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From: Doug Carpenter <dcarpenter@csefire.com>
To: <nrcrep@nrc.gov>
Date: Tue, Apr 11, 2006 11:11 AM
Subject: Response from "Comment on NRC Documents"

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

Doug Carpenter (dcarpenter@csefire.com) on Tuesday, April 11, 2006 at 11:06:51

Document_Title: NUREG-1824 EPRI 1011999
Verification and Validation of Selected Fire MOdels for Nuclear Power Plant Applications
Volume 2

Comments: COMMENTS ON DRAFT NUREG-1824 REPORT – VOLUME 2

Page 1-1

- Forth paragraph, second sentence, "were put into effect by" should be replaced with "were developed by".

- Forth paragraph, "Define the model and scenarios..." should be part of the bullet point list.

Page 2-3

- Last sentence ("Chapter 3 discusses...") should be upfront in this section.

- Second sentence, "...evaluate the potential for credible fire scenarios." Consider changing to "...to evaluate the potential hazard associated with credible fire scenarios."

Page 3-1

- Second paragraph, "FDTs is not a model per se, but a set..." Should change to "FDTs is a set of algebraic..." These correlations are considered models, although very simplistic.

Page 3-2

- The first sentence in Section 3.1, should describe the "hot gas layer temperature" as the "average hot gas layer temperature". An important aspect with respect to the limitations of the use of such variables.

- First paragraph of Section 3.1.1 needs additional discussion of other factors that effect temperatures in compartments. An energy balance on the compartment needs to be discussed as well as entrainment into the plume.

- The discussion of mass flow rate is not really relevant to the MQH model, while an energy balance that includes convective losses through opening is relevant. This section needs more of a description of the conditions that the MQH model is trying to model so the user can understand the limitations of the correlation.

- Fourth paragraph of Section 3.1.1, instead of "statistical" perhaps you should refer to the correlation as a "best fit" of dimensionless variables to the data from relevant compartment fire tests.

- Fourth paragraph of Section 3.1.1, second to last sentence. Replace "set" with "located".
- Section 3.1.1, fourth paragraph, I would suggest deleting reference to Walton and Thomas [14].

SISP Review Complete

Template = ADM-013

E-RIDS = ADM-03

Add = M. Talley (MXS3)

This adds nothing new to the section since you have included the original reference to the work.

Page 3-3

- Variables associated with Equation 3-1, Av is the area is really Ao which is the area of the opening and not the total area of the opening.

- Middle of page, "..., and can be used for different construction materials by summing the AT values for the various wall, ceiling, and floor elements." This is incorrect. For different materials, you need to use a weighted approach and summing the AT and the associated hk. Please see Page 122 of Enclosure Fire Dynamics by Quintiere. Need to expand this section to include a description of the correct methodology.

Page 3-4

- The discussion of the thermal penetration time should be the first topic associated with the simplified heat transfer equations. There should also be a brief discussion of "thermally thick" and " thermally thin" to put the thermal penetration time into context. Then discuss the equations associated with each condition.

- Last paragraph, fourth sentence, change "...the material thermal inertia." To "...the thermal inertia of a solid material."

Page 3-5

- Top of page, "Since heat does not pass through such materials,..." should read 'Since heat does not reacily pass through such materials,..."

- First paragraph, fifth sentence, "The thermal response properties (k..." should read "The thermal inertia (k..."

- Section 3.1.2, delete reference to Walton and Thomas [14]. This adds nothing new to the section since you have included the original reference to the work. In addition, the same error associated with Equation 3-6 with the missing AT is in reference [14] and may be the source of the error.

- The equation for K1 is missing AT .

- The list of variables for Equation 3-6 is missing AT also.

- Section 3.1.3, remove cites to references [13] and [14]. These additional references add nothing new.

Page 3-6

- Middle of page, "The above correlation for forced-ventilation fires can be used for different construction materials by summing the AT values for the various wall, ceiling, and floor elements." This is incorrect. For different materials, you need to use a weighted approach and summing the AT and the associated hk. Please see Page 122 of Enclosure Fire Dynamics by Quintiere. Need to expand this section to include a description of the correct methodology.

- Section 3.1.4, "This model is only valid for times up to 2000 seconds." Where did this limitation come from? Need to add a brief discussion as to why this is a valid limitation.

- Section 3.1.4, the same previous discussion of summing the AT hk for specific materials is also valid for this correlation. Need to add a brief discussion here also.

Page 3-7

- Section 3.2.1 should have a more expanded discussion of how Equation 3-10 was derived based on a non-steady implementation of the conservation of mass.

Page 3-8

- Equation 3-10 is not the generalized equation as derived by Yamana and Tanaka. It is the form of the general equation for n = 0 (i.e. for steady state HRR). This should be discussed in this section.

Page 3-10

- First sentence; suggest changing "natural convection" to "natural ventilation".

- Middle of page, suggest changing "forced convection" to "forced ventilation".

