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Smokeview (Version 5) - A Tool for Visualizing Fire Dynamics Simulation Data Volume I: User's Guide

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National Institute of Standards and Technology
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Building and Fire Research Laboratory

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Preface

Smokeview is a software tool designed to visualize numerical calculations generated by fire models such as the Fire Dynamics Simulator (FDS), a computational fluid dynamics (CFD) model of fire-driven fluid flow or CFAST, a zone fire model. Smokeview visualizes smoke and other attributes of the fire using traditional scientific methods such as displaying tracer particle flow, 2D or 3D shaded contours of gas flow data such as temperature and flow vectors showing flow direction and magnitude. Smokeview also visualizes fire attributes realistically so that one can *experience* the fire. This is done by displaying a series of partially transparent planes where the transparencies in each plane (at each grid node) are determined from soot densities computed by FDS. Smokeview also visualizes static data at particular times again using 2D or 3D contours of data such as temperature and flow vectors showing flow direction and magnitude.

Smokeview and associated documentation for Windows, Linux and Mac/OSX may be downloaded from the web site `http://fire.nist.gov/fds` at no cost.

About the Author

Glenn Forney is a computer scientist at the Building and Fire Research Laboratory (BFRL) of NIST. He received a bachelors of science degree in mathematics from Salisbury State College in 1978 and a master of science and a doctorate in mathematics at Clemson University in 1980 and 1984. He joined the NIST staff in 1986 (then the National Bureau of Standards) and has since worked on developing tools that provide a better understanding of fire phenomena, most notably Smokeview, a software tool for visualizing Fire Dynamics Simulation data.

Disclaimer

The US Department of Commerce makes no warranty, expressed or implied, to users of Smokeview, and accepts no responsibility for its use. Users of Smokeview assume sole responsibility under Federal law for determining the appropriateness of its use in any particular application; for any conclusions drawn from the results of its use; and for any actions taken or not taken as a result of analysis performed using this tools.

Smokeview and the companion program FDS is intended for use only by those competent in the fields of fluid dynamics, thermodynamics, combustion, and heat transfer, and is intended only to supplement the informed judgment of the qualified user. These software packages may or may not have predictive capability when applied to a specific set of factual circumstances. Lack of accurate predictions could lead to erroneous conclusions with regard to fire safety. All results should be evaluated by an informed user.

Throughout this document, the mention of computer hardware or commercial software does not constitute endorsement by NIST, nor does it indicate that the products are necessarily those best suited for the intended purpose.

Acknowledgements

A number of people have made significant contributions to the development of Smokeview. In trying to acknowledge those that have contributed, we are inevitably going to miss a few people. Let us know and we will include those missed in the next version of this guide.

The original version of Smokeview was inspired by Frames, a visualization program written by James Sims for the Silicon Graphics workstation. This software was based on visualization software written by Stuart Cramer for an Evans and Sutherland computer. Frames used tracer particles to visualize smoke flow computed by a pre-cursor to FDS. Judy Devaney made the multi-screen eight foot Rave facility available allowing a stereo version of Smokeview to be built that can display scenes in 3D. Both Steve Satterfield and Tere Griffin on many occasions helped me demonstrate Smokeview cases on the Rave inspiring many people to the possibility of using Smokeview as a *virtual reality-like* fire fighter training facility.

Many conversations with Nelson Bryner, Dave Evans, Anthony Hamins and Doug Walton were most helpful in determining how Smokeview could be adapted for use in fire fighter training applications.

Smokeview would not be possible without the use of a number of software libraries developed by others. Mark Kilgard while at Silicon Graphics developed GLUT, the basic tool kit for interfacing OpenGL with the underlying operating system on multiple computer platforms. Paul Rademacher while a graduate student at the University of North Carolina developed GLUI, the software library for implementing the user friendly dialog boxes.

Significant contributions have been made by those that have used Smokeview to visualize complex cases; cases that are used to perform both applied and basic research. The resulting feedback has improved Smokeview as a result of their interaction with me, pushing the envelope and not accepting the status quo.

For applied research, Daniel Madrzykowski, Doug Walton and Robert Vettori of NIST have used Smokeview to analyze fire incidents. Steve Kerber has used Smokeview to visualize flows resulting from positive pressure ventilation (PPV) fans. David Stroup has used Smokeview to analyze cases for use in fire fighter training scenarios. Conversations with Doug Walton have been particularly helpful in identifying needed features and clarifying how best to make their implementation user friendly. David Evans, William (Ruddy) Mell and Ronald Rehm used Smokeview to visualize *urban-wildland interface* fires. For basic research, Greg Linteris has used Smokeview to visualize fire simulations involving the cone calorimeter. Anthony Hamins has used Smokeview to visualize the structure of CH_4/air flames undergoing the transition from normal to microgravity conditions and fire suppression in a compartment. Jiann Yang has used Smokeview to visualize smoke or particle number density and saturation ratio of condensable vapor.

This user's guide has improved through the many constructive comments of the reviewers Anthony Hamins, Doug Walton, Ronald Rehm, and David Sheppard. Chuck Bouldin helped port Smokeview to the Macintosh.

Many people have sent in multiple comments and feedback by email, in particular Adrian Brown, Scot Deal, Charlie Fleischmann, Jason Floyd, Simo Hostikka, Bryan Klein, Davy Leroy, Dave McGill, Brian McLaughlin, Derek Nolan, Steven Olenick, Stephen Priddy, Boris Stock, Jason Sutula, Javier Trelles, and Christopher Wood.

Feedback is encouraged and may be sent to glenn.forney@nist.gov .

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Introduction

1.1 Overview

Smokeview is an advanced scientific software tool designed to visualize numerical predictions generated by fire models such as the Fire Dynamics Simulator (FDS), a computational fluid dynamics (CFD) model of fire-driven fluid flow [1] and CFAST, a zone model of compartment fire phenomena [2]. This report documents version 5 of Smokeview. For details on setting up and running FDS cases read the FDS User's guide [3].

FDS and Smokeview are used to model and visualize time-varying fire phenomena. However, FDS and Smokeview are not limited to fire simulation. For example, one may use FDS and Smokeview to model other applications such as contaminant flow in a building. Smokeview performs this visualization by displaying time dependent tracer particle flow, animated contour slices of computed gas variables and surface data. Smokeview also presents contours and vector plots of static data anywhere within a simulation scene at a fixed time. Several examples using these techniques to investigate fire incidents are documented in Refs. [4, 5, 6, 7].

Smokeview is used before, during and after model runs. Smokeview is used in a post-processing step to visualize FDS data after a calculation has been completed. Smokeview may also be used during a calculation to monitor a simulation's progress and before a calculation to setup FDS input files more quickly, one can then use Smokeview to edit or create blockages by specifying the size, location and/or material properties.

Figure 1.1 gives an overview of how data files used by FDS, Smokeview and Smokezip, a program used to compress FDS generated data files, are related. A typical procedure for using FDS and Smokeview is to:

1. Set up an FDS input file.

2. Run FDS. FDS then creates one or more output files interpreted by Smokeview to visualize the calculation results.

3. Run Smokeview to analyze the output files generated by step 2. by either double-clicking the file named `casename.smv` with the mouse (on the PC) or by typing `smokeview casename` at a command line. Smokeview may also be used to create new blockages and modify existing ones. The blockage changes are saved in a new FDS input data file.

This publication documents step 3. Steps 1 and 2 are documented in the FDS User's Guide [3].

Menus in Smokeview are activated by clicking the right mouse button anywhere in the Smokeview window. Data files may be visualized by selecting the desired `Load/Unload` menu option. Other menu options are discussed in Appendix B. Many menu commands have equivalent keyboard shortcuts. These shortcuts are listed in Smokeview's `Help` menu and are described in Appendix C. Visualization

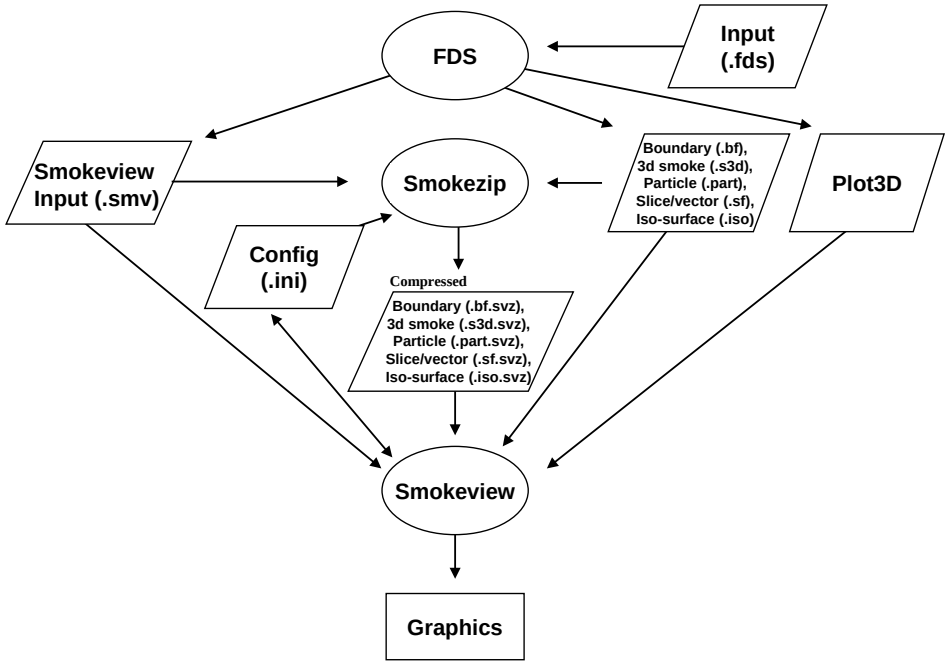


Figure 1.1: Diagram illustrating files used and created by the Fire Dynamics Simulator (FDS), Smokezip and Smokeview.

features not controllable through the menus may be customized by using the Smokeview preference file, `smokeview.ini` , discussed in Appendix D.3.

Smokeview is written in C [8] and Fortran 90 [9] and consists of about 90,000 lines of code. The C portion of Smokeview visualizes the data, while the Fortran 90 portion reads in the data generated by FDS (also written in Fortran 90). Smokeview uses the 3D graphics library OpenGL [10] and the Graphics Library Utility Toolkit (GLUT) [11]. Smokeview uses the GLUT software library so that most of the development effort can be spent implementing the visualizations rather than creating an elaborate user interface. Smokeview uses a number of auxiliary libraries to implement image capture (GD [12, 13], PNG [14], JPEG [15]), image and general file compression (ZLIB [16]) and dialog creation (GLUI [17]). Each of these libraries is portable running under UNIX, LINUX, OSX and Windows 9x/2000/XP/Vista allowing Smokeview to run on these platforms as well.

1.2 Features

Smokeview is a program designed to visualize numerical calculations generated by the Fire Dynamics Simulator. The version of FDS used to run the cases illustrated in this report is given by:

```
Fire Dynamics Simulator

Version: 5.5.3; MPI Disabled; OpenMP Disabled
SVN Revision Number: 7031
Compile Date: Fri, 29 Oct 2010

Consult FDS Users Guide Chapter, Running FDS, for further instructions.
```

```
Hit Enter to Escape...
```

The version of Smokeview described here and used to generate most figures in this report is given by:

```
Smokeview 5.6 - Oct 29 2010

Version: 5.6
Smokeview (64 bit) Revision Number: 7032
Compile Date: Oct 29 2010
Platform: WIN64  (Intel C/C++)
```

1.2.1 Visualizing Data

Smokeview visualizes data primarily generated by FDS. Smokeview visualizes data that is both dynamic and static. Dynamic data is visualized by animating particle flow (showing location and *values* of tracer particles), 2D contour slices (both within the domain and on solid surfaces) and 3D iso surfaces. 2D contour slices can also be drawn with colored vectors that use velocity data to show flow direction, speed and value. Static data is visualized similarly by drawing 2D contours, vector plots and 3D level surfaces.

Particles

Lagrangian or moving particles can be used to visualize the flow field. Often these particles represent smoke or water droplets.

Particle data may also be visualized as streak lines (a particle drawn where it has been for a short period of time in the past). Streak lines are a good method for displaying motion with *still* pictures.

Slices - 2D contours

Animated 2D shaded color contour plots are used to visualize gas phase information, such as temperature or density. The contour plots are drawn in horizontal or vertical planes along any coordinate direction. Contours can also be drawn in shades of grey.

Animated 2D shaded color contour plots are also used to visualize solid phase quantities such as radiative flux or heat release rate per unit area.

Vector slice files may be visualized if U, V and W velocity slice files are recorded. Though similar to solidly shaded contour animations (the vector colors are the same as the corresponding contour colors), vector animations are better than solid contour animations for highlighting flow features since vectors accentuate the direction that flow is occuring.

A 3D region of data may be visualized using slice files. Slices may be moved from one plane to the next just as with PLOT3D files (using up/down cursor keys or page up/page down keys). Data for 3D slice files are generated by specifying a 3D rather than a 2D region with the `&SLCF` keyword.

Data computed at cell centers rather than interpolated at cell nodes may be visualized. This is useful for investigating numerical algorithms as the data visualized has not been interpolated before being seen.

Surfaces - 3D contours

Isosurface or 3D level surface animations may be used to represent flame boundaries, layer interfaces and various other gas phase variables. Multiple isocontours may be stored in one file, allowing one to view several isosurface levels simultaneously.

Volumetric - Realistic Smoke

Smoke and fire (heat release rate per unit volume) are displayed realistically using a series of partially transparent planes. The smoke transparencies are determined by using smoke densities computed by FDS. The fire and sprinkler spray transparencies are determined by using a heuristic based on heat release rate and water density data, again computed by FDS. Various settings for the 3D smoke option may be set using the *3D Smoke* dialog box found in the `Dialogs` menu. The windows version of Smokeview uses the graphical processing unit (GPU) on the video card to perform some of the calculations required to visualize smoke.

1.2.2 Exploring Data

Data Mining

The user can analyze and examine the simulated data by altering its appearance to more easily identify features and behaviors found in the simulation data. One may flip or reverse the order of colors in the colorbar and also click in the colorbar and slide the mouse to highlight data values in the scene. These options may be found under `Options/Shades`.

The user may click in the time bar and slide the mouse to change the simulation time displayed. One use for the time bar and color bar selection modes might be to determine when smoke of a particular temperature enters a room.

Data Filtering

The *File/Bounds Settings...* dialog box allows one to set bounds, to chop or hide data and in the case of slice file data to time average. The data chopping feature is useful for highlighting data. A ceiling jet, for example, may be visualized by hiding ambient temperature data, data below a prescribed temperature. Using time averaging allows one to smooth noisy data over a user selectable time interval.

Data coloring

Multiple colorbars are available for displaying simulation data. New colorbars may be created using the colorbar editor. Colorbars may then be adapted to best highlight the simulation data visualized. Regions in the simulation with certain data values may be highlighted by clicking on the colorbar.

Data Compression

- An option has been added to the LOAD/UNLOAD menu to compress 3D smoke and boundary files. The option shells out to the program smokezip which runs in the background enabling one to continue to use Smokeview while files are compressing.

1.2.3 Exploring the Scene

Motion/View

The *motion/view* dialog box may be used to allow more precise control of scene movement and orientation. Cursor keys have been mapped to scene translation/rotation to allow easy navigation within the scene. Viewpoints may be saved for later access.

The first person or eye view mode for moving allows one to move through a scene more realistically. Using the cursor keys and the mouse, one can move through a scene *virtually*.

Scene Clipping

It is often difficult to visualize data in complicated geometries due to the number of obstructed surfaces. Interior portions of the scene may be seen more easily by *clipping* part of the scene away.

Stereo views

A method for displaying stereo/3D images has been implemented that does not require any specialized equipment such as shuttered glasses or quad buffered enabled video cards. Stereo pair images are displayed side by side after invoking the option with the *Stereo* dialog box or pressing the "S" key (upper case). A 3D view appears by relaxing the eyes, allowing the two images to merge into one. Pressing the "S" key again results in stereo views generated by displaying red and blue versions of the scene. Glasses with a red left lens and a blue right lens are required to view the image.

1.2.4 Customizing the Scene

Objects

A method for drawing objects (an object being a heat detector, smoke detector, sprinkler sensor *etc.*) has been implemented in Smokeview 5. These objects look more realistic. Objects are specified in a data file rather than in Smokeview as C code. This allows one to customize the *look* and *feel* of the objects (to match the types of detectors/sprinklers that are being used) without requiring code changes in Smokeview.

Annotating Cases

The `LABEL` keyword is used to help document Smokeview output. It allows one to place colored labels at specified locations at specified times. A second keyword, `TICK` keyword places equally spaced tick marks between specified bounds. These marks along with `LABEL` text may be used to specify length scales in the scene.

The *User Tick Settings* tab of the Display dialog box provides an easier way to place ticks with length annotations along coordinate axes.

Texture Mapping

JPEG or PNG image files may be applied to a blockage, vent or enclosure boundary. This is called texture mapping. This allows Smokeview scenes to appear more realistic. These image files may be obtained from the internet, a digital camera, a scanner or from any other source that generates these file formats. Image files used for texture mapping should be *seamless*. A seamless texture as the name suggests is periodic in both horizontal and vertical directions. This is an especially important requirement when textures are tiled or repeated across a blockage surface.

1.2.5 Automating the Visualization

Scripting

Smokeview may be run in an unattended mode using instructions found in a script file. These instructions direct Smokeview to load data files, load configuration files, set view points and time values in order to document a case by rendering the Smokeview scene into one or more image files. The script file may be created by Smokeview as a user performs various actions or may be created by editing a text file.

Virtual Tour

A series of checkpoints or key frames specifying position and view direction may be specified. A smooth path is computed using Kochanek-Bartels splines [18] to go through these key frames so that one may control the position and view direction of an observer as they move through the simulation. One can then see the simulation as the observer would. This option is available under the `Tour` menu item. Existing tours may be edited and new tours may be created using the *Tour* dialog box found in the `Dialogs` menu. Tour settings are stored in the local configuration file (casename.ini).

Chapter 2

Getting Started

2.1 Obtaining Smokeview

Smokeview is available at http://fire.nist.gov/fds . This site contains links to various installation packages for different operating systems. It also contains documentation for Smokeview and FDS, sample FDS calculations, software updates and links for requesting feedback about the software.

After obtaining the setup program, install Smokeview on the PC by either entering the setup program name from the Windows Start/Run... menu or by double-clicking the downloaded Smokeview setup program. The setup program then steps through the program installation. It copies the FDS and Smokeview executables, sample cases, documentation and the Smokeview preference file `smokeview.ini` to the a default directory. The setup program also defines PATH variables and associates the `.smv` file extension to the Smokeview program so that one may either type Smokeview at any command line prompt or double click on any `.smv` file. Smokeview uses the OpenGL graphics library which is a part of all Windows distributions.

Most computers purchased today are perfectly adequate for running Smokeview. For Smokeview it is more important to obtain a fast graphics card than a fast CPU. If the computer will run both FDS and Smokeview then it is important to obtain a fast CPU as well.

2.2 Running Smokeview

Smokeview may be started on the PC by double-clicking the file named `casename.smv` where casename is the name specified by the `CHID` keyword defined in the FDS input data file. Menus are accessed by clicking with the right mouse button. The `Load/Unload` menu may be used to read in the data files to be visualized. The `Show/Hide` menu may be used to change how the visualizations are presented. For the most part, the menu choices are self explanatory. Menu items exist for showing and hiding various simulation elements, creating screen dumps, obtaining help *etc*. Menu items are described in Appendix B.

To use Smokeview from a *command line*, open a command shell on a PC or a UNIX shell on a UNIX workstation. Then change to the directory containing the FDS case to be viewed and type:

```
smokeview casename
```

where casename is the name specified by the `CHID` keyword defined in the FDS input data file. Data files may be loaded and options may be selected by clicking the right mouse button and picking the appropriate menu item.

Smokeview opens two windows, one displays the scene and the other displays status information. Closing either window will end the Smokeview session. Multiple copies of Smokeview may be run simultaneously if the computer has adequate resources.

Normally Smokeview is run during an FDS run, after the run has completed and as an aid in setting up FDS cases by visualizing geometric components such as blockages, vents, sensors, *etc*. One can then verify that these modelling elements have been defined and located as intended. One may select the color of these elements using color parameters in the `smokeview.ini` to help distinguish one element from another. `smokeview.ini` file entries are described in section D.3.

Although specific video card brands cannot be recommended, they should be *high-end* due to Smokeview's intensive graphics requirements. These requirements will only increase in the future as more features are added. A video card designed to perform well for *fancy* computer games should do well for Smokeview. Some apparent bugs in Smokeview have been found to be the result of problems found in video cards on older computers.

Chapter 3

Manipulating the Scene Manually

The scene may be manipulated from two points of view, a world or global view and a first person or *eye* view. These views may be switched by pressing the "e" key or by selecting the appropriate radio button in the *Motion/View* dialog box.

3.1 World View

The scene may be rotated or translated while in world view, either directly with the mouse or by using controls contained in the *Motion/View/Render* dialog box. This dialog box is opened from the Dialogs>Motion/View/Render menu item and is illustrated in Figure 3.1.

Clicking on the scene and dragging the mouse horizontally, vertically or a combination of both results in scene rotation or translation depending upon whether the left, middle or right mouse button is depressed.

left mouse button horizontal and vertical mouse motion results in scene rotation.

middle mouse button Horizontal mouse movement when the middle mouse button is depressed results in scene translation from side to side along the X axis. Vertical mouse movement results in scene translation into and out of the computer screen along the Y axis. Alternatively, one can depress the CTRL key and the left mouse button to achieve the same effect.

right mouse button Vertical mouse movement when the right mouse button is depressed results in vertical scene translation along the Z axis. Horizontal mouse movement has no effect. Alternatively, one can depress the ALT key and the left mouse button to achieve the same effect. Note that the right mouse button is also used to display Smokeview menus. To switch this behavior to scene movement, press the *M* key. Press the *M* key again to switch back to menu use.

The *Motion/View/Render* dialog box, illustrated in Figure 3.1 may be used to move the scene in a more controlled manner. For example, buttons in the *Motion* region allows one to translate or rotate the scene. The `Horizontal` button allows one to translate the scene horizontally in a left/right or in/out direction while the `Vertical` button allows one to translate the scene in an up/down direction.

Controls in the *Window Properties* region of the *Motion/View/Render* dialog box allow one to change the scene magnification or zoom factor and the projection method used to draw objects (perspective or size preserving). These two projection methods differ in how objects are displayed at a distance. A perspective projection for-shortens or draws an object smaller when drawn at a distance. An isometric or size preserving projection on the other hand draws an objects the same size regardless of where it is drawn in the scene.

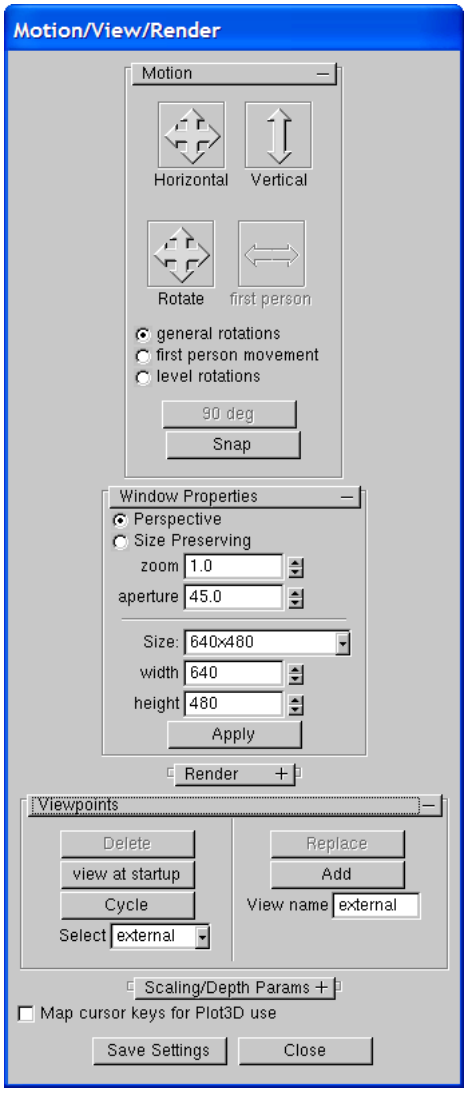


Figure 3.1: Motion/View Dialog/Render Box - Motion, Window Properties and Viewpoint Regions. Rotate or translate the scene by clicking an *arrow* and dragging the mouse. The Motion/View/Render Dialog Box is invoked by selecting `Dialogs>Motion/View/Render`.

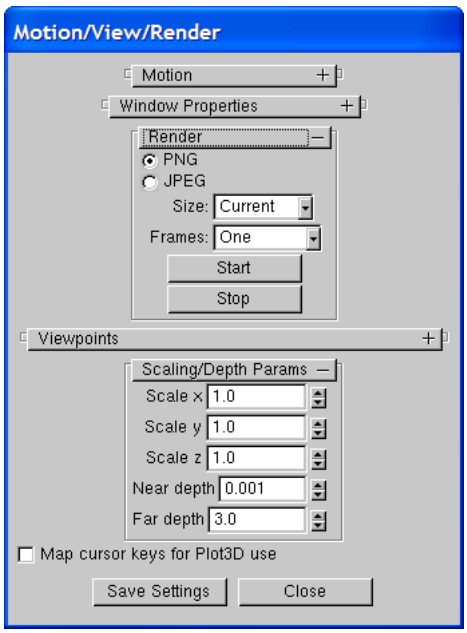


Figure 3.2: Motion/View Dialog/Render Box. Render and Scaling/Depth regions.

