Computer Models
For
Fire and Smoke

Model Name: CFAST

Version: 7.0.1

Date: December 9, 2015

Classification: Zone

Very Short Description: CFAST is a two-zone fire model capable of predicting the environment in a multi-compartment structure subjected to a fire. It calculates the time-evolving distribution of smoke and gaseous combustion products as well as the temperature throughout a building during a user-prescribed fire.

Modeler(s), Organization(s): NIST

User's Guide: R. D. Peacock, P. A. Reneke, and G. P. Forney, CFAST – Consolidated Fire and Smoke Transport (Version 7) Volume 2: User's Guide. Technical Note 1889v2, National Institute of Standards and Technology, Gaithersburg, Maryland, December 2015.

Technical References: R.D. Peacock, K.B. McGrattan, G.P. Forney, and P.A. Reneke. CFAST – Consolidated Fire and Smoke Transport (Version 7) Volume 1: Technical Reference Guide. Technical Note 1889v1, National Institute of Standards and Technology, Gaithersburg, Maryland, December 2015.

Validation References: R.D. Peacock, G.P. Forney, and P.A. Reneke. CFAST – Consolidated Fire and Smoke Transport (Version 7) Volume 3: Verification and Validation Guide. Technical Note 1889v3, National Institute of Standards and Technology, Gaithersburg, Maryland, December 2015.

Availability: http://cfast.nist.gov (Software and documentation)
https://github.com/firemodels/cfast (Code repository)

Model Actively Supported?: Yes

Price: Free

Necessary Hardware: Windows, Linux, and OSX operating systems (GUI front end available only for Windows).

Computer Language: FORTRAN 2008

Size: Case Dependent

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Detailed Description: CFAST is a two-zone fire model that predicts the thermal environment caused by a fire within a compartmented structure. Each compartment is divided into an upper and lower gas layer. The fire drives combustion products from the lower to the upper layer via the plume. The temperature within each layer is uniform, and its evolution in time is described by a set of ordinary differential equations derived from the fundamental laws of mass and energy conservation. The transport of smoke and heat from zone to zone is dictated by empirical correlations. Because the governing equations are relatively simple, CFAST simulations typically require a few tens of seconds of CPU time on typical personal computers.

The equations used in CFAST take the form of an initial value problem for a system of ordinary differential equations. These equations are derived from the conservation laws of mass and energy (equivalently the first law of thermodynamics) and the ideal gas law. These equations predict the evolution in time of the compartment pressure, layer height, and layer temperatures due to the gains and losses of mass and energy. The assumption of a zone model is that properties such as temperature can be approximated throughout a control volume by a representative average value.

The exchange of mass and enthalpy between zones is due to physical phenomena such as fire plumes, natural and forced ventilation, convective and radiative heat transfer, and so on. For example, a vent exchanges mass and enthalpy between zones in connected rooms, a fire plume typically adds heat to the upper layer and transfers entrained mass and enthalpy from the lower to the upper layer, and convection transfers enthalpy from the gas layers to the surrounding walls. The momentum equation is explicitly included since conditions within a control volumes are assumed to be uniform. Of course, included plume entrainment, ceiling jet, and vent flow correlations are applications of momentum principles used for specific purposes within the model.

It is designed to predict the environment in a building subject to unwanted fires in order to make judgments on safety of occupants and the building structure. The model incorporates the evolution of species, such as carbon monoxide, which are important to the safety of individuals subjected to a fire environment. It also includes estimates of the temperature evolution of targets, detectors and sprinklers.

The CFAST model has been subjected to extensive validation studies by NIST and others. Although some differences between the model and the experiments were evident in these studies, they are typically explained by limitations of the model and uncertainty of the experiments. Most prominent in the studies reviewed was the over-prediction of gas temperature often attributed to uncertainty in soot production, radiative fraction and uncertainty in interpretation of thermocouple data. Still, studies typically show predictions accurate within 10 % to 25 % of measurements for a range of scenarios. Like all predictive models, the best predictions come with a clear understanding of the limitations of the model and care in the choice of data provided to the calculations.