Page 3-11

- First sentence, suggest changing "Researchers define flame height as..." to "The flame height is defined as the ..."

- Suggest moving the first sentence to the end of the first paragraph.

- Second paragraph, "Flame height typically depends on whether the flame is laminar or turbulent. In general, laminar flames are short, while turbulent flames are tall." This is not correct. See Figure 4.7 in second edition of Drysdale. Suggest that these two sentences be removed.

Page 3-12

- First sentence, "The above correlations can also be used to determine the length of the flame extension along the ceiling and to estimate radiative heat transfer to objects in enclosures." While there are correlations that can be used to determine flame extension under ceilings, it is not these specific correlations. Also, while the flame height is required to estimate the view factor for some thermal radiant calculations, these flame height correlations do not estimate the radiative heat transfer. Suggest that this sentence be deleted.

- Section 3.4.1, "Chapter 4 presents the flame height correlations for fires burning near walls and corners." Chapter 4 of this document is titled Mathematical and Numerical Robustness. Chapter 4 of which document?

- (2), suggest deleting "...attributed to the combustion."

Page 3-13

- Section 3.5.1; suggest adding a definition of a point source and a discussion of when such an approximation is appropriate (i.e. at distances where local variations in the source do not have a significant impact on the variable being predicted).

- Last paragraph; suggest changing "(e.g. hydrocarbons)" to "(e.g. higher order hydrocarbons)".

- Section 3.5.1; suggest adding a short discussion that the use of Equation 3-18 has shown to have good accuracy as long as it is applied more than two flame diameters from the flame.

Page 3-14

- Bottom of page, suggest deleting "horizontal" from the definition of the variable Af.

Page 3-15

- Section 3.5.2, this correlation/spread sheet was not used for data comparison. Suggest deleting this section.

Page 3-17

- (5), suggest deleting this bullet.

Page 3-18

- Suggest deleting "hypothetical" from the variable list associated with the virtual origin. Suggest it reads "vertical distance of the virtual origin relative to the fire source"

- Last paragraph; suggest adding that the virtual origin is a correction factor necessary because of the introduction of a finite area source in a point source model.

Page 3-20

- (4); suggest replacing "...are more significant than the buoyant forces..." with "...dominate the forces due to buoyancy...".

Page 4-1

- Second paragraph; suggest deleting from "The equations used..." to the end of the paragraph. These two sentences do not seem to add anything new to the discussion.

Page 5-1

- The second paragraph may benefit from a rewording.

- Suggest deleting fourth paragraph. It is not correct and the relevant discussion is included in Section 5.2.

Page 5-7

- Suggest deleting "...all the correlations are stable...".

Page 6-1

- The brief descriptions should include a short description of the materials that make up the floor, walls, and ceiling for each test series. References should be provided that tell the reader where the data came from.

Page 6-2

- Second to last paragraph; suggest deleting "...the researchers..." The sentence should read "For comparison, the following equation for the relative difference between the model and experimental results was used:"

Page 6-3

- Section 6.1; the title is Hot Gas Layer Temperature and Height. This section does not address the height. Need to add discussion associated with Figure A-5.

- Section 6.1, first paragraph; "HGL Height calculations were not evaluated ..." Not true, see Figure A-5.

- ICFMP BE #2, the results for BE 2-3 do not seem to be reproducible using Table A-3 and the appropriate spread sheet calculation. In addition, the relative difference may be artificially inflated since the calculation uses peak differences. The calculations produce a second increasing temperature trend that seems to be associated with a change from

Page 6-4

- Top of page; "The model calculations were performed with mineral wool as the wall material because it is much less conductive than steel and results in more realistic model results." The most appropriate approach is to treat the wall as a composite material. The thermal inertia for each individual wall lining. Suggest you use recalculate with a thermal inertia weighted for material thickness as appropriate for a composite wall. This should show an under-prediction of the temperature rise, which is what was generally found by Beyer. This under-prediction increases with increasing temperature rise (see Beyler reference).

- ICFMP BE #3, the explanation related to the use of the Method of Beyler and leakage rates is probably not the critical difference. More likely, the specified thermal inertia is the source. The range of thermal inertia over all the tests series differ at least by an order of magnitude, while this is not be the case for the series of tests used to develop the correlations. So far, the NBS test series seems to provide the best agreement with respect to the trend and relative difference. The thermal inertia of the interior lining was 0.012, which is on the same order of magnitude as the thermal inertias in the tests used to develop the MQH correlation. I would suggest that this discussion be added in the relevant sections when discussing the relative differences.

- ICFMP BE #4, I would suggest providing a more detailed explanation as to why the ratio of fire size to compartment size can affect the comparisons.

- ICFMP BE #5, differences are likely not the result of a smaller fire, but because of the differences in wall materials as mentioned in the previous comments.

- FM/SNL, I would suggest that a more detailed description of the configuration of the ventilation system be provided with a discussion of how this may have contributed to the temperature differences. For example, could system configuration promote mixing that would destroy the two-layer assumption used in the correlations? This may explain the lower temperatures experienced in the tests.

