Babcock & Wilcox

Ret. + Chron file

Power Generation Group

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July 20, 1979

Mr. John Bickel
Advisory Committee on Reactor Safeguards
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Subject: TMI-2 Incident, Gas Bubble Volume Estimate

Dear Mr. Bickel:

In response to your recent request directed to our Mr. J. . Hicks for information regarding B&W estimations of the gas bubble size during the early stages of the TMI-2 incident, please see the attached graph.

This graph is self-explanatory and should fully address your request. If you have further questions, please refer them to me.

Very truly yours,

James D. Agar /for

James H. Taylor
Manager, Licensing

JHT:dsf

Encl.

cc: R. B. Borsum (B&W)

bcc: J. D. Agar
J. H. Hicks
G. O. Geissler
D. A. Nitti
E. R. Kane

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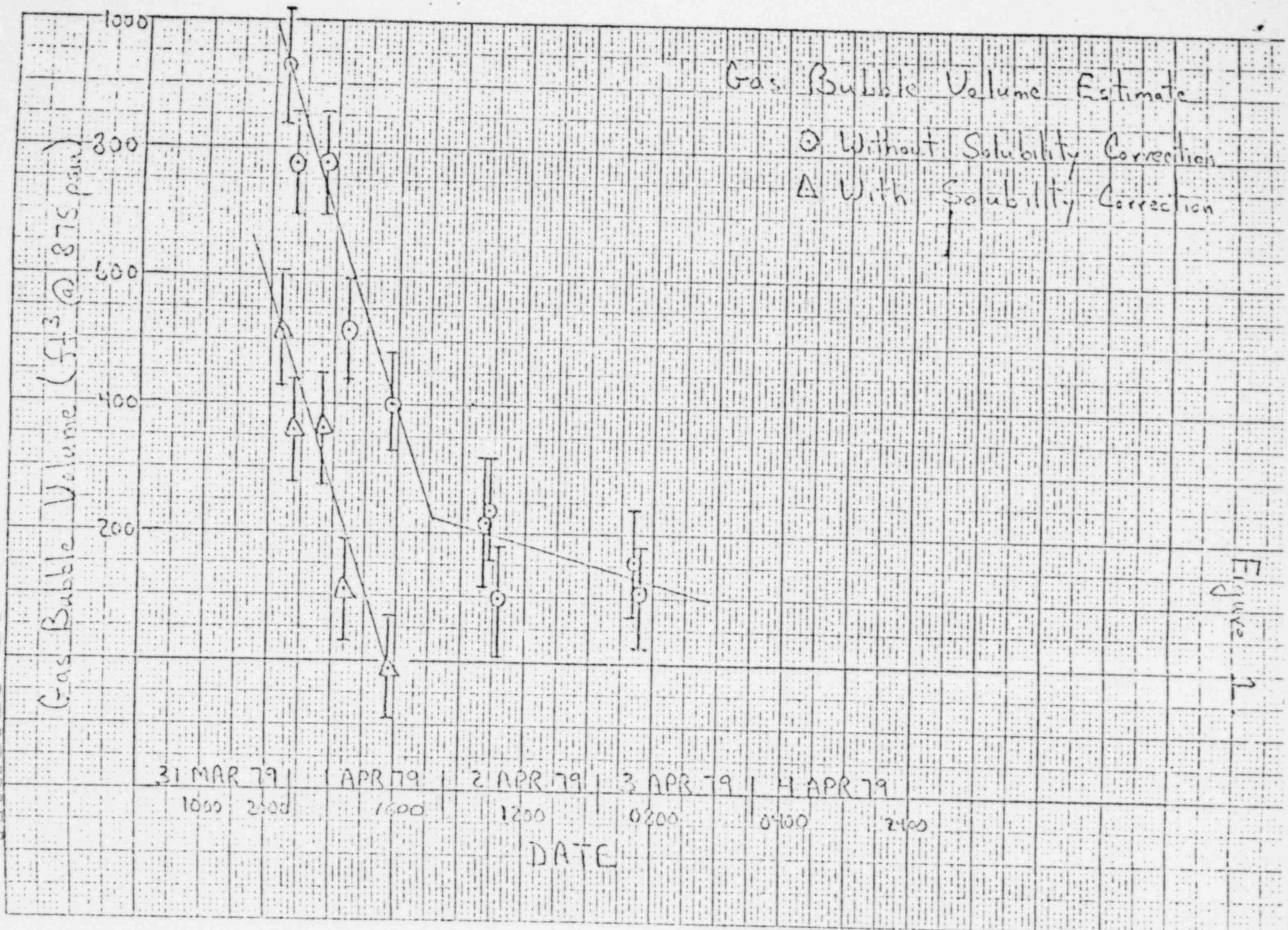

Gas Bubble Volume Estimate
⊙ Without Solubility Correction
Δ With Solubility Correction
Gas Bubble Volume (ft³ @ 875 psia)
1000
800
600
400
200
31 MAR 79
1 APR 79
2 APR 79
3 APR 79
4 APR 79
1000
2200
1600
1200
0800
0400
2400
DATE

Figure 1

EVALUATION OF BUBBLE SIZE IN THE REACTOR COOLANT SYSTEM

1. Model to be Used

The ideal gas law was used to derive the initial relationship, i.e.:

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2} \qquad (1)$$

Since the reactor coolant system temperature varied on a few degrees during the test periods (T_1/T_2) would be extremely small and were dropped from the correlation. Secondly we assumed at the end of the test that

$$V_2 = V_1 + \Delta V. \qquad (2)$$

Substituting into Equation (1) this becomes

$$P_1V_1 = P_2(V_1 + \Delta V). \qquad (3)$$

Solving for V_1

$$V_1 = \left[\frac{P_2}{P_1 - P_2}\right]\Delta V . \qquad (4)$$

Looking at the system operation, we find we must examine a number of components to account for the change in the bubble volume.

The first component is the pressurizer level. To compute the volume contribution from the pressurizer

$$\Delta V_P = C_{PZR}\left(\frac{v^{RCC}}{v_2^{PZR}} L_2^{PZR} - \frac{v^{RCC}}{v_1^{PZR}} L_1^{PZR}\right) \qquad (5)$$

To compute the volume contribution from the makeup tank

$$\Delta V_{MUT} = C_{MUT}\left(\frac{v^{RCS}}{v^{MUT}}\right)\left(L_2^{MUT} - L_1^{MUT}\right) \qquad (6)$$

Since the makeup tank temperature was usually constant, it was not necessary to include a correction to the specific volumes from beginning to the end of the test.