Controls in the *Render* and *Scaling Depth* regions, as illustrated in Figure 3.2, allow one to render images using either PNG or JPEG file formats and to scale the Smokeview scene (say for visualizing tunnel scenarios) in any or all of the coordinate directions.

The `zoom` and `aperture` edit boxes allow one to change the magnification of the scene or equivalently the angle of view across the scene. The relation between these two parameters is given by

$$\text{zoom} = \tan(45^\circ/2)/\tan(\text{aperture}/2)$$

A default aperture of 45° is chosen so that Smokeview scenes have a normal perspective.

`View` may be used to reset the scene back to either an external, internal (to the scene), or previously saved viewpoint.

Rotate about A pull down list appears in multi-mesh cases allowing one to change the rotation center. Therefore one could rotate the scene about the center of the entire physical domain or about the center of any one particular mesh. This is handy when meshes are defined far apart.

Rotation Buttons Rotation buttons are enabled or disabled as appropriate for the mode of scene motion. For example, if *about world center - level rotations* has been selected, then the `Rotate X` and `Rotate eye` buttons are disabled. A rotation button labeled `90 deg` has been added to allow one to rotate 90 degrees while in *eye center* mode. This is handy when one wishes to move down a long corridor precisely parallel to one of the walls. The first click of *90 deg* snaps the view to the closest forward or side direction while each additional click rotates the view 90 degrees clockwise.

View Buttons A viewpoint is the combination of a location and a view direction. Several new buttons have been added to this dialog box to save and restore viewpoints. The scene is manipulated to the desired orientation then stored by pressing the **Add** button which adds the new viewpoint or the **Replace** button which replaces this viewpoint with the currently selected one. To change

Table 3.1: Keyboard mappings for *eye centered* or first person scene movement.

Key	Description
up/down cursor w/s	move forward/backward
`ALT` + left/right cursor `a/d`	slide left/right
`ALT` + up/down cursor	move up/down
left/right cursor	rotate left/right
`Page Up/Down`	look up/down
`Home`	look level
Pressing the `SHIFT` key while moving, sliding or rotating results in a 4x speedup of these actions.	

the view to a currently stored viewpoint, use the **Select** listbox to select the desired viewpoint. The **Delete** button may be used to remove a viewpoint from the stored list. The **View name** text box may be used to change the name or label for the selected viewpoint. The **view at startup** button is used to specify the viewpoint that should be set when Smokeview first starts up.

3.2 Eye View

Radio buttons in the *Motion/View* dialog box allow one to toggle between world, eye centered and world level rotation scene movement modes. These modes may also be changed by using the "e" key. When in *eye center* mode, several key mappings have been added, inspired by popular computer games, to allow for easier movement within the scene. For example, the up and down cursor keys allow one to move forward or backwards. The left and right cursor keys allow one to rotate left or right. Other keyboard mappings are described in Table 3.1.

Chapter 4

Creating Custom Objects

Smokeview visualizes FDS devices such as heat and smoke detectors, sprinklers, sensors using instructions contained in a data file named `objects.svo`. Smokeview also uses these instructions to represent people (avatars) in FDS-EVAC simulations and to represent trees and shrubs in an FDS WUI simulations. The Smokeview implementation of FDS devices is referred to as objects in this chapter.

The object instruction file is located in the directory where FDS and Smokeview are installed.[1]. The instructions correspond to OpenGL library calls, the same type of calls Smokeview uses to visualize FDS cases. Smokeview then acts as an interpreter executing OpenGL commands as specified in the object definition file. Efficiency is attained by compiling these instructions into display lists, terminology for an OpenGL construct for storing and efficiently drawing collections of OpenGL commands. New objects may be designed and drawn without requiring modifications to Smokeview and more importantly may be created by someone other than the Smokeview developer.

The appearance of an object may be fixed or it may be altered based upon data specified in an FDS input file. The `sensor` object is drawn as a small green sphere with a fixed diameter. Its appearance is the same regardless of how an FDS input file is set up. The appearance of the `tsphere` object (t for texture) depends on data specified in the FDS input file. One may specify the diameter of the sphere and an image to cover it with (the image is known as a texture map).

As with preference or `.ini` files, Smokeview looks for object definition files in three locations: in a file named `objects.svo` in the FDS/Smokeview installation directory, in a file named `objects.svo` in the casename directory and in a file named `casename.svo` also located in the casename directory where `casename` is the name of the case being visualized.

This section describes how to create new objects. Though all of the examples are given for drawing FDS devices, the intent of this procedure is to be more general allowing Smokeview to draw other types of objects such as people walking.

4.1 Object File Format

The first statement in an object definition is the keyword `OBJECTDEF` (or `AVATARDEF` when defining a *person*). The next statement is the name or label for the object. Following this are the instructions used for creating the object. Each instruction consist of zero or more data values followed by a command. Comments may be placed anywhere in the object definition file by adding text after a double slash '//'.

Data from FDS may be optionally communicated to the object definition by placing a series of labels, written as `:var1 ... :varn`, at the beginning of the definition. These data values may then be accessed later in the definition using `$var1` to access data in `:var1`, `$var2` to access data in `:var2` *etc.*.

[1]The current objects.svo file containing documentation and a listing of object definitions is listed in Appendix D.6

The data place in these `:vari` labels is specified in the FDS input file using the `SMOKEVIEW_PARAMETERS` keyword on the `&PROP` input line.

There are two types of instructions, instructions for drawing basic geometric objects such as cubes, disks, spheres and instructions for manipulating these objects through transformations such as scaling, rotation and translation. Collectively these instructions specify the type, location and orientation of objects used to represent objects. The important feature of this process is that new objects may be designed and drawn without the need to modify Smokeview.

Some examples of argument/instruction pairs are `d drawsphere` for drawing a sphere of diameter `d` or `x y z translate` for translating an object by (x,y,z). The symbols `d`, `x`, `y` and `z` are specified in the object file using a numerical constant such as 1.23 or using a reference such as $var to data located elsewhere.

Transformation commands are cumulative, each command builds on the effects of the previous one. The commands `push` and `pop` isolate these effects by saving and restoring the geometric state.

The format for an object definition file is given in more detail in Figure 4.1. Each object definition consists of one or more frames. A frame is used to represent various states of the object. Objects such as thermocouples which do not activate use just one frame. Other objects such as sprinklers or smoke detectors which do activate use two frames, the first for normal conditions and the second for when the object has activated.

Figure 4.2 illustrates a simple example of an object definition used to draw a sensor along with the corresponding Smokeview view.. The definition uses just one frame. A sphere is drawn with color yellow and diameter 0.038 m. Push and pop commands are not necessary because there is only one object and no transformations are used.

The example illustrated in Figure 4.3 is more complicated. It shows a definition of a heat detector along with a corresponding Smokeview view. The definition uses two frames. The first frame represents the heat detector's inactive state, the second frame represents the active state (commands after the `NEWFRAME` keyword). This definition uses disks, a truncated cone and spheres. The scale and translate commands are used to draw these objects at the proper size. The translate command then positions them properly. Two frames are defined for both the inactive and active (after the heat detector has activated.) states.

Figure 4.4 shows an example of a definition used to draw a scaled sphere using scalings obtained from an FDS input file along with the corresponding Smokeview view. This definition is set up so that if the label value 'D' has a value greater than 0.0 then a sphere is drawn with diameter D otherwise an ellipsoid is drawn with dimensions 'DX', 'DY' and 'DZ'. This definition uses just one frame. The scaled sphere/ellipsoid is drawn using data specified on the `SMOKEVIEW_PARAMETERS` keyword in the FDS input file.

Figure 4.5 gives Smokeview views for several objects defined in the `objects.svo` file. A more complete list is found in the FDS User's Guide [3]. The object's origin is identified by two intersecting tubes. The origin is placed where FDS records data for these objects.

4.2 Elementary Geometric Objects

The objects described in this section are the building blocks used to construct more complex objects. Each command used to draw an elementary geometric object consists of one or more arguments followed by the command, for example, the command sequence `0.3 drawsphere` draws a sphere with diameter 0.3 (all units as with FDS are in meters).

Some portion of the object is designated as the origin, *i.e.* with coordinate $(0,0,0)$. The origin location is indicated by the intersection two cylinders, a red cylinder indicating the up or (0,0,1) direction, and a green cylinder indicating the *orientation* or (1,0,0) direction. The origin location and orientation and up directions are used by the transformation commands described in the next section to assemble the elementary objects

```
// ************ object file format ********************

//  1. comments and blank lines may be placed anywhere
//  2. any line not beginning with "//" is part of the definition.
//  3. the first non-comment line after OBJECTDEF is the object name
//  4. an object definition may contain, labels, numerical constants
//     a number), string constants (enclosed in " ") and/or
//     commands (beginning with a-z)
//  5. a label begins with ':' as in :dx
//  6. the label :dx may be accessed afterward using $dx
//  7. An object may contain multiple frames or states.  A new frame with
//     an object is defined using NEWFRAME

// OBJECTDEF // OBJECTDEF begins the object definition

//   object_name // name or label for object
//   :var1 ... :varn  // a series of labels may be specified for use by
//                    // the object definition.  Data is copied to these
//                    // label locations using the SMOKEVIEW_PARAMETERS
//                    // &PROP keyword or from a particle file. The data
//                    // in :varn may be referenced  elsewhere in the
//                    // definition using $varn

//   // A series of argument/command pairs are specified on one or
//   // more lines.

//   arg1 ... argn command1 arg1 ... argn command2 ...

//   // An argument may be a numerical constant (e.g. 2.37), a string
//   // (e.g. "SKYBLUE"), a label (e.g. :var1),  or a reference to a
//   // label located elsewhere (e.g. $var1)

//  NEWFRAME    // beginning of next frame
//   more argument/command pairs for the next object frame
//   ....
```

Figure 4.1: Object file format.

```
OBJECTDEF
 sensor
 1.0 1.0 0.0  setcolor
 0.038 drawsphere
```

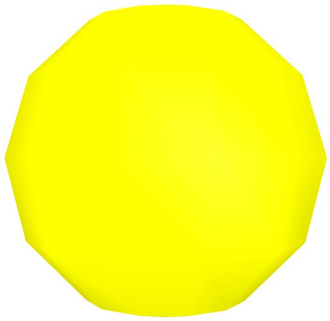


Figure 4.2: Instructions for drawing a sensor along with the corresponding Smokeview view.

described in this section so that more complex parts may be created.

DRAWARCDISK The command, `a d h drawarcdisk`, draws a portion of circular disk with angle a, diameter d and height h. The origin is located at the center of the disk's base.

`60.0 0.25 0.50 drawarcdisk`

DRAWCIRCLE The command, `d drawcircle` , draws a circle with diameter d. The origin is located at the center of the circle.

`0.50 0.30 drawcone`

DRAWCONE The command, `d h drawcone`, draws a right circular cone where d is the diameter of the base and h is the height. The origin is located at the center of the cone's base.

DRAWCUBE The command, `s drawcube`, draws a cube where s is the length of the side. The origin is located at the center of the cube. An oblong box, a box with different length sides, may be drawn by using `scale` along with `drawcube`. For example, `1.0 2.0 4.0 scale 1.0 drawcube` creates a box with dimensions $1 \times 2 \times 4$.

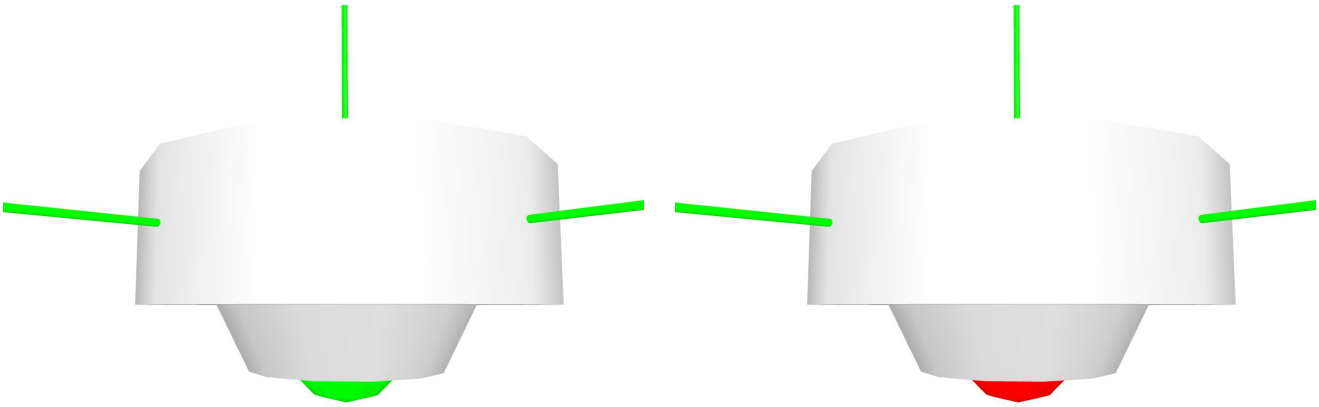
`0.25 drawcube`

Heat detector Instructions

```
OBJECTDEF
 heat_detector          // label, name of object

 // The heat detector has three parts
 //   a disk, a truncated disk and a sphere.
 //   The sphere changes color when activated.

 0.8 0.8 0.8 setcolor  // set color to off white
 push 0.0 0.0 -0.02 translate 0.127 0.04 drawdisk pop
 push 0.0 0.0 -0.04 translate 0.06 0.08 0.02 drawtrunccone pop
 0.0 1.0 0.0 setcolor
 push 0.0 0.0 -0.03 translate  0.04 drawsphere pop
 // push and pop are not necessary in the last line
 //   of a frame.  Its a good idea though, to prevent
 //   problems if parts are added later.
NEWFRAME  // beginning of activated definition
 0.8 0.8 0.8 setcolor
 push 0.0 0.0 -0.02 translate 0.127 0.04 drawdisk pop
 push 0.0 0.0 -0.04 translate 0.06 0.08 0.02 drawtrunccone pop
 1.0 0.0 0.0 setcolor
 push 0.0 0.0 -0.03 translate 0.04 drawsphere pop
```



inactive active

Figure 4.3: Instructions for drawing an inactive and active heat detector along with the corresponding Smokeview view.

```
OBJECTDEF // object for a general ball
 ball
 :R=0 :G=0 :B=0 :DX :DY :DZ :D=-.1
 $D 0.0 :DGT0 GT
 $R $G $B setrgb
 $DGT0 IF
  $D drawsphere
  ELSE
  $DX $DY $DZ scalexyz 1.0 drawsphere
 ENDIF
 NO_OP
```

```
FDS input lines to create ball

The data labels (:R=0 :G=0 :B=0 :DX :DY :DZ :D=-.1) in the object file
correspond to the SMOKEVIEW_PARAMETERS inputs in the FDS input file
though the order may be different.

&PROP ID='ball' SMOKEVIEW_PARAMETERS(1:5)='R=0','G=0','B=255',
                        'DX=0.25','DY=.5','DZ='1.0' SMOKEVIEW_ID='ball' /
&DEVC XYZ=0.5,0.8,2.5, QUANTITY='TEMPERATURE' PROP_ID='ball' /
```

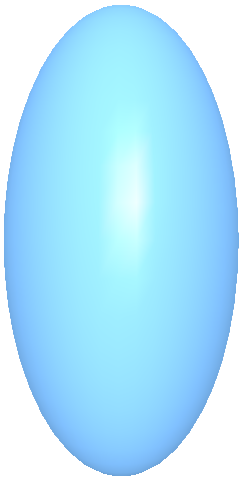


Figure 4.4: Instructions for drawing the dynamic object, ball, along with the corresponding FDS input lines and the Smokeview view.

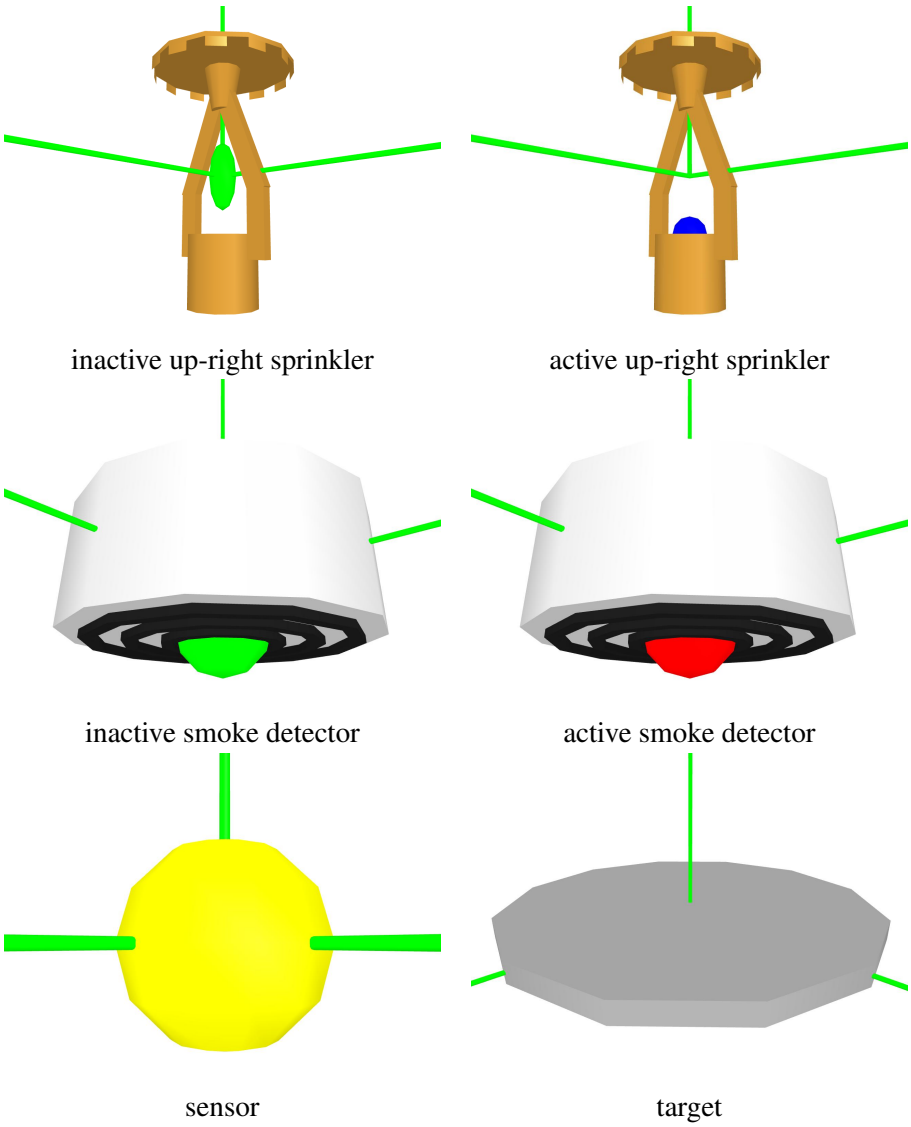


Figure 4.5: Smokeview view of several objects defined in the objects.svo file. The object origin occurs at the intersection of the thin (green) lines. This where FDS records data values for this object.

0.25 drawcubec

DRAWCUBEC The command, `s drawcubec`, is the same as `s drawcube` except that the origin is located at the front, left, bottom corner of the cube rather than at the cube center. An oblong box, a box with different length sides, may be drawn by using `scale` along with `drawcubec`. For example, `1.0 2.0 4.0 scale 1.0 drawcube` creates a box with dimensions $1 \times 2 \times 4$.

DRAWDISK The command, `d h drawdisk`, draws a circular disk with diameter d and height h. The origin is located at the center of the disk's base.

0.25 0.50 drawdisk

0.25 0.50 drawcdisk

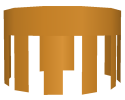
DRAWCDISK The command, `d h drawcdisk`, draws a circular disk with diameter d and height h. The origin is located at the center of the disk. This command is a shortcut for `h 2.0 :hd2 div $hd2 offsetz d h drawdisk`.

DRAWHEXDISK The command, `d h drawhexdisk`, draws a hexagonal disk with diameter d and height h. The origin is located at the center of the hexagon's base.

0.5 0.25 drawhexdisk

DRAWLINE The command, `x1 y1 z1 x2 y2 z2 drawline`, draws a line between the points (x_1, y_1, z_1) and (x_2, y_2, z_2).

0.5 0.1 0.2 1 drawnotchplate



0.5 0.1 0.2 -1 drawnotchplate

DRAWNOTCHPLATE The command, `d h nh dir drawnotchplate`, draws a notched plate. This object is used to represent a portion of a sprinkler where d is the plate diameter, h is the plate height (not including notches), nh is the height of the notches and dir indicates the notch orientation (1 for vertical, -1 for horizontal). The origin is located at the center of the plate's base.

DRAWPOINT The command, `drawpoint`, draws a point (small square). The command, `s setpointsize` may be used to change the size of the point. The default size is 1.0 .

5 0.35 0.15 drawpolydisk

DRAWPOLYDISK The command, `n d h drawpolydisk`, draws an n-sided polygonal disk with diameter d and height h. The origin is located at the center of the polygonal disk's base. The example to the left is a pentagonal disk.

DRAWRING The command, `di do h drawring`, draws a ring where `di` and `do` are the inner and outer ring diameters and h is the height of the ring. The origin is located at the center of the ring's base.

0.3 0.5 0.1 drawring

0.25 drawsphere

DRAWSPHERE The command, `d drawsphere`, draws a sphere with diameter d. The origin is located at the center of the sphere. As with an oblong box, an ellipsoid may be drawn by using `scale` along with `drawsphere`. For example, `1.0 2.0 4.0 scale 1.0 drawsphere` creates an ellipsoid with semi-major axes of length 1, 2 and 4. This is how the ball at the bottom of the heat detector in Figure 4.3a is drawn.

DRAWTRUNCCONE The command, `d1 d2 h drawtrunccone`, draws a right circular truncated cone where d1 is the diameter of the base, d2 is the diameter of the truncated portion of the cone and h is the height or distance between the lower and upper portions of the truncated cone. The origin is located at the center of the truncated cone's base.

0.5 0.2 0.4 drawtrunccone

4.3 Visual Transformations

As with geometric commands, transformation commands consist of zero or more arguments followed by the command. Transformation commands are used to directly or indirectly change how drawn objects appear. Visual transformations make changes directly, changing the location and orientation of drawn objects, setting drawing attributes such as point size, line width or object color or saving and restoring the geometric state. Arithmetic transformations, described in the next section, make changes indirectly by operating on data which in turn is used as inputs to various drawing commands.

Visual transformation commands map directly to counterparts in OpenGL. The rotate and translate commands change the origin (translate) or orientation of the x,y,z axes (rotate). The offsetx, offsety and offsetz commands translate objects along just one axis. The PUSH command is then used to save the origin or axis orientation while the POP command is used to restore the origin and axis orientation.

GETTEXTUREINDEX The command

```
"texture_file" :texture_index GETTEXTUREINDEX
```

finds the index in an internal Smokeview table containing the entry texture_file (a file containing a texture map image). This index is used by other object drawing routines that support texture mapping (presently drawtsphere).

GTRANSLATE The command, `x y z gtranslate`, translates objects in a global reference frame, the same reference frame used to define FDS geometry. Objects drawn after the gtranslate command are moved by x, y and z along the x, y and z cartesian axes respectively. Equivalently, one can think of think of `x y z gtranslate` as translating the origin by (-x,-y,-z).

OFFSETX The command, `x offsetx`, translates objects drawn afterwards by x along the x axis.

OFFSETY The command, `y offsety`, translates objects drawn afterwards by y along the y axis.

OFFSETZ The command, `z offsetz`, translates objects drawn afterwards by z along the z axis.

POP The command, `pop`, restores the origin and axis orientation saved using a previous `pop` command. The total number of `pop` and `push` commands must be equal, otherwise a fatal error will occur. Smokeview detects this problem and draws a red sphere instead of the errantly defined object.

PUSH The command, `push`, saves the origin and axis orientation. (see above comment about number of `push` and `pop` commands).

ROTATEAXIS The command, `angle x y z rotateaxis`, rotates objects drawn afterwards by `angle` degrees about an axis defined by the vector (x,y,z).

ROTATEXYZ The command, `x y z rotatexyz`, rotates objects from the vector $(0,0,1)$ to the vector (x,y,z) . The axis of rotation computed internally by Smokeview is $(0,0,1)\times(x,y,z) = (-y,x,0)$ (a vector perpendicular to the plane formed by vectors $(0,0,1)$ and (x,y,z)) . The cosine of the angle of rotation is $z/\sqrt{x^2+y^2+z^2}$

ROTATEX The command, `r rotatex`, rotates objects drawn afterwards `r` degrees about the x axis.

ROTATEY The command, `r rotatey`, rotates objects drawn afterwards `r` degrees about the y axis.

ROTATEZ The command, `r rotatez`, rotates objects drawn afterwards `r` degrees about the z axis. A cone or any object for that matter may be drawn upside down by adding a `rotatez` command as in `180 rotatez 1.0 0.5 drawcone`.

SCALEXYZ The command, `x y z scalexyz`, stretches objects drawn afterwards by x, y and z respectively along the x, y and z axes. The `scalexyz` along with the `drawsphere` commands would be used to draw an ellipsoid by stretching a sphere along one of the axes.

SCALE The command, `xyz scale`, stretches objects drawn afterwards xyz along each of the x, y and z axes (equivalent to `xyz xyz xyz scalexyz`).

SETBW The command, `grey setbw`, sets the red, green and blue components of color to grey (equivalent to grey grey grey setcolor). As with the `setcolor` command, `setbw` is only required when the grey level changes, not for each object drawn.

