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CONTAIN Assessment of the NUPEC Mixing Experiments

Supplement 1

Douglas W. Stamps, Kenneth K. Murata

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CONTAIN Assessment of the NUPEC Mixing Experiments*
Supplement 1

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Abstract

In the original report (Reference 1), to which this report is a supplement, the results of CONTAIN code calculations were presented for five thermal-hydraulic experiments performed in the NUPEC 1/4-scale model containment, including the International Standard Problem ISP-35. In the original report, calculated helium concentrations were presented per NUPEC's specifications for ISP-35. In contrast, this supplemental report presents the helium concentrations on a conventional dry basis, which is physically consistent with the gas chromatography data. These conventionally defined dry helium concentrations are compared with the previously reported results and are found to exhibit trends that are more consistent with measured data. While agreement between the predicted results and data is substantially improved in general for the M-8-1 experiment using these helium concentrations as opposed to the ISP-35 specifications, general improvement in agreement is not observed in all cases.

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The authors would like to thank R. Gasser and R. Griffith for their valuable technical comments. Special thanks are extended to A. Notafrancesco for his support and the opportunity to perform this work.

1.0 BACKGROUND

Several series of tests were performed in the NUPEC 1/4-scale model containment [2] to investigate the thermal hydraulics of coinjecting helium and steam into a containment with and without the operation of water sprays. The tests simulated the thermal hydraulics of a severe accident in a nuclear power plant under simplified conditions in which helium (as a nonflammable substitute for hydrogen) and steam were released into a containment. The CONTAIN code was used to calculate the thermal hydraulic conditions in five NUPEC experiments: M-4-3, M-5-5, M-7-1 (International Standard Problem ISP-35), M-8-1, and M-8-2. These calculated results were compared with the data in the original report [1].

In these experiments, helium concentrations were measured using gas chromatography. Gas samples were extracted from the model containment through sample lines. Most of the sampling was done at elevated temperatures and pressures. The gas samples were cooled, dried by using an in-line desiccant, and analyzed in the gas chromatograph at ambient pressure. The resulting helium concentration data were reported on a dry basis, that is, the molar concentration of helium was determined for the dry helium-air mixtures.

As part of the International Standard Problem ISP-35, NUPEC specified that the calculated helium concentrations for a given compartment be reported according to the following formula [2]

$$C_{He} = \frac{m_{He}RT_0}{VP_0} \times 100 \quad (1-1)$$

In this equation, C_{He} is the helium concentration, m_{He} is the helium mass in the compartment, R is the gas constant for helium with respect to mass ($R=2.077$ kJ/kg-K), T_0 is the standard state temperature (273.15 K), P_0 is the standard state pressure (101.325 kPa), and V is the total compartment volume. Helium concentrations for tests M-4-3, M-5-5, M-7-1, M-8-1, and M-8-2 were calculated from CONTAIN output using the above prescription and reported in [1].

Unfortunately, the above prescription causes the reported dry-basis helium concentrations to depend erroneously on the standard state temperature and pressure. Within the ideal gas approximation, the helium concentrations determined under the conditions in the gas chromatograph are the same as the conventional dry helium concentrations in each compartment at its temperature and pressure and should not depend on what is used for the standard temperature and pressure. Such dry-basis helium concentrations are obtained from the equation

$$C_{He, Dry} = \frac{C_{He, Wet}}{1 - X_{H_2O}} \quad (1-2)$$

In this equation, $C_{He, Dry}$ and $C_{He, Wet}$ are the helium concentrations on a dry and wet basis, respectively, and X_{H_2O} is the steam mole fraction. The wet-basis helium concentration is the actual molar concentration of helium in the helium-air-steam mixture. Note that the ideal gas approximation is quite good for noncondensing gases under typical containment conditions,

but steam may depart appreciably from ideality. However, under the test conditions the error produced by the ideal gas assumption is less than 1%.

The dry-basis helium concentrations obtained from the CONTAIN calculations were recalculated using Equation (1-2), and these new results are reported here. These new results are physically consistent with the gas chromatography data and should be used for comparisons with the data instead of the results given in the original report. Other results besides the helium concentrations, such as the gas temperature and pressure and the wall temperature, have not changed from the results presented in the original report. Accordingly, we limit our discussion in this report to comparisons between the recalculated dry helium concentrations and the original concentrations and the data. All other comparisons should be taken from the original report.

