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December 9, 1983

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Accident Source Term Program Office
Office of Nuclear Regulatory Research
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Dear Mike:

I am enclosing comments with regard to the last meeting of the Source Term Review Committee. I apologize for sending in these remarks so late. I am also sending a copy of these comments directly to Mel Silberberg.

Sincerely,

Albert B Reynolds

A. B. Reynolds, Professor
Dept. of Nuclear Engineering
and Engineering Physics

ABR:ph

Encl.

Received 12/15/83
MJ

Copies to:

(1) M. Silberberg, ASTPO
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(6) T. Kress, ORNL
(7) R. Wichner, ORNL
(8) D. Powers, SNL
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COMMENTS ON THE OCTOBER SOURCE TERM REVIEW MEETING AND ON CHAPTER V
BMI-2104

A. B. Reynolds
8 December, 1983

1. For future development of CORSOR, J. L. Kelly and I suggest the use of Arrhenius plots of fission product release fractions, i.e., K versus 1/T, instead of the plots used in NUREG-0772 and BMI-2104. Thus K would have the form, $K_o e^{-Q/RT}$, instead of the CORSOR (or NUREG-0772) form, $Ae^{BT}$.

   A detailed description of work by James L. Kelly and Michael E. McGown and myself is appended to this report to support our recommendation of the Arrhenius model.

2. I note that the wall and floor surface areas in the containment are tabulated in Table 6.6 of Volume V for the large PWR containment. There is much more surface area from pipes and structures inside the containment. Are all of these areas included?

   A common industry complaint is that neither all of the surface area nor all of the heat capacity of the pipes and structures inside the containments is included in calculating condensation and removal of fission products. It would be useful to list the internal heat capacity used in the MARCH calculations and internal structure surface areas in addition to the wall and floor surface areas in the containment (and perhaps the upper plenum, etc. in the primary system) so that industry people could compare with their analyses. (Not only would this be useful to industry people who often think Battelle/NRC source term calculations are too conservative--it would also be useful to explain to nuclear critics who think Battelle/NRC source term calculations are too low why so much fission product depletion occurs in these volumes.)

3. Another suggestion, similar to the #2 above, is to add sketches that illustrate the large amount of structure (surface plus heat capacity) and the tortuous pathways in the containment building (and perhaps in the primary system upper plenum). For example, look at Fig. 4.4 in Volume 1 (or Fig. 4.7). This figure creates the impression that there is a rather clear path between a pipe break or the reactor cavity and the containment wall. Industry people stress that the pathways are actually complex, with many surfaces (pipes, concrete walls, etc.) along the way on which material can condense or plate out. Fig. 4.4 (and Fig. 4.7) is useful for its simplicity in illustrating the message of the figure. However, perhaps a companion figure should immediately follow each simplistic figure illustrating somehow the actual complexity of the geometry and structures that affect the pathways and attenuation of the aerosols. [I am just sensitive to the people who tell me that it rained inside the TMI containment for 3 days due to all the surfaces and heat capacity, etc. I don't know whether this is true. And, if true, I don't know whether the Battelle codes (MARCH, I suppose) would have predicted that.]

4. Still another suggestion. Provide a detailed list (in tabular form, easy to see and reference) of all of the attenuation mechanisms being accounted for in each of the codes--especially TRAP-MELT and NAUA. These are listed to some extent in Volume I, Section 5.3, but maybe they could be collected and highlighted in a table. I recently saw a list produced by Milt Levenson (of Bechtel, and current ANS president) of all the natural mechanisms that would take out aerosols, and he talked as if many of these were not considered in codes. I expect that they <u>are</u> being considered in codes as effective as those being

used by Battelle, but a list would allow people to see this.

5. Since little detail was provided by Westinghouse for the upper plenum, the suggestion I made in items 2-4 may not be very relevant for this region. I note that Battelle discusses this problem in § 6.1 of volume V. I understood Battelle people to say at the last meeting that this lack of information created a problem for them, but they seem to say in § 6.1 that it's not really a problem because flow through detailed geometry could not be analyzed anyway. Despite industry's admonitions to take all surfaces and geometries into account, I suggest that NRC/Battelle can only take the most conservative approach in the absence of details from industry. Hence, to the extent that industry fails to provide details of the geometry, they damage their own case.

