

detailed information about the room contents, and there is much greater uncertainty in the total heat release rate as the fire spreads from object to object.

Validation studies of FDS prior to the Investigation were aimed more on design applications than reconstructions. The reason is that design applications usually involve prescribed fires and demand a minimum of thermophysical properties of real materials. Transport of smoke and heat is the primary focus, and measurements can be limited to well-placed thermocouples, a few heat flux gauges, gas samplers, etc. Phenomena of importance in forensic reconstructions, like second item ignition, flame spread, vitiation effects, and extinction, are more difficult to model and more difficult to study with well-controlled experiments. Uncertainties in material properties and measurements, as well as simplifying assumptions in the model, often force the comparison between model and measurement to be qualitative at best. Nevertheless, current validation efforts, including those conducted for the Investigation, are moving in the direction of these more difficult issues.

4.3 FDS ACCURACY FOR FIRES OF KNOWN HEAT RELEASE RATE

The compartment spray burner fire tests described in Section 3.4.3 were designed to assess the accuracy of the fire model's predictions for scenarios in which the heat release rate (HRR) of the fire was prescribed. It was necessary to assess the basic transport algorithms within the model with calculations where the source of mass and energy was known before embarking on more complicated simulations of entire furnished compartments burning. The compartment was heavily instrumented so that all of the energy from the fire could be accounted for and reported in terms of conductive losses to walls, convective flux through openings, etc. Figure 4-1 displays a snapshot from an animation of one of the simulations. With the large number of measurements, it was possible to go beyond the traditional point-by-point comparison and discover why the model either over-predicted or under-predicted a given measurement. It was possible to compare the transport of energy, starting with the combustion of fuel, and ending with effluent exiting into a large hood. Based on these integrated quantities, discrepancies in heat flux and gas concentration predictions could be tied to errors in the overall energy budget, allowing for an assessment of the accuracy of various components within the model.

Prior to each of the tests, a prediction of the thermal environment in the compartment was determined using FDS. Following the tests, the prediction and experimental results were compared. Figure 4-2 compares measured and predicted gas temperatures at various elevations within the room during Test 5, in which an insulated steel truss section was exposed to a 3 MW fire for roughly 50 min. The complete set of test results and their analysis can be found in NIST NCSTAR 1-5E. The analysis of the data showed that FDS predictions of the compartment gas temperatures, major species concentrations, heat fluxes, wall temperatures, and flow velocities were within 10 percent of the measurements, an uncertainty that could be traced to the uncertainty in the measured heat release rate, an input parameter for the model. Exceptions were for near-field measurements of heat flux and wall temperature in the plume impingement region on the ceiling, and at the base of the fire on the floor. These predictions were within 20 percent of the experimental measurements and were largely due to simplifications of the spray burner geometry and in-flame fire physics. For the simulations of the WTC fires, the objective was to predict the upper layer gas temperatures from fires spread over a large area. Discrepancies in near-field phenomena were not expected to affect the large scale predictions significantly.