Therefore, I would consider the current results to be semiquantitative. The air-water mixing experiments quoted in Part II must be analyzed carefully, especially with regard to scaling, before they are of use in explosion analysis. More new data are available from SNL that should also be analyzed. The important limitation about these current data is that they are at 1-atm pressure. All the mixing models suggest a significant increase in fuel-coolant mixing as ambient pressure increases, and this needs to be examined.

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Response to "Comments on 'An Assessment of Steam-Explosion-Induced Containment Failure. Parts I–IV'" by M. L. Corradini

Corradini's comments[1] are more along the lines of the kind of technical exchange we envision in our methodology (see second paragraph of our response to Berman).[2] We welcome them, and we welcome the opportunity to respond.

Referring to his main headings:

1. *Subjectivity:* The issue raised here is that Part I does not emphasize enough the subjective component of the quantification. It is not clear what would have been enough, and we have no problem with the additional emphasis added here. Let me reiterate, however, the two important ideas that exemplify our own note of emphasis in this area. The one refers to the overall methodology that seeks to establish a successive approximation scheme with many independent investigators contributing toward enriching the basis and refining these judgments. The other refers to what we call "intangible uncertainty"; it is impossible to quantify but we expect it to diminish gradually as a result of the synergistic effect of multiple independent contributions to this process (see also Ref. 3).

2. *Limitations:* We certainly agree.

3. *Documentation:* We found the Steam Explosion Review Group (SERG) experience very useful and took advantage of it to appropriately revise the manuscript. As an important aspect of our methodology, we invited the members to document any remaining reservations in letters included in the appendix of the U.S. Nuclear Regulatory Commission report that contains our papers.[4] In addition to the three letters discussed here, a letter from R. Anderson (Argonne National Laboratory) has been received and included.

4. *Technical Analysis, Sensitivity:* The energy (and fuel mass in premixture) threshold can be easily obtained from information provided in Part I. It is estimated as something over 25 t. Still, though, the whole point here is to get away from bounding analyses, which are generally agreed to be not a very fruitful approach for severe accidents.

The second sensitivity indicates that with the generous uncertainties adopted for premixing, the lower plenum failure

constitutes an essential ingredient for avoiding alpha-failure, and it is precisely for this reason that it was presented. As noted, however, the input for this sensitivity was created by *extrapolating* the low-energy results and the assumed margins for uncertainty, linearly. As noted in Part III, our results are consistent with past structural analyses that indicate lower plenum failure for explosions of ~1 GJ. Past work did not consider energy partition in detail and cannot be used for assessing the accuracy of our estimates of dissipation associated with failure of the lower head. However, we have now refined estimates of premixing, and we can quantify propagating explosions in the lower plenum (two-dimensional), thus we are repeating the fluid/structure analysis as promised in the conclusion to Part III.

Regarding the suggested conflict of our energy partition numbers with those of previous studies, we do not agree with the implication that our numbers are off. On the one hand, the studies sited[5,6] used a simple partition idea and did not consider the fluid/structure dynamics as we have done in some detail. On the other hand, our low-energy results suggest a roughly 50:50 partition, which is consistent with the results of Bohl and Butler.[7]

It takes some thinking to get used to it, but a properly formulated and quantified probabilistic study reflects all uncertainties it needs to, and *does not need* extraneous sensitivity (or parametric) studies. The problem with such studies is that inevitably one is drawn to bounding analyses (as evidenced in Corradini's letter) and that is precisely what probabilistic studies are meant to avoid in the first place!

5. *Technical Analysis, Premixing:* Unfortunately, Corradini's discussion here is focused on models rather than on results! As noted in Part II and reiterated in our response to Berman, real progress in this area will be achieved when various results can be clearly compared and scrutinized independently. To this date our results, of Part II, stand alone. We have just generated a comparison with our own three-fluid model[8] (see Figs. 1 and 3 in our response[2] to Berman), but no other results could be quoted by any of the discussers!

In fact, Corradini's table is oversimplified. All entries shown in it are discussed in detail in our Part II. We will not repeat ourselves here. Furthermore, we have seen nothing published from the Integrated Fuel/Coolant Interaction code as yet, and we have serious concerns about employing hydrodynamic fragmentation data of the type considered by Pilch in premixing analyses. Finally, on the appropriateness of available experimental data, see our response to Marshall.[9]

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