The third contribution to volume change due to the thermal expansion of the water in the primary coolant system.

$$\Delta V_{TEMP} = M_{RCS}\left(\frac{\delta v^{RCS}}{\delta T^{RCS}}\right)\left(T_2^{RCS} - T_1^{RCS}\right) \quad (7)$$

The fourth contribution to the volume change is the compression of the reactor coolant due to the increase in pressure.

$$-M_{RCS}\left(\frac{\delta v^{RCS}}{\delta P^{RCS}}\right)(P_2 - P_1) \quad (8)$$

The last term is a pressure correction to account for the change in solubility of the hydrogen due to pressure increase.

$$M_{RCS}\left(\frac{\delta S}{\delta P}\right)(P_2 - P_1) \quad (9)$$

Since the test was relatively slow, the concentration was assumed to stay close to saturation (see attached curve). It was decided not to try to include a temperature correction as the 280 degree temperature of the operating loop was in or near the minimum of the solubility curve for hydrogen. Thus the model becomes:

$$V_{Bubble} = \frac{P_2}{P_1 - P_2}\left[C_{PZR}\left(\frac{v^{RCS}}{v_2^{PZR}} L_2^{PZR} - \frac{v^{RCS}}{v_1^{PZR}} L_1^{PZR}\right)\right.$$

$$+ C_{MUT}\left(\frac{v^{RCS}}{v^{MUT}}\right)\left(L_2^{MUT} - L_1^{MUT}\right) - M_{RCS}\left(\frac{\delta v^{RCS}}{\delta T^{RCS}}\right)\left(T_2^{RCS} - T_1^{RCS}\right)$$

$$\left.- M_{RCS}\left(\frac{\delta v^{RCS}}{\delta P^{RCS}}\right)\left(P_2 - P_1\right) + M_{RCS}\left(\frac{\delta S}{\delta P}\right)\left(P_2 - P_1\right)\right]$$

P_2 = RC Sys. Press. after change

P_1 = RC Sys. Press. before change

C_{PZR} = Level to Volume Conversion for Pzr. = 3.178 ft^3/in.

C_{MUT} = Level to Volume Conversion for MUT = 4.128 ft^3/in.

v^{RCS} = Specific volume of water at RCS temp, superheated steam tables

v_2^{PZR} = Specific volume of water at Pzr. temp after change, saturated steam tables

v_1^{PZR} = Specific volume of water at Pzr. temp before change, saturated steam tables

v^{MUT} = Specific volume of water at MUT temp, saturated steam tables

L_2^{PZR} = Level in pressurizer after change, inches

L_1^{PZR} = Level in pressurizer before change, inches

L_2^{MUT} = Level in makeup tank after change, inches

L_1^{MUT} = Level in makeup tank before change, inches

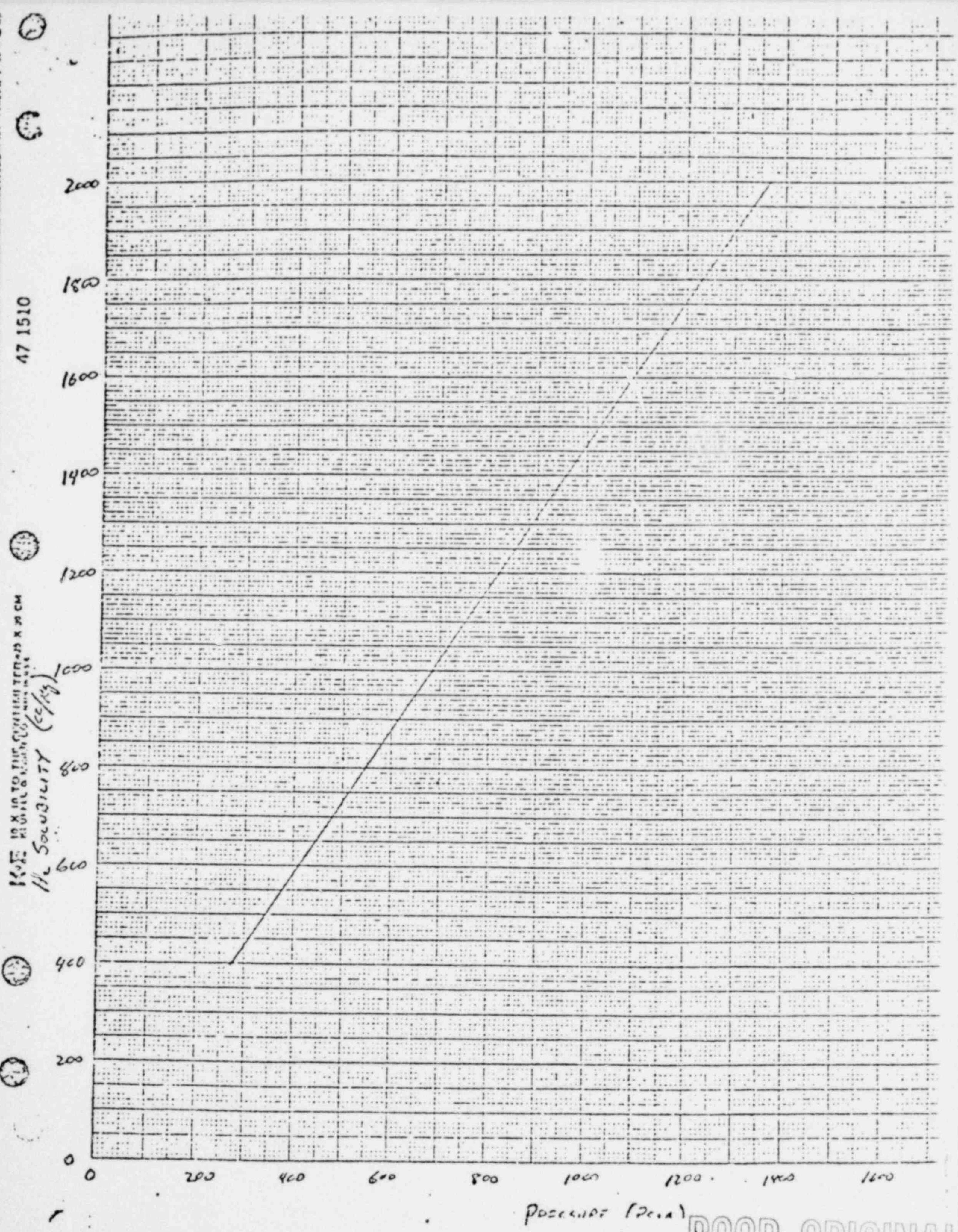
$\frac{\delta v^{RCS}}{\delta T^{RCS}}$ = Change in RCS specific vol. per °F = 9×10^{-6} ft^3/Lbm-F