SETCOLOR The command, `"color name" setcolor`, obtains sets the color to the red, green and blue components of the FDS standard color `color name`.

SETLINEWIDTH The command, `w setlinewidth` sets the width of lines drawn with the `drawline` and `drawcircle` commands.

SETPOINTSIZE The command, `s setpointsize`, sets the size of points drawn with the `drawpoint` command.

SETRGB The command, `r g b setrgb`, sets the red, green and blue components of the current color. Any objects drawn afterwards will be drawn with this color. This command is not required for each object part drawn. The color component values range from 0 to 255.

TRANSLATE The command, `x y z translate`, translates objects drawn afterwards by x, y and z along x, y and z axes respectively relative to the current (local) reference frame.

4.4 Arithmetic Transformations

Arithmetic transformation commands allow one to indirectly change how objects are drawn using information passed from FDS. This information is passed using the `SMOKEVIEW_PARAMETERS` keyword on the `&PROP` namelist statement. These commands transform data to change the inputs of subsequent object commands.

ADD The command,

`a b :val add`,

is used to compute the value, $val = a + b$, where a and b are either numerical constants or references to previously defined data. The result, *val* is placed in the label `:val` accessible later in the definition file using $val.

CLIP The command,

`val_in val_min val_max :val_clipped clip`,

is used to clip a value `val_in` between `val_min` and `val_max` using

$$\text{val\_clipped} = \max(\text{val\_min}, \min(\text{val\_in}, \text{val\_max}))$$

The inputs, `val_in`, `val_min` and `val_max` are either numerical constants or references to previously defined data. The clipped result is placed in the label `:val_clipped` accessible later in the definition file using `$val_clipped`.

DIV The command,

`a b :val div`,

is used to compute the value, $val = a/b$, where a and b are either numerical constants or references to previously defined data. If the denominator, `b`, is zero then the result, *val*, returned is zero. and is placed in the label `:val` accessible later in the definition file using $val.

EQ The command,

`a b eq`,

is used to copy data from the label b to a, *ie* performs the operation a=b.

GETT The command,

`:time gett`,

is used to obtain the current simulation time. The simulation time is placed in the label `:time` accessible later in the definition file using $time.

MIRRORCLIP The command,

`val_in val_min val_max :val_clipped` mirrorclip,

is used to clip a value `val_in` between `val_min` and `val_max` using

$$\begin{aligned} \text{val\_1} &= \text{mod}(\text{val\_in} - \text{val\_min}, 2(\text{val\_max} - \text{val\_min})) \\ \text{val\_clipped} &= \begin{cases} \text{val\_min} + \text{val\_1} & \text{val\_1} \leq \text{val\_max} - \text{val\_min} \\ \text{val\_max} - \text{val\_1} & \text{val\_1} > \text{val\_max} - \text{val\_min} \end{cases} \end{aligned}$$

MULT The command,

```
a b :val mult,
```

is used to compute the value, $val = ab$, where a and b are either numerical constants or references to previously defined data. The result, *val* is placed in the label `:val` accessible later in the definition file using $val.
The inputs, `val_in`, `val_min` and `val_max` are either numerical constants or references to previously defined data. The clipped result is placed in the label :`val_clipped` accessible later in the definition file using $`val_clipped`.

MULTIADDT The command,

```
a b :val multiaddt,
```

is used to compute the value, $val = at + b$, where t is the simulation time and a and b are either numerical constants or references to previously defined data. The result, *val* is placed in the label `:val` accessible later in the definition file using $val. This allows one to change how an object appears as a function of time (changing its size, rotating it, changing its color *etc.*).

The command, `a b :val multiaddt`, is a shortcut for

```
:time gett a $time :at mult $at b :val add
```

PERIODICCLIP The command,

`val_in val_min val_max :val_clipped periodicclip`,

is used to clip a value `val_in` between `val_min`and `val_max` using

$$\text{val\_clipped} \quad = \quad \text{val\_min} + \text{mod}(\text{val\_in} - \text{val\_min}, \text{val\_max} - \text{val\_min})$$

The inputs, `val_in`, `val_min` and `val_max` are either numerical constants or references to previously defined data. The clipped result is placed in the label :`val_clipped` accessible later in the definition file using $`val_clipped`.

SUB The command,

```
a b :val sub,
```

is used to compute the value, $val = a - b$, where a and b are either numerical constants or references to previously defined data. The result, *val* is placed in the label `:val` accessible later in the definition file using $val.

4.5 Logical and Conditional Operators

Logical and conditional operators are used in conjunction to test values and execute portion of an object definition depending on the results of the test. Logical operators return 1 if the test is true and 0 if the test is false.

AND The command

```
a b :val AND
```

returns 1 in :val if both a and b are true (any value other than 0), otherwise it returns 0.

GT The command

```
a b :val GT
```

returns 1 in :val if a is greater than b, otherwise it returns 0.

GE The command

```
a b :val GE
```

returns 1 in :val if a is greater than or equal to b, otherwise it returns 0.

IF,ELSE,ENDIF Consider the object command sequence

```
$val IF
 arg1 arg2 command1 arg1 arg2 command2 ....
ELSE
 arg1 arg2 command3 arg1 arg2 command4 ....
ENDIF
```

The value `$val` is typically generated from a previous logical operation (*ie* with `GE, LT` *etc.*). The commands between the `IF` and `ELSE` operators are executed if `$val` is not 0 otherwise the commands between `ELSE` and `ENDIF` are executed. The `ELSE` operator is optional.

LT The command

```
a b :val LT
```

returns 1 in :val if a is less than b, otherwise it returns 0.

LE The command

```
a b :val LE
```

in :val if a is less than or equal to b, otherwise it returns 0.

OR The command

```
a b :val OR
```

returns 1 in :val if either a or b are true (any value other than 0), otherwise it returns 0.

Chapter 5

Manipulating the Scene Automatically - The Touring Option

The touring option allows one to specify arbitrary paths or tours through or around a Smokeview scene. One may then view the scenario from the vantage point of an observer moving along one of these paths. A tour may also be used to observe time dependent portions of the scenario such as blockage/vent openings and closings. The default view direction is towards the direction of motion. The path tension and start and stop times may be changed with the **Advanced Settings** dialog box illustrated in Figure 5.2b.

When Smokeview starts up it creates a tour, called the *circle tour* which surrounds the scene. The *circle* tour and a user defined tour are illustrated in Figure 5.1. The circle tour is similar to the `Tour` menu option found in earlier versions of Smokeview. The user may modify the *circle* tour or define their own tours by using the *Tour* dialog box illustrated in Figure 5.2. The user places several points or keyframes in or around the scene. Smokeview creates a smooth path going through these points.

5.1 Tour Settings

An existing tour may be modified by selecting it from the **Select Tour:** listbox found in the *Edit Tour* dialog box illustrated in Figure 5.2a. A new tour may be created by clicking the **New Tour** button. A newly created tour goes through the middle of the Smokeview scene starting at the front left and finishing at the back right. A tour may also be modified by editing the text entries found in the *local* preference file, casename.ini under the **TOUR** keyword.

The speed traversed along the tour is determined by the time value assigned to each keyframe. If the **Constant Speed** checkbox is checked then these times are determined given the distance between keyframes and the velocity required to traverse the entire path in the specified time as given by the *start time* and *stop time* entries found in the *Advanced Settings* dialog box illustrated in Figure 5.2b.

Three different methods for viewing the scene may be selected. To view the scene from the point of view of the selected tour, check the **View From Tour Path** checkbox. To view the scene from a keyframe (to see the effect of editing changes), select the **View From Selected Keyframe** checkbox. Unchecking these boxes returns control of scene movement to the user.

5.2 Keyframe Settings

A tour is created from a series of keyframes. Each keyframe is specified using time, position and view direction. Smokeview interpolates between keyframes using cubic splines to generate the path or tour. An

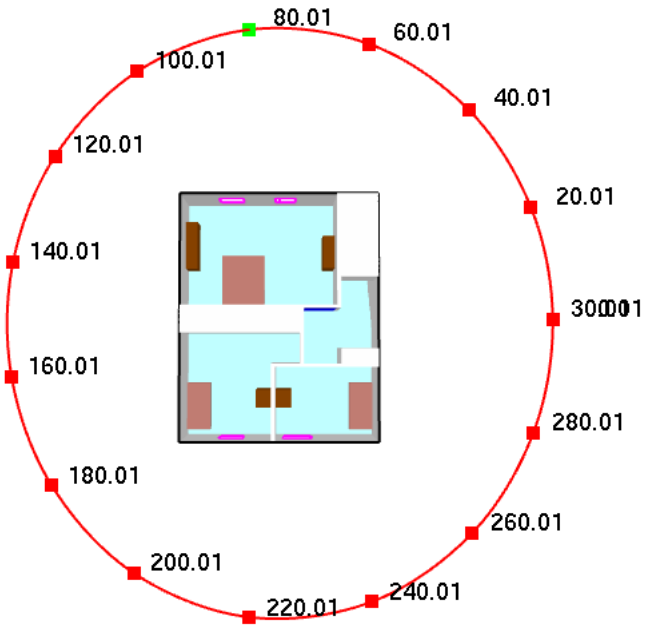


Figure 5.1: Overhead view of townhouse example showing the default *Circle* tour and a user defined tour. The square dots indicate the keyframe locations. Keyframes may be edited using the Touring or Advanced Touring dialog boxes.

initial tour is created by pressing the *Add Tour* button. This tour has two keyframes located at opposite ends of the Smokeview scene. Additional keyframes may be created by selected the *Add* button.

The position and viewpoint of a keyframe may be adjusted. First it must be selected. A keyframe may be selected by either clicking it with the left mouse button or by *moving* through the keyframes using the **Next** or **Previous** buttons. The active keyframe changes color from red to green. In Figure 5.1, the active or selected keyframe is at time 40 s. Keyframe positions may then be modified by changing data in the t, X, Y or Z edit boxes. A different view direction may also be set.

A new keyframe is created by clicking the **Add** button. It is formed by averaging the positions and view directions of the current and next keyframes. If the selected keyframe is the last one in the tour then a new keyframe is added beyond the last keyframe.

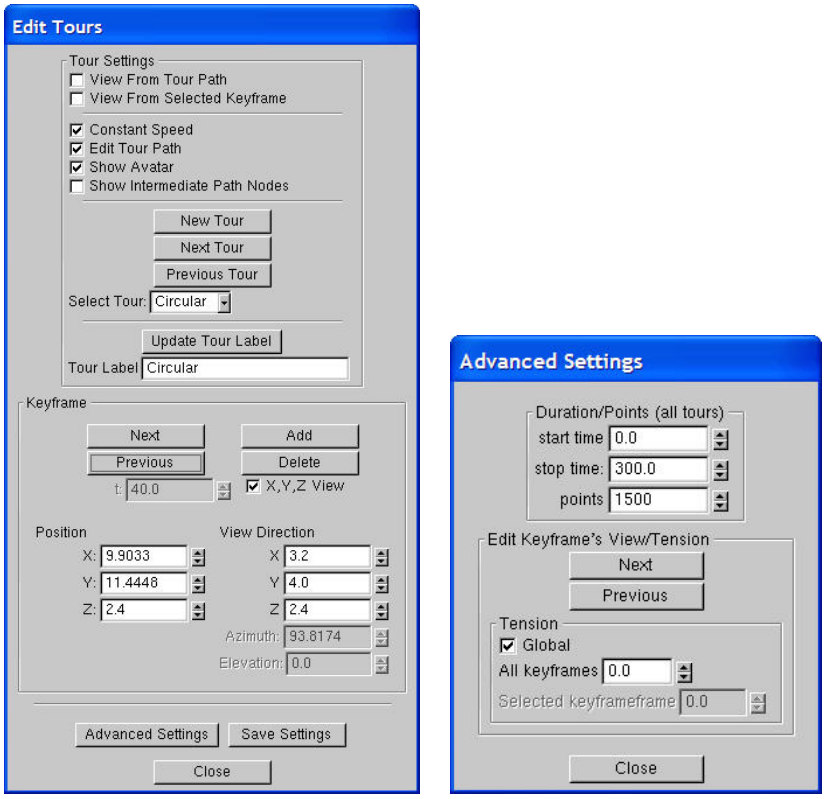
A keyframe may be deleted by clicking the **Delete** button. There is no **Delete Tour** button. A tour may be deleted by either deleting all of its keyframes or by deleting its entry in the casename.ini file.

5.3 Advanced Settings

The *Advanced Settings* dialog box is only necessary if one wishes to override Smokeview's choice of tension settings. This dialog box is opened by clicking the **Advanced Settings** button contained in the *Edit Tours* dialog box.

A view direction may be defined at each keyframe by either setting direction angles relative to the path (an azimuth and an elevation angle) or by setting a direction relative to the scene geometry (a cartesian (X,Y,Z) view direction).

Path relative view directions are enabled by default. To define a cartesian view direction, select the **X,Y,Z View** check box and edit the X, Y and Z View edit boxes to change the view location. To define an



a) basic options b) advanced options

Figure 5.2: The Touring dialog boxes may be used to select tours or keyframes, change the position or view direction at each keyframe and change the tension of the tour path.

path relative view direction, uncheck the **X,Y,Z View** check box and edit the Azimuth and Elevation edit boxes. Checking the **View From Selected Keyframe** checkbox in the *Edit Tours* dialog box allows one to see the effects of the view changes from the keyframe being edited. To see the effect of a change in one of the keyframe's parameters, uncheck the **View From Selected Keyframe** checkbox and position the tour locator (vertical and horizontal red lines) near the keyframe. The horizontal red line always points in the view direction.

Spline tension settings may also be changed using the *Advanced Settings* dialog box, though normally this is not necessary except when one wishes abrupt rather than smooth path changes. Kochanek-Bartels [18] splines (piecewise cubic Hermite polynomials) are used to represent the tour paths.

The cubic Hermite polynomials for each interval are uniquely specified using a function and a derivative at both endpoints of the interval (*i.e. 4 data values*). These derivatives are computed in terms of three parameters referred to as *bias*, *continuity* and *tension*. Each of these parameters range from -1 to 1 with a default value of 0. The tension value may be set for all keyframes at once (by checking the **Global** checkbox) or for each keyframe separately. The bias and continuity values are set to zero internally by Smokeview. A tension value of 0 is set by default, a value of 1 results in a linear spline.

5.4 Setting up a tour

The following steps give a simple example of setting up a tour in the townhouse scenario. The tour will begin at the back of the house, go towards the front door and then end at the top of the stairs. These steps are illustrated in Figure 5.3.

1. Start by clicking the `Dialog>Tours...` menu item which opens up the *Edit Tours* dialog box.

2. Click on the `New Tour` button in the *Edit Tour* dialog box. This creates a tour, illustrated in Figure 5.3a, starting at the front left of the scene and ending at the back right. This tour has two keyframes. The elevation of each keyframe is halfway between the bottom and top of the scene.

3. Click on the `Edit Tour Path` checkbox. This activates buttons that allows the user to edit the properties of each individual keyframe. Click on the square dot at the back of the townhouse. This is the first keyframe. Change the "Z" value to 1.0. Click on the second dot and change its "Z" value to 1.0.

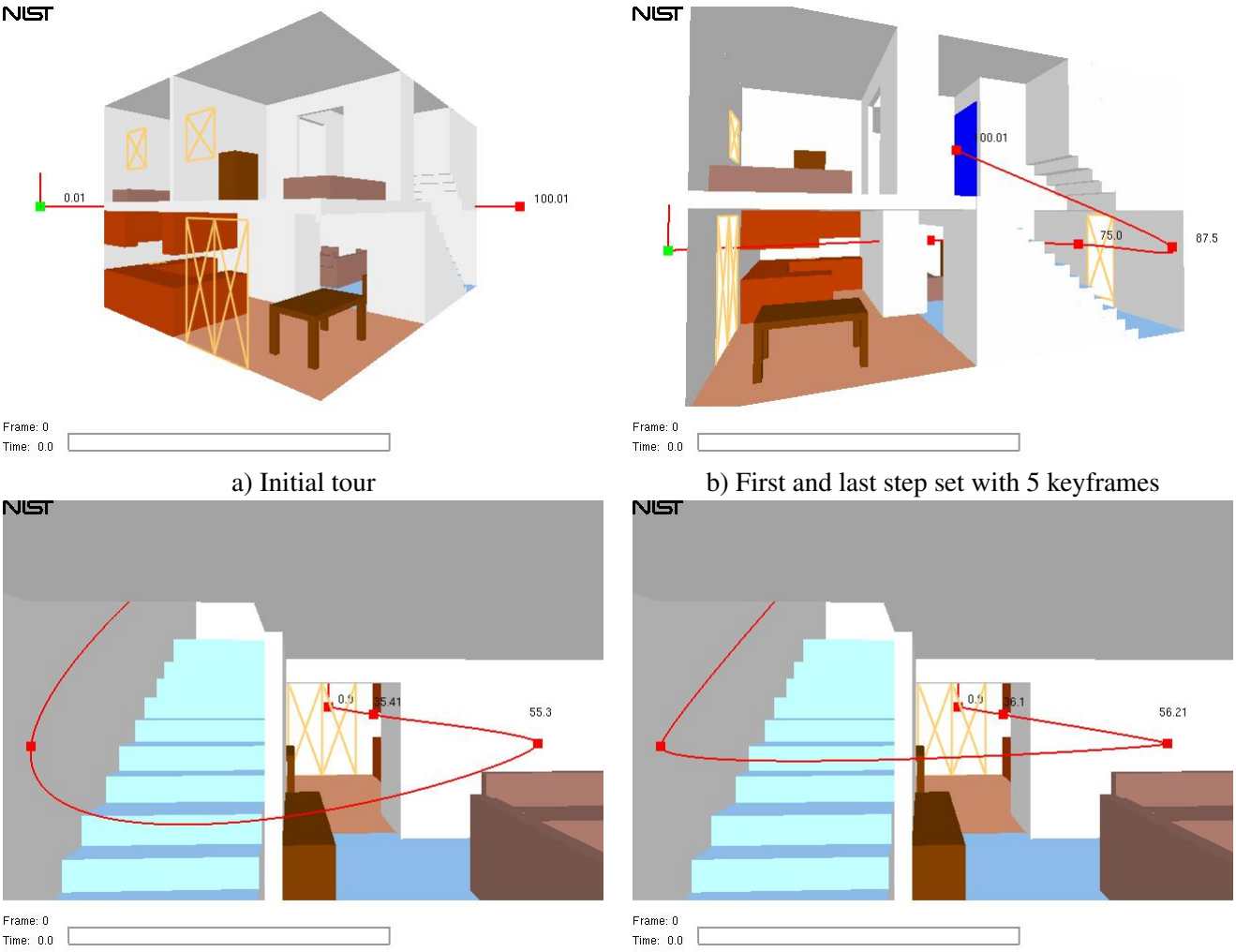
4. Click on the `Add` button, found inside the *Edit Keyframe's Position* panel, three times. This will add three more key frames to the tour which will be needed so that the path bends up the stairs. You should now have five keyframes.

5. Move the first keyframe at the back of the townhouse near the double door by setting X, Y, Z positions to (3.8,-1.0,1.6). Move the last keyframe to the top of the steps by setting X, Y, Z positions to (6.0,3.6,4.1). The path should now look like Figure 5.3b.

6. Move the second, third and fourth keyframes to positions (4.0,4.0,1.6), (4.0,6.8,1.6) and (6.0,6.8,1.6). The path should now look like Figure 5.3c.

7. Click on the `Advanced Settings` button. Check the `Global` checkbox and set the `All keyframes` edit box to 0.5. This *tightens* up the spline curve reducing the dip near the stairs that occurs with the tension=0.0 setting. The path should now look like Figure 5.3d.

8. Click on the `Save Settings` button to save the results of your editing changes.



a) Initial tour

b) First and last step set with 5 keyframes

c) All keyframe positions set (tension=0.0)

d) Tension set to 0.75

Figure 5.3: Tutorial examples for Tour option.

9. To see the results of the tour, click on the *View From Tour Path* check box.

The point of view of the observer on this path is towards the direction of motion. Next the view direction will be changed to point to the side while the observer is on the first floor.

1. Click on the `Advanced Settings` button if it is not already open.
2. Uncheck the *View From Tour Path* checkbox in the *tour* dialog box and make sure that the `X,Y,Z View` checkbox is unchecked.
3. Click on the dot representing the first keyframe. Then change *Azimuth* setting to 90 degrees. To see the results of the change, go back and check the *View From Tour Path* checkbox.
4. Uncheck the *View From Tour Path* checkbox again. Now select the second and third keyframes and change their azimuth settings to 90 degrees.

With this second set of changes, the observer will look to the side as they pass through the kitchen and living room. The observer will look straight ahead as they go up the stairs.

Chapter 6

Running Smokeview Automatically - The Scripting Option

6.1 Overview

Smokeview may be run in an automatic or batch mode using instructions found in a text file. The intent of the scripting option is to allow one to reproducibly document a case. A script may be re-run resulting in newly generated images guaranteed to correspond properly with the previously generated ones whenever changes occur in the FDS input file or in the FDS or Smokeview applications.

Script instructions direct Smokeview to perform actions such as loading data files, moving the scene to a specified view point, setting the time and rendering the scene. Smokeview settings such as font sizes, file bounds, label visibility *etc.* are set by using the script command LOADINI to load a custom named .ini file. A simplified scripting language results by allowing most customizations to be performed through the use of .ini files.

6.2 Creating a Script

Scripts may be created by Smokeview using the script recorder feature or may be created by editing a text file using commands described in the glossary that follows. A script may be run using three methods. It may be run from within Smokeview using the *Load/Unload>Script Option* menu or from the Scripts panel of the File/Bounds dialog box illustrated in Figure **??**. It may also be run from a Windows command shell using the command

```
smokeview -runscript casename
```

where casename is the name specified by the `CHID` keyword defined in the FDS input data file.

The recorder is turned on using the *Load/Unload>Script Option* menu and selecting *Start Recording*. After performing a sequence of steps, it is turned off and the script is saved. Typically steps involve loading data files, setting view points, setting times and rendering images.

6.2.1 Example 1

This example describes the steps used to create a simple script. This script will load a slice file and then display and render it at 10 s, 20 s, 30 s, 40 s and 50 s. The script corresponding to the steps listed below is given in Figure 6.2 .

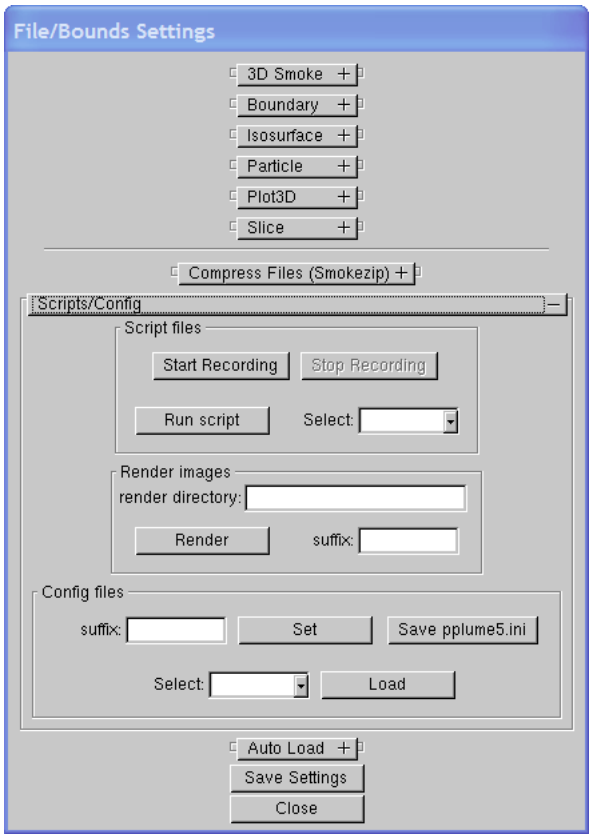


Figure 6.1: Script Dialog Box. The script dialog box allows one to setup and run smokeview scripts. The Script Dialog Box is invoked by selecting `Dialogs>File/Bounds`.

Figure 6.2: Script commands generated using the Smokeview script recorder option.

Note that the keyword, RENDERDIR, may used to *direct* that rendered images be placed in any directory not just the current one. Also, the RENDERONCE keywords in this script have a blank line afterwards (put there by default by the Smokeview script recorder). In this case, Smokeview uses the the default name for the resulting rendered image file. If this line is not blank, it is then used for the file name.

1. Obtain the test case script_slice_test.fds from the Verification/Visualization directory in the FDS−SMV repository.

2. Run the case with FDS

3. After opening the case in Smokeview, select the *Load/Unload>Script Options>Start Recording* menu item.

4. Load a slice file (doesn't matter which one).

5. Move the time bar to 10 s and then press the 'r' key. Repeat for 20 s, 30 s, and 40 s

6. Unload the slice file. (Not necessary, this step just makes the script action more obvious.)

7. Select the *Load/Unload>Script Options>Stop Recording* menu item. This is very important. The script will not be saved if you exit Smokeview without selecting this option.

8. Run the script using the *Load/Unload>Script Options* menu .

6.2.2 Example 2

This example describes the steps used to create a script that is more involved. It is listed in Figure 6.3 which in turn was used to create the images illustrated in Figure 6.4. The script built here will create three images, a slice file viewed and clipped from the left at 5 s, the same slice file viewed from the center at 10 s, and again the same slice file viewed and clipped from the right at 15 s. The center slice is not clipped.

Several preliminary steps need to be performed before script actions may be recorded. In particular a left and right view point will be defined and an .ini file will be setup that contains clipping values for the left and right slice file images.