2.0 RESULTS

The results of the CONTAIN predictions for five NUPEC tests, M-4-3, M-5-5, M-7-1, M-8-1, and M-8-2, were presented in the original report [1]. Two different versions of CONTAIN and two different nodalization schemes were used in that study. The CONTAIN 1.12W version was used to illustrate the behavior of the old CONTAIN flow solver, which uses an average-density formulation for the treatment of gas gravitational heads. CONTAIN 1.12XBG was used to illustrate the behavior of the new hybrid flow solver that was implemented officially in CONTAIN 2.0 [3]. The latter uses either a donor cell formulation or the average-density formulation depending on a stability criterion [4]. The two nodalizations use 28 cells and 35 cells, respectively. In the 28-cell nodalization, each cell corresponds to a compartment, or room. In the 35-cell nodalization some of the compartments, such as the dome and pressurizer rooms, were subdivided further. In such compartments, when variations within the compartment were significant, the most appropriate cell to compare with the data was used. The results for each of the four types of variables of interest (gas and wall temperatures, helium concentrations, and gas pressures) were presented for three vertical columns of rooms that were representative of the inner, middle, and outer regions of the facility. In the original report, helium concentrations were calculated from Eq. (1-1), as specified by NUPEC, and compared with the data. In the present report, dry helium concentrations were calculated from Eq. (1-2) by post-processing the original CONTAIN output files. No new CONTAIN runs were necessary. Therefore, all of the previous conditions and limitations of the calculations discussed in [1] are applicable.

The new results are presented in the following manner: the best-estimate results for each of the five NUPEC tests are presented first, and then the results from the sensitivity studies. This order follows that of the original report [1], in which the best-estimate results were presented in Chapter 3, and results from the sensitivity studies were presented in Chapter 4. To help the reader understand the nature of the experiments, a brief description of each test is also provided here. Since comparisons between the calculated results and the data were discussed in detail in the original report, the discussions here are largely limited to a comparison of the recalculated and original helium concentrations. Note that each figure in the present report corresponds to one in the original, and the figure cross-references are given in Table 2-1. Note also that the figures here display both the recalculated and original helium concentrations, as well as the experimental data.

2.1 CONTAIN Assessment of NUPEC Test M-4-3

The gas pressure at the beginning of test M-4-3 was approximately 101 kPa, and the wall and gas temperatures were at room temperature (approximately 27°C to 32°C). At the beginning of the experiment, helium and steam were coinjected into one of the four steam generator foundation compartments (compartment 8). Water sprays were not used in this experiment. The helium and steam mass flow rates were constant at 0.027 kg/s and 0.33 kg/s, respectively, during the 30-minute injection period. It was assumed that helium and saturated steam were injected into the containment at 20°C and 110°C, respectively.

The best-estimate predictions for the helium concentrations are shown in Figures 2.1-2.3. Figure 2.1 shows the results for the steam generator foundation compartment 8 and for the rooms directly above it. Figure 2.2 shows the results for a vertical column of outer rooms, including the lower general compartment 4 and the rooms directly above it. Figure 2.3 shows the results for a number of rooms in the center of the containment.

Note that the recalculated helium concentrations follow the trends in the data better. For example, in Figures 2.1 and 2.2, the rise in the recalculated helium concentrations begins to flatten out at late times, which is consistent with the data. In contrast, the slopes of the original helium concentrations are steeper and depart from the data. However, while this trend is captured better by the recalculated concentrations, it is not clear that the agreement overall has improved.

2.2 CONTAIN Assessment of NUPEC Test M-5-5

The gas pressure at the beginning of test M-5-5 was approximately 101 kPa and the wall and gas temperatures were approximately 7°C to 17°C. At the beginning of the experiment, helium was injected into steam generator foundation compartment 8, and water sprays were injected into the hemispherical region of the dome (compartment 25). The helium and spray water were injected at a constant mass flow rate of 0.027 kg/s and 19.4 kg/s, respectively, during the 30-minute injection period. It was assumed that both the helium and water sprays were injected into the containment at 19°C. The spray water was injected through 21 hollow-cone nozzles located in the hemispherical region of the dome. The average droplet diameter was assumed to be 0.75 mm.