$\frac{\delta v^{RCS}}{\delta P^{RCS}}$ = Change in RCS specific volume per pound pressure = -10^{-7} ft^3/Lb-PSI

$\frac{\delta S}{\delta P}$ = Change in solubility of H_2 per pound pressure = 5.839×10^{-7} ft^3/Lbm-PSI

M_{RCS} = Mass of RCS = $6.166 \times 10^{+5}$ lbs.

It should be noted that the volume calculated is at the initial condition with the absorbed (desorbed) hydrogen removed.


He Solubility (cc/kg)
2000
1800
1600
1400
1200
1000
800
600
400
200
0
0
200
400
600
800
1000
1200
1400
1600
Pressure (psia)
K&E 10 X 10 TO THE CENTIMETER 18 X 25 CM
47 1510

711
073

Babcock & Wilcox

4/1/79 GAS VOLUME CALCULATIONS
0730

NUMBERS HAVE STAG. AROUND 820 ± 250 CFM.

4/1/	0530	820
		"
		"
		"
3/31	11:55	655
3/31	8:30	765
3/31	7:25	334

ED JORDAN OF NRC

Kane/Marsh - Bubble Calc.

EK This is Ed Kane.

TM This is Ted Marsh.

EK Oh, I was just going to call you, Ted.

TM O.K. Good! Is Billy there?

EK No. He's elsewhere now.

TM O.K. Well, I'd like asking him one quick question.

EK O.K. What's that?

TM I hope the answer is yes, and then we can leave him alone.

TM The answer is the delta level term in his equations for the makeup tank, is the delta level that he's calculating levels, initial minus level final?

EK Yes.

TM Or is it delta level final minus level initial?

EK O.K. Is it level initial minus

TM Level final. I agree with your terms as long as the delta level terms for the makeup tank is level initial minus level final and not vice versa.

EK OK.

TM I'd also like to ask him if he considers the effect of solubility, the temperature, effective hydrogen solubility with temperature, to not be important and that's why he excluded that term. You've got the solubility of hydrogen with pressure but not the solubility of hydrogen with temperature.

EK Is solubility of hydrogen with temperature important?

TM That's right.

EK Let me feed this back to you. We have just got off the phone with Met Ed and our people up at the site. We believe they are doing the test properly and are taking data properly. Now, they were not using the equation with all the correction factors. However, we did a quick check on it, and since they're only using the data from the start of the transient to when the pressure is increased, we believe that from a cursory check of their numbers, that their numbers are conservative if you use all the correction factors.

TM Let me ask you this. Did they show repeatability. In other words, I understand they went from a higher pressure back down to a lower pressure and then took some data.

EK Our understanding -- they said that they're only doing the calculations starting from the initial pressure and going to the higher pressure.

That sounds like what you described to me then. Right, that sounds like just what you told me the last time we talked.

And they say that's what they're doing and that's what they're basing all their calculations on.

OK. Now you say that the formulas they were using did not include corrections which I don't have the formula that they're using. I have the latest one.

EK I'm trying to locate that now.

TM Tell me what corrections were omitted.

EK All the last three terms I got from Billy's equation.

TM The last three terms?

EK All the sensitivity correction factors, including like the change in solubility with pressure.

TM OK

E Since they're increasing pressure by not doing that, that's a conservative calculation. -- At least Billy indicated it was. I don't have his equations here. OK?

So the net result is we believe they're doing the test correctly and we now have no reason to question that the data is reasonably correct.

TM Have you checked their calculations? Have you got their data and run spot checks?

EK We have gotten some of their data and we're rechecking that now.

TM OK. You're doing spot checks on it. At your leisure, can you get Billy back and have him call me. I have to leave for a second to get somebody else to discuss it, but will you call me back in a few minutes so we can continue this discussion on this thing.

EK If necessary ... because Billy needs to be doing some other work for us.

TM I understand. OK. Let's do it this way. Can you ask him those two questions over his shoulder and let him say "yes" or "no" and then call me back.

EK Right. We'll do that.

TM Is this Ed or Jim.

EK This is Ed. I haven't got a chance to leave yet. Goodby.

Kane/Lanning - LOFT Semi Scale Test

This is Ed Kane.

Ed, this is William Lanning. Is Bert Dunn around?

Not in the immediate neighborhood.

How about

Cudlin?

Cudlin? No I can get him back here quick enough, though. Have you run the semi scale test?

My question is to do the semi scale test, what initial __________ temperature should we start at? I'm thinking we should start at a higher temperature than what we are presently at, 280. O.K.? Implement this procedure there's good possibility delay of term. Right?

If what?

As I understand this emergency cooldown procedure if you lose anti-coolant pump you may wait ____________ circulation.

That's possible, yes.

During that time period your ________ is going to heat up.

Not much.

Not much?

You might get up to 290.

What kind of time?

Well, if we lose reactor coolant pump we're not going to waiting around very long.

O.K., so you're saying anything close to 280 then we're all right then.

Yeah, you know, it's not going to be 350 or anything like that.

All right.

Because they'll dump that system as quick as they can.

O.K.

Fine. That answers my question, then.

O.K.

O.K. Thanks.

7:13 p.m.
4/1/79

Conversation - Ron Scroggins/Ed Kane

EK OK what can I do for you, Ron?

RS OK, I just talked to Don Roy and he said we'd better get things in order here. You're probably getting the same kind of questions from numbers of sources. The question has to do with the method they're using that seems to be reducing the bubble size which is using the pressurizer spray off the primary coolant. OK?

EK Yeh.

