Comparison of Fire Model Predictions with Experiments Conducted in a Hangar with a ceiling Height of 14.9 m

W. D. Davis, K. A. Notarianni, and K. B. McGrattan
Building and Fire Research Laboratory
National Institute of Standards and Technology, USA

The purpose of this study is to examine the predictive capabilities of fire models using the results of two fire experiments conducted in an aircraft hangar with a ceiling height of 14.9 m (49 ft). The fire experiments were conducted at Barbers Point, Hawaii by NIST in conjunction with the United States Navy [1]. This study is designed to investigate fire model applicability at a ceiling height where only a limited amount of experimental data is available. Some earlier efforts to compare computer fire models with experimental data at heights above 14 m include Walton [2], Duong [3] and Notarianni and Davis [4]. Model predictions compared with the experiments include: plume centerline temperature at the ceiling, temperature variation of the ceiling jet both radially from fire center and in depth beneath the ceiling, ceiling jet velocity, draft curtain filling and spilling times, temperature variation across the draft curtain and smoke detector activation. The fire models included in the study are the plume correlations of Heskestad [5] and McCaffrey [6], the ceiling jet correlation of Alpert [7], the zone models CFAST [8], FPEtool [9], and LAVENT [10], and the computational fluid dynamics models (CFD) CFX [11] and LES [12].

The fire experiments conducted in a Navy hangar at Barbers Point were designed to test a number of fire detection devices which could be used to detect fires in large spaces. The fires experiments consisted of eleven JP-5 pan fires with and without a draft curtain. The fire experiments were located at the floor of the hangar and were positioned 12.2 m from the center of the hangar where the ceiling height was 14.9 m. The roof consisted of built-up tar and gravel over a corrugated metal deck and exhibited only a 3 degree slope. The metal deck was directly supported by 0.25 m I beams which run the width of the hangar and are spaced 4.1 m on center.

There were no permanent draft curtains in the hangar. A temporary draft curtain made of fire retardant canvas was constructed for the fire experiments modeled here. The draft curtain area measured 24.4 m in length, 18.3 m in width and 3.7 m in depth.

Instrumentation included a load cell to measure the fuel burning rate, thermocouples to measure the gas temperature near the ceiling at radial distances of 0.0 m, 1.5 m, 3.0 m, 6.1 m, 8.5 m, 9.1 m and 11.6 m from the geometric center of the fire and 0.3 m beneath the ceiling, thermocouples to measure the temperature profile at 6.1 m and 9.1 m radially from fire center and at distances of 0.15 m, 0.30 m, 0.46 m, 0.61 m and 0.76 m beneath the ceiling, gas velocity measurements 6.1 m radially from fire center and 0.3 m beneath the ceiling, and smoke detectors which activated at a sensitivity of 8.2 % per meter. Details of the experimental configuration are available in reference 1. Two of the eleven experiments were chosen for modeling comparisons based on the excellent load cell data and plume behavior experienced during the tests. These tests consisted of a 0.6 m by 0.6 m square pan fire and a 1.5 m diameter pan fire which reached heat release rate values of 500 kW and 2.7 MW respectively. Both tests were conducted with the draft curtain in place.

The results of the analysis indicated that no single fire model could match the experimental measurements within a 25 % accuracy in all categories investigated. The models performed best in the comparison of centerline temperature predictions at the ceiling where most of the models predicted the experimentally measured temperature rise to within 50 % of the measured value. The poorest performance involved the comparison of the radial temperature variation from fire center along the ceiling where only three of the models could predict the measured variation within 50 %. Smoke detector activation predictions were also poor as none of the models which had a smoke detector algorithm predicted the detector activation time within 50 %. Other comparisons where several of the models provided predictions to within 50 % of the measured values included draft curtain filling time, temperature variation beneath the ceiling and ceiling jet velocity.

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