The best-estimate predictions for the helium concentrations are shown in Figures 2.4-2.6. Figure 2.4 shows the results for the steam generator foundation compartment 8, which is the source compartment, and the rooms directly above it. Figure 2.5 shows the results for a vertical column of outer rooms including the lower general compartment 4 and the rooms directly above it. Figure 2.6 shows the results for a number of rooms in the center of the containment.

The data in test M-5-5 provide an excellent opportunity to compare the recalculated and original helium concentrations. Since steam was not injected in this test, the wet and dry helium concentrations were approximately the same, and there is little ambiguity in what the sampled concentrations should have been. According to Eq. (1-1), the dry helium concentration should be directly proportional to the mass of helium present in a compartment. Since the mass injection rate of helium was also constant in this test, this means that the predicted dry concentrations should on the average increase linearly with time. If we further assume that the relative distribution of helium did not change rapidly with time after an initial mixing period, the predicted local helium concentrations should also increase linearly with time. This late-time linear behavior is exhibited by the original results, as shown for example in Figure 2.4. In contrast, the recalculated helium concentrations tend to exhibit linear behavior at intermediate times but then flatten out at late times. This departure from linear behavior at late times is more consistent with the data. Note that the direct proportionality with mass implied by Equation (1-1) cannot be correct in general. Take the case, for example, of a compartment that has

only helium and steam in it. In this case the dry concentration should be 100% regardless of the mass of helium in the compartment.

2.3 CONTAIN Assessment of NUPEC Test M-7-1

The gas pressure at the beginning of test M-7-1 was 139.7 kPa and the wall and gas temperatures were approximately 65°C to 70°C. At the beginning of the experiment, helium and steam were coinjected into the steam generator foundation compartment 8, and water sprays were injected into the hemispherical region of the dome (compartment 25). The helium mass flow rate increased linearly from zero to 0.03 kg/s over the first 15 minutes of the experiment and then decreased linearly to zero during the next 15 minutes. The steam mass flow rate decreased linearly from 0.08 kg/s to 0.03 kg/s during this 30-minute period. It was assumed that helium and saturated steam were injected into the containment at 14°C and 110°C, respectively. Water sprays were injected at a constant mass flow rate of 19.4 kg/s for the same 30-minute period at a constant temperature of 40°C. The spray water was injected through 21 hollow-cone nozzles located in the hemispherical region of the dome. The average droplet diameter was 0.75 mm.

The best-estimate predictions of the helium concentrations are shown in Figures 2.7-2.9. Figure 2.7 shows the results for steam generator foundation compartment 8, and the rooms directly above it. Figure 2.8 shows results for a vertical column of outer rooms, consisting of the lower general compartment 4 and the rooms directly above it. Figure 2.9 shows results for a number of rooms in the center of the containment. In general, under the conditions in this test, there is little difference between the recalculated and original helium concentrations.

2.4 CONTAIN Assessment of NUPEC Test M-8-1

The gas pressure in the facility at the beginning of test M-8-1 was approximately 101 kPa and the wall and gas temperatures were at room temperature (approximately 7°C to 10°C). At the beginning of the experiment, helium and steam were coinjected into the pressurizer compartment 22. Water sprays were not used in this experiment. The helium and steam mass flow rates were constant at 0.027 kg/s and 0.33 kg/s, respectively, during the 30-minute injection period. It was assumed that helium and saturated steam were injected into the containment at 10°C and 108°C, respectively.

The best-estimate predictions for the helium concentrations are shown in Figures 2.10-2.12. Figure 2.10 shows the results for steam generator foundation compartment 8 and the rooms directly above it. Figure 2.11 shows the results for a vertical column of outer rooms, consisting of the lower general compartment 4 and the rooms directly above it. Figure 2.12 shows results for a number of rooms in the center of the containment, including the lower pressurizer compartment 16, which was a dead-ended compartment, and the upper pressurizer compartment 22, which was the source compartment. The recalculated helium concentrations with the hybrid flow solver and 35-cell nodalization agree substantially better with the data than the original ones. This is shown, for example, in Figure 2.10.