- NBS Multi-Room, I would suggest that a more detailed explanation be provided with respect to the alternative method of data reduction could have affected the comparison results.

Page 6-5

- You should be able to reproduce the plume correlation results if the experiments are conducted under the same conditions as the experiments used to develop the correlations. I would suggest emphasizing that these correlations are being used to extrapolate the results in different conditions as opposed to a comparison of a different set of data that is similar to the data used to develop the correlation. Thus, it may not be the correlations that are creating the difference, but the application to a different set of conditions.

Page 6-7

- Flame Height, same as previous comment with respect to plumes.

- Is there a figure for the flame height results? If not, for consistency, there should be.

- Section 6.4, "As described in Chapter 3..." Chapter 3 of which document?

Page 6-8

- "This spreadsheet uses Drysdale's equation for calculating the radiant heat flux." While this equation is described in Drysdale's book, I believe it may not be directly attributed to Drysdale.

Page 7-2

- It is unclear if the section titled Bibliography contain references that were used in the developrnent of this report or if it contains additional reading materials. May want to delete this section.

Page A-2

- Third paragraph, "Also, the reduction method used to estimate experimental layer height from thermocouple three does not apply to closed compartments." The rationale for not including HGL laye· height is at the very least unclear to the reader. This should be better explained or reevaluated to insu·e it is a valid rationale.

Page A-4

- Figure A-1 does not seem to be reproducible using the provided inputs and the appropriate spreadsheet. I would suggest rechecking this plot.

- Figure A-1, I would suggest that the second peak is artificial due to a change in how the heat transfer coefficient is calculated within the spreadsheet. The thermal penetration time would not predict the transient heat transfer to the walls over time. This is consistent with the experimental data that does not show a similar trend. The introduction of the second peak increases the relative difference. I would suggest showing two plots for the "thermally thick" and the "thermally thin" cases. If this is not possible, then a detailed discussion of this needs to be provided in the report.

Page A-3

- Figure A-2, I would suggest pulling out Test 4 and Test 10 and place them into a new figure that corresponds to Table A-5.

- Figures A-2, A-3, and A-4 should correspond to Tables A-3, A-4, and A-5.

Page A-10

- There are no references in the text for Figure A-5 or any other figures. Need to provide references to all figures in the text of the report.

- "...only depict the early times of the test..." Figure A-5 shows data for the experiments that extends past the height of the opening. I would suggest reducing the time scale of the plots.

- It is not clear why a relative difference comparison was not calculated for this data. I would suggest that this should be calculated and included in the report.

Page A-11

- FigureA-5, the correlations assume no transport lag of the smoke to the ceiling or a filling time for large volumes before the layer develops and descends. This phenomenon is captured in the experimental data, but not the correlations. Thus, there would be a shift in time of the model results when compared to the experimental results. Currently, it shows an over prediction, while a time shift may show an under-prediction. There are correlations developed by Mowrer that may be useful. At the very least, there needs to be a discussion of this in the text.

Page A-13

- Figure A-6, the trend looks good, but again there is a time lag for the experimental data that is not captured in the correlation. This needs to be explained in the report.

- Section A.1.4, the HRR was also an order of magnitude less than in BE #4.

Page A-19

- Section A.1.7., seems to define these variables differently than in other sections. I would suggest reviewing the definitions and calculations to correct any inconsistenty.

Page A-20

- A-2, no references to figures in text.

Page A-22

- Figure A-10, need to discuss that the experimental temperatures are most likely higher because of the development of the upper layer that is not accounted for in the plume correlations.

Page A-28

- Table A-15, this correlation is only valid at distances greater than an L/D of 2.5. This table and Figure A-14 should be screened to determine which data meets the L/D criteria.

Overall Comments

- Need to provide a discussion of the results with respect to the wall lining materials used in the tests versus those used in the tests to develop the correlation.

- Need to provide references of where the thermal properties were obtained.

- If two correlations were included in a spreadsheet, the report only reports the results of one of the correlations. I would suggest redoing the relevant plots to include the results from the other correlation.

- There is some error introduced by imposing a constant HRR when the experimental HRR is changing with time. I would suggest including a discussion of this in the relevant sections of the report.

- There should also be a discussion of the how the spreadsheets handle the thermal penetration time and the heat transfer coefficient. The calculation method usually requires the use of the "thermally thin" case or the "thermally thick" case throughout the calculation. The spreadsheets switch how the heat transfer coefficient is calculated during a transient simulation. This approach was never intended to predict the temperature near this transition point. This approach creates artificially higher temperatures and a larger relative difference that needs to be discussed.

- It may be useful to characterize in the report the ratio of the size of the fire to the volume/height of the compartment for the experimental tests as well as for the tests used to develop the temperature correlations. This may be helpful in the discussion of why there is a significant difference in the relative difference.

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