RS The question was, you know, forgetting for the moment the inclination that there may or may not be any oxygen in the bubble and system, if there were a mixture of hydrogen and oxygen, would that spray process be preferentially purging hydrogen or oxygen?

EK I think oxygen is more soluble in water.

RS That was our feeling. We have a number here like about 2 to 1.

EK Yes. So that would mean that it would be preferentially purging oxygen.

RS Yes, that's what we would think.

OK, if you hear anything different, let me just leave the number in case something comes up. These are questions coming down to us from the site also. They're all trying to noodle around what may be causing the bubble to reduce and other factors, obviously. The number here is (301) 427-7650.

EK OK.

RS All right?

EK OK.

7:35 p.m.
4/1/79

Conversation - Ed Kane/Don Davis - What is Boron Concentration?

EK This is Ed Kane.

DD Yeh, Don Davis.

EK Yes, Don.

DD We're going to need later on in a few minutes to talk to somebody about reactor physics from that core. Do you have somebody that we can talk with?

EK Sure do.

DD OK, we got an unconfirmed report that the boron concentration is only 825 ppm.

EK I see one guy over here from our Fuels group. Do you have a number? We're at 15-2200 ppm. Did you hear that?

DD Who was that?

EK We're going to check on that. Our number is 1500-2200 ppm.

DD OK. What we'd like to do is to understand the needed worth of boron for an unrodded and rodded configuration.

EK They're working on those calculations or have done them.

DD Yes, I figured you had. Who should we call, you again?

EK Yes.

OK, we'll have Howie Richings get in touch with you in about 10 or 15 minutes. OK?

EK OK - will do.

DD By that time, I figured you guys could scratch up your notes.

JHT I tell you what, Don. This is Jim Taylor. Why don't you, instead of him calling us and our guys maybe not being here. Why don't we call you and we'll try to do it within that time frame? But it might be a few minutes later and there's no sense in calling back and them not being here.

DD OK, fine, fine. Call into 28180.

EK 28180, we got it.

DD Thanks! Hey, OK, everything going OK?

EK Seems to be.

DD OK

EK Seems to be.

DD Are you guys making any sense out of the substantive reduction in bubble size?

EK Trying to. Coming up with some theories.

OK, Zoltan Rostozcy will be calling I guess Billy Bingham to get an idea of the derivation of the equation.

JHT? Ted Morrison has already called us three times and Tom Tolford has called us once on the subject.

DD Yes, I know.

7:35 p.m.
4/1/79

Conversation - Ed Kane/Don Davis (cont'd)

I don't quite understand why another one. I thought it was all settled.

DD Well, I guess there are some residual questions and hopefully, this will resolve it. I guess the importance is that it's awfully good news if that's the situation, but one problem is what mechanistically can cause such a large change in volume.

EK Yes, we're looking at that.

DD OK. But you don't have an answer yet.

EK I think we may have some answers. We have some speculations and theories.

DD OK, so you're just checking out your speculations.

EK Right.

DD Well, if this thing gets difficult with Zoltan, give me a ring.

EK You mean in the middle of the call with Zoltan.

DD I gather you've talked with him before.

JHT Lots and lots of times and for a long, long time; so we'll get back to you, Don.

DD I understand he only had two specific questions.

JHT That's the way we all start out. (That'll take about four hours.) Those are just the main headings.

We'll talk to you later, Don.

DD That's making me feel bad.

EK See you later.

DD Thank you.

EK Bye Bye.

4/1/79

Conversation - Z. Rostozcy/J. Taylor/E.Kane - Bubble Calculations

JHT Hello.

ZR This is Zoltan Rostozcy from NRC. May I speak to Billy Bingham?

JHT Zoltan, this is Jim Taylor. How are you doing?

ZR Oh, thank you, fine.

JHT We just got off the phone saying that there had been five people calling in the last hour about the bubble calculations, and we don't know right this minute where Billy is. Can we have your number and call you back as soon as we find him?

ZR Yes, the question is the same -- the bubble calculation.
Yes, my number is (301) 492-7141.

JHT OK, we'll call you back as soon as we can get him.

ZR Thank you.

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TAPE
PHONE CONVERSATIONS

✓ 1. 6:50 4/1/79 KANE/LANNING
LOFT SEMI SCALE TEST.

✓ 2. 7:10 KANE /MARCH
BUBBLE CALC.

✓ 3. RON SCROGGINS. / KANE 7:25

✓ 4. 7:35 DAVIS /KANE
WHAT IS BORON CONC.

✓ 5. Z. ROSTOZCY / KANE / TAYLOR
BUBBLE CALCULATIONS.

J. H. Taylor

3/31/79
Telecon 9:30 P.M.

Vince?

Hi Jim, how are you doing?

Oh, hi. How are you doing? Who else is there?

You right now.

We want to give you some feedback on these calculations that Chuck Morgan and Charlie Pryor had been making.

O.K.

On the reactor vessel.

Yea, on the hydrogen problem?

Yea.

O.K.

Let me first of all, well I'll let them go ahead and then I want to come back and talk about the availability of oxygen.

Jim, why don't you hold on a second and let me get another guy down here that should here this side of research. People at research are doing some of this work.

O.K.

They're right down the hall, let me get them would you please.

All right.

Thank you.

I have two people here from the Research Center, they can identify themselves.

____ Cunningham and Joe Murphy.

Joe Murphy and who else please?

Mark Cunningham.

Oh, o.k. Thank you. All right, we got here in the rim, Fred Burk, Chuck Morgan, Charlie Pryor, and myself, Jim Taylor. And so I guess the place to start will be to let Chuck Morgan tell you about the calculations he made in terms of developing the force and then (Fred are you gonna) Fred Burk will talk about the stress calculation.

A couple of hours ago we talked about calculations assuming that we had a asymmetric mixture of hydrogen and oxygen up there and a saturated water vapor. Since that time we've looked at what a actual mixture be and there's something less than 50% of the oxygen available that would be required to completely react with all the hydrogen. So I just did another calculation assuming that there was 50% of the oxygen. Actually there's probably only about 40% enough. I did a calculation assuming that you had 50% of the oxygen that would take to get complete combustion. And I went through and came out with a maximum temperature of 5,540 and a pressure of 5,808.

_____________________. Give me the pressure number again.

Five thousand, eight hundred and eight.

Five thousand, eight hundred and eight?