Despite this improved agreement, the agreement between the data and recalculated results is still not very good in the pressurizer compartments. The data in Figure 2.12 show that the final

helium concentrations in these compartments were approximately 80%. In contrast, the recalculated final dry helium concentration in the upper compartment is predicted to be 100%. This implies that the only other gas that could have been present in the room at late time was steam, which is a plausible result. The lower pressurizer compartment 16 was dead-ended at the bottom and communicated only with the upper pressurizer compartment 22 through a small opening with an area of 0.55 m^2 . Steam and helium injected into the upper compartment escaped into the rest of the containment through three relatively small openings with a total area of 0.66 m^2 at the top of the compartment. The helium sample tube in this compartment was approximately 1 m lower than the lowest of these three openings. At the given steam flow rate, it is unlikely that air could have entered this compartment from the openings at the top. In fact, a volume of steam equal to the volume of the compartment was injected approximately every minute. It seems reasonable that the air initially present would have been flushed out of the compartment after a few minutes of steam injection. The data show that the helium concentration in the upper compartment reached a nearly steady-state condition after approximately 6 to 7 minutes, a period consistent with the steam flow rate. Thus, the reason for the discrepancy between the recalculated concentrations and the data is not known.

The data also show that the helium concentration in the lower compartment eventually reached that in the upper compartment after 17 to 18 minutes. This is also reasonable since the opening between the two compartments was so small. In contrast, the recalculated concentrations predict much too low a helium concentration in the lower compartment. This underprediction may in part reflect a shortcoming of the nodalization, namely that it did not permit recirculating flow between the two compartments. In the CONTAIN calculation, only a small amount of helium was exchanged between the two compartments through pressurization effects. Despite the relatively poor agreement in the pressurizer room concentrations, the concentrations in the other parts of the containment apparently are not greatly affected, because of the relatively small pressurizer room volumes.

2.5 CONTAIN Assessment of NUPEC Test M-8-2

The gas pressure at the beginning of test M-8-2 was 142.4 kPa and the wall and gas temperatures were approximately 67°C to 72°C . At the beginning of the experiment, helium and steam were coinjected into the upper pressurizer compartment 22 while water sprays were injected into the hemispherical region of the dome (compartment 25). The helium mass flow rate increased linearly from zero to 0.03 kg/s over the first 15 minutes and then decreased linearly to zero during the next 15 minutes. The steam mass flow rate decreased linearly from 0.08 kg/s to 0.03 kg/s during this 30-minute period. It was assumed that helium and saturated steam were injected at 10°C and 104°C , respectively. Water sprays were injected at a constant mass flow rate of 19.4 kg/s for the same 30-minute period at a constant temperature of 40°C . The spray water was injected through 21 hollow-cone nozzles located in the hemispherical region of the dome. The average droplet diameter was assumed to be 0.75 mm.

The best-estimate predictions for the helium concentrations are shown in Figures 2.13-2.15. Figure 2.13 shows the results for the steam generator foundation compartment 8, and the rooms directly above it. Figure 2.14 shows the results for a vertical column of outer rooms, consisting of the lower general compartment 4 and the rooms directly above it. Figure 2.15

shows the results for a number of rooms in the center of the containment, including the source compartment 22 and the lower pressurizer compartment 16. With the exception of the dome at late times, only small differences were found between the recalculated and original helium concentrations.

2.6 Sensitivity Studies

Two types of sensitivity studies were discussed in Reference 1. The first set of calculations systematically examined the effects of using the two different code versions and nodalization schemes that are discussed in the introductory Section 2.0. Comparisons in this regard were made with respect to NUPEC tests M-4-3, M-7-1, M-8-1, and M-8-2. The recalculated helium concentrations for these tests are compared with the original results in Figures 2.16-2.23. The second set of calculations examined different techniques for modeling the thermal hydraulics of the water sprays. The recalculated and original helium concentrations for the spray sensitivity cases are shown in Figure 2.24.

