Response to "Comments on 'An Assessment of Steam-Explosion-Induced Containment Failure. Parts I–IV'" by B. W. Marshall, Jr.

To a large extent Marshall's letter contains a repeat and embellishment of Berman's points[1] on fixed-diameter particles (comment 1), single-field representation of the coolant (comment 2), and validation with experiments (comment 3). These points have been fully addressed in our response[2] to Berman (especially in our third paragraph) and there is no need for further repetitions. It is sufficient, therefore, to focus the discussion here on the available experimental base (Sec. I.A of the letter).

Marshall cites work at Argonne National Laboratory (ANL) (Spencer et al.[3,4] and Gabor et al.[5]) and Sandia National Laboratories (SNL) (Marshall et al.[6]) as the pertinent experiments on premixing, and he suggests that we have missed an important opportunity to test our computational tools. The simple answer is that these experiments provide no information of premixing and, therefore, cannot be used for the suggested purpose. To our knowledge (confirmed by personal communication with Spencer,[7] who also indicated that some data analysis currently under way *might* provide some information on premixing) the ANL experiments were not intended for premixing; the SNL experiments ostensibly were, but they were so poorly instrumented that we have to wonder why they were ever run!

As Figs. 1 through 4 of the letter indicate, only the outer mixture diameter (single jets) is given, and this information is a far cry from what one would call premixture information. The key parameters of a premixture are its water and melt contents; none are available in these experiments! Furthermore, as evidenced in the discussion, Marshall seems to associate expansion of the mixture region (externally observed) with "extensive fragmentation" of the jet. This *may* be so, but we will not know for sure until these experiments are run properly and with the proper instrumentation. Finally, the cited references provide no information on the details of the jet entry configuration, nor indeed of the melt entry velocity.

Regarding the "implication for reactor safety" section, we would like to briefly note the following:

1. Marshall commits the same error as Berman in applying the Theofanous-Saito[8] ideas to a multiple-jet geometry. This is where steaming limitations come into play, and this is the whole point of Part II (Ref. 9).

2. The Theofanous-Saito ideas were confirmed with a detailed analysis by Epstein and Fauske.[10] Marshall must take another look at Theofanous-Saito; far from ignoring steam generation, it is an essential aspect (as in the Epstein-Fauske analysis) of the argument. Marshall's "data" are utterly inadequate (as elaborated above) to dispute the conclusions of these two studies.

3. Marshall states that "it is obvious from our experiments at SNL . . . that the characteristic diameter of the fuel *changes with time*." In light of what he measured (or could see!) in these experiments (i.e., Figs. 1 through 4), this is simply an incredible assertion.

To conclude, we would like to reiterate that we have put forth a fully documented one-of-a-kind calculation to predict *upper bounds* on premixing. Subsequently, we have shown that steam clip results in lower premixtures (see Figs. 1 and 3 of our response to Berman[2]) and we claim that ignoring fragmentation is conservative. We have also developed a scaling approach to test this prediction in the relevant regimes.[11] We are comfortable with our positions, and Marshall will need much more than vague references to vague experimental results to dispute these positions convincingly. Indeed, it would be so much more constructive if he could offer a positive contribution himself.

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Comments on "An Assessment of Steam-Explosion-Induced Containment Failure. Parts I–IV"

INTRODUCTION

My comments are a distillation of this report[1] as a member and vice-chairman of the U.S. Nuclear Regulatory Commission (NRC) Steam Explosion Review Group (SERG) (Refs. 2