6. I reiterate what many have said: The report needs more schematics showing the control volumes in MARCH. Figures like Fig. 6.3 in Volume V are woefully inadequate.

   In Fig. 6.2 (Vol V), what are structures 1, 2, and 3, for example? They are not illustrated anywhere. The gas outlet (Fig. 6.2) approaches the structure 1 temperature; is this coincidence or would the reason be obvious if I had any concept of where the gas outlet was relative to the position of structure 1?

   In Fig. 6.1a, Vol V, where are ROD (__, __)? I thought I had figured out the formula for TRO (__, __) in Volume I, but I can't figure out the numbering sequence for ROD (__, __). It seems crucial to me that once Battelle goes to the trouble of plotting temperatures for positions, or rods, that they should define (by another picture) what the numbers mean. Moreover, ROD (12,1) appears <u>twice</u> on Fig. 6.1a.

Also ROD (12,1) in Fig. 6.1b looks like neither of the ROD's (12,1) in Fig. 6.1a. Things like this really discourage the reader from going on.

What are Volumes 2 and 3 on Figures 6.11 and 6.12 of Vol V? Again these volumes were not explained, but their temperatures are plotted.

7. I would like to know the correlation for h used for film boiling in the model presented by Powers at the October meeting. In fact, I would like to have a writeup of all of the calculations presented by Powers at that meeting in order to remember what he was doing and its significance.

8. I do not recall a satisfactory response to Kastenburg's question about possible bypass of the suppression pool for BWR accidents. Are scenarios possible for dry well wall failure or blowout of penetrations through the dry well so that the suppression pool is bypassed? Is it Battelle's (and NRC's) position that bypass of the suppression pool is impossible for MARK III but perhaps possible for MARK I? I would like to have the position restated at the January meeting.

9. I see that Battelle is trying to answer the often repeated question "Where is all the water?" by showing water inventories, for example, in Tables 6.3 and 6.4 in Volume V. This is a useful addition. I suggest that inventories at time zero should also be included in those tables for quick reference to allow the reader to assure himself easily and quickly that a complete water mass balance exists at all stages of the calculation.

10. Bravo for Zumwalt's plots. The importance of early containment failure on I and Cs release was recognized by most of us early in the review, which prompted our concern about understanding containment