Because of the number of results for the four tests, comparisons between the different code versions and nodalization schemes in the first set of calculations were primarily limited to the dome compartment. The dome was chosen since it constituted 71% of the total containment volume. In most tests, the differences between code versions and nodalization schemes were not large enough to merit a more extensive discussion. However, test M-8-1 differed in that the midpoint injection location and the absence of sprays resulted in highly stratified conditions. The hybrid flow solver as implemented in CONTAIN 1.12XBG was clearly superior to the old flow solver in predicting such conditions. Therefore, other rooms in addition to the dome were used to illustrate the advantages. Additional discussion of the ability of the hybrid flow solver to predict test M-8-1, as well as a general discussion of CONTAIN's ability to predict stratified flows using the hybrid flow solver, is given in [4].

The comparisons between the recalculated and original helium concentrations in the dome are given in Figures 2.16-2.18 and 2.23. The most pronounced differences between the two sets of helium concentrations occur in test M-8-1 with the hybrid flow solver and the 35-node scheme and in test M-8-2. Figures 2.19-2.22 show helium concentrations for a middle column of rooms in test M-8-1 for all four possible combinations of code versions and nodalization schemes. The recalculated helium concentrations are in general in better agreement with the data than the original ones.

Test M-7-1 was designated as an International Standard Problem (ISP-35). Consequently, this test was studied more extensively than most of the other tests. The second set of sensitivity calculations examines different techniques for modeling the thermal hydraulics of water sprays. The cases shown in Figure 2.24 are as follows: in best-estimate case 1, sprays were assumed to drive a large convection loop which concentrated the water drops in the center of the facility and enhanced wall-to-gas heat transfer; in case 2, the spray pattern was based on that expected for unconfined geometries and included impingement of water sprays on the containment wall; in case 3, a uniform spray pattern in the dome was assumed with no spray impingement or forced convection; and in case 4, the same assumptions as in case 3 were used but the nodalization was changed to the 28-cell scheme. Figure 2.24 shows that in all these

cases there are no significant differences between the recalculated and original helium concentrations.

Table 2-1 Cross-references between the figures in the original report [1] and those in the present supplemental report.

Original Figure in Reference 1	Figure in Present Supplement
Figure 3.1	Figure 2.1
Figure 3.2	Figure 2.2
Figure 3.3	Figure 2.3
Figure 3.9	Figure 2.4
Figure 3.10	Figure 2.5
Figure 3.11	Figure 2.6
Figure 3.20	Figure 2.7
Figure 3.21	Figure 2.8
Figure 3.22	Figure 2.9
Figure 3.28	Figure 2.10
Figure 3.29	Figure 2.11
Figure 3.30	Figure 2.12
Figure 3.36	Figure 2.13
Figure 3.37	Figure 2.14
Figure 3.38	Figure 2.15
Figure 4.1	Figure 2.16
Figure 4.5	Figure 2.17
Figure 4.9	Figure 2.18
Figure 4.13	Figure 2.19
Figure 4.14	Figure 2.20
Figure 4.15	Figure 2.21
Figure 4.16	Figure 2.22
Figure 4.17	Figure 2.23
Figure 4.22	Figure 2.24

Figure 2.1. Comparison between the CONTAIN predictions and data for helium concentrations in compartments 8, 15, 21, and 25 in NUPEC test M-4-3. Thick lines represent recalculated dry helium concentrations while the thin lines represent helium concentrations based on NUPEC specifications and reported in [1].

Figure 2.2. Comparison between the CONTAIN predictions and data for helium concentrations in compartments 4, 12, and 25 in NUPEC test M-4-3. Thick lines represent recalculated dry helium concentrations while the thin lines represent helium concentrations based on NUPEC specifications and reported in [1].

Figure 2.3. Comparison between the CONTAIN predictions and data for helium concentrations in compartments 1, 2, 16, 19, and 22 in NUPEC test M-4-3. Thick lines represent recalculated dry helium concentrations while the thin lines represent helium concentrations based on NUPEC specifications and reported in [1].

Figure 2.4. Comparison between the CONTAIN predictions and data for helium concentrations in compartments 8, 15, 21, and 25 in NUPEC test M-5-5. Thick lines represent recalculated dry helium concentrations while the thin lines represent helium concentrations based on NUPEC specifications and reported in [1].

Figure 2.5. Comparison between the CONTAIN predictions and data for helium concentrations in compartments 4, 12, and 25 in NUPEC test M-5-5. Thick lines represent recalculated dry helium concentrations while the thin lines represent helium concentrations based on NUPEC specifications and reported in [1].