Yea. And that assumes that the volume stays constant that it is not going to do that it's going to expand some. So I think that is a conservative pressure.

________ pressure or over pressure?

No, that is total pressure.

Oh.

O.K.

This is in the reactor vessel.

Right.

O.k. what does that, you said that you took only 50% of the oxygen.

One half.

One half of the oxygen required for complete combustion. But that is more oxygen then we have, then we calculate we have there, right now.

That's greater than 4 to 1 ratio hydrogen to oxygen.

Right.

O.k. Some far we have been talking to be talking only in something of the order of 2 to 3 percent oxygen ____.

Well, let us, we just had some recalculations done by one of our Chemical people here, Don Nettie and he made calculations to see what amount of decomposed hydrogen or I mean decomposed oxygen would be there now, 10 days from now, and 30 days. No, I'm sorry. Now, 10 days from the start of the transient and 30 days from the start of the transient. And he came up with numbers of 183 cubic feet at a thousand psi. Now 386 cubic feet at 10 days and 687 cubic feet at 30 days.

What was that last number?

Six eight seven.

O.K.

So we might want to talk about that more between Don Nettie and whoever up there made those calculations.

O.K. basically we've been coordinating most of the hydrogen stuff through Bob Refling at FAI.

Who?

Bob Refling at FAI has been coordinating most of the hydrogen stuff that we are doing.

J. H. Taylor

3/31/79
Telecon 9:30 P.M.

___________________.

Hay Jim.

Yea.

There was a duplication of effort being done here one by Linbranch and one by the Research people.

Yea.

Right now. I recon the Research people have it because I don't have any people left here.

Hay Vince you're there, aren't you?

Hay, that's equal to three.

Are you guys having any problems with the ratio?

No, I think I understand, I'm not sure where it came from but I haven't been following the problem very closely.

O.K.

Hay, I got to go out to get a bite to eat and I'll be back in an hour or so. If they want to talk to anybody who should I tell them to call and under what number.

I got the number here.

You got it o.k.

I'll get it to you.

What does that convert to now instead. Now when you talk about 5808 total pressure, tell me what that means as far as structuring on that head.

Vince?

Yea.

We sort of worked the problem backwards. We had insurance people working the same time we had the pressure people working, and we worked backwards to come up with an allowable pressure.

O.k.

O.k. essentially what we did, I'm not sure about the conversations that went on in the past, but we looked at both the head, circle head, the studs, and assumed that the shock waves propogated down through the vessel and also looked at the hooped stretches in the finished portion of the shell as well.

What about the core itself?

No. only the reactor vessel.

_____________________ tested before.

No. Actually the internals of the plenum and the core would act to absorb quite a bit of the energy. And we put

Hay, what can of ______ can we run now.

Well, I understand that we put the entire energy on the vessel, because we understood the minute concern was whether we would break the vessel or not .

Right. Don Montgomery ____________.

O.k. essentially we looked at those three areas and we determined that the hoop stretch in the vessel will be governing, if we assume that this pressure acted, didn't dissapate any in traveling down from the overhead reaching down into the thin portion of the vessel.

Yea.

We did several things. We assume that we had a triangular pulse over a 2 mil second duration.

All right.

We looked at the natural frequency of the shell itself, came up with a low ____________ factor, based on the natural frequencies of the shell and of the pulse, duration of the pulse.

What did you get for that?

1.45

145 o.k.

1.45

1.45?

Right. _____________________.

Bob Lide is the, we calculated the reliable pressure of about 6200 psi, 6186.

6186?

Right.

You saying they got about 300 psi margin.

Right.

Now that calculation we did is awfully conservative because you assume that this is just a false way that it is propergating down through the fluid. It is only acting on a small length of the shell at any one time. So a PR of a T type calculation with an amplification factor is pretty conservative.

Basic pressure is pretty conservative in a thousand psi - right.

Right now - yes.
What temperature are you looking at?

28C
What does 350 do to you?
Beg your pardon
What does 350 do to you?
You mean if we go to 350 and keep the same pressure?
Yes
It would knock the pressure down a little I think because you would put partial pressure of a water vapor in a gas region - that's more water vapor in there and that would absorb some of the energy so that the max. pressure would not be as high.
okey so I guess what you are telling me right now is that you would not anticipate a failure if you had an explosion in there.

That's right - we ratiod 4 to 1.

Well - let me just make one point here - is that based on the assumption that we have only 50% of the gas and 50% of the oxygen required to burn all the hydrogen.

That's about what we think we have.
Wait a minute I can't hear you. Hang on we have the fire department going by. They are on there way to TMI to.

How many cubic feet are you calculating based on tests

Pressure does not make any difference ______

But it would really be about 165 ______

Of oxygen?

His numbers would be 50% of ______
You guys still talking or what
Yes

J.H. Taylor

3/31/79
Telecon 9:30 PM

Hold on just a moment Ed. Typed conversation between engineers most garbled

365 plus 452 gives you 817 total cubic feet of hydrogen and so 50% of that would be 409 - you only got a 183 so you only got about 25% - that is at this time.

But then you won't have enought hydrogen -

Then you what.

Then it would be the other way around you burn all the hydrogen you have left ______

But right now it is only 25 to 30% of the oxygen thereby ________________

If we use 50% it is really going to knock the pressure down

Okey Vince we have less then 50% of the hydrogen available now in the neighborhood of 25 to 30%.

What we think is really there - we made the calculation conservatively assuming that it was 50% there.

Okey

But from those numbers there about what time would you indicate that we would have 50%

Okey - Just a minute Vince -

More calculations

Some time within now and about 10 days -

3/31/79

5:35 p.m.

TELEPHONE CONVERSATION WARREN HAZELTON/B D. LIAW/KLUCFER/KANE/MORGAN/ TAYLOR/PRYOR

ERK: This is Ed Kane from B&W. We have some calculations on the pressure surge due to a hydrogen excursion in the vessel. Who are we talking to anyway?

WH: This is Warren Hazelton.

ERK: I have Chuck Morgan here with some new numbers.

Great.

