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From: David Schowalter <dgs@fluent.com>
To: <nrcrep@nrc.gov>
Date: Wed, Mar 29, 2006 10:57 AM
Subject: Response from "Comment on NRC Documents"

Below is the result of your feedback form. It was submitted by

David Schowalter (dgs@fluent.com) on Wednesday, March 29, 2006 at 10:57:13

Document_Title: Verification and Validation of Selected Fire Models for Nuclear Power Plant Applications (NUREG-1824, Vols. 1-7)

Comments:
NUREG 1824 describes several levels of fire modeling capabilities, along with verification and validation studies. CFD calculations via the FDS code are put forward as being the highest fidelity capability available. It is clear that for simple geometries and with sufficient grid resolution, FDS is a very appropriate code. What is not mentioned, however, is that there are commercial CFD packages available that have extended capabilities not available in FDS that would reduce critical safety gaps by improving accuracy of fire modeling in important scenarios. The major concerns regarding the FDS code that could be resolved with commercial CFD are the following:

1) Limitations of models acknowledged on page xxi. It is made clear that user knowledge has an impact, but how can the user be assured of approaching a given problem in the best way when there is little technical support for a government code? Page xxv also reads, "Technical review of fire models is also necessary to ensure that those using the models can accurately assess the adequacy of the scientific and technical bases for the models, select models that are appropriate for a desired use, and understand the levels of confidence that can be attributed to the results predicted by the models." This is an important statement, and it needs to be made clear how this technical review will occur.

2) Geometry limitations. It is made clear in the NUREG that FDS is limited to rectilinear geometries. Storage casks and containment buildings in particular, however, are typically cylindrical, with many enclosed geometric complexities. Enforcing a stair step mesh on these geometries could have a very significant impact on the accuracy of the results, especially when it comes to predicting surface temperatures and heat fluxes, the most critical safety element in modeling a fire's impact on the safety of critical components. The applicability of FDS to calculating surface fluxes and temperatures was given a " yellow" rating based on the validation calculations, but it is likely that matters would be much worse with more complex geometries, as admitted by the authors, and this compromises the safety of a plant or cask design using FDS for analysis. As an example, a spherical section cap, similar to the top of a containment chamber, discretized with body fitted coordinates in!
to 240 cells, has a surface area error of just 0.37%. The same area discretized into a stairstep mesh has a surface area error of 46%.

The document rightly explains that grid resolution also has a large impact on what geometric features can be modeled. The rectilinear mesh approach in FDS does not allow significantly finer resolution in some areas than in others, which would limit the mesh size while increasing resolution where it is needed, to capture important geometric and flow features. This can be particularly important in terms of resolving small openings in a cask or room. If the pressure drop is not captured accurately, then the evolution of the fire can be highly inaccurate, possibly causing analysts to reach incorrect conclusions about safety.

3) The FDS documentation mentions parallelization, but there is no discussion of scalability of its parallel approach.

4) Grid resolution impact on numerical error is addressed, but not the assumptions underlying the LES method, which requires that the mesh be roughly two orders of magnitude smaller than the largest

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turbulent structures for the approach to be valid. This places very stringent requirements on the mesh resolution, without providing the flexibility of using alternative turbulence modeling approaches.

5) FDS uses a mixture fraction approach for combustion, in which all reactants will eventually burn regardless of temperature. This can be highly unrealistic.

Because some commercially available CFD packages address these issues, this should be covered in the NUREG to better educate the analysts who will be using these tools.

Additionally, the NUREG should establish a methodology for estimating overall simulation uncertainty, accuracy, and bias in results, just as is required for LOCA safety analyses. Ideally, different users using the same tool to solve the same problem will get the same results, within some acceptable variance. How to ensure this is not covered in the NUREG.

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