Figure 2.6. Comparison between the CONTAIN predictions and data for helium concentrations in compartments 2, 16, 19, and 22 in NUPEC test M-5-5. Thick lines represent recalculated dry helium concentrations while the thin lines represent helium concentrations based on NUPEC specifications and reported in [1].

Figure 2.7. Comparison between the CONTAIN predictions and data for helium concentrations in compartments 8, 15, 21, and 25 in NUPEC test M-7-1. Thick lines represent recalculated dry helium concentrations while the thin lines represent helium concentrations based on NUPEC specifications and reported in [1].

Figure 2.8. Comparison between the CONTAIN predictions and data for helium concentrations in compartments 4, 12, and 25 in NUPEC test M-7-1. Thick lines represent recalculated dry helium concentrations while the thin lines represent helium concentrations based on NUPEC specifications and reported in [1].

Figure 2.9. Comparison between the CONTAIN predictions and data for helium concentrations in compartments 2, 16, 19, and 22 in NUPEC test M-7-1. Thick lines represent recalculated dry helium concentrations while the thin lines represent helium concentrations based on NUPEC specifications and reported in [1].

Figure 2.10. Comparison between the CONTAIN predictions and data for helium concentrations in compartments 8, 15, 21, and 25 in NUPEC test M-8-1. Thick lines represent recalculated dry helium concentrations while the thin lines represent helium concentrations based on NUPEC specifications and reported in [1].

Figure 2.11. Comparison between the CONTAIN predictions and data for helium concentrations in compartments 4, 12, and 25 in NUPEC test M-8-1. Thick lines represent recalculated dry helium concentrations while the thin lines represent helium concentrations based on NUPEC specifications and reported in [1].

Figure 2.12. Comparison between the CONTAIN predictions and data for helium concentrations in compartments 1, 2, 16, 19, and 22 in NUPEC test M-8-1. Thick lines represent recalculated dry helium concentrations while the thin lines represent helium concentrations based on NUPEC specifications and reported in [1].

Figure 2.13. Comparison between the CONTAIN predictions and data for helium concentrations in compartments 8, 15, 21, and 25 in NUPEC test M-8-2. Thick lines represent recalculated dry helium concentrations while the thin lines represent helium concentrations based on NUPEC specifications and reported in [1].

Figure 2.14. Comparison between the CONTAIN predictions and data for helium concentrations in compartments 4, 12, and 25 in NUPEC test M-8-2. Thick lines represent recalculated dry helium concentrations while the thin lines represent helium concentrations based on NUPEC specifications and reported in [1].

Figure 2.15. Comparison between the CONTAIN predictions and data for helium concentrations in compartments 1, 2, 16, 19, and 22 in NUPEC test M-8-2. Thick lines represent recalculated dry helium concentrations while the thin lines represent helium concentrations based on NUPEC specifications and reported in [1].

Figure 2.16. Comparison between the dome helium concentration data of NUPEC test M-4-3 and the CONTAIN predictions, using two different code versions and nodalizations. Thick lines represent recalculated dry helium concentrations while the thin lines represent helium concentrations based on NUPEC specifications and reported in [1].

Figure 2.17. Comparison between the dome helium concentration data of NUPEC test M-7-1 and the CONTAIN predictions, using two different code versions and nodalizations. Thick lines represent recalculated dry helium concentrations while the thin lines represent helium concentrations based on NUPEC specifications and reported in [1].

Figure 2.18. Comparison between the dome helium concentration data of NUPEC test M-8-1 and the CONTAIN predictions, using two different code versions and nodalizations. Thick lines represent recalculated dry helium concentrations while the thin lines represent helium concentrations based on NUPEC specifications and reported in [1].

Figure 2.19. Comparison between the CONTAIN predictions and data for helium concentrations in compartments 8, 15, 21, and 25 in NUPEC test M-8-1. The CONTAIN 1.12W code version and the 28-node scheme were used. Thick lines represent recalculated dry helium concentrations while the thin lines represent helium concentrations based on NUPEC specifications and reported in [1].