Obtaining and setting up the example

1. Obtain the test case script_test.fds from the Verification/Visualization directory in the FDS−SMV repository. Copy this file to a separate directory if a local copy of the repository already exists (so that svn updates will not overwrite the script file generated in this example). Of course, these steps may be repeated for any test case that have data files defined.

2. Run the case with FDS

3. Open the case in Smokeview

4. Open the Scripts/Config panel of the File/Bounds dialog box, the Clip Geometry dialog box and the Viewpoints panel of the Motion/View dialog box.

Preliminary Steps - Setting up the viewpoints

1. Rotate the scene slightly to the right of center so that you can see the left side of the geometry. In the Viewpoints panel of the Motion/View dialog change `new view` to `left` then click on the *Add* button.
2. Rotate the scene slightly to the left of center so that you can see the right side of the geometry. In the Viewpoints panel of the Motion/View dialog change `new view` to `right` then click on the *Add* button.
3. Click the *Save Settings* button.

An .ini file has now been saved with two custom view points defined named left and right.

Preliminary Steps - Defining clip planes and creating additional .ini files

Defining the left clipping plane.

1. Click on the Clip Blockages + Data radio button,
2. change the *Clip Lower x* value 0.5 after checking the check box next to edit field.
3. Save an .ini file named script_test_left.ini by entering the text `left` in the suffix field of the Config files section of the Scripts/Config dialog.
4. Click on the Set button then the Save script_test_left.ini button.

Defining the right clipping plane.

1. Click on the Clip Blockages + Data radio button,
2. change *Clip Upper x* value 1.0 after checking check box next to edit field.
3. Save an .ini file named script_test_right.ini by entering the text `right` in the suffix field of the Config files section of the Scripts/Config dialog.
4. Click on the Set button then the Save script_test_right.ini button.

Two .ini files named `scripts_test_left.ini` and `scripts_test_right.ini` have now been created.

Recording the Script

The script may be recorded now that the .ini files and viewpoints have been created. The following steps reference the Scripts/Config dialog.

1. Click on the Start Recording button
2. Load the $y = 0.8$ temperature slice from the Load/Unload menu.
3. Generate the left image
   (a) Select the script_test_left.ini file and click on Load
   (b) Select the left view from the View menu.

```
// note: The RENDERDIR pathname has been changed to point
//       to where the Smokeview User guide script figures are kept
RENDERDIR
 ..\..\Manuals\SMV_5_User_Guide\SCRIPT_FIGURES
LOADINIFILE
 script_test.ini
SETVIEWPOINT
 left
LOADFILE
 script_test_05.sf
SETTIMEVAL
 5.012974
RENDERONCE
 script_test_left_05
SETVIEWPOINT
 center
SETTIMEVAL
 10.006555
RENDERONCE
 script_test_center_10
SETVIEWPOINT
 right
SETTIMEVAL
 15.006024
RENDERONCE
 script_test_right_15
```

Figure 6.3: Script commands generated using the Smokeview script recorder option.

(c) Set the time to 5.0

(d) Set the render suffix to left_05 and press the Render button

4. Generate the center image

   (a) Select the script_test.ini file and click on Load

   (b) Select external from the View menu.

   (c) Set the time to 10.0

   (d) Set the render suffix to right_10 and press the Render button

5. Render the right image

   (a) Select the script_test_right.ini file and click on the Load button

   (b) Select the right view from the View menu.

   (c) Set the time to 15.0

   (d) Set the render suffix to right_15 and press the Render button

6. Click on the Stop Recording button

6.3 Script Glossary

This section contains documentations for the script commands. Commands fall into three logical categories. Commands to load data files, commands to position the scene in both time and space and commands to output the scene to image files.

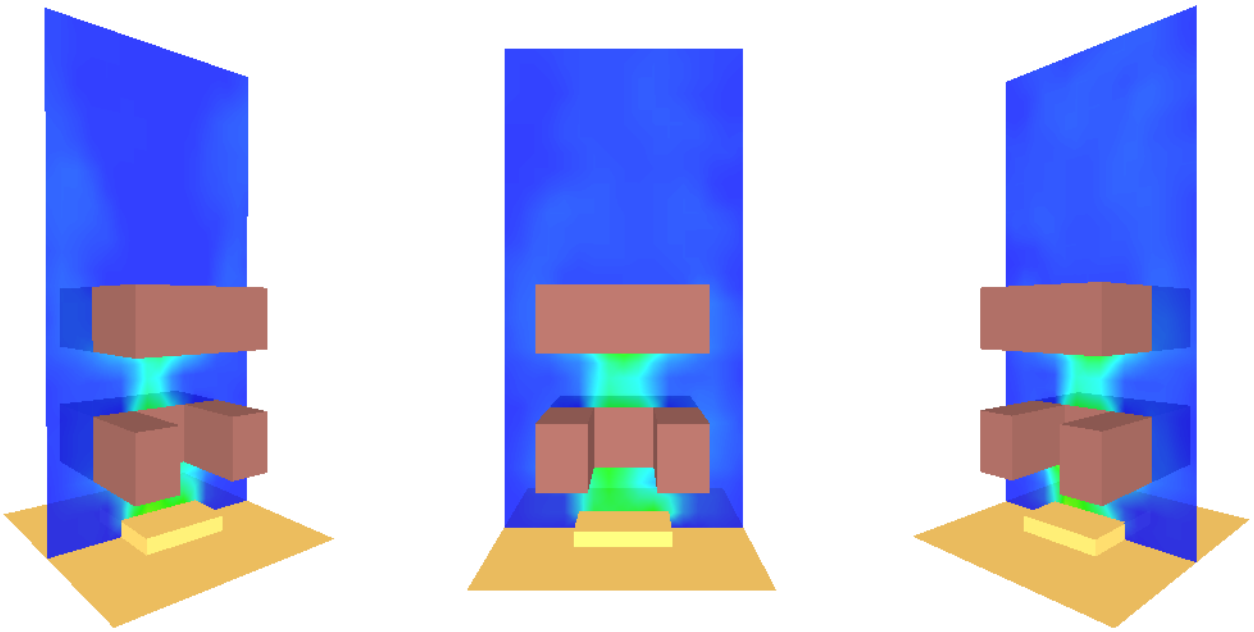


Figure 6.4: Smokeview images generated using script detailed in Figure 6.3

6.3.1 Loading and Unloading Files

LOADFILE Use LOADFILE to load a particular file. Smokeview will determine what kind of file it is (3d smoke, slice *etc.*) and call the appropriate routine to load the data.
Use other LOAD commands to load files of the specified type for all meshes. Usage:

```
LOADFILE
  file (char)
```

LOADINIFILE Use LOADINIFILE to load a configuration of `.ini` file. Usage:

```
LOADINIFILE
  file (char)
```

LOADVFILE Use LOADVFILE to load a particular vector slice file. Smokeview will load the file specified along with the corresponding U, V and W velocity slice files if they are available. Usage:

```
LOADVFILE
  file (char)
```

LOADBOUNDARY Load a boundary file of a particular type. The type is the same as what Smokeview displays in the Load menus for boundary files. Usage:

```
LOADBOUNDARY
   type (char)
```

LOAD3DSMOKE soot mass fraction

LOAD3DSMOKE Load a 3D smoke file. Two types are supported `soot mass fraction` or `HRRPUV`. Usage:

```
LOAD3DSMOKE
  type (char)
```

LOADPARTICLES Load particle files. Only particle files created with FDS version 5 or later are supported. Usage:

```
LOADPARTICLES
```

PARTCLASSCOLOR Show a particular particle class. Class names supported for a given run are displayed in the Particle Class Smokeview menu. Usage:

```
PARTCLASSCOLOR
   color (char)
```

PARTCLASSTYPE Show a particular particle type. Type names supported for a given run are displayed in the Particle Type Smokeview menu. Usage:

```
PARTCLASSTYPE
   type (char)
```

LOADPLOT3D Load a plot3D file for a given mesh at a specified time. Usaage:

```
LOADPLOT3D
  mesh number (an integer form 1 to the number of meshes) time (float)
```

PLOT3DPROPS Specifies PLOT3D plot properties that apply to all PLOT3D plots currently being displayed. Usage:

```
PLOT3DPROPS
  plot3d type (int) showvector (0/1) (int) vector length index (int) plot3
```

where

- plot3d type - is an integer from 1 to the number of PLOT3D file components (usually 5),
- showvector - is 1 to draw vectors, 0 otherwise
- vector length index, is an integer index from 0 to 6 pointing to an internal Smokeview array used to determine vector size.
- plot3d display type - is 0 for stepped contours, 1 for line contours and 2 for continuous contours

SHOWPLOT3DDATA Specifies a particular PLOT3D plot to be displayed (mesh number, whether visible or not, orientation and position) Usage:

```
SHOWPLOT3DDATA
  mesh number (int) plane orientation (int)  display show/hide (0/1) (int)
```

where

- mesh number - the mesh number (ranges from 1 to the number of meshes),
- orientation - direction or orientation of the plane being plotted, 1 for YZ planes, 2 for XZ planes and 3 for XY planes
- display - 0 if PLOT3D plane is hidden, 1 if it is displayed
- position - position of PLOT3D plane

LOADISO Load an iso-surface file of a given type. The type is the same as what Smokeview displays in the Load menus for iso-surface files. Usage:

```
LOADISO
  type (char)
```

LOADSLICE Load a slice file of a given type. The type is the same as what Smokeview displays in the Load menus for slice files. The plane orientation is specified by using 1 for x, 2 for y and 3 for z. Usage:

```
LOADSLICE
  type (char)
  1/2/3 (int)  val (float)
```

LOADVSLICE Load a vector slice file of a given type. The type is the same as what Smokeview displays in the Load menus for slice files. The plane orientation is specified by using 1 for x, 2 for y and 3 for z. Usage:

```
LOADVSLICE
 type (char)
 1/2/3 (int)  val (float)
```

UNLOADALL Unload all data files currently loaded. Usage:

```
UNLOADALL
```

6.3.2 Controlling the Scene

LOADTOUR Load a tour of a given name. Usage:

```
LOADTOUR
 type (char)
```

UNLOADTOUR Unload a tour.

```
UNLOADTOUR
```

SETTIMEVAL Set the time for displaying data to a specified value. Usage:

```
SETTIMEVAL
  time (float)
```

SETVIEWPOINT Set a view point . The view point must have been previously defined and saved in an .ini file. Usage:

```
SETVIEWPOINT
  viewpoint (char)
```

EXIT Cause Smokeview to quit. Usage:

```
 EXIT
```

6.3.3 Rendering Images

RENDERDIR Specify a directory where rendered files should go. Usage:

```
RENDERDIR
  directory name
```

Smokeview automatically converts directory separators (‘/’ for Linux/Mac systems and ‘//’ for Windows systems) to the separator appropriate for the host system.

RENDERONCE Render the current scene. Usage:

```
RENDERONCE
```

```
 file name (optional)
```

Smokeview will assign the filename automatically if the entry after the RENDERONCE keyword is blank.

RENDERDOUBLEONCE Render the current scene at double resolution. Usage:

```
RENDERDOUBLEONCE
 file name (optional)
```

As with RENDERONCE, Smokeview will assign the filename automatically if the entry after the RENDERDOUBLEONCE keyword is blank.

RENDERALL Renders a frame for each time step optionally skipping frames. Usage:

```
RENDERALL
  skip (integer)
  file name base (char) (or blank to use smokeview default)
```

Part II

Visualization

Chapter 7

Realistic or Qualitative Visualization - 3D Smoke

FDS generates several data files visualized by Smokeview. Each file type may be loaded or unloaded using the `Load/Unload` menu described in Appendix B.2. Visualizations produced by these data files are described in this and the following sections. The format used to store each of the data files is given in the FDS User's Guide [3].

Visualizing smoke realistically is a daunting challenge for at least three reasons. First, the storage requirements for describing smoke can easily exceed the disk capacities of present 32 bit operating systems such as Linux, *i.e.* file sizes can easily exceed 2 gigabytes. Second, the computation required both by the CPU and the video card to display each frame can easily exceed 0.1 s, the time corresponding to a 10 frame/s display rate. Third, the physics required to describe smoke and its interactions with itself and surrounding light sources is complex and computationally intensive. Therefore, approximations and simplifications are required to display smoke rapidly.

Smoke visualization techniques such as tracer particles or shaded 2D contours are useful for quantitative analysis but not suitable for virtual reality applications, where displays need to be realistic and fast as well as accurate. The approach taken by Smokeview is to display a series of parallel planes. Each plane is colored black (for smoke) with transparency values pre-computed by FDS using time dependent soot densities also computed by FDS corresponding to the grid spacings of the simulation. The transparencies are adjusted in real time by Smokeview to account for differing path lengths through the smoke as the view direction changes. The graphics hardware then combines the planes together to form one image.

Fire by default is colored a dark shade of orange wherever the computed heat release rate per unit volume exceeds a user-defined cutoff value. The visual characteristics of fire are not automatically accounted for. The user though may use the *3D Smoke* dialog box to change both the color and transparency of the fire for fires that have *non-standard* colors and opacities.

The windows version of Smokeview has the option of using the GPU or graphics programming unit to perform some of the calculations required to visualize realistic smoke. These calculations consist of adjusting the smoke opaqueness as pre-computed in FDS to account for off-axis viewing directions. The GPU performs the computations in parallel while the former method using the CPU performs them sequentially. For many (but not all) cases, the use of the GPU results in a smoke drawing speed up of 50 % or more. This option is turned on or off by pressing the *G* key.

Figure 7.1 illustrates a visualization of realistic smoke.

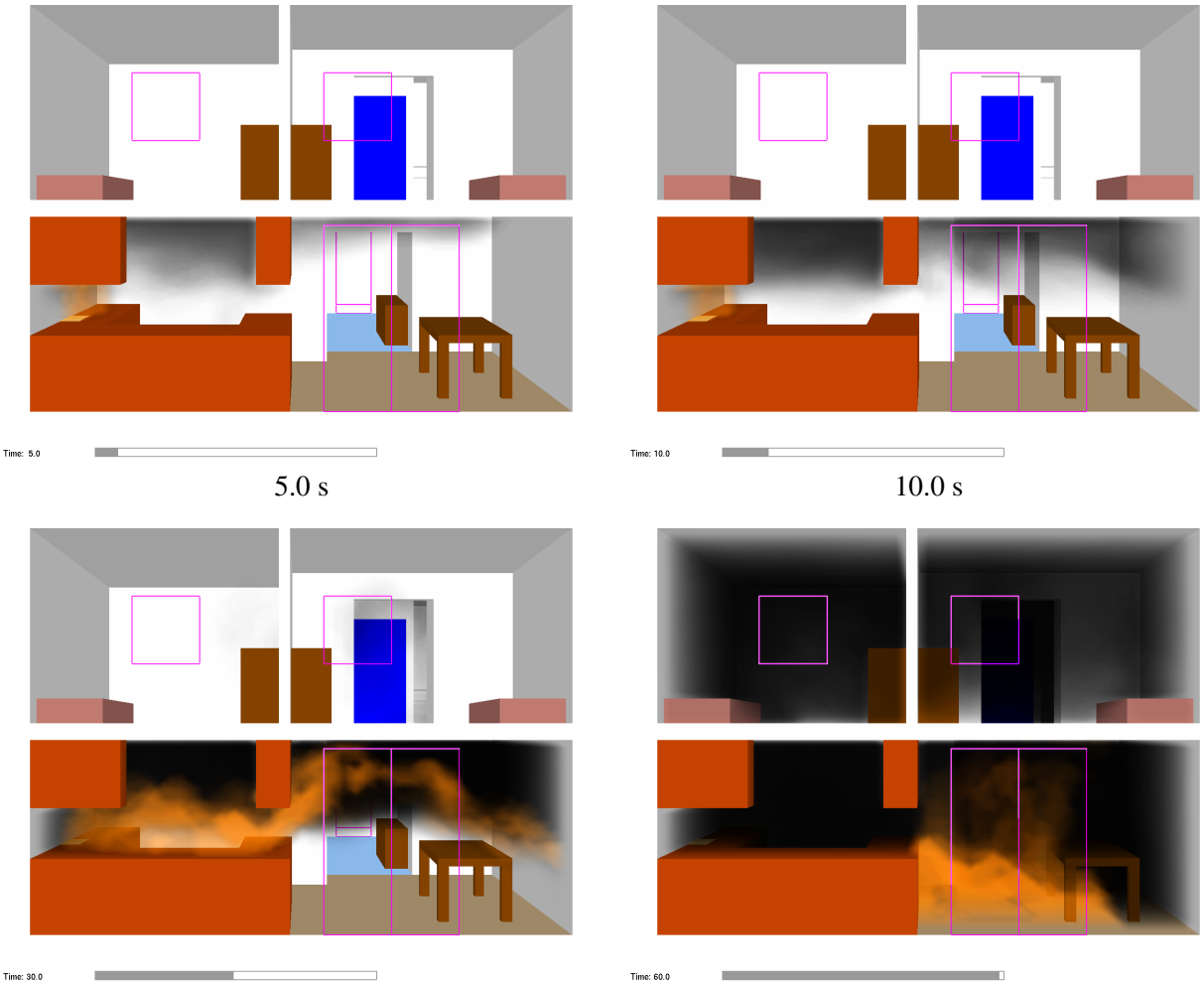


Figure 7.1: Smoke3d file snapshots at various times in a simulation of a townhouse kitchen fire.

Chapter 8

Scientific or Quantitative Visualization

8.1 Tracer Particles and Streaklines - Particle Files

Particle files contain the locations of tracer particles used to visualize the flow field. Figure 8.1 shows several snapshots of a developing kitchen fire visualized by using particles where particles are colored black. If present, sprinkler water droplets would be colored blue. Particles are stored in files ending with the extension `.prt5`[1] and are displayed by selecting the particle file entry from the `Load/Unload` menu.

Streaklines are a technique for showing motion in a still image. Figure 8.2 shows a snapshot of the same kitchen fire using streak lines instead of particles. The streaks begin at 6 s and end at 10 s.

Particle file data may be converted to an isosurace using Smokezip. The isosurface location is defined in terms of particle density and the isosurface color is defined in terms of averaged particle values. See Chapter 17.1 for more details on using Smokezip for generating isosurface files from particle files and Section **??** for some examples.

8.2 2D Shaded Contours and Vector Slices - Slice Files

Slice files contain results recorded within a rectangular array of grid points at each recorded time step. Continuously shaded contours are drawn for simulation quantities such as temperature, gas velocity and heat release rate. Figure 8.3 shows several snapshots of a vertical animated slice where the slice is colored according to gas temperature. Slice files have file names with extension `.sf` and are displayed by selecting the desired entry from the `Load/Unload` menu.

To specify in FDS a vertical slice 1.5 m from the $y = 0$ boundary colored by temperature, use the line:

```
&SLCF PBY=1.5 QUANTITY='TEMPERATURE' /
```

A more complete list of output quantities may be found in Ref. [3].

New data coloring Smokeview uses a new more precise method for coloring data occurring in slice, boundary and PLOT3D files. This is illustrated in Figure 8.4. The colors are now crisper and sharper, more accurately representing the underlying data. This is most noticeable when selecting the colorbar with the mouse. As before this causes a portion of the colorbar to turn black and the corresponding region in the scene to also turn black. Now the black color is accurate to the pixel so this feature could be used to highlight regions of interest. The improved accuracy is a result of the way color interpolations are performed. The new method uses a 1D texture map (the colorbar) to color data. Colors are interpolated within the colorbar. Color interpolations with the former method occurred within the color cube.

[1] Particle files created with FDS version 4 and earlier use the `.part` extension

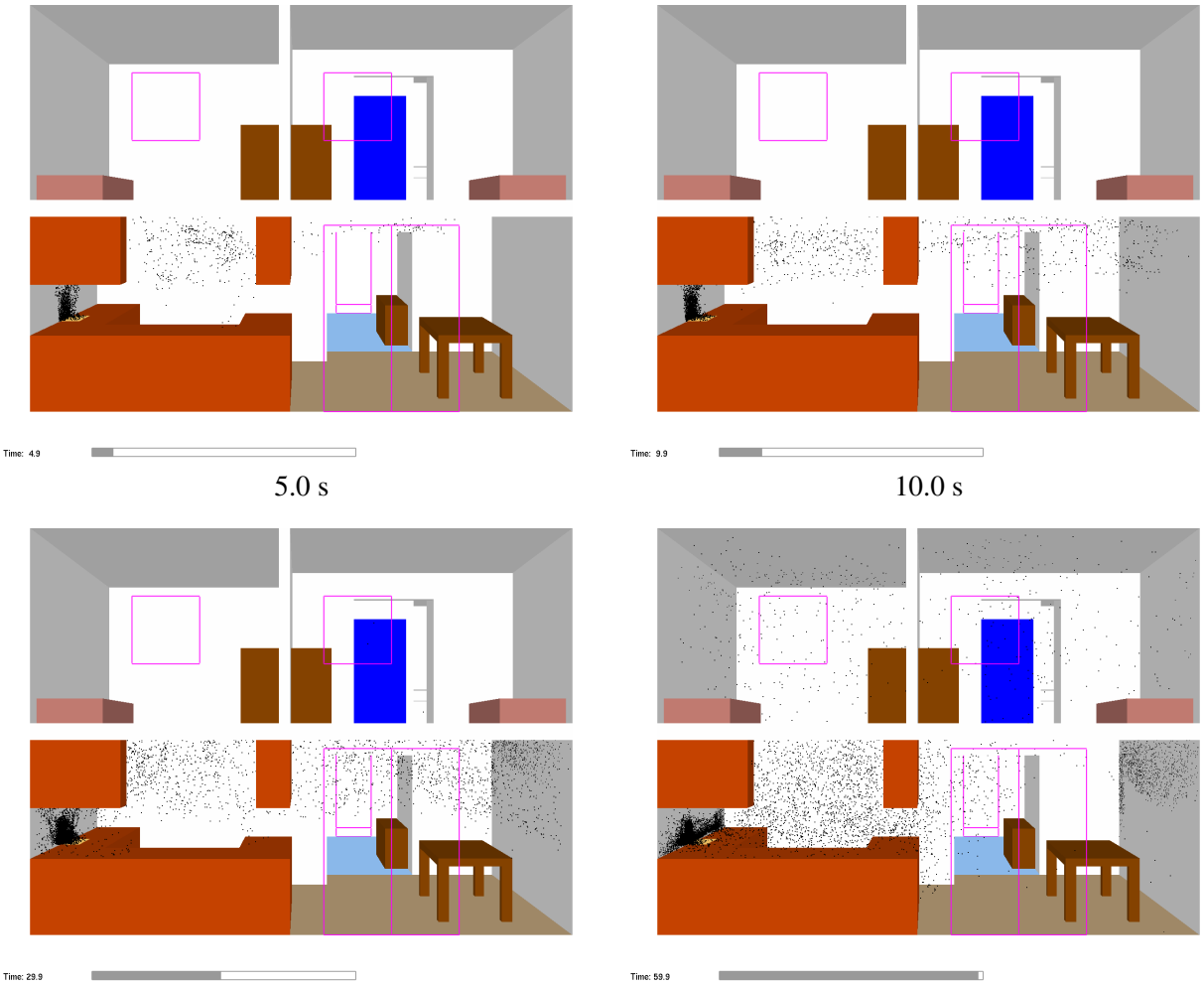


Figure 8.1: Townhouse kitchen fire visualized using tracer particles.

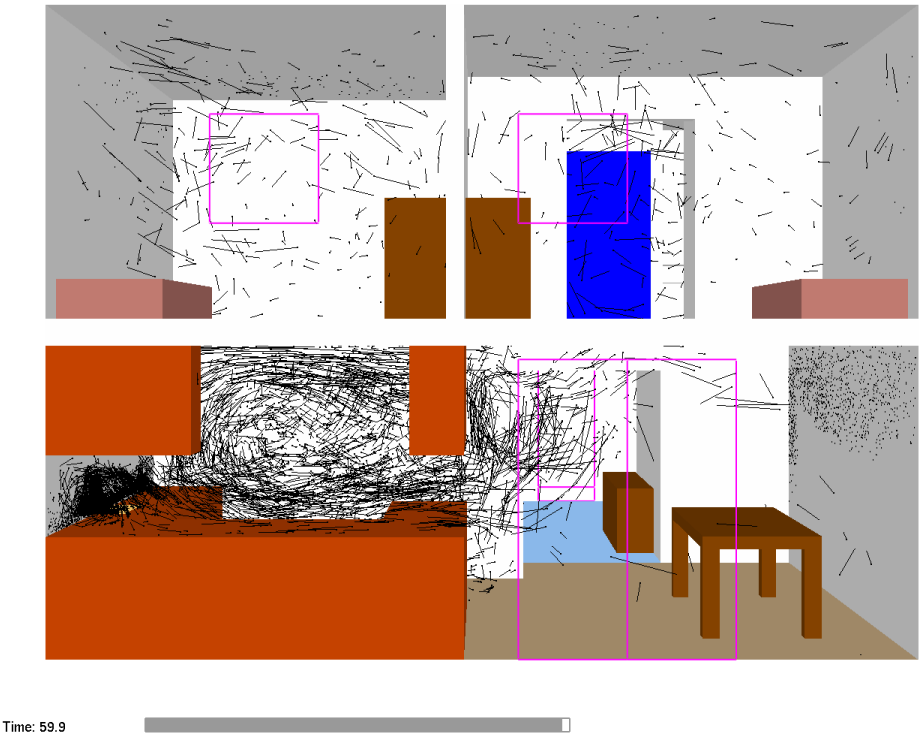


Figure 8.2: Townhouse kitchen fire visualized using streak lines. The *pin heads* shows flow conditions at 10 s, the corresponding *tails* shows conditions 0.25 s.