: Yeah. After I talked with somebody about an hour and one half or so ago - I realized I did not have the effect of the water vapor in the calculation. What I have done is a thermodynamic equilibrium calculation to find out what percent of the hydrogen actually reacts and made a conservative calculation assuming that if you have a stoichiometric mixture of hydrogen and oxygen in that gas dome along with the partial pressure of water that you would get - the temperature of the water now at 285°F you would get about .053 bowl fraction of water vapor and the rest is a stoichio/metric mixture of hydrogen and oxygen. Then just did a calculation guess a temperature - get the equilibrium constant go through the calculation and find out what the percent of the reaction was and then do ______ bounce to see if I could come out to the final temperature and I got of the match at a temperature of 7500 degrees roentgen, which would give a pressure of 7850 psi.

Is that overpressure or is that the total?

That is total.

Yeah. I think we have been informed as exactly what we are doing wrong here - these curves I was using I think would end up as being the pressure rate because all of the curves were for ____pressures and what happens here is that if we take a pressure ratio it comes up to pretty high pressures too. The other thing we have been doing is to try and determine whether or not it is a realistic assumption to assume you have Stochiometric ~~symmetric~~ ratios of hydrogen and oxygen and______these temperatures___ fission.

From what we've looked at it is not - - you can't get enough - Well, we don't think you can get anywhere near enough oxygen up there. Jim what did you say you get about, only about, a third the amount of oxygen you need for complete combusion?

Yes. We make just a very, very (this is Jim Taylor, Warren) rough, quick calculation and it looks like the amount of oxygen that was there might be lower than what would be assumed to completely oxydize this hydrogen by maybe a factor of three

Yeah, right. O.K.

Of course if you did that well my final result is that 66% of the hydrogen reacted with the oxygen - you only had 35% of the oxygen available. That would drop that way down to, I don't know I guess 45 or 50 percent of the hydrogen reacting and then that drops that pressure to three or four thousand psi maybe. We can go through the calculation if you would like. .

What was the basis for determining the amount of oxygen available?

In the calculation I did they got to 7850 - I just assume I had a stoichiometric mixture - I had all the oxygen available now.

What about the ______

JHT: The other one was assuming that the water that had come in from the borated water storage tank was saturated with oxygen and that the radiolytic decomposition product had taken place up to some time like about 48 hours. This would be a little bit more now but it was just _____ radiolysis and water saturated oxygen saturated water.

O.K. but what about the radiolysis - that reaction goes both ways.

We assume that that reaction was not working.

O.K., O.K. You still came up with a lot less oxygen.

Yeah, we really ought to go back and confirm that. We were just looking for a quick check to see whether what we were doing here was conservative and we will go back and double check that.

O.K., very good. Is that all?

Well, I don't know whether you heard the final results of what 7850 pounds do to the system.

No, what did it do?

CP: Well, this is Charlie Pryor. I have been making some stress calculations on a reactor vessel and really just assuming no dynamic amplification factor or static situation and looking at allowable stresses around the vessel and head through the studs and in the lower region assuming we would have a shock wave set up by this, it looks like the studs can take in the neighborhood of 11000psi and the vessel head can take around 12000

CP: psi and the beltline region would take around 7800 psi. Now that Is just assuming a static situation. From what I understand of this type type of effect that may be set up here from such an excursion we would have a very, very fast peak and a shock wave traveling at say mach 1 or two in a period of say triangular shape pulse of maybe 2 milli-seconds or less, which might mean that we would actually not have any dynamic amplification at all and we are looking at that right now. But, the calculations are somewhat conservative in the sense that I used the ASME code allowable stresses. O.K., which have a built in factor of safety in them and we are about the allowable stress in the 7850 that Chuck has calculated are about together now, so taking into account the conservatisms that you guys have just been talking about and the conservatisms in the code, I think we might be O.K.

Charlie..

Yes. This is________

Yeah. How are you.

I'm fine. The . . . (lost conversation)

CP: I don't have those right now but I think the shell frequencies are going to be 50 hertz or so. I don't know exactly what they are. We are looking at that right now. We are setting up a model to do an actually a transient analysis now.

I just did a simple calc with assumed ______ for the head of the vessel and the little _______ on the ______________________________ and I came up with about 50 Hertz.

CP: O.K.

(lost conversation)

How sure are you of the two milliseconds?

CP: Not sure.

What level of __________have you got? What kind of __________ did you put on it? How ________________?

CP: That is the unknown in this. How to compute the shape of the wave and the time history of the wave. I personally am not able to put any number on an _______ on that. It would just be a total guess on my part.

(lost conversation)

Could you guys get somebody else who is more expert to give you some advice on that or give us some advice?

Well we are trying to do that. We are working through another consultant too but apparently we haven't got _____numbers yet so we don't have. . . they are still working on it.

Do you think it would really be triangular _____ or would it be closer to a very deep ramp off and then a slower drop off. In otherwords the right half of a triangle? Closer to a flagpole.

The particular person I talked to here felt like it would be closer to a triangular pulse. He indicated it would disintegrate as fast as it did build up.

That person was using a shock tube analogy though and I don't know if that is really good. I don't think we have anybody here that really knows how the pulse would act.

Charlie

Yes.

(lost conversation)

CP: B.D., we are setting up a finite element model/analysis of the vessel so we can do a transient analysis, but we are not really working on what the shape of that wave might be, what the period of the wave is.

That is important, because you have got to get a _____ratio of the duration to the vessel frequency for a half of a triangle than you would for if you build a ________triangle.

CP: That is right.

_____________when you can get a good handle on what the pulse looks like.

CP: Well if you go back maybe we could do this. I agree with you on that but if we go back and we were to take some conservatism out of the. . . I can't see us getting an amplification more than two, O.K.

(lost conversation)

CP: and 1.5 is an upper limit on the triangle where the decay time is equal to the rise time.

(lost conversation)

CP:Right

CP: Now if you go back and reduce this pressure further from taking less conservative assumptions on the pressure than I think our best bet would be to try to get the pressure calculation reasonable and then I think we could just go ahead and take a dynamic amplification factor of one a one half or so times that and demonstrate that we will be all right.

_______________ 1.8 would probably be better if you wanted________ (lost conversation)

CP: Yeah. O.K., if we have to go to 1.8 then we right now are going to be over the stress limit.

How about if you consider. .

CP: With the 7500 psi.

(lost conversation)

CP: Yeah, that's right. You can go back and do some conservatisms out of the material properties and look at strain rate effects. That is right.

(lost conversation) We are trying to figure out what this thing is going to do in reality. ___________

CP: Yeah. I realize that.

