Computer Models For Fire and Smoke

Model Name: LAVENT (Link Actuated VENTs)

Version: 2.0

Classification: Zone Model

Very Short Description: A zone model which predicts the activation of fusible links as a function of depth below the ceiling and distance from the plume center in response to a ceiling jet produced by a user specified fire. Included in the model are the effects of venting of smoke through ceiling vents and the smoke containment of draft curtains. The model computes the temperature profile across the ceiling caused by convective heating from the ceiling jet and radiative heating from the fire. Included with LAVENT is a graphics program designed to provide easy analysis of the computation.

Modeler(s), Organization(s): L.Y. Cooper and William D. Davis; Building and Fire Research Laboratory, National Institute of Standards and Technology, Gaithersburg, MD. USA. (L.Y. Cooper is currently at Hughes Associates)

User's Guide: Davis, William D. and Cooper, Leonard Y., "Estimating the Environment and the Response of Sprinkler Links in Compartment Fires with Draft Curtains and Fusible Link-Actuated Ceiling Vents – Part II: User Guide for the computer Code LAVENT," U.S. National Institute of Standards and Technology, NBSIR 89-4122, (1989).

Davis, William D. and Cooper, Leonard Y., "A Computer Model for Estimating the Response of Sprinkler Links to Compartment Fires with Draft Curtains and Fusible Link-Actuated Ceiling Vents," Fire Technology, 27, (1991) p. 113.

Technical References: Cooper, L.Y., "Estimating the Environment and the Response of Sprinkler Links in Compartment Fires with

Draft Curtains and Fusible Link-Actuated Ceiling Vents – Part 1: Theory," National Institute of Standards and Technology, NBSIR 88-3734, (1988).

Cooper, L.Y., "Estimating the Environment and the Response of Sprinkler Links in Compartment Fires with Draft Curtains and Fusible Link-Actuated Ceiling Vents-Theory," Fire Safety Journal, 16, (1990) p. 137.

Validation References: Walton, W. D.and Notarianni, K. A., "Comparison of Ceiling Jet Temperatures Measured in an Aircraft Hangar Test Fire With Temperatures Predicted by the DETACT-QS and LAVENT Computer Models," National Institute of Standards and Technology, NISTIR 4947, (1993).

Notarianni, K. A. and Davis, W. D., "Use of Computer Models to Predict Temperature and Smoke Movement in High Bay Spaces," National Institute of Standards and Technology, NISTIR 5304, (1993).

Davis, W. D., Notarianni, K A., and Tapper, P. Z., "An Algorithm for Estimating the Plume Centerline Temperature and Ceiling Jet Temperature in the Presence of a Hot Upper Layer," National Institute of Standards and Technology NISTIR 6178 (1998).

Availability: Available from the NIST/BFRL web site http://fire.nist.gov/. The software and documentation is found under the selection Fire Modeling Software Online.

Price: free

Necessary Hardware: 540 kB of memory and one of the following operating systems: MSDOS, WINDOWS 3.1, 95, 98 or 2000.

Computer Language: FORTRAN 77

Size: 292 kB of disk space is requred for the executable. Input and output file sizes are very small.

Contact Information:
William D. Davis
National Institute of Standards and Technology
100 Bureau Dr. Stop 8642
Gaithersburg, MD. 20899-8642.
301-975-6884
william.davis@nist.gov

Detailed Description:

The required inputs include the height, length, and width of the room, number of ceiling vents, the fusible link operating each vent, and area of each vent, perimeter of the draft curtain and height from the floor to the bottom of the curtain, the heat capacity, thermal conductivity, density, and thickness of the ceiling and wall materials, the ambient temperature of the room, the number of fusible links, distance of each link from the plume center, distance of each link below the ceiling, the response time index (RTI) of each link and the fuse or activation temperature of each link, the height of the fire, the diameter of the fire or the power per unit area of the fire and the heat release rate of the fire, the time interval for data output and the time duration of the calculation. LAVENT uses menus for the input of data and will accept either SI units or English units. There is an input section for the user to change the parameters used by the numerical solvers to solve the differential and partial differential equations.

The program outputs include a listing of the input values, the time, the upper layer height, temperature, and mass, the fire heat release rate, the vent area open in the ceiling, the temperature of each link, the ceiling jet velocity and temperature at the position of each link, the temperature distribution across the ceiling located radially from the plume center, and the heat flux to the bottom and top of the ceiling. The program outputs are stored in a user named file and also in a graphics file named GRAPH.OUT. The graphics program, GRAPH, uses the graphics file, GRAPH.OUT, to produce two-dimensional plots of the user specified variables on the computer screen. Postscript files for the graphics output can be produced by the graphics program in order to obtain hardcopy output of the graphs.

LAVENT is a two-zone compartment fire model that includes a two-dimensional model of the fire-driven ceiling jet. The physical phenomena included in this model are the heating of fusible links by the ceiling jet as a function of radial distance from the plume center, vertical distance below the ceiling, and RTI (response time index) of the link, the control of the smoke and heat of the upper layer through the use of draft curtains and ceiling vents, and the heating of the ceiling through radiation from the fire and convection from the ceiling jet.

The user of LAVENT must be aware of the following assumption when applying LAVENT to fire situations. LAVENT should be used in large, well-ventilated compartments where the heating of the lower layer is negligible and the fire is not ventilation limited. The absorption of radiation from the fire by the upper layer is neglected. The effect on the ceiling of flames reaching the ceiling is not included in the model. The time required for the plume to reach the ceiling and flow along the ceiling is not included in the activation time for the sprinkler links. If the fire is small, conductive cooling of the ceiling may become important. Conductive cooling of the links to the ceiling is not included in the fusible link model. For calculations done inside the plume stagnation region ($r/H < 0.2$), the model assumes that the ceiling jet temperature and velocity are equal to their values at $r/H = 0.2$. Here r is the radial distance from the plume center and H is the height of the ceiling. When H is large, the value of r where r/H = 0.2 can become quite large.

The user must be aware that speeding up the calculation by using too few annuli to describe the ceiling may reduce overall accuracy. The option to change the number of annuli in the ceiling was added to the Solver Parameter menu of the program after the Users Guide was published.

If the radiation flux to the ceiling is high, the FLUX UPDATE INTERVAL should be reduced in the solver parameter menu in order to update the thermal conduction calculation at shorter time intervals. If the FLUX UPDATE INTERVAL is too long, a temperature oscillation in the solver may result which will cause the solver to crash. In general, LAVENT handles most compartment fire calculations without problems using the default settings found in the default case.