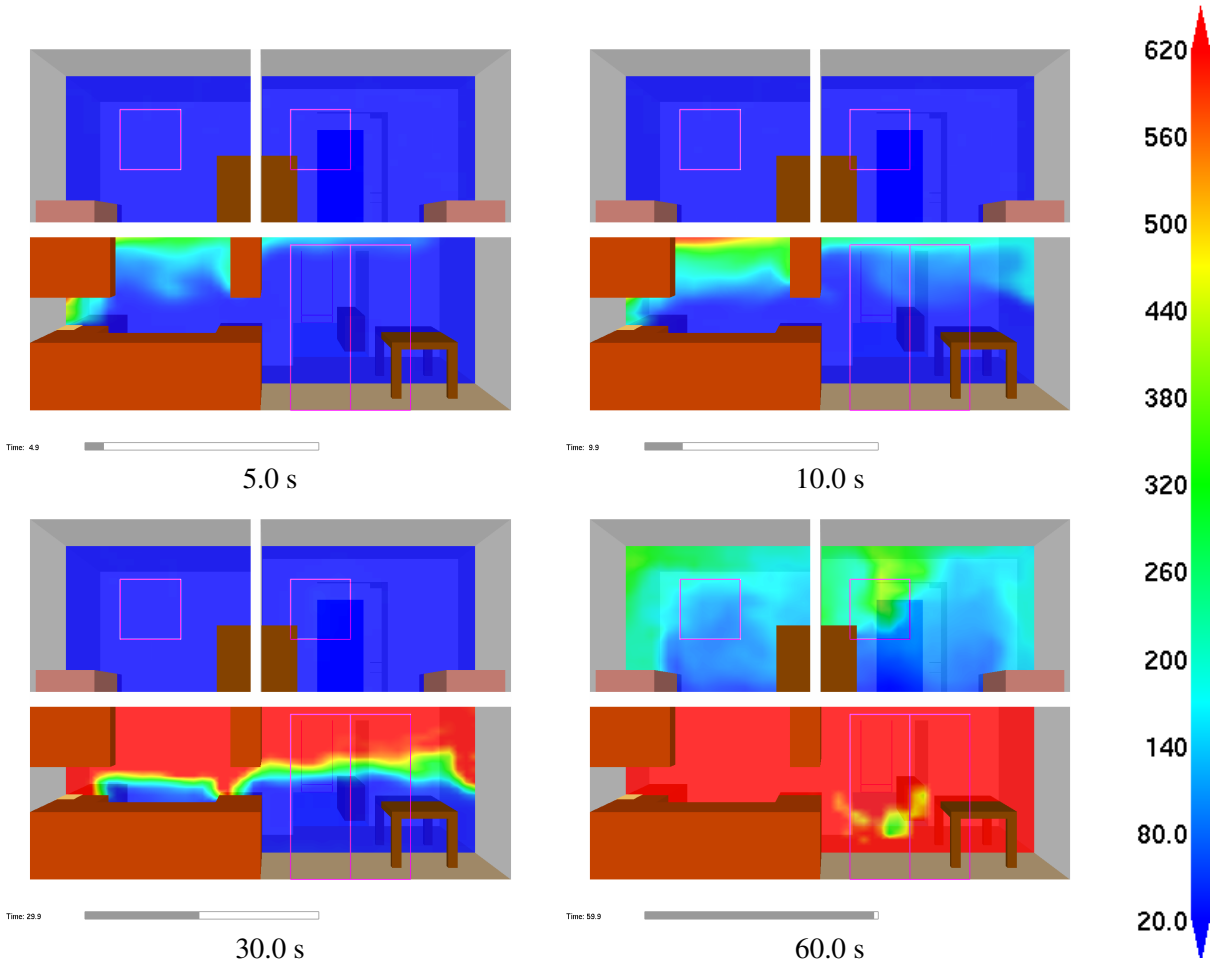
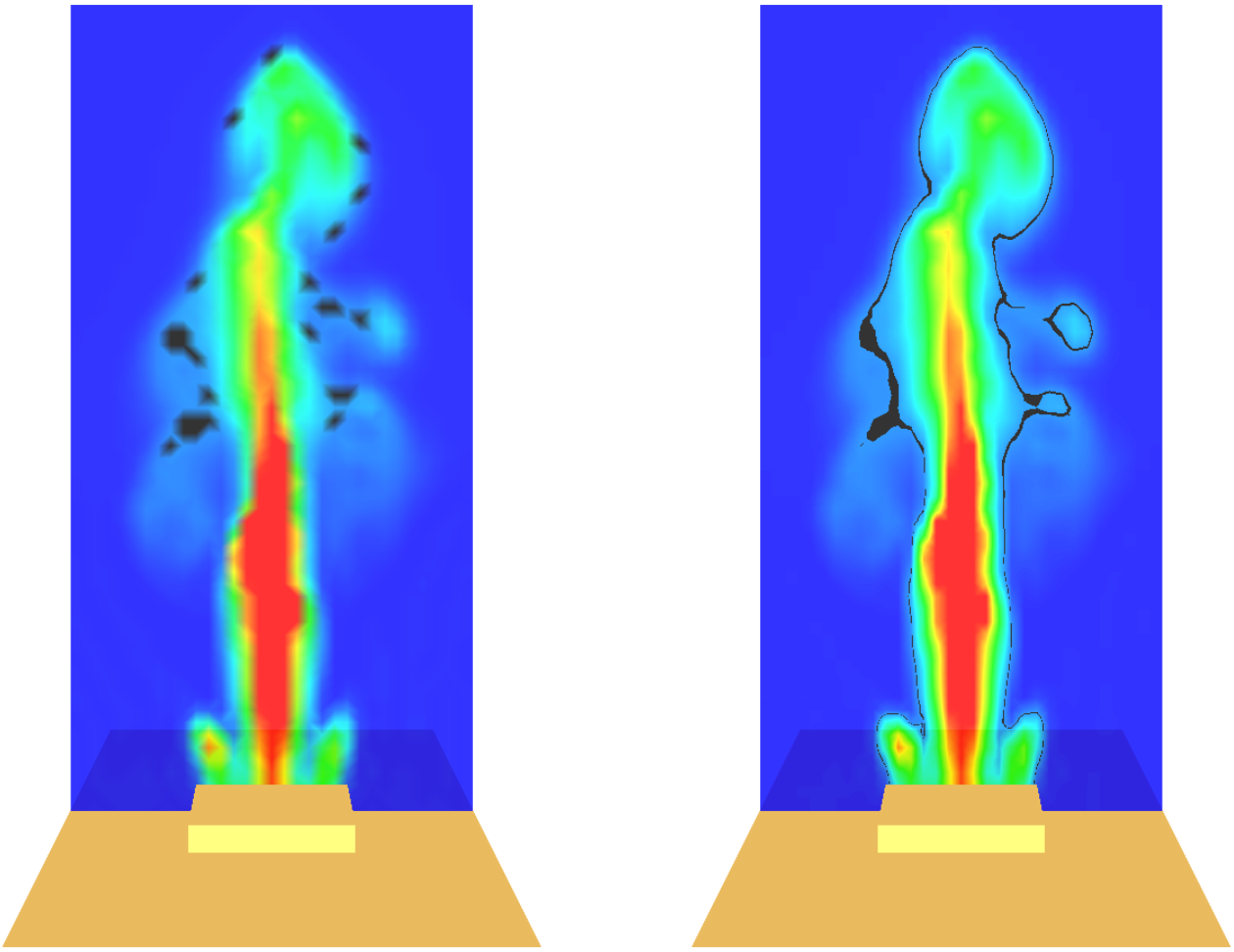


Figure 8.3: Slice file snapshots of shaded temperature contours at various times in a simulation. These contours were generated by adding "`&SLCF PBY=1.5, QUANTITY='TEMPERATURE' /`" to the FDS input file.



colors interpolated using a 3D color cube

colors interpolated using a 1D texture color bar

Figure 8.4: Slice file snapshots illustrating old and new method for coloring data.

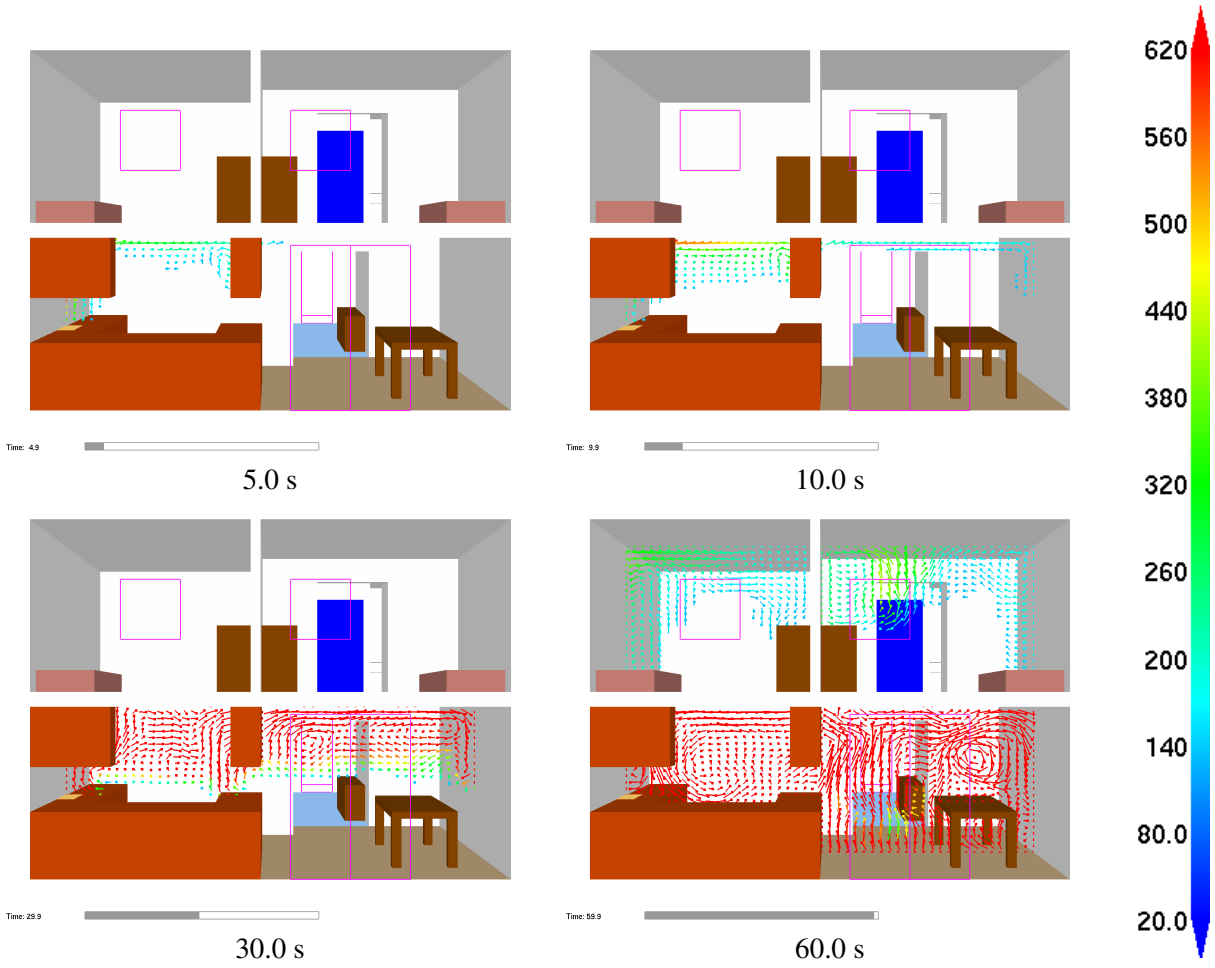


Figure 8.5: Vector slice file snapshots of shaded vector plots. These vector plots were generated by using "`&SLCF PBY=1.5,QUANTITY='TEMPERATURE',VECTOR=.TRUE. /`".

3D Slice Files The user may visualize a 3D region of data using slice files. The slices may be moved from one plane to the next just as with PLOT3D files (using left/right, up/down cursor keys or page up/page down keys). To specify in FDS a cube of data from 1.0 to 2.0 in each of the X, Y and Z directions, use the line:

```
&SLCF XB=1.0,2.0,1.0,2.0,1.0,2.0 QUANTITY='TEMPERATURE' /
```

Animated vectors are displayed using data contained in two or more slice files. The direction and length of the vectors are determined from the U, V and/or W velocity slice files. The vector colors are determined from the file (such as temperature) selected from the `Load/Unload` menu. The length of the vectors can be adjusted by pressing the `'a'` key. For cases with a fine grid, the number of vectors may be overwhelming. Vectors may be skipped by pressing the `'s'` key. Figure 8.5 shows a sequence of vector slices corresponding to the shaded temperature contours found in Figure 8.3.

To generate the extra velocity files needed to view vector animations, add `VECTOR=.TRUE.` to the above `&SLCF` line to obtain:

```
&SLCF PBY=1.50,QUANTITY='TEMPERATURE',VECTOR=.TRUE. /
```

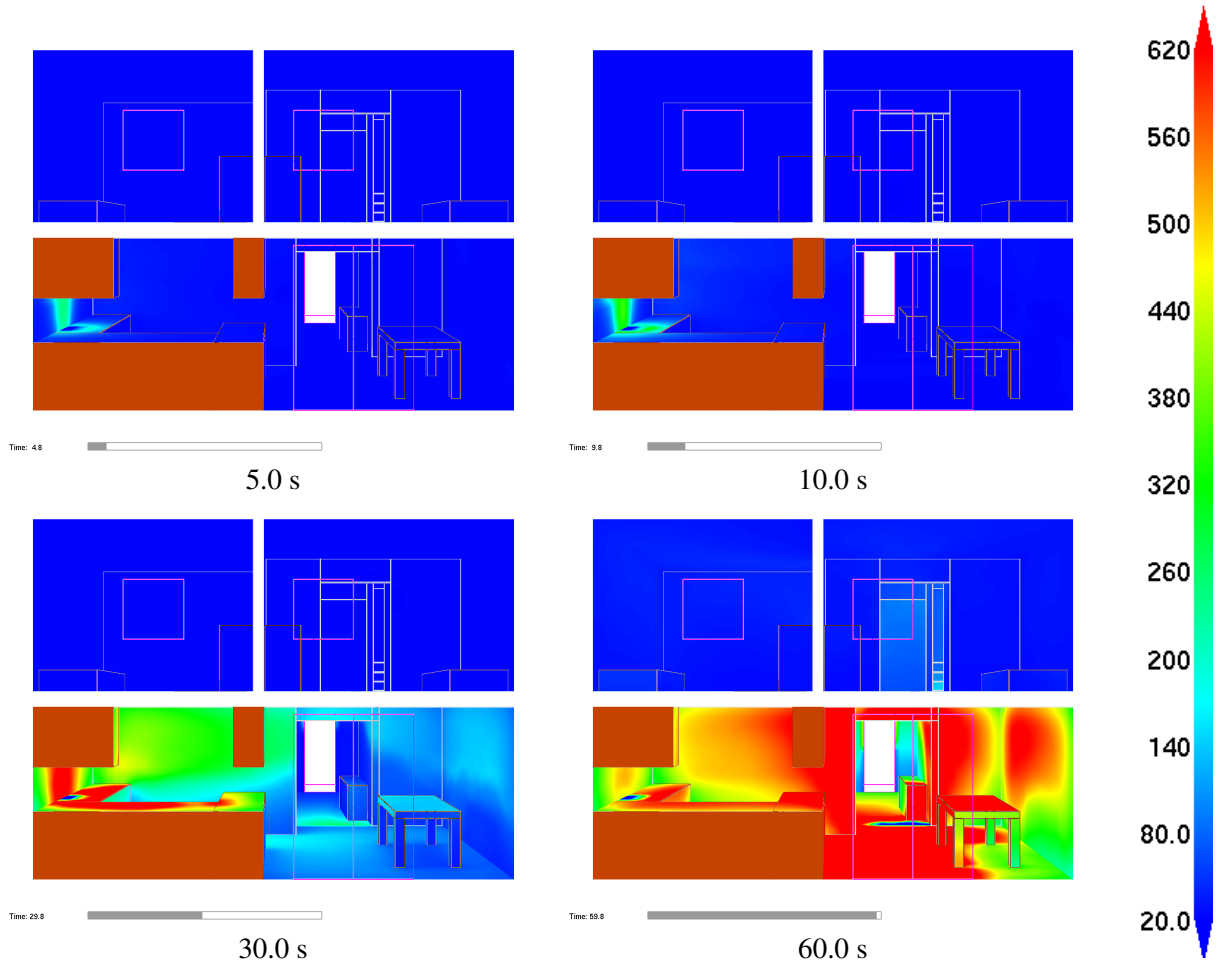


Figure 8.6: Boundary file snapshots of shaded wall temperatures (cell averaged data). These snapshots were generated by using "`&BNDF QUANTITY='WALL_TEMPERATURE'/`".

8.3 2D Shaded Contours on Solid Surfaces - Boundary Files

Boundary files contain simulation data recorded at blockage or wall surfaces. Continuously shaded contours are drawn for quantities such as wall surface temperature, radiative flux, *etc*. Figure 8.8 shows several snapshots of a boundary file animation where the surfaces are colored according to their temperature. Boundary files have file names with extension `.bf` and are displayed by selecting the desired entry from the `Load/Unload` menu. Figure 8.7 shows the same snapshots as in Figure 8.8 except that data below 200 °Cis chopped.

A boundary file containing wall temperature data may be generated by using:

```
&BNDF 'WALL_TEMPERATURE' /
```

Loading a boundary file is a memory intensive operation. The entire boundary file is read in to determine the minimum and maximum data values. These bounds are then used to convert four byte floats to one byte color indices. To drastically reduce the memory requirements, simply specify the minimum and maximum data bounds using the *Set Bounds* dialog box. This should be done before loading the boundary file data. When this is done, memory for the boundary file data is allocated for only one time step rather than for all time steps.

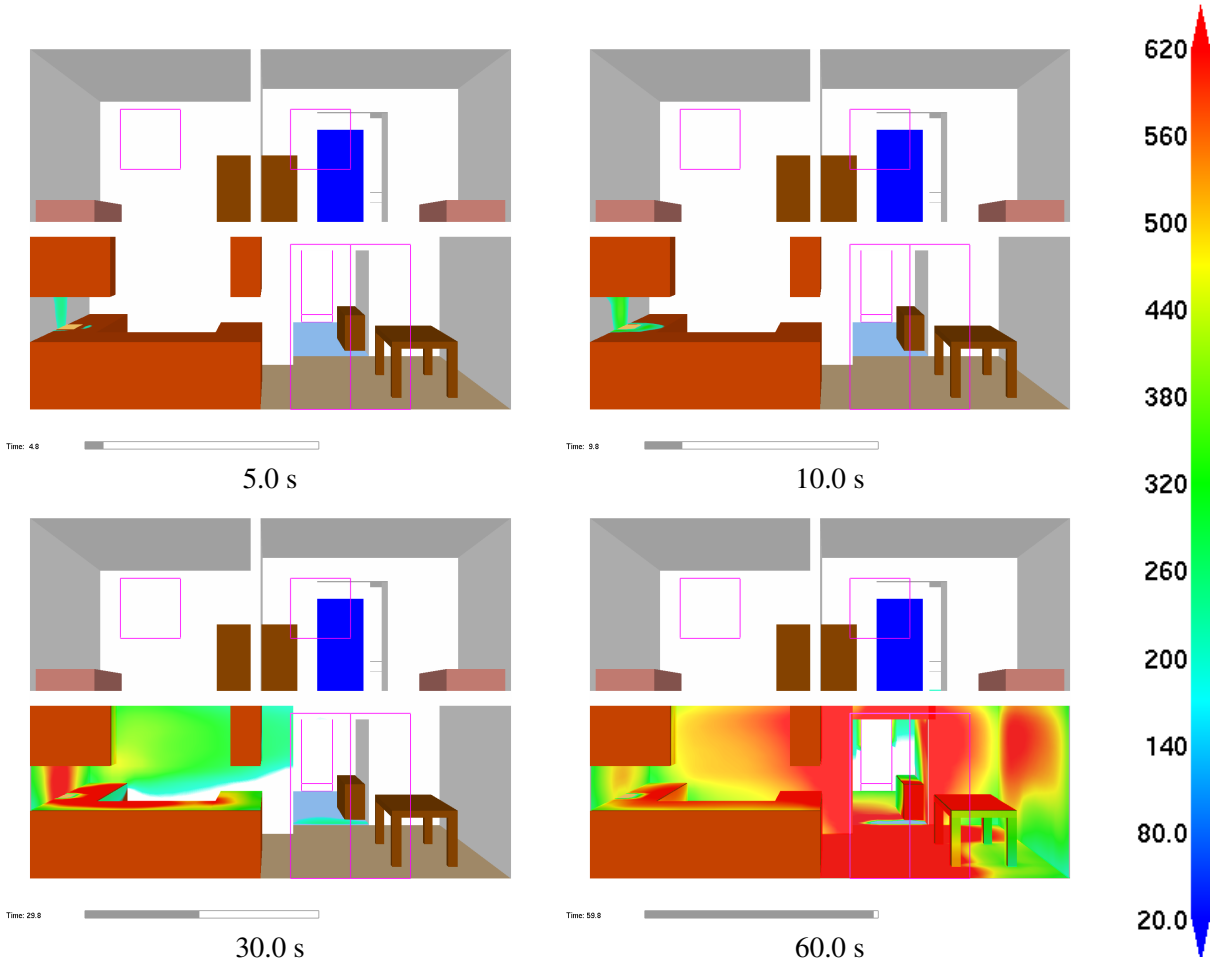


Figure 8.7: Boundary file snapshots of truncated shaded wall temperatures (cell averaged data). Data values are truncated or chopped below 200 °C. These snapshots were generated by using "`&BNDF QUANTITY='WALL_TEMPERATURE'/`".

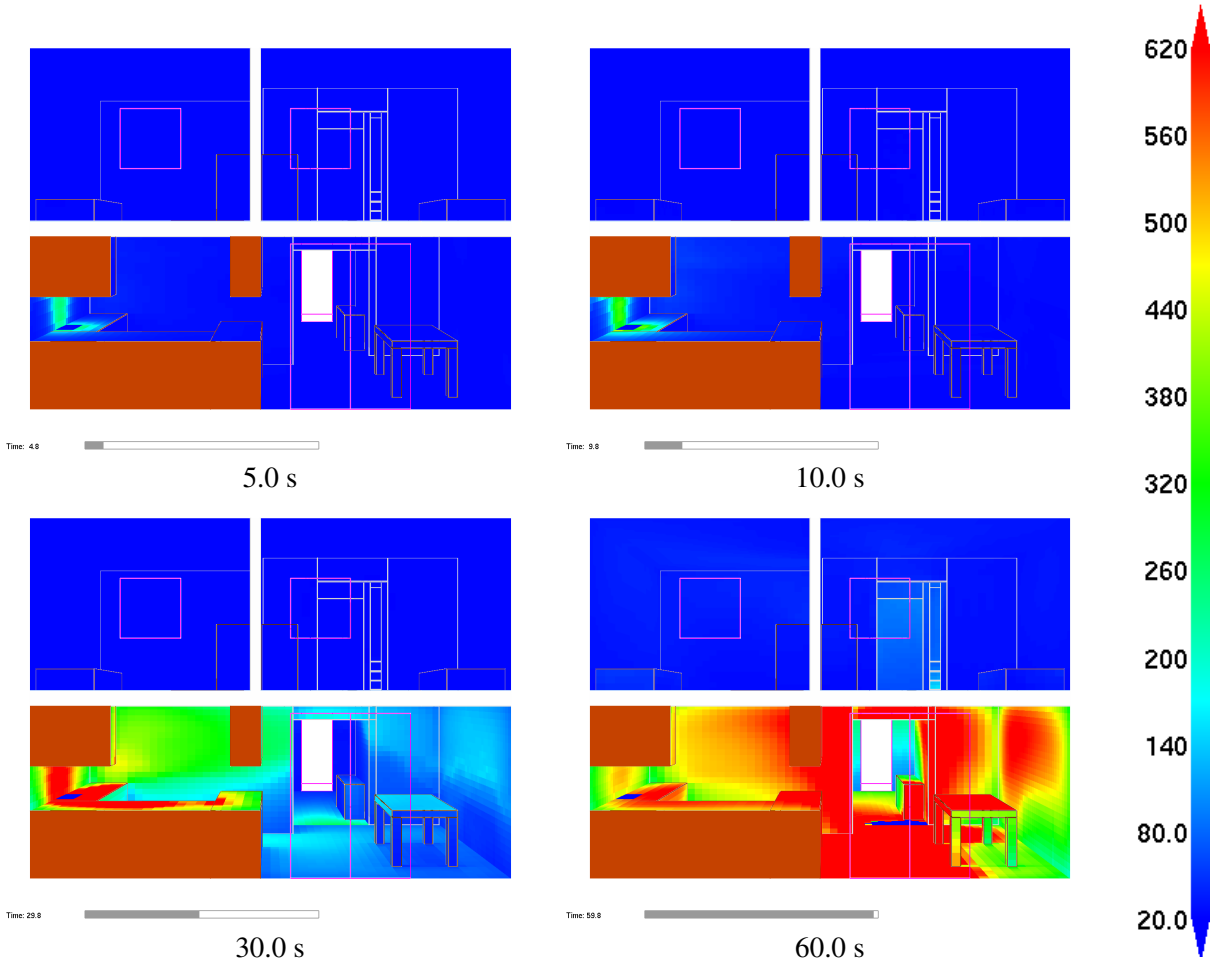


Figure 8.8: Boundary file snapshots of shaded wall temperatures (cell centered data) These snapshots were generated by using "`&BNDF QUANTITY='WALL_TEMPERATURE' CELL_CENTERED=.TRUE. /`".