Figure 2.20. Comparison between the CONTAIN predictions and data for helium concentrations in compartments 8, 15, 21, and 25 in NUPEC test M-8-1. The CONTAIN 1.12XBG version and the 28-node scheme were used. Thick lines represent recalculated dry helium concentrations while the thin lines represent helium concentrations based on NUPEC specifications and reported in [1].

Figure 2.21. Comparison between the CONTAIN predictions and data for helium concentrations in compartments 8, 15, 21, and 25 in NUPEC test M-8-1. The CONTAIN 1.12W version and the 35-node scheme were used. Thick lines represent recalculated dry helium concentrations while the thin lines represent helium concentrations based on NUPEC specifications and reported in [1].

Figure 2.22. Comparison between the CONTAIN predictions and data for helium concentrations in compartments 8, 15, 21, and 25 in NUPEC test M-8-1. The CONTAIN 1.12XBG version and the 35-node scheme were used. Thick lines represent recalculated dry helium concentrations while the thin lines represent helium concentrations based on NUPEC specifications and reported in [1].

Figure 2.23. Comparison between the dome helium concentration data of NUPEC test M-8-2 and the CONTAIN predictions, using two different code versions and nodalization schemes. Thick lines represent recalculated dry helium concentrations while the thin lines represent helium concentrations based on NUPEC specifications and reported in [1].

Figure 2.24. Comparison of the predicted results for the dome helium concentration using different methods for treating the water spray flow pattern in the facility. A description of each case is given in Section 2.6. Thick lines represent recalculated dry helium concentrations while the thin lines represent helium concentrations based on NUPEC specifications and reported in [1].

3.0 SUMMARY

This supplemental report describes an alternative approach for determining the predicted helium concentrations in NUPEC tests M-4-3, M-5-5, M-7-1, M-8-1, and M-8-2, which were previously analyzed in the original companion report [1]. In that report the predicted helium masses in each compartment were converted to helium concentrations per NUPEC's specifications for test M-7-1 (ISP-35). Such masses were converted to concentrations according to Eq. (1-1), which was supposed to reflect the process required to prepare the gas samples for analysis by gas chromatography.

The gas chromatograph measured the concentration of helium in dried helium-air mixtures. Within the ideal gas approximation, the concentration of helium in a dry sample analyzed by the gas chromatograph at ambient temperature and pressure should be the same as the concentration of helium in the containment at elevated temperature and pressure, provided the steam is ignored when that concentration is calculated from the gas inventory. Dry-basis concentrations that are physically consistent with the gas chromatography data are therefore obtained by using Eq. (1-2).

All of the original results involving helium concentrations in [1] were recalculated using this equation, and the new results have been presented here. The recalculated values should be used instead of those in the original report. No new CONTAIN runs were performed so that all of the previous conditions and limitations on the calculations are still valid.

The recalculated dry helium concentrations have been compared with the original results and with the data to determine the impact of the changes. The recalculated concentrations show improved agreement with certain trends in the data. For example, the initial rise in the recalculated dry helium concentrations in test M-5-5 tends to flatten out with time in a manner similar to that observed in the data, whereas the original results show a more linear increase. In addition, in test M-8-1, which exhibited highly stratified conditions, the recalculated concentrations with the hybrid flow solver and 35-node scheme agree significantly better with the data than the original results. However, although significant improvement in the agreement between the predicted results and the data is apparent in some cases, such improvement was not found in all cases.

4.0 REFERENCES

1. Stamps, D. W., "CONTAIN Assessment of the NUPEC Mixing Experiments," SAND94-2880, Sandia National Laboratories, Albuquerque, NM, August 1995.
2. "Final Comparison Report on ISP-35: NUPEC Hydrogen Mixing and Distribution Test (Test M-7-1)," OECD/GD(95)29, NEA/CSNI/R(94)29, Organization for Economic Cooperation and Development (OECD), Paris, France, December 1994.
3. Murata, K. K., et al., "Code Manual for CONTAIN 2.0: A Computer Code for Nuclear Reactor Containment Analysis," NUREG/CR-6533, SAND97-1735, Sandia National Laboratories, Albuquerque, NM, December 1997.
4. Murata, K. K. and Stamps, D. W., "Development and Assessment of the CONTAIN Hybrid Flow Solver," SAND96-2792, Sandia National Laboratories, Albuquerque, NM, November 1996.

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