_________________pretty good _____factor out of that.

Probably I think we can be set up to run inside of one hour.

One thing you might do if you have people available is to check and see what would be realistic vapor combination of water vapor, hydrogen and oxygen taking into consideration the fact you may get recombination of hydrogen and oxygen up there as well. We don't have anybody here expert in that at the moment.

Plus the fact that there has been a slight amount of venting going on.

Well not of this volume as we know of.

Maybe there has. What do you know, we haven't heard much.

Don't get estatic, Warren. What I mean is that there has been venting going on from the reactor coolant system and this space is being water flowing through this space and over up into the pressurizer where some of the gas is being stripped out.

O.K., good. We haven't heard that. We are sort of in a vacuum.

It is a slow process. We are not sure how fast the tapping. But there has been some venting going on.

O.K., good.

Not directly from this space, now let me make sure I am clear on that.

Not directly from this space.

O.K.

You will be getting back to us, right.

O.K., thank you.

(end of tape)

0200

TELEPHONE MEMO RECORD

Don Davis of the NRC called at 0220, 30 March 79, and spoke with D. F. Hallman and R. J. Finnin.

He indicated that the NRC was requesting Met. Ed. to look at their ability to vary RC system pressure in order to evaluate the site of any non-condensible gas bubble in the reactor vessel.

He repeated the NRC's request to know what contingencies/plans are available for the initiation of the Decay Heat System.

Finally, he wanted to know if B&W had tried to postulate the flow blockage mechanism that would cause the incore thermocouple readings we are seeing. Had we looked at the possibility of steam being channelled up the CRD guide tubes to the upper plenum. Don Hallman said we were looking into this, but he had no first hand knowledge. Don agreed to try to have someone at B&W call the NRC back (492-8160) to discuss this further.

ACTION: J. S. Tulenko is preparing to discuss flow blockage mechanisms.
D. E. Lee is working on a procedure for transferring to Decay Heat.

R. J. FINNIN

RJF/pwc

Item #1 was covered by a second call at ≈ 0400.
Taylor, Tulenko, Andrews
Davis, Watson.

TELECON: TOM NOVAK (NRC) ~ 23:40 ON MAR 29, 1979
2340

RADIOLYTIC HYDROGEN GENERATION

D.A. NITTI

@ 22:00 HRS 3/29

20 HRS on 3/28
22 HRS on 3/29
42 HRS @ 22:00 HRS

$EV = 1.7 \times 10^{30}$ ← (ASSUMES TOO HIGH AN ENERGY ABSORPTION EFFICIENCY)

$$\frac{0.45 \frac{\text{atoms}}{\text{hev}}}{6.03 \times 10^{23} \frac{\text{atom}}{\text{gmmol}}} \times \frac{1.7 \times 10^{30} (EV)}{100 \left(\frac{ev}{hev}\right)} \times \frac{22{,}400 \frac{cc}{gmmol}}{28317 \frac{cc}{FT^3}} = 10{,}035 \ FT^3 \ H_2$$

	EV IN CORE FOR MHA	8.1×10^{29}
10%	EV IN SOL'N FOR MHA	0.85×10^{29}
	TOTAL EV FOR MHA	8.95×10^{29}

REF: TMI-2 FSAR APPENDIX 15 E

$$\frac{0.45 \times 8.95 \times 10^{29} \times 22400}{6.03 \times 10^{23} \times 100 \times 28317} = 5284 \ FT^3 \ H_2$$

FOR G_{H_2} OF 0.5 VOL OF H_2 WOULD BE 5871 FT^3 H_2
FOR G_{O_2} OF 0.25 " " O_2 " " 2936 FT^3 O_2
8807 FT^3 STD

(275 FT^3 COMPRESSED)

$$\text{COMPRESSION RATIO} = \frac{935 \text{ PSIA}}{14.7 \text{ PSIA}} \times \frac{502\,°R}{997\,°R} = 32$$

0245 AM
3/30/79

JIM LOGAN
JIM MOORE
BILL LOWE
TOM CREMANS

384 - ~~2320~~
5070

INDEPENDENT CALCS
GPU 1575 FT^3
NRC ≅ 1300 FT^3

(OVER)

POOR ORIGINAL

AIR ADDED TO RCS WITH WATER FROM BWST

PERRY'S CHE HANDBOOK P.675 IN 3[RD] ED

VOLUME IN HEAD REGION	
HEAD	800 FT^3
PLENUM	1000 FT^3
OVERFLOW	500 FT^3
	2300 FT^3

AIR: $H = 5 \times 10^{+4}$ @ 6°C (42°F)
$H = 6.6 \times 10^4$ @ 20°C (68°F)

935 PSIA @ 537°F

$$p = H\chi$$

H = HENRY LAW CONST
p = PARTIAL PRESS. IN ATMOSPHERES
χ = MOLE FRACTION

$$\chi = \frac{p}{H} = \frac{1\ ATM}{5 \times 10^4} = 2 \times 10^{-5} = \frac{\frac{M_a(g)}{29\ (g/gm\text{-}mol)}}{\frac{M_a(g)}{29\ (g/gm\text{-}mol)} + \frac{1000\ gm}{18\ (g/gm\text{-}mol)}}$$

VERY SMALL

$M_a\ (g/kg) = 0.0322$ gm air
$m_a\ (mol/kg) = 1.11 \times 10^{-3}$
$V_a\ (cc/kg) = 24.9$ cc/kg

$$\frac{473\,000\ gal\ in\ BWST}{55\ FT\ (ELEV)} \times 33\ FT\ LEVEL\ CHANGE = 284{,}000\ gal$$

$$284{,}000\ gal \times 8.33\ \frac{LBS}{gal} \times 0.4536\ \frac{Kg}{LB} = 1.072 \times 10^6\ Kg\ BWST\ ADDED$$

$$VOLUME\ OF\ AIR\ ADDED = \frac{1.072 \times 10^6\ Kg \times 24.9\ \frac{cc}{Kg}}{28{,}317\ \frac{cc}{FT}} \times \frac{14.7\ PSIA}{935\ PSIA} \times \frac{997°R}{502°R} = 29\ FT^3$$