8.4 3D Contours - Isosurface Files

The surface where a quantity such as temperature attains a given value is called an isosurface. An isosurface is also called a level surface or 3D contour. Isosurface files contain data specifying isosurface locations for a given quantity at one or more levels. These surfaces are represented as triangles. Isosurface files have file names with extension .iso and are displayed by selecting the desired entry from the `Load/Unload` menu.

Isosurfaces are specified in the FDS input file with the `&ISOF` keyword. To specify isosurfaces for temperatures of 30°C and 100°C as illustrated in Figure 8.9 add the line:

```
&ISOF QUANTITY='TEMPERATURE', VALUE(1)=30.0, VALUE(2)=100.0 /
```

to the FDS input file. A complete list of isosurface quantities may be found in Ref. [3]

Smokezip may be used to generate isosurfaces from particle data. Isosurface locations indicate a boundary separating particle and no-particle regions, *i.e.* wherever particle density is 0.5 particles per grid cell. Isosurface coloring is determined using averaged particle data. Representing particle data with an isosurface is useful when particles are used to model objects such as trees especially when the objects are viewed up close. See Chapter 17.1 for more details on generating isosurface files from particle files. Figure 8.10 shows a snapshot of a burning tree modeled using particles. The tree is visualized using both particles and an isosurface generated from these same particles.

8.5 Static Data - Plot3D Files

Data stored in Plot3D files use a format developed by NASA [19] and are used by many CFD programs for representing simulation results. Plot3D files store five data values at each grid cell. FDS uses Plot3D files to store temperature, three components of velocity (U, V, W) and heat release rate. Other quantities may be stored if desired.

An FDS simulation will automatically create Plot3D files at several specified times throughout the simulation. Plot3D data is visualized in three ways: as 2D contours, vector plots and isosurfaces. Figure 8.11a shows an example of a 2D Plot3D contour. Vector plots may be viewed if one or more of the U,V and W velocity components are stored in the Plot3D file. The vector length and direction show the direction and relative speed of the fluid flow. The vector colors show a scalar fluid quantity such as temperature. Figure 8.11b shows vectors. The vector lengths may be adjusted by depressing the "a" key. Figure 8.12 gives an example of isosurfaces. Plot3D data are stored in files with extension `.q`.

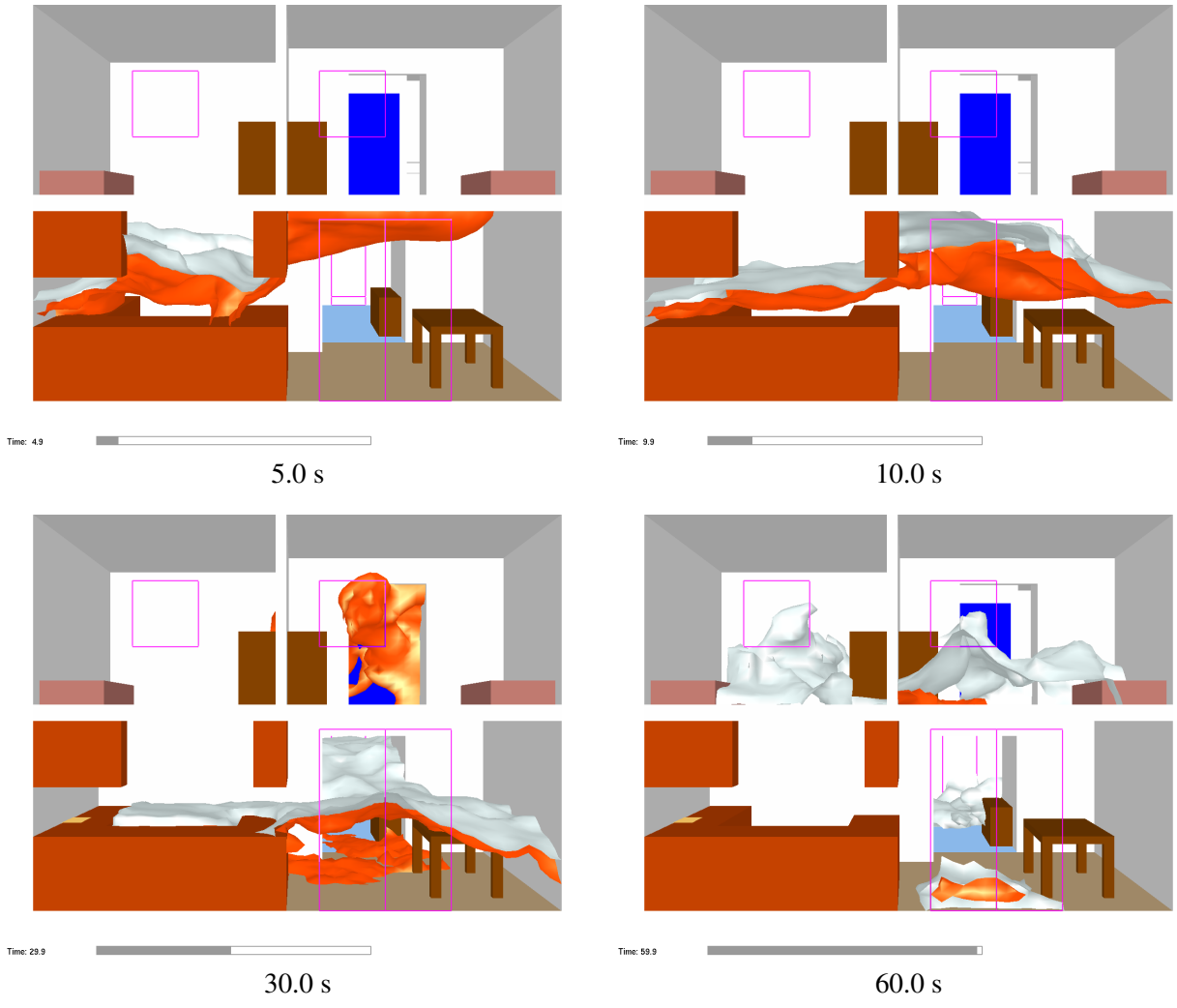
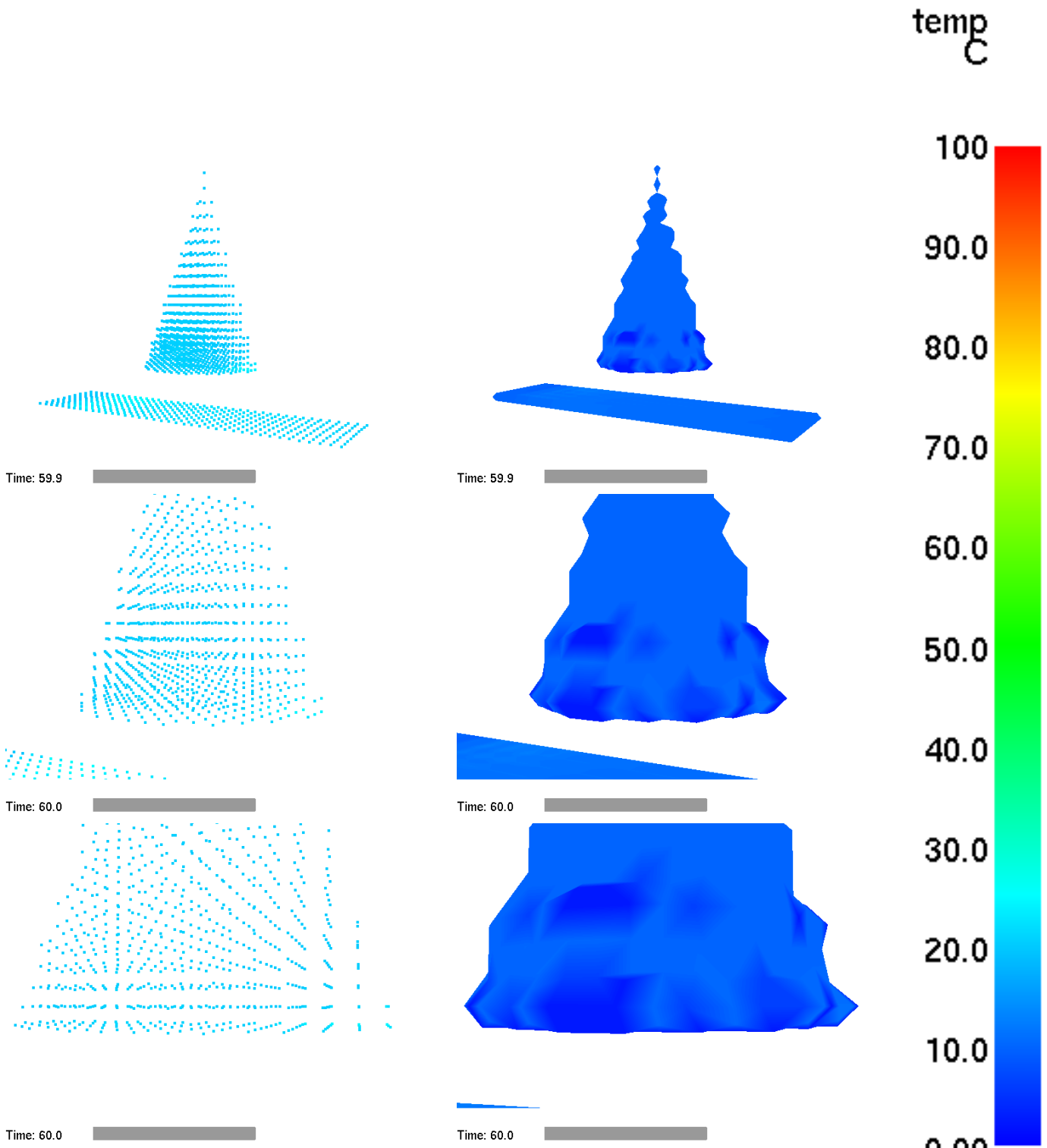


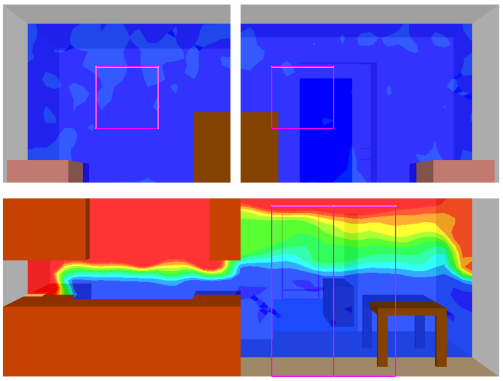
Figure 8.9:
Isosurface file snapshots of temperature levels. The orange surface is drawn where the air/smoke temperature is 30 °C and the white surface is drawn where the air/smoke temperature is 100 °C. These snapshots were generated by adding "`&ISOF QUANTITY='TEMPERATURE',VALUE(1)=30.0,VALUE(2)=100.0 /`" to the FDS input file.



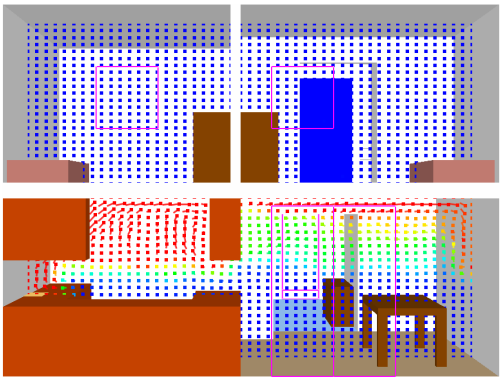
particles at 60.0 s s

isosurface at 60.0 s

Figure 8.10: Tree fire visualized using particles and isosurfaces generated from particles.

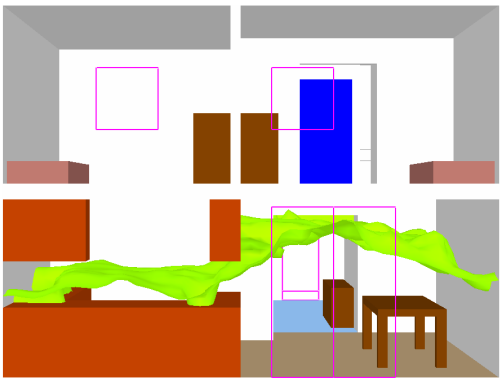


a) shaded 2D temperature contour plots in a vertical plane through the fire

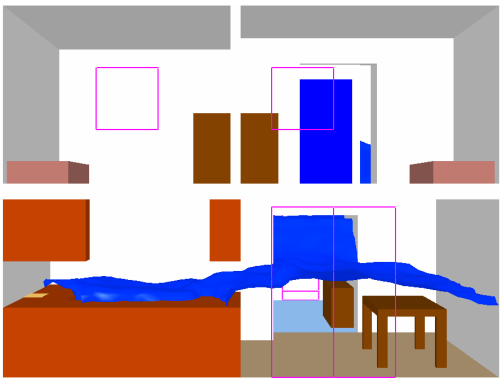


b) shaded temperature vector plot in a vertical plane through the fire. The “a” key may be depressed to alter the vector sizes. The “s” key may be depressed to alter the number of vectors displayed.

Figure 8.11: Plot3D contour and vector plot examples.



a) temperature isosurface at 440 °C



b) temperature isosurface at 560 °C

Figure 8.12: Plot3D isocontour example.

Chapter 9

Visualizing Zone Fire Data

Smokeview may be used to visualize data simulated by a zone fire model. The zone fire model, CFAST [2], creates data files containing geometric information such as room dimensions and orientation, vent locations *etc.*. It also outputs modeling quantities such as pressure, layer interface heights, and lower and upper layer temperatures. Smokeview visualizes the geometric layout of the scenario. It also visualizes the layer interface heights, upper layer temperature and vent flow. Vent flow is computed internally in Smokeview using the same equations and data as used by CFAST. For a given room, pressures , P_i, are computed at a number of elevations, h_i using

$$P_i = P_f - \rho_L g \min(h_i, y_L) - \rho_U g \max(h_i - y_L, 0)$$

where P_f is the pressure at the floor (relative to ambient), ρ_L and ρ_U are the lower and upper layer densities computed from layer temperatures using the ideal gas law and g is the acceleration of gravity. When densities vary continuously with height, this becomes $P_i = P_f - \int_0^h \rho(z) g dz$. A pressure difference profile is then determined using pressures computed on both sides of the given vent.

In the visualization, colors represent the gas temperature of the vent flow. The colors change because the flow may come from either the lower (cooler) or upper (hotter) layer. The length and direction of the colored vent flow region represents a vent flow speed and direction. Plumes are represented as inverted cones with heights calculated in Smokeview using the same correlation as CFAST and heat release rate data computed by CFAST. A Smokeview view of the one room sample case that comes with the CFAST installation is illustrated in Figure 9.1.

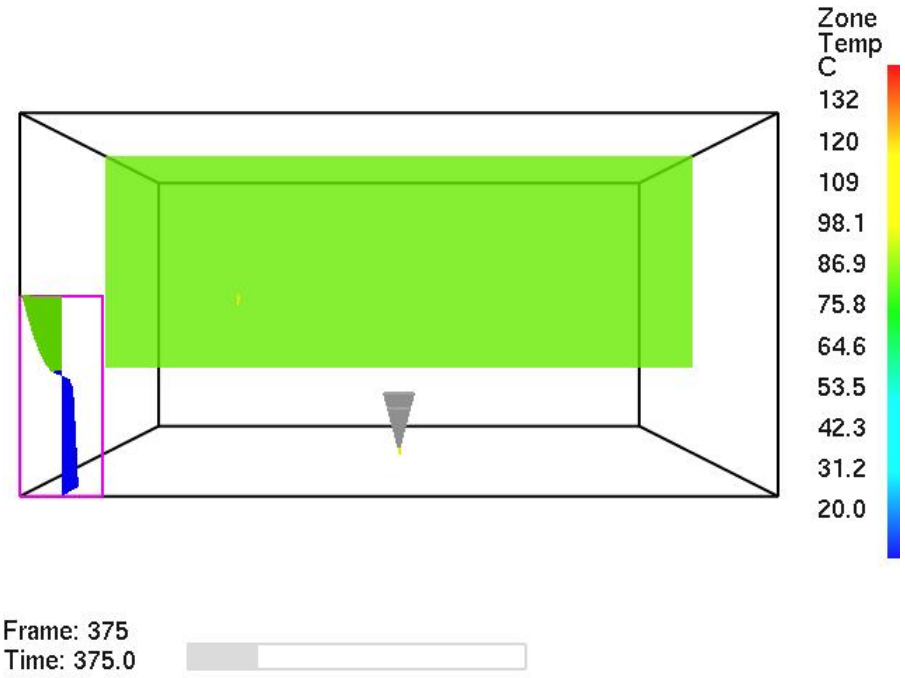


Figure 9.1: CFAST 6.0 Standard case showing upper layer and vent flow at 375 s.

Part III

Miscellaneous Topics

Chapter 10

Setting Options

10.1 Setting Data Bounds

Normally, Smokeview determines data bounds automatically when it loads data. Sometimes, however, it is desirable to override Smokeview's choice. This allows for consistent color shading when displaying several data files simultaneously.

The *File/Bounds...* dialog box is opened from the `Dialogs` menu. Each file type in Figure 10.1 (slice, particle, Plot3D *etc*) has a set of *radio buttons* for selecting the variable type that data bounds are to be applied to. These variable types are determined from the files generated by FDS and are automatically recorded in the `.smv` file. The data bounds are set in a pair of edit boxes. Radio buttons adjacent to the edit boxes determine what type of bounds should be applied. The `Update` and `Reload` buttons are pressed to make the new bounds take effect.

The `Plot3D` and `Slice File` portions of the *File/Bounds* dialog box have additional controls used to chop or hide data. The settings used in Figure 10.2 were used to generate the ceiling jet visualized in Figure 10.3. Data values less than 140 °C are chopped or not drawn in the figure.

Slice file data may be time averaged or smoothed over a user selectable time interval. This option is also implemented from the Slice File section of the *File/Bounds* dialog box (see Figure 10.2.

The **Boundary File** portion of the *File/Bounds* dialog box has an **Ignition** checkbox which allows one to visualize when and where the blockage temperature exceeds its ignition temperature.

The bounds dialog for PLOT3D display allows one to select between three different types of contour plots: shaded, stepped and line contours.

10.2 3D Smoke Options

Figure 10.4 allows one to override Smokeview's choice for several of the 3D smoke parameters. The user may specify the color of the fire and the grey level of the smoke. A grey level of n where n ranges from 0 to 7 results in a color of $(2^n, 2^n, 2^n)$ where the three components represent red, green and blue contributions. The **hrrpuv cutoff** input refers to the heat release rate required at a node before Smokeview will color the node as fire rather than smoke. The **50% flame depth** allows one to specify the transparency or optical thickness of the fire (for visualization purposes only). A small value results in opaquely drawn fire while a large value results in a transparently drawn fire. The **Absorption Parameter** setting refers to how the smoke slices are drawn. The **adjust off-center** setting causes Smokeview to account for non-axis aligned paths. The **adjust off-center + zero at boundary** accounts for off center path lengths and zeros smoke density at boundaries in order to remove graphical artifacts.

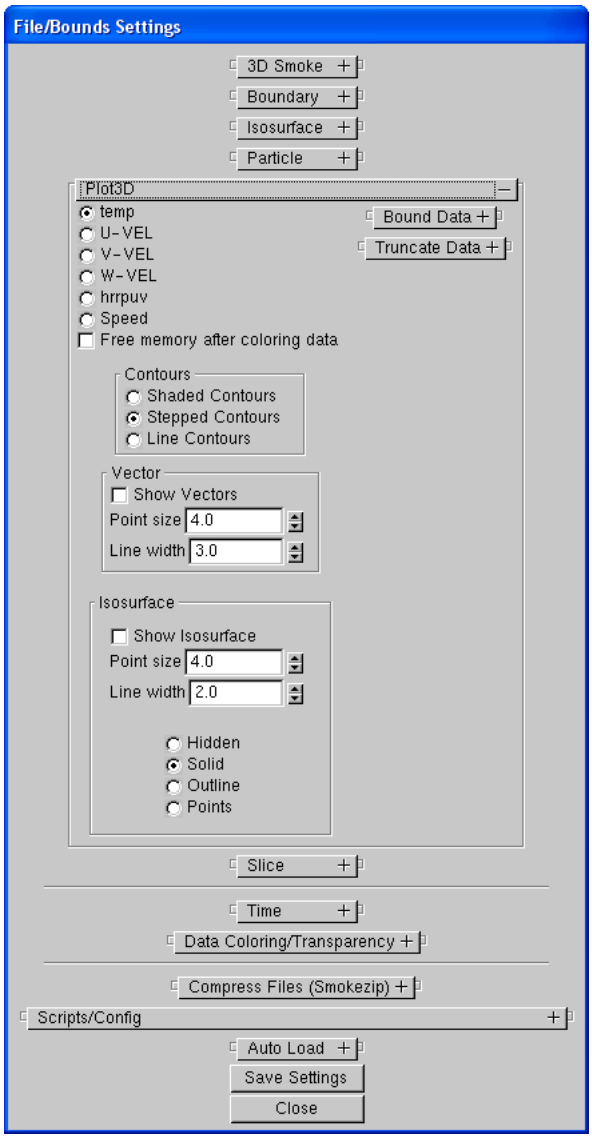


Figure 10.1: *File/Bounds* dialog box showing PLOT3D file options. Select a variable and a bounds type *check box/radio button*, then enter a lower and/or upper bound. Data may be excluded from the plot by selecting a *Truncate* bound. Select type of contour plot to be displayed. Press *Reload...* or *Update* for the new bounds to take effect.

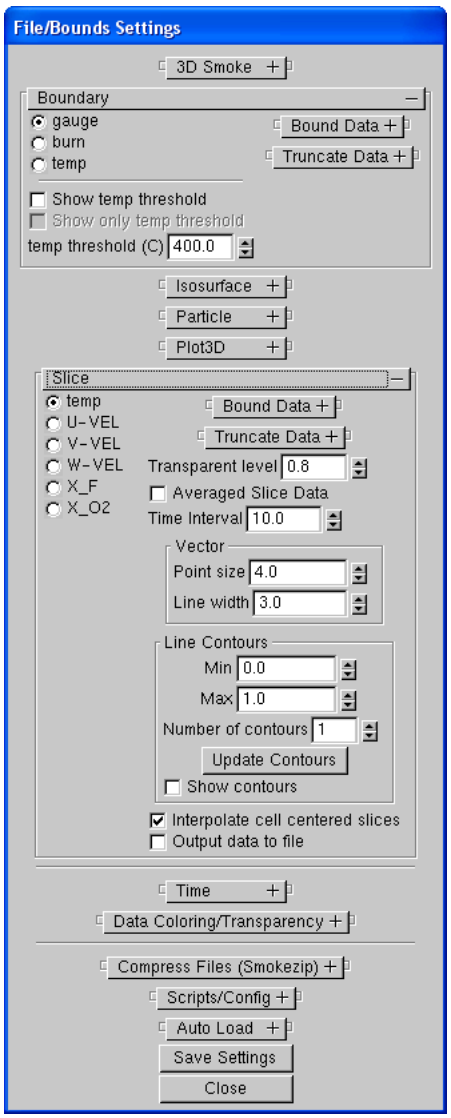


Figure 10.2: *File/Bounds* dialog box showing slice and boundary file options. Select a variable and a bounds type *check box/radio button*, then enter a lower and/or upper bound. In the slice portion, data may be excluded from the plot by selecting a *Truncate* bound. In the boundary portion, ignited materials may be highlighted if a wall temperature boundary file has been saved. Press *Reload...* or *Update* for the new bounds to take effect.