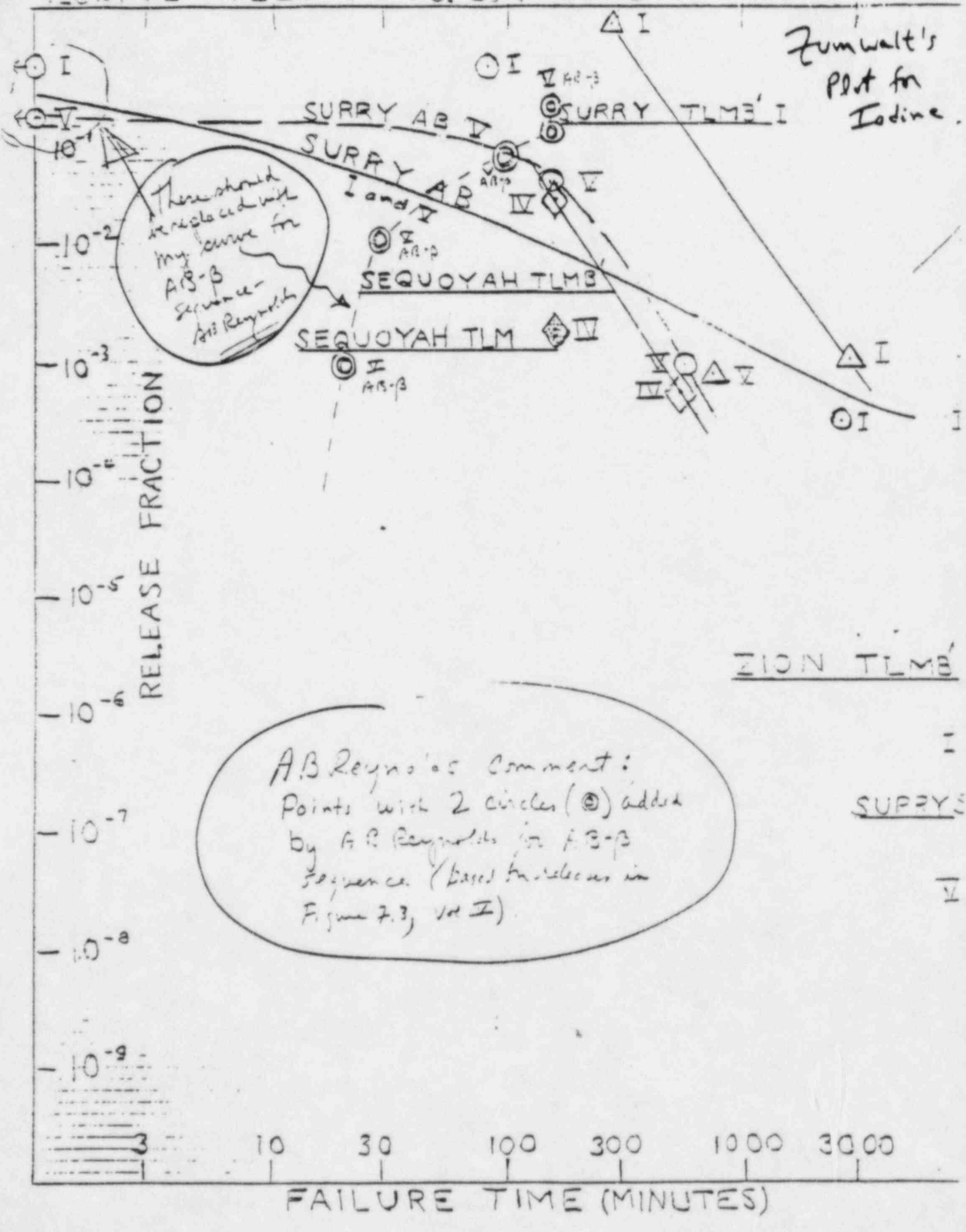
failure better before definitive answers about source term could be obtained. The Zumwalt-type plot displays information in a useful way.

One note I might add to Zumwalt's plots. He shows the fractional releases for the AB-$\beta$ as occurring at essentially zero time (since containment is bypassed). However I looked at Figure 7.3 of Volume V and noted that releases (from the auxiliary building) occur at a later time. I have plotted the results for iodine on Zumwalt's plot (see next page).

It would be useful to add the type of containment failure to Zumwalt's points, i.e. list $\gamma$, $\delta$, $\varepsilon$, etc. beside each point.

11. I suggest adding containment failure times to the final release fractions in Section 7. (They currently appear in Volume V on a table with times for core melting and vessel failure). I found myself searching for these times when I was checking Zumwalt's curves, and trying to see which kind of containment failures ($\beta$, $\gamma$, $\delta$, $\varepsilon$) corresponded to his data points. Since Zumwalt's plot is useful, it would also be useful to put the containment failure times directly on the final tables in Section 7. (The only confusion arises for the $\beta$ sequence since "containment failure" exists from the start while the final release occurs much later.)

12. I recommend that review committee members be supplied with the papers directly related to source term presented by the national lab researchers at the NRC safety research meeting at Gaithersburg in October. These were discussed in the "Inside NRC" in the October 31 issue in which the impression is that so many problems have been identified that the source term can hardly be specified. Relevant


IODINE RELEASE VS. CONTAINMENT FAILURE TIME
Zumwalt's Plot for Iodine.
SURRY AB V
SURRY AB I and V
SURRY TLMB I
SEQUOYAH TLMB
SEQUOYAH TLM
These should be replaced with my curve for AB-B Sequence - AB Reynolds
ZION TLMB
I
SURRY
V
A.B Reynolds Comment:
Points with 2 circles (◎) added by A.B Reynolds for AB-B Sequence. (Based on release in Figure 7.3, Vol II)
RELEASE FRACTION
$10^{-1}$
$10^{-2}$
$10^{-3}$
$10^{-4}$
$10^{-5}$
$10^{-6}$
$10^{-7}$
$10^{-8}$
$10^{-9}$
3
10
30
100
300
1000
3000
FAILURE TIME (MINUTES)

papers by Gieseke, Kress, Wichener, Lipinski, Powers, Niemczyk and Owczarski were discussed in "Inside NRC."