AT TEMP = 537
PRESS = 935

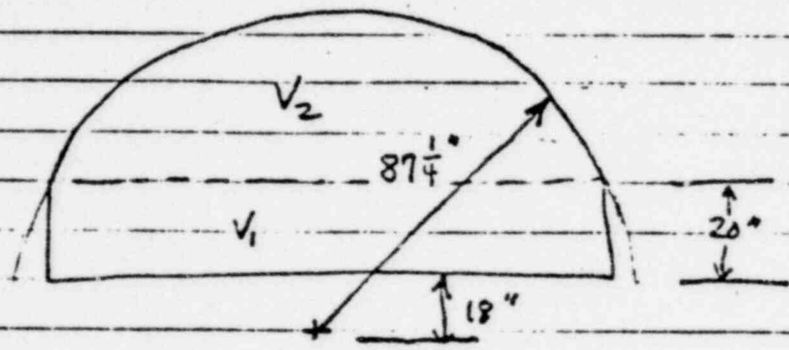
$$\frac{1.072 \times 10^6\ Kg \times 24.9\ \frac{cc}{Kg}}{28{,}317} = 943\ FT$$

AT TEMP = 0°F
PRESS = 14.7 PSIA

POOR ORIGINAL

Volume Calculations — CWP — 3/29/79

Reactor Vessel Head Volume



$$V_1 = \pi r^2 h = \pi (82")^2 (20")$$

$$V_1 = 422{,}481 \ in^3$$

$$V_1 = 244 \ ft^3$$

$$V_2 = \sim \tfrac{2}{3}\pi R^3 - V_1$$

$$V_2 = \tfrac{2}{3}\pi \left(\tfrac{87}{12}\right)^3 - 244$$

$$V_2 = 554 \ ft^3$$

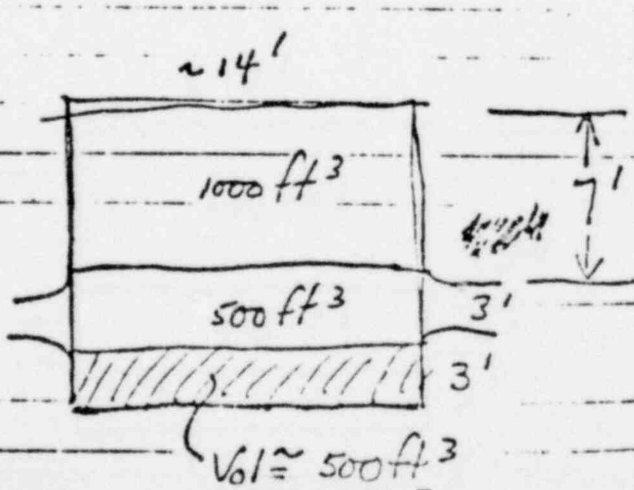
$$V_{head} = V_1 + V_2 = \underline{798 \ ft^3}$$

650
800

Plenum Volume

$$V = \pi r^2 h = \pi (49) 13$$

$$V_{PLENUM} = \underline{2000 \ ft^3}$$



PARTIAL PRESSURE OF H_2 NORMALLY MU TANK WHICH IS SUFFICIENT TO SUPPRESS RADIOLYTIC DECOMPOSITION

$H_H = 7.65 \times 10^4$ @ 60°C (140°F) CH.E. HBK P.675

$V_H = 20 \frac{cc}{Kg}$

$x_H = \frac{20\ cc\ H_2}{Kg\ H_2O} \times \frac{18\ gm/gm\ mol}{1000\ gm/Kg} \times \frac{1}{22,400\ \frac{cc\ H_2}{gm\ mol}} = 1.607 \times 10^{-5}$

$p = Hx_H = 7.65 \times 10^4 \times 1.607 \times 10^{-5} = 1.23$ ATM → 18 PSI H_2 IN MAKEUP T.

PARTIAL PRESSURE OF H_2 IN RCS REQUIRED TO SUPPRESS RADIOLYTIC DECOMPOSITION

$H = 11 \times 10^5 \frac{PSI}{gm\ mol} \times \frac{ATM}{14.7\ PSI} = 7.5 \times 10^4$ ✓ @ 75°F

$= 2.52 \times 10^5 \frac{PSI}{gm\ mol}$ @ 537°F

} BMI-T-25 TABLE 2

500	2.90
537	2.52
600	1.86

$p = yP \qquad p = Hx$

$y = \frac{H}{P} x$

$y = \frac{2.52 \times 10^5}{935} \times 1.607 \times 10^{-5}$

MOL FRACT. IN VAPOR = $y = 4.32 \times 10^{-3}$ ✓

$p = Hx = 2.52 \times 10^5 \frac{PSI}{gm\ mol} \times \frac{20\ cc\ H_2}{Kg\ H_2O} \times \frac{18\ gm/gm\ mol}{1000\ gm/Kg} \frac{1}{22,400\ cc} = 4.05$ PSI

ASSUME AN 800 FT^3 BUBBLE

VOL AIR @ 537°F + 935 PSI	= 29 FT^3	= 1192 gm moles
VOL H_2 @ " "	= 184 FT^3	= 7418 gm moles
VOL O_2 @ " "	= 92 FT^3	= 3709 gm moles
VOL STEAM @ " "	= 495 FT^3	= 26,096 gm moles
	800 FT^3	

N_{STEAM} 479 $\frac{FT^3}{M}$

POOR ORIGINAL

$y_H = 0.193$

y IN 800 FT^3 BUBBLE IS 45 TIMES LARGER THAN y OF 4.32×10^{-3} REQUIRED TO SUPPRESS HYDROGEN PRODUCTION

TOM NOVAK SEEMED TO ACCEPT THIS CONCLUSION

Telephone Memo Record

On March 29, 1979 at 8:00 pm we received a telephone call from T. Novak (NRC) who raised concern about radiolytic decomposition of gas and resultant accumulation in the upper dome of the reactor vessel. NRC indicated that they had calculated possibly as much as 1200 cubic feet could exist in the reactor vessel. They requested we check the reasonableness of these numbers.

Pressurizer pressure and level figures which they had been looking at was as follows:

TIME	PRESSURE	LEVEL
2:10 p.m.	852 psig	355 in.
3:00 p.m.	920 psig	323 in.
7:00 p.m.	945 psig	321 in.

Actions:

1. Volume calculations by C. W. Pryor for volume above the core.
2. Radiolytic decomposition calculations - D. A. Nitti.