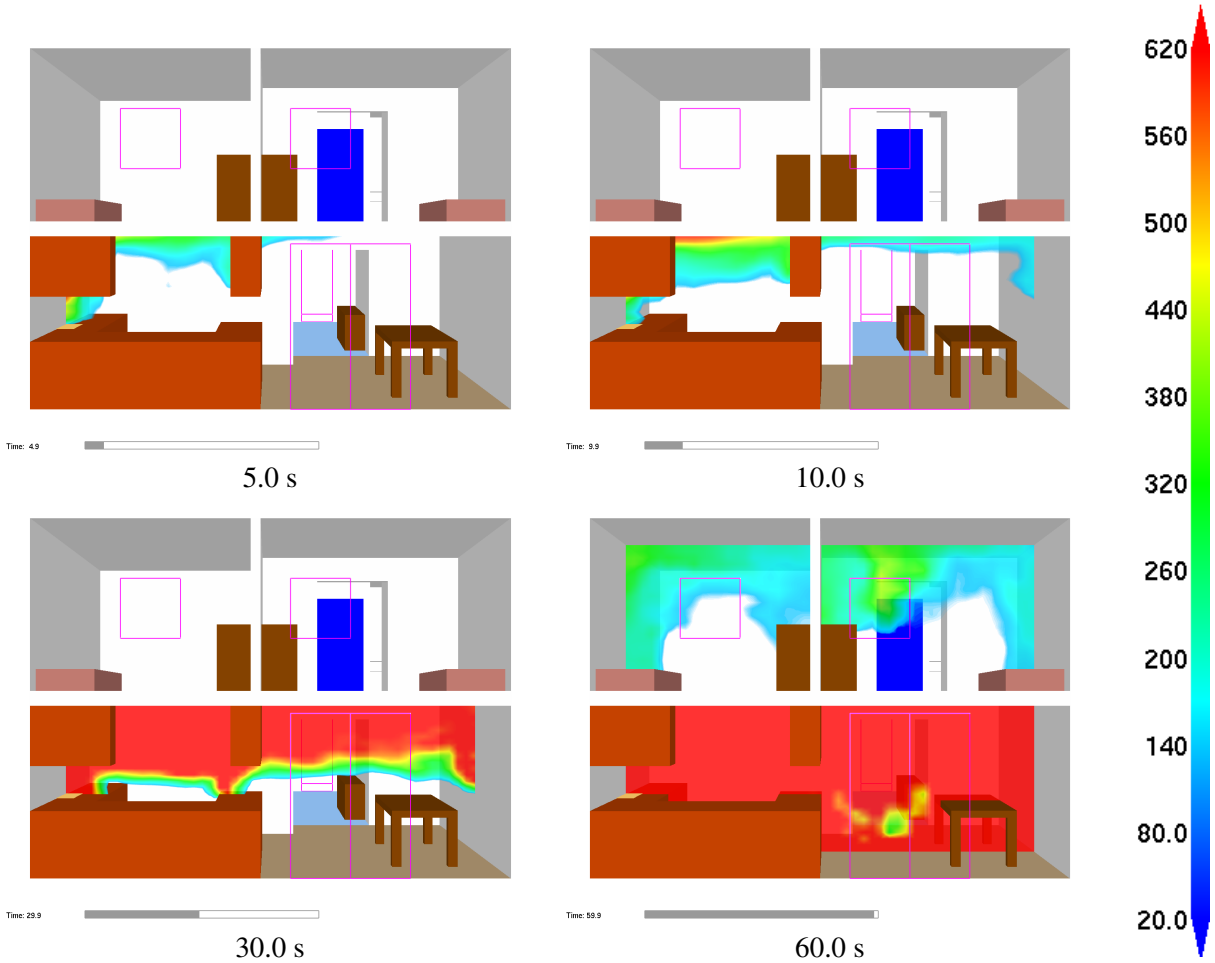


Figure 10.3: Ceiling jet visualization created by *chopping data* below 140 °C using the `Bounds Dialog Box` as illustrated in Figure 10.2.

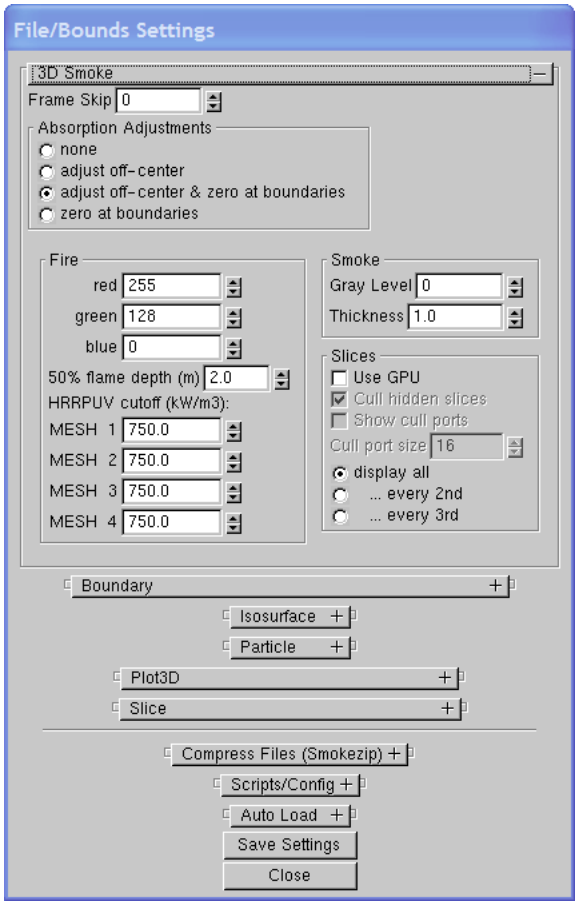


Figure 10.4: Dialog box for setting 3D smoke options.

10.3 Plot3D Viewing Options

Plot3D files are more complicated to visualize than time dependent files such as particle, slice or boundary files. For example, only the transparency and color characteristics of a time file may be changed. With Plot3D files however, many attributes may be changed. One may view 2D contours along the X, Y and/or Z axis of up to six[1] different simulated quantities, view flow vectors and iso or 3D contours. Plot3D file visualization is initiated by selecting the desired entry from the Load/Unload Plot3D sub-menu and as with time files one may change color and transparency characteristics.

10.3.1 2D contours

Smokeview displays a 2D contour slice midway along the Y axis by default when a Plot3D file is first loaded, To step the contour slice up by one grid cell along the Y axis, depress the space bar. Similarly to step the contour slice down by one grid cell along the Y axis, depress the "–" key. To view a contour along either the X or Z axis, depress the x or z keys respectively. Depressing the x, y or z keys while the contour is visible will cause it to be hidden. The Plot3D variable viewed may be changed by either depressing the "p" key or by selecting the Solution Variable sub-menu of the Show/Hide menu.

10.3.2 Iso-Contours

Iso-contours also called 3D contours or level surfaces may be viewed by depressing the "i key or by selecting the Plot3D>3D Contours sub-menu of the Show/Hide menu.

10.3.3 Flow vectors

If at least one velocity component is present in the Plot3D file then the "v" key may be depressed in order to view flow vectors. The length and direction of the vector indicates the flow direction and speed. The vector color indicates the value of the currently displayed quantity. A small dot is drawn at the end of the line to indicate flow direction. The vector lengths as drawn may be changed by depressing the "a" key. Vector plots may be very dense when the grid is finely meshed. The "s" key may be depressed in order to skip vectors. For example, all vectors are displayed by default. If the "s" is depressed then every other vector is skipped.

10.4 Display Options

10.4.1 General

The *Display* dialog box, illustrated in Figure 10.5, allows one to set various options to control the display or *look* of the Smokeview scene. It may be invoked by selecting the Dialogs>Display menu item. This dialog box also allows one to show or hide loaded data files.

10.4.2 Stereo

Smokeview implements several methods for displaying scenes in stereo or 3D. Each method separates the Smokeview scene in some way and sends a *left version* to your left eye and a *right version* to your right eye. Each method then creates two versions of the scene, one version for each eye.

[1]The FDS software stores temperature, three components of velocity (denoted u, v and w) and heat release per unit volume. If at least one velocity component is stored in a Plot3D file, then Smokeview adds speed to the Plot3D variable list.

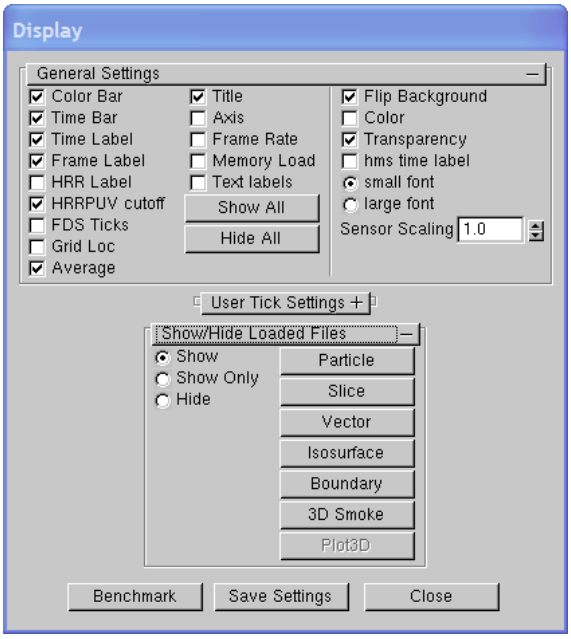


Figure 10.5: Dialog Box for setting miscellaneous Smokeview scene properties.

The first method, denoted sequential stereo, works by displaying images for the left and right eye alternately in time. Shuttered glasses synchronized with the monitor are used to ensure that only the left eye sees the left image and only the right eye sees the right image. A monitor displaying this type of stereo should have a refresh rate of at least 120 frames per second (60 frames per second for each eye) otherwise flickering is noticeable. Unfortunately, most of today's LCD flat panel monitors typically do not have refresh rates faster than 60 to 80 frames per second. This method (for Smokeview) requires a video card that supports OpenGL *QUAD buffering*. This Smokeview stereo option may be enabled from the command line by using the `-stereo` option.

The second method, denoted left/right stereo, displays the two images side by side. With practice, one can merge both images without requiring specialized glasses (though they are available if desired) especially if the images are small and not separated by a large angle. A trick for seeing the stereo effect is to place a finger from each hand in the center of each picture. Then relax your eyes while trying to *merge* your two fingers together. Figure 10.6 show an example of the left/right method for generating a stereo image. This method can generate full colored images and requires no equipment (for most people) to view but results in smaller images.

The third method, uses color to separate left and right images. One method denoted red/blue stereo, displays red and blue versions of each image. Glasses with a red left lens and a blue right lens are required to view the image. As with the shuttered glasses for sequential stereo, the colored glasses *separate* the images enabling each eye to see only one image. Red/blue colored glasses may be obtained inexpensively. They also may be made using using red and blue cellophane or by coloring clear plastic with read and blue marking pens. Figure 10.7 uses the red/blue method for generating a stereo image. This method generates full size images, requires only inexpensive glasses to view but can only display monochrome images. The red/cyan method for displaying stereo images works similarly to the red/blue method. The main difference is that since cyan is the made up of green and blue (the *opposite* in some sense of red), the combination of red and cyan lenses allow all colors to pass to your eyes.

Figures 10.8 uses the red/cyan method for generating a stereo image. As with red/blue, this method generates full size images. However, as stated earlier, this method allows Smokeview scenes to be displayed

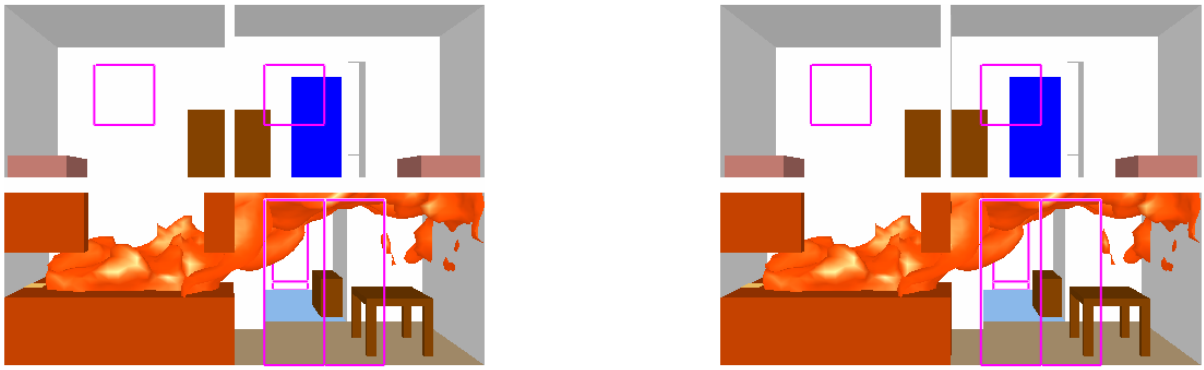


Figure 10.6: Stereo pair view of a townhouse kitchen fire. To aid in viewing the stereo effect, place a finger in front of each image. Relax your eyes allowing your two fingers and stereo pair images to merge into one.

in full color.

Figure 10.9 shows the dialog box used to configure the stereo option. If the *-stereo* command line option was used and the video card supports shuttered stereo display then the *shuttered checkbox* in the dialog box will be enabled.

10.5 Clipping Scenes

It is difficult to view the interior of a scene when modelling complicated geometries. To alleviate this problem, portions of the scene may be hidden or clipped by setting up to six clipping planes. OpenGL draws the scene on one side of a clipping plane but not the other. In general, a clipping plane may have any orientation. Smokeview defines two clipping planes for each of the three coordinate axes. The two x axis clipping planes clip regions with x coordinates smaller than an 'x_{min}' clipping value and larger than an 'x_{max}' value. The y axis and z axis clipping planes behave similarly. Clipping plane values are specified using the *Clipping* dialog box which is opened by selecting the Dialogs>Clip Geometry menu item. Figure 10.10 shows this dialog box with the y_{max} plane active. Figure 10.11 shows three versions of a scene. Figure 10.11a is drawn with no clipping. Figure 10.11b is drawn clipping just the geometry (blockages). Figure 10.11c is drawn clipping both the geometry and the data.

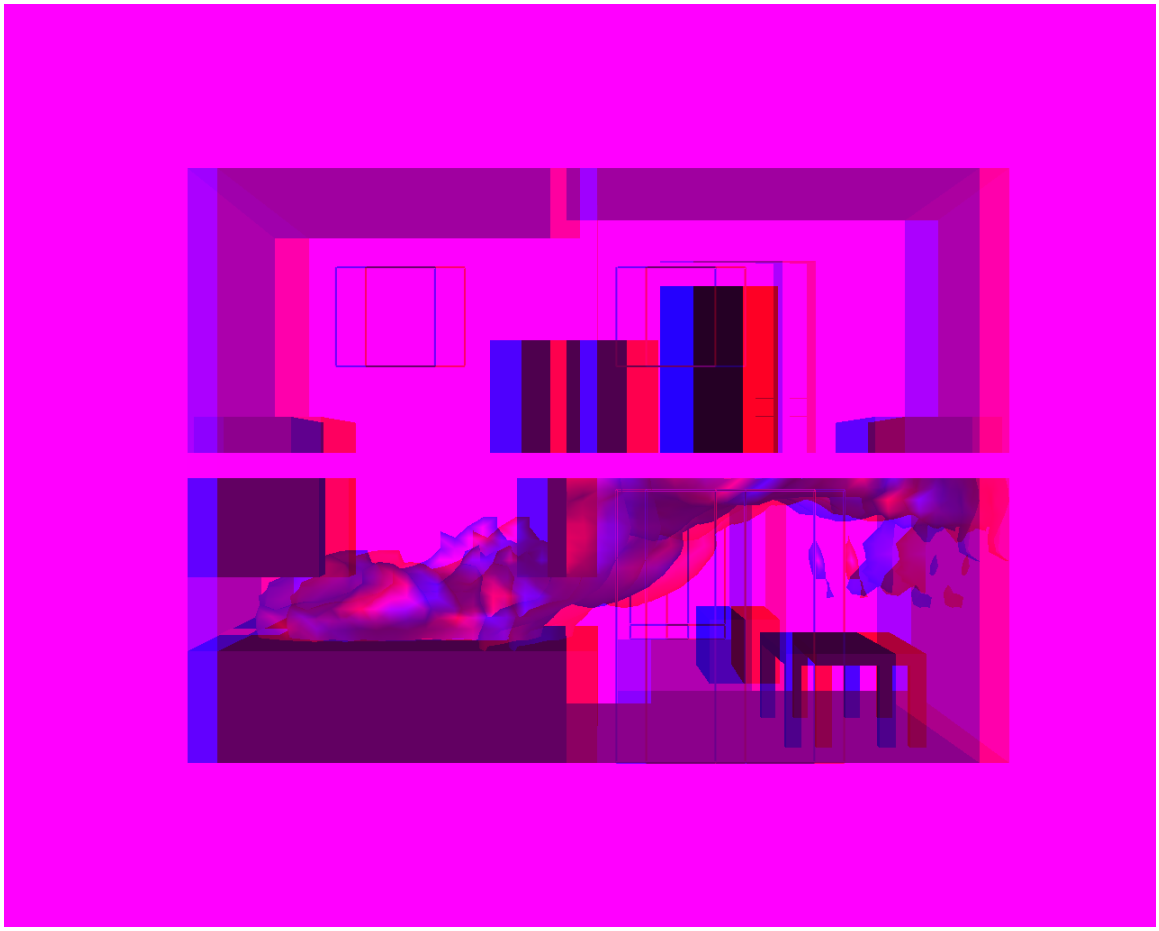


Figure 10.7: Red/blue stereo pair view of a townhouse kitchen fire. Red/blue glasses are required to see the 3D stereo effect.

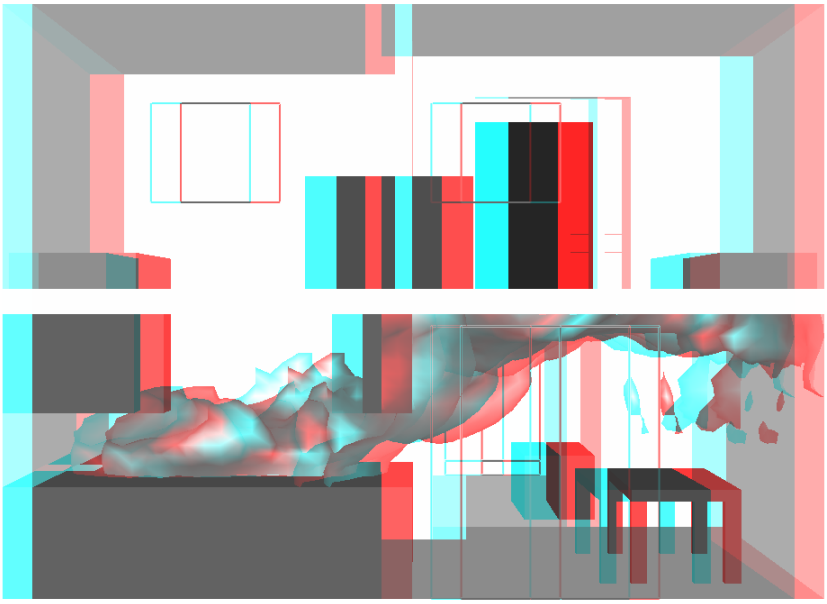


Figure 10.8: Red/cyan stereo pair view of a townhouse kitchen fire. Red/cyan glasses are required to see the 3D stereo effect.

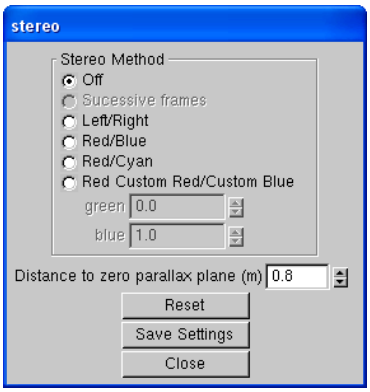


Figure 10.9: Dialog box for activating the stereo view option.

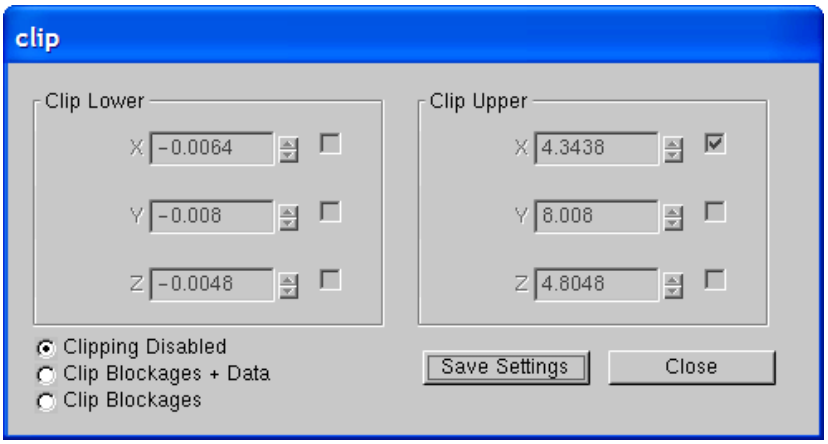
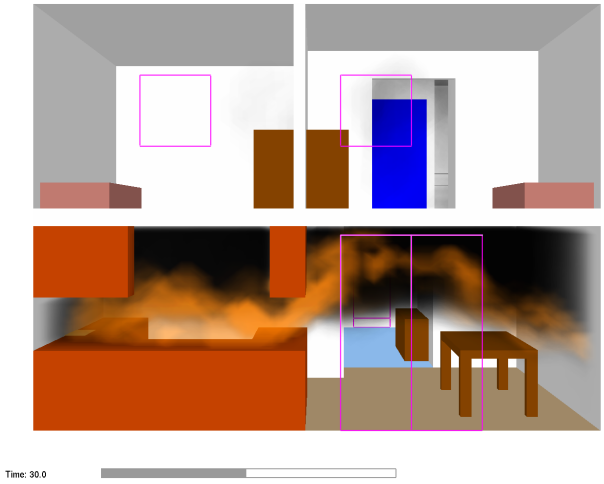
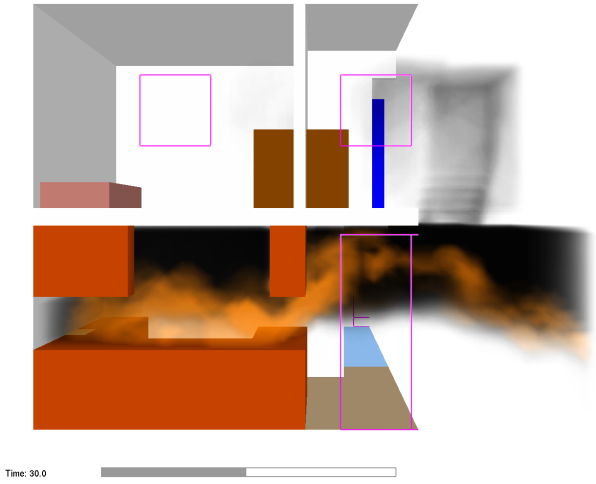


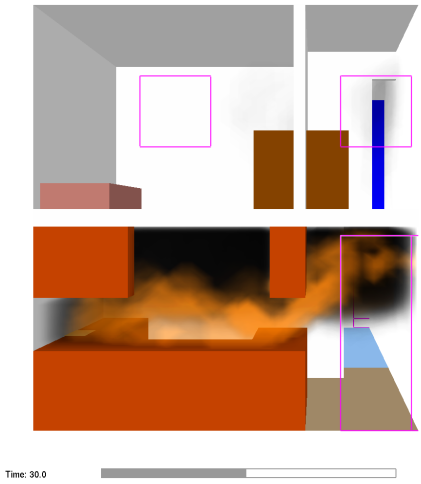
Figure 10.10: *Clipping* dialog box. Minimum and maximum clip plane values for X, Y and Z planes are set using the clipping dialog box. One has the option when clipping of hiding the geometry and data or just the geometry.



a) no clipping



b) clip blockages



b) clip blockages and data

Figure 10.11: Three views of a scene. The first view is drawn without clipping, the second view shows the scene clipping only the geometry (blockages), the third view shows the scene slipping both the geometry and the data.

Chapter 11

Coloring Data

11.1 Overview

A colorbar is used to map data with color. A colorbar is normally visualized by displaying its color in sequence forming a bar or rectangle. When designing a colorbar, it is convenient to also visualize it by thinking of color spatially associating red, green and blue color components with x, y and z spatial coordinates. A colorbar may then be thought of as a path within a cube where the lower left bottom cube corner is colored black and the upper right top corner is colored white. Other corners are colored red, green, blue, cyan, magenta and yellow depending on their color components present. Figure 11.1 gives several examples of colorbars pre-defined by Smokeview. Each image was generated using the colorbar editor illustrated in Figure 11.2.

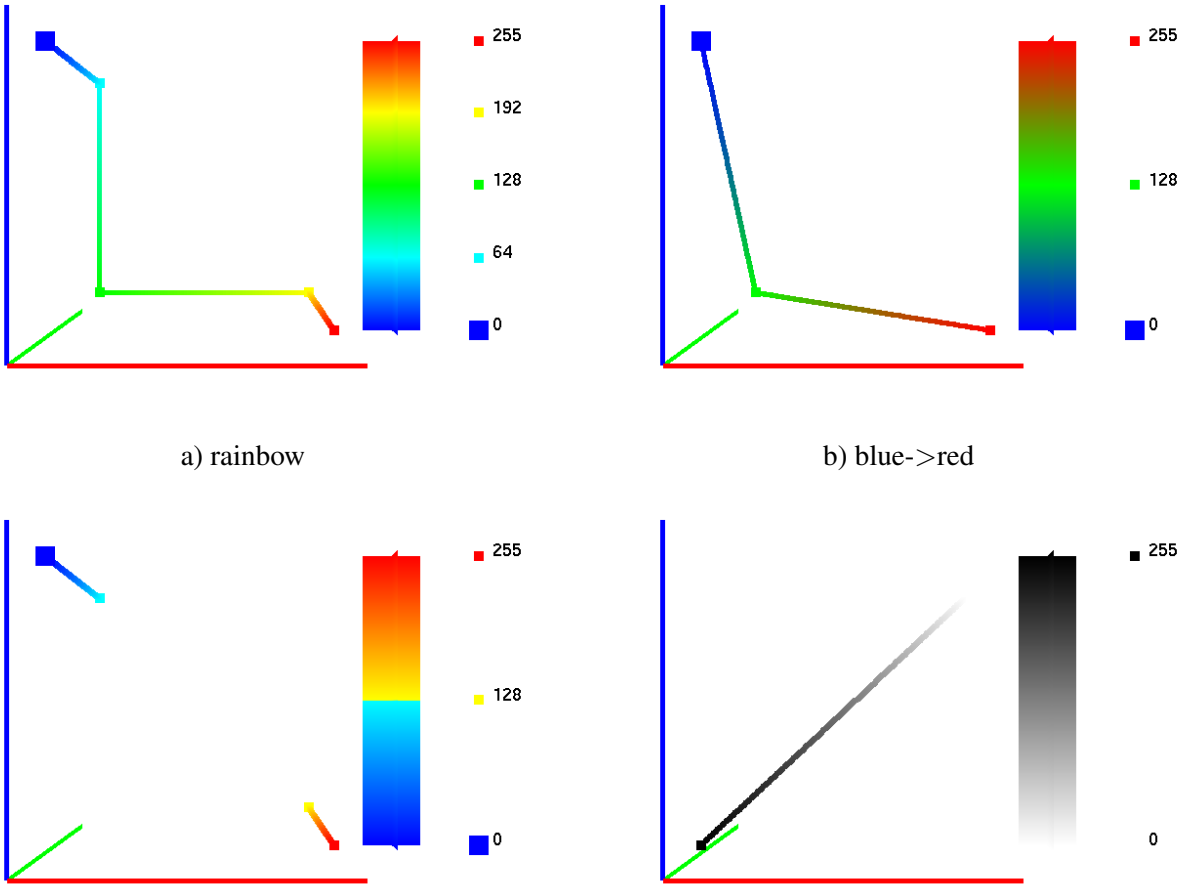
A colorbar in Smokeview consists of a set of color nodes forming a path within a cube. This way of visualizing it is helpful in defining new colorbars by allowing one to more easily judge changes in color within the colorbar. Though most colorbars paths are continuous, a colorbar path need not be. Discontinuous colorbars are useful for highlighting regions in a simulation with a particular property, for example where the temperature exceeds the boiling point of water or in a topographic map where a shoreline (zero elevation) occurs. Figure 11.1c gives an example of a colorbar with a break. This colorbar jumps in the middle from a shade of cyan to a shade of yellow.

