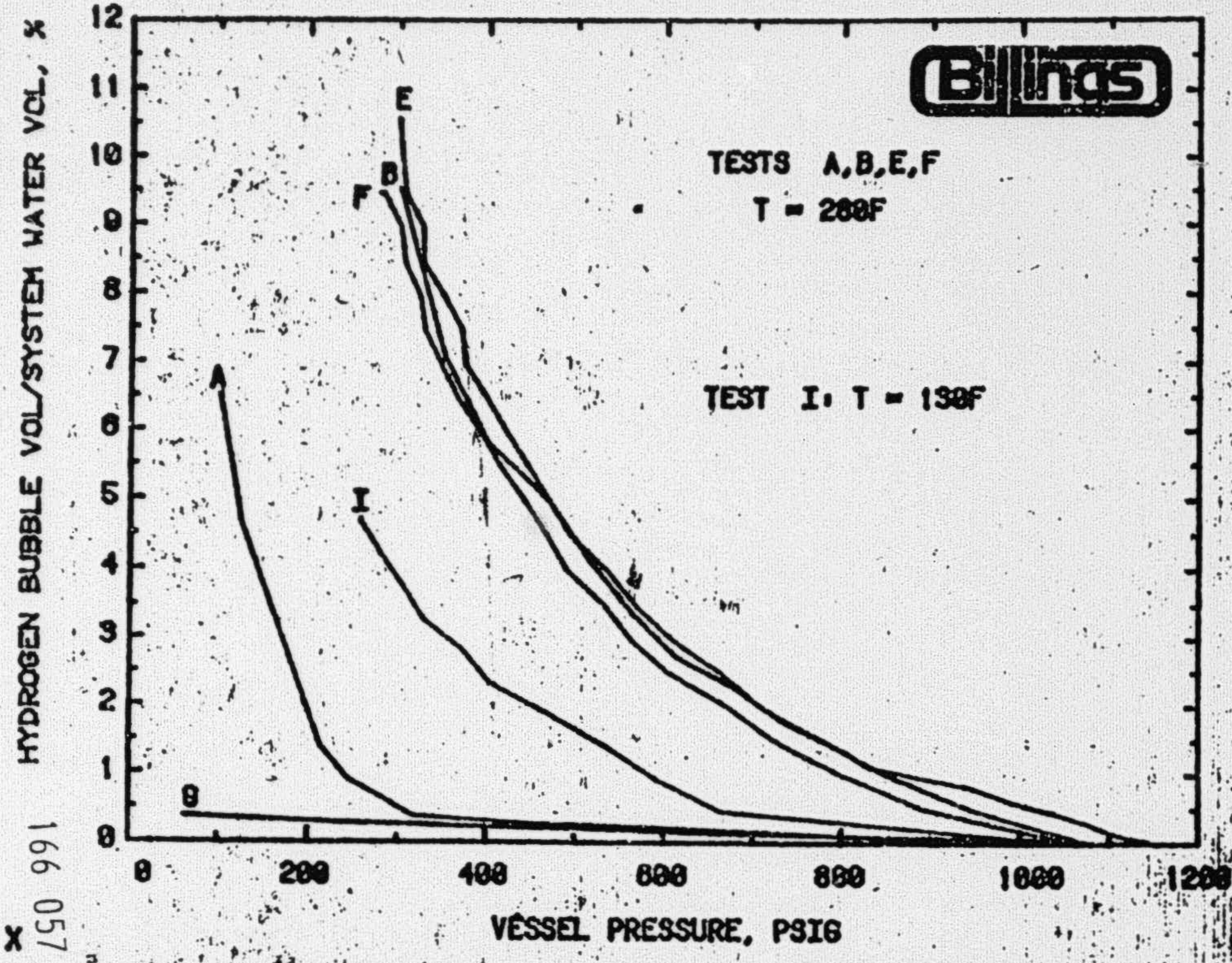
H2 BUBBLE GROWTH WITH P DROP AT CONST T



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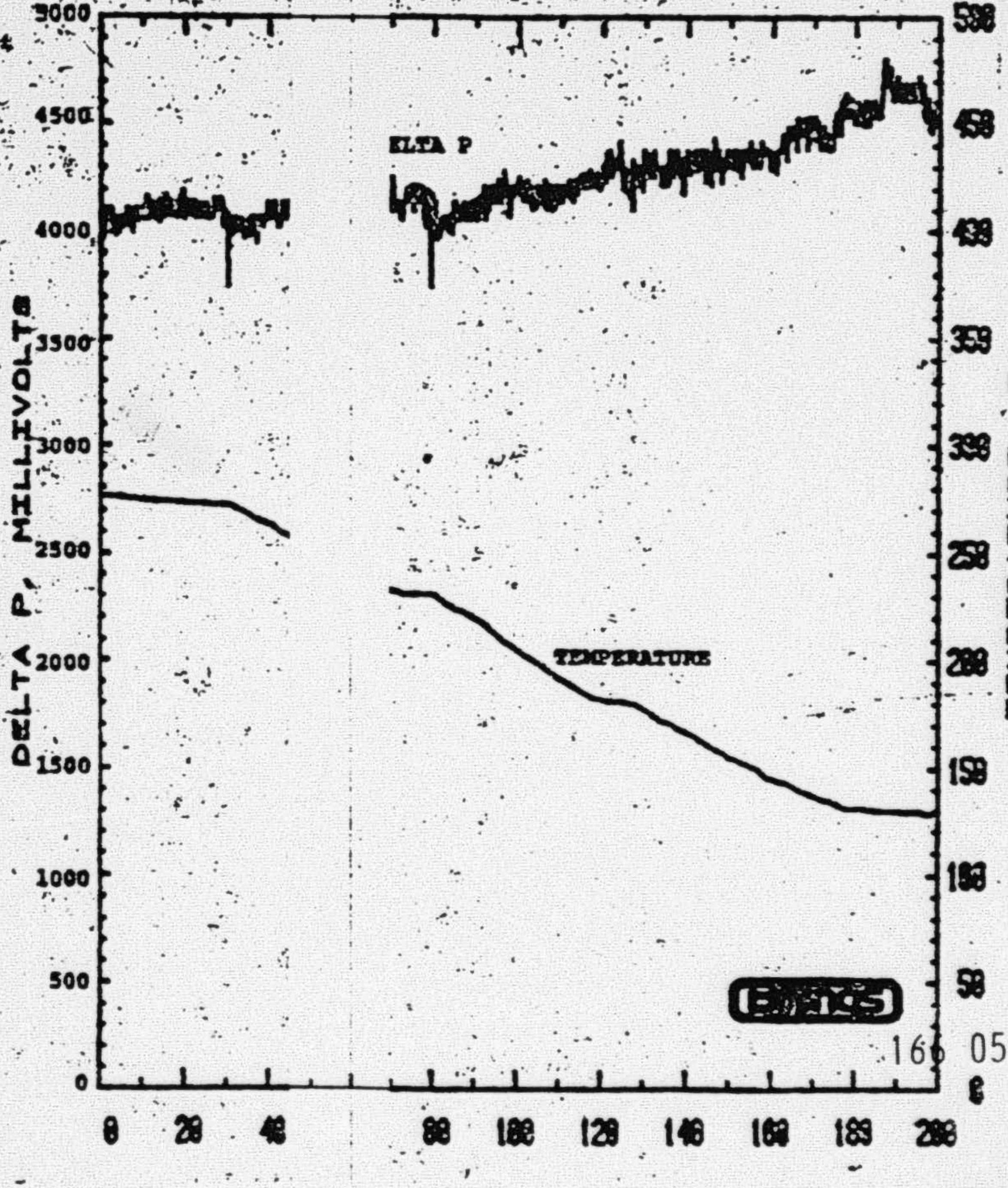
X

Effect of H_2 on ΔP_D measurement f(Temperature)

REACTOR SIMULATION TEST-I 4/11/79



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