11.2 Using the Colorbar Editor

The Colorbar Editor dialog box is opened from the `Dialogs` > `Customize Colorbar` menu entry. When this menu item is selected, a spatial representation of the currently selected colorbar is displayed within the Smokeview scene along the Colorbar Editor dialog box. The FDS simulation scene is hidden by default but may be shown along with the colorbar display by unchecking the *Hide scene* checkbox.

The colorbar is represented visually in two ways. First, as a series of colored nodes and lines. The nodes and lines are a spatial representation of the colorbar where as stated earlier the r, g, b color components are mapped to x, y, z spatial coordinates. Second, as a rectangle with a series of colored squares and numbered indices displayed along side. (This rectangle is equivalent to the colorbar displayed beside a regular Smokeview scene). The numbered indices indicate the position in the colorbar where the node color occurs. Once the node indices and colors are defined, Smokeview interpolates to form a table of colors (256 rows, 3 columns).

The Colorbar Editor dialog box contains a list of colorbars pre-defined by Smokeview and others if defined by the user. A new colorbar is created by selecting the *New* button . The new colorbar is created initially by making a copy of the currently selected colorbar. Once created, it may be altered by adding/deleting



a) rainbow

b) blue->red

c) blue->red split

d) white->black

Figure 11.1: Colorbar Examples. Several colorbars are presented both as a 1D strip of changing color, each color corresponding to a different data value and as a 3D path where the x, y, z spatial locations of a color node correspond to the red, green and blue components of the color at that node.

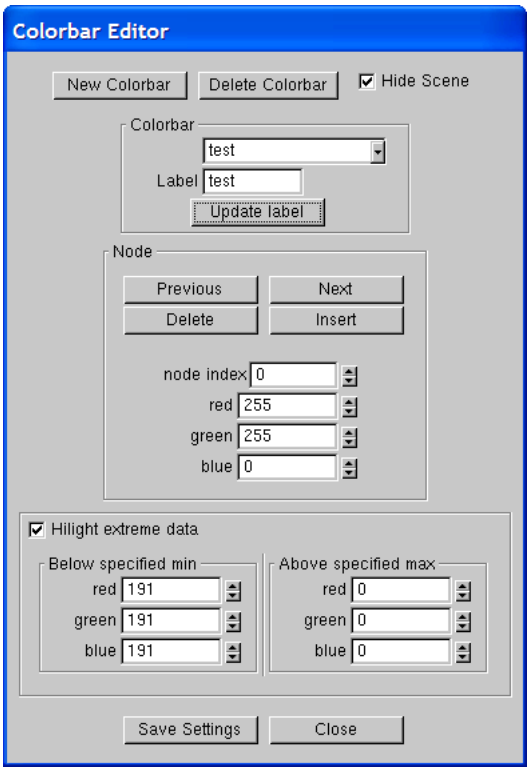


Figure 11.2: Colorbar Editor dialog box.

nodes with the *Add/Delete* buttons and altering color with the red, green, blue spinners. Note that only colorbars created by a user may be changed. The *Add/Delete* and other buttons for modifying colorbar characteristics are only enabled for user defined colorbars. They are disabled for Smokeview predefined colorbars. Colorbar definitions (only colorbars created by the user) are saved in the Smokeview configuration (.ini) file.

The bottom portion of the Colorbar Editor dialog box is used to define colors for extreme data. That is, data occurring below the specified minimum or above the specified maximum. This data may be highlighted by selecting the *Highlight Extreme Data* checkbox. The color used to highlight this data may also be specified. The colors defined using this dialog box are shown in the triangular regions at the top and bottom of the colorbar.

Chapter 12

Smokeview - Demonstrator Mode

A simplified version of Smokeview may be invoked in order to present a fire scenario for training or demonstration purposes. All actions are performed using one unified dialog box, illustrated in Figure 12.1. This dialog box is opened for the user at startup and allows the user to select data to be viewed, tours to travel along, viewpoints to observe and scene manipulation to perform. Smokeview loads data when it starts up. The intent is to allow one not using Smokeview daily to more easily make use of Smokeview's capabilities.

In order to setup this demonstration mode, several tasks need to be performed. The results of these tasks are recorded in the `casename.ini` file. These tasks are detailed below.

1. Define one or more tours that give the user an overview of the data or that highlight important aspects of the scenario. Tours are setup using the *Touring* dialog box.

2. Define one or more viewpoints that highlight some important aspect of the simulation scenario. The viewpoint is defined by manipulating the scene as desired and then selecting the *View¿Save* menu item. The viewpoint label may be changed by using the *Motion/View* dialog box.

3. Pick the data to be viewed from a set of temperature and oxygen slice files and a set of 3D smoke and HRRPUV files.

   (a) Load the desired files into Smokeview.

   (b) Select these files for *auto-loading* by selecting the *Auto Load Now* panel in the *File/Bounds* dialog box and pressing the *Save Auto Load File List* button.

   (c) Compress these files with Smokezip using the `-auto` option . This option will only compress files selected with Smokeview for *autoloading*. Note that compression can either be performed at a command line by typing `smokezip -auto casename` or by using the *Load/Unload¿Compression* menu item.

4. Save the settings and choices selected by saving a *casename.ini* configuration file for the case.

5. Create a `.svd` file by copying the `casename.smv` to `casename.svd` .

6. Copy all the compressed files and the files: `casename.ini`, `casename.end` and `casename.svd` file to a separate directory. This directory is then is what one would distribute to be demonstrated.

The demonstrator mode of Smokeview is activated by double-clicking on `casename.svd`. Smokeview treats this file just like `casename.smv` except that it opens up the `Demonstrator Mode` dialog box and hides the standard Smokeview menus. Smokeview then loads the selected slice, 3D smoke and HRR files and opens the dialog box illustrated in Figure 12.1.

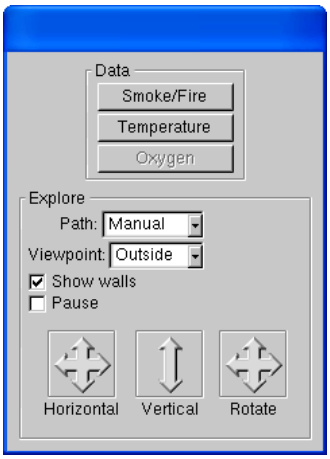


Figure 12.1: *Demonstrator* dialog box. This dialog box allows the user to 1) switch between temperature, oxygen and realistic views of the data, select tours and viewpoints and to manipulate the scene using translations and rotations.

This dialog box is used to toggle the data viewed by pressing the `Smoke/Fire`, `Temperature` or `Oxygen` buttons. The scene may be manipulated by clicking the mouse in one of the *arrow* buttons and dragging. The scene may also be manipulated as before by pressing the mouse within the scene and dragging. Views and/or tours may be selected using the corresponding *pull down* box.

Chapter 13

Texture Maps

Texture mapping is a technique used by Smokeview to make a scene appear more realistic by pasting images onto obstructions or vents. For example, to apply a wood paneling image to a wall, add the keywords `TEXTURE_MAP='paneling.jpg', TEXTURE_WIDTH=1., TEXTURE_HEIGHT=2.` to the `&SURF` line where **paneling.jpg** is the JPEG file containing the texture map (SGI users should use RGB files instead of JPEG) and **TEXTURE_WIDTH** and **TEXTURE_HEIGHT** are the characteristic dimensions of the texture map in meters. Note that the image will not appear when Smokeview first starts up. The user must select the texture maps using the `Show/Hide` menu.

One can create texture maps using a digital camera or obtain them commercially. The maps should be *seamless* so that no breaks or seams appear when the maps are tiled on a blockage or vent. This is important, because Smokeview replicates the image as often as necessary to cover the blockage or vent.

When the texture does have a pattern, for example windows or bricks, the keyword `TEXTURE_ORIGIN` may be used to specify where the pattern should begin. For example,

```
&OBST XB=1.0,2.0,3.0,4.0,5.0,7.0, SURF_ID='wood paneling',
      TEXTURE_ORIGIN=1.0,3.0,5.0 /
```

will apply paneling to an obstruction whose dimensions are 1 m by 1 m by 2 m, such that the image of the paneling will be positioned at the point (1.0,3.0,5.0). The default value of `TEXTURE_ORIGIN` is (0,0,0), and the global default can be changed by added a `TEXTURE_ORIGIN` statement to the `MISC` line.

Figure 13.1 shows a simple application of a texture applied to two different blockages and a vent. The same jpeg file was used in two different `&SURF` lines so that the texture could be stretched by differing amounts (using the `TEXTURE_WIDTH` parameter.) The FDS data file used to create this Figure follows.

```
&HEAD CHID='sillytexture', TITLE='Silly Test Case SVN $Revision: 4751 $' /
&MISC TEXTURE_ORIGIN=0.1,0.1,0.1 /

&MESH IJK=20,20,02, XB=0.0,1.0,0.0,1.0,0.0,1.0 /
&TIME TWFIN=0. /
&SURF ID     = 'TEXTURE 1'
      TEXTURE_MAP= 'nistleft.jpg'
      TEXTURE_WIDTH=0.6
      TEXTURE_HEIGHT=0.2 /

&SURF ID     = 'TEXTURE 2'
      TEXTURE_MAP= 'nistleft.jpg'
      TEXTURE_WIDTH=0.4
      TEXTURE_HEIGHT=0.2 /

&OBST XB=0.1,0.3,0.1,0.7,0.1,0.3, SURF_ID='TEXTURE 1'  /
&OBST XB=0.5,0.9,0.3,0.7,0.1,0.5, SURF_ID='TEXTURE 2',
      TEXTURE_ORIGIN=0.5,0.3,0.1  /
```

Figure 13.1: Texture map example. The same texture was applied to two different blockages and a vent (with different widths) by assigning different TEXTURE_WIDTH parameters in the input file.

```
&VENT XB=0.0,0.0,0.2,0.8,0.2,0.4, SURF_ID='TEXTURE 1',
      TEXTURE_ORIGIN=0.0,0.2,0.2 /
&VENT XB=0.3,0.9,0.0,0.0,0.3,0.5, SURF_ID='TEXTURE 1',
      TEXTURE_ORIGIN=0.9,0.0,0.3 /
&TAIL /
```

Chapter 14

Using Smokeview to Debug FDS Input Files

One of the most difficult tasks in setting up an FDS input file is defining the geometry (blockages, vent locations *etc*) properly. Smokeview may be used to debug FDS input files by making short model runs and observing whether blockages, vents and other geometric features of a model run are located correctly. Blockages may then be created or changed using a text editor and location information provided by the *Examine Blockages* dialog box called from the `Dialogs` menu.

The following is a general procedure for identifying problems in FDS input files. Assume that the FDS input data file is named `testcase1.fds`.

1. In the FDS input file, set the stop time to 0.0 using `TWFIN=0.0` on the `&TIME` line. This causes FDS to read the input file and create a `.smv` file without performing lengthy startup calculations.

2. Run the FDS model (for details see the FDS User's Guide [3])

   FDS creates a file named `testcase1.smv` containing information that Smokeview uses to visualize model.

3. To visualize the model, open `testcase1.smv` with Smokeview by either typing `smokeview testcase1` at a command shell prompt or if on the PC by double-clicking the file `testcase1.smv`.

4. Make corrections to the FDS data file, if necessary. Using the `COLOR` or `RGB` option of the `OBST` keyword to more easily identify blockages to be edited. For example, to change a blockage's color to red use:

   ```
   &OBST XB=0.0,1.0,0.0,1.0,0.0,1.0, COLOR='RED' /
   ```

   or

   ```
   &OBST XB=0.0,1.0,0.0,1.0,0.0,1.0 RGB=255,0,0 /
   ```

   Save testcase1.fds file and go back to step 2.

5. If corrections are unnecessary, then change the `TWFIN` keyword back to the desired final simulation time, remove any unnecessary FDS `COLOR` keywords and run the case.

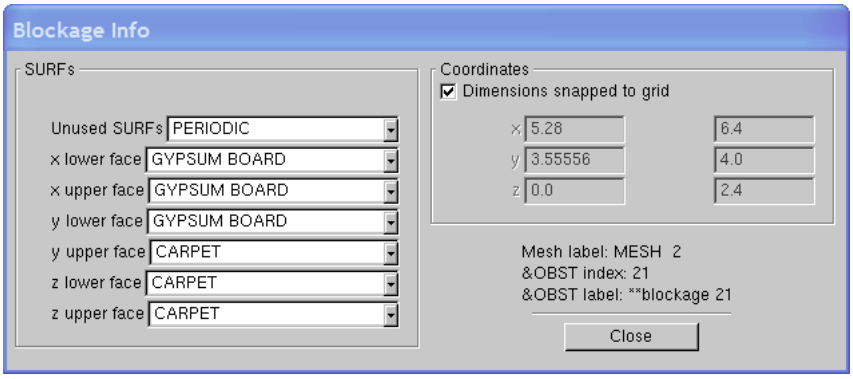


Figure 14.1: Examine Blockages Dialog Box.

14.1 Examining Blockages

Blockages locations and SURF properties may be examined by selecting the menu item `Examine Blockages` which opens up the dialog box illustrated in Figure 14.1. Note, clipping planes need to be turned off when using this dialog box. Associating unique colors with each surface allows the user to quickly determine whether blockages are defined with the proper surfaces. One can then verify that these modeling elements have been defined and positioned as intended. Position coordinates are displayed *snapped* to the nearest grid line or as specified in the input file.

Chapter 15

Making Movies

A movie can be made of a Smokeview animation by converting the visualized scene into a series of PNG or JPEG files, one file for each time step and then combining the individual images together into one movie file. More specifically:

1. Set up Smokeview by orienting the scene and loading the desired data files.
2. Select the Options/Render menu and pick the desired frame skip value. The more frames you include in the animation, the smoother it will look. Of course more frames result in larger file sizes. Choose fewer frames if the movie is to appear on a web site.
3. Use a program such as the Antechinus Media Editor (`http://www.c-point.com`), Apple Quicktime Pro (`http://www.quicktime.com`), or Adobe Premiere Pro (`http://www.adobe.com`), to assemble the JPEGS or PNGS rendered in the previous step into a movie file.

The default Smokeview image size is 640×480 . This size is fine if the movie is to appear in a presentation located on a local hard disk. If the movie is to be placed on a web site then care needs to be taken to insure that the generated movie file is a reasonable size. Two suggestions are to reduce the image size to 320×240 or smaller by modifying the `WINDOWWIDTH` and `WINDOWHEIGHT` `smokeview.ini` keywords and to reduce the number of frames to 300 or less by skipping intermediate frames *via* the `Options/Render` menu.

Sometimes when copying or *capturing* a Smokeview scene it is desirable, or even necessary, to have a margin around the scene. This is because the capturing system does not include the entire scene but itself captures an indented portion of the scene. To indent the scene, either press the "h" key or select the Option>Viewpoint>Offset Window menu item. The default indentation is 45 pixels. This may be changed by adding/editing the WINDOW_OFFSET keyword in the `smokeview.ini` file.

Note, the Smokeview animation must be running when the render command is selected or only one frame will be saved instead of the entire image sequence.

Chapter 16

Annotating the Scene

16.1 Overview

Smokeview scenes may be annotated by using the User Ticks dialog box or by using the TICKS and LABEL keywords. The User Ticks dialog box is easier to use but has limited flexibility in tick and label placement. A user may use the TICKS and LABELS keywords to duplicate the functionality of the User Ticks dialog box and also place text anywhere in the scene and at any time throughout the simulation. This added generality makes it more difficult to exploit.

16.2 User Ticks Settings Dialog Box

The User Ticks Settings dialog box allows one to place ticks and labels along one or more orthogonal coordinate axes. The user may specify tick spacing, number of sub-tick intervals and how far axes extend. There is an automatic placement option that allows the tick axes to be placed based upon the orientation of the scene. The user may specify which tick axes are visible if the automatic placement option is not invoked. Figure 16.1 illustrates the User Ticks Settings dialog box. It is a panel of the Display dialog box. Figure 16.2 shows the ticks and labels resulting from the dialog box.

16.3 TICKS and LABELS keywords

Tick marks and label annotation can be also placed within the 3D scene using the TICKS and LABELS keywords. FDS places tick marks and labels documenting the scene dimensions. To replace or customize these annotations add the `TICK` keyword to a .smv file using the following format:

```
TICKS
xb yb zb xe ye ze nticks
ticklength tickdir r g b tickwidth
```

where `xb`, `yb`, and `zb` are the x, y and z coordinates of the first tick; `xe`, `ye` and `ze` are the x, y and z coordinates of the last tick and `nticks` is the number of ticks. The coordinate dimensions are in physical units, the same units used to set up the FDS geometry. The parameter `ticklength` specifies the length of the tick in physical units. The parameter `tickdir` specifies the tick direction. For example 1(-1) places ticks in the positive(negative) x direction. Similarly, 2(-2) and 3(-3) place ticks in the positive(negative) y and positive(negative) z directions.

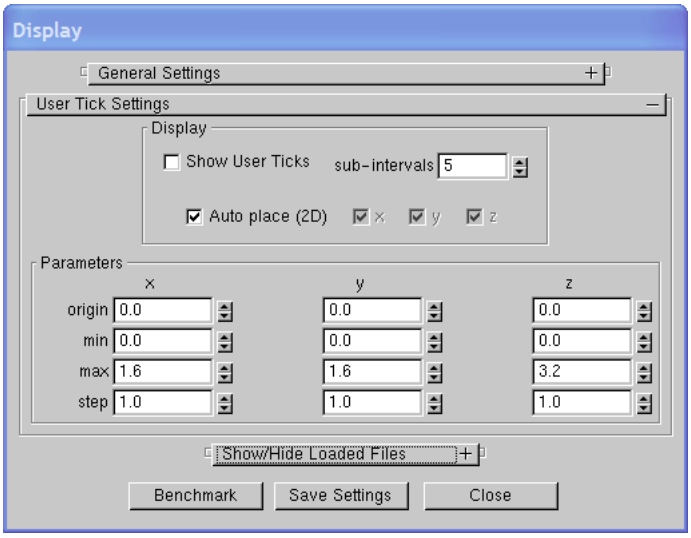


Figure 16.1: Ticks Dialog Box. The Ticks Dialog Box is invoked by selecting `Dialogs>Display`.

Figure 16.2: Annotation example using the Ticks dialog box

```
TICKS
0.0 0.0 0.0 8.0 0.0 0.0 5
0.5 -2.0 -1. -1.0 -1.0 4.0
TICKS
1.0 0.0 0.0 9.0 0.0 0.0 5
0.25 -2.0 -1. -1.0 -1.0 4.0
TICKS
0.0 0.0 0.0 0.0 0.0 2.0 3
0.5 -1.0 -1. -1.0 -1.0 4.0
TICKS
0.0 0.0 0.0 0.0 4.0 0.0 5
0.5 -1.0 -1. -1.0 -1.0 4.0
LABEL
0.0 -0.6 0.0 -1.0 0.0 0.0 0.0 20.0
0
LABEL
2.0 -0.6 0.0 -1.0 0.0 0.0 0.0 20.0
2
LABEL
4.0 -0.6 0.0 -1.0 0.0 0.0 0.0 20.0
4
LABEL
6.0 -0.6 0.0 -1.0 0.0 0.0 0.0 20.0
6
LABEL
8.0 -0.6 0.0 -1.0 0.0 0.0 0.0 20.0
8
LABEL
9.5 -0.6 0.0 -1.0 0.0 0.0 0.0 20.0
m
```

Figure 16.3: TICKS and LABEL commands used to create image in Figure 16.4

The color parameters `r`, `g` and `b` are the red, green and blue components of the tick color each ranging from 0.0 to 1.0. The foreground color (white by default) may be set by setting any or all of the `r`, `g` and `b` components to a negative number. The `tickwidth` parameter specifies tick width in pixels. Fractional widths may be specified.

The `LABEL` keyword allows a text string to be added within a Smokeview scene. The label color and start and stop appearance time may also be specified. The format is given by

```
LABELS
x y z r g b tstart tstop
label
```

where (`x, y, z`) is the label location in cartesian coordinates and `r, g, b` are the red, green and blue color components ranging from 0.0 to 1.0. Again, if a negative value is specified then the foreground color will be used instead (white is the default). The parameters, `tstart` and `tstop` indicate the time interval when the label is visible. The text string is specified on the next line (`label`).

Figure 16.3 shows how the `TICKS` and `LABELS` keywords can be used together to create a *ruler* with major and minor tick marks illustrated in Figure 16.4.

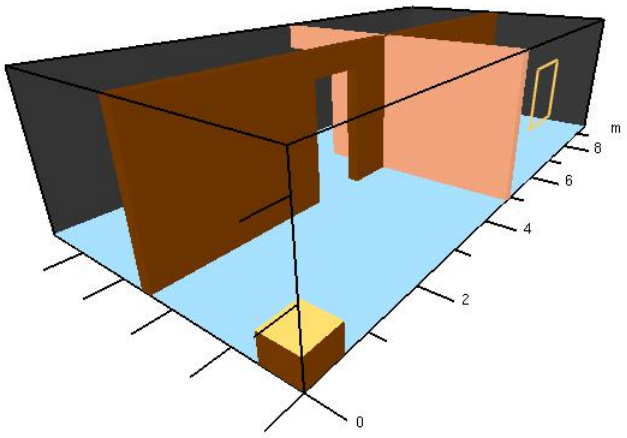


Figure 16.4: Annotation example using the TICKS and LABEL keyword.

Chapter 17

Utilities

Several utilities are included with the FDS/Smokeview distribution allowing one to more easily analyze and generate data. Smokezip may be used to compress FDS data files resulting in quicker load times in Smokeview. Smokediff may be used to compare two FDS cases. Smokediff generates another .smv file and a set of data files which can be viewed with Smokeview. Background may be used to take advantage of multiple core computers by running more than one FDS case at a time. This is most useful when running a long list of FDS cases. Background runs a case whenever the CPU load is below a specified level.

17.1 Compression - Using Smokezip to reduce FDS file sizes

3D smoke, boundary, isosurface and slice files may be compressed using the utility Smokezip. FDS data files may also be compressed from within Smokeview using the compression menu item found in the `Load/Unload` menu. File compression may also be activated from the Compressions, Autoload section of the *File Bounds* dialog box illustrated in Figure 17.1. Compression is performed using the ZLIB compression library (see http://www.zlib.org). Smokeview compresses files in the background allowing one to continue visualizing cases. Smokeview adds the label *ZLIB* to Load menu entries for any file that has been compressed. Smokezip adds the extension .svz to any FDS data file that has been compressed.

The usage for Smokezip (which may be obtained by typing smokezip -help at a command line) is

```
smokezip 1.4(6960) - Oct 15 2010

Compresses various Smokeview data files

smokezip [options]  casename

options:
-2  - overwrites 2d slice compressed files
-3  - overwrites 3d smoke files
-b  - overwrites boundary compressed files
-i  - overwrites iso-surface compressed files
-p  - overwrites PLOT3D files
-part2iso - generate isosurfaces from particle data
-f  - overwrites all compressed files
-bounds - estimate data bounds for all file types
-bb - estimate data bounds for boundary files
-bs - estimate data bounds for slice files
-bp - estimate data bounds for plot3d files
-n3 - do not compress 3d smoke files
-nb - do not compress boundary files
-np - do not compress PLOT3D files
-ni - do not compress isosurface files
-ns - do not compress slice files
-t nthread - Compress nthread files at a time (up to 16)
```

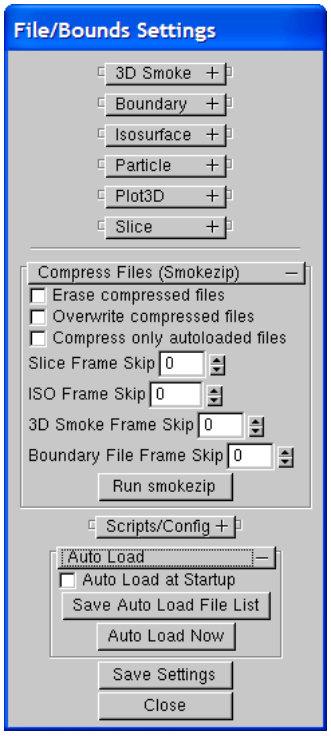


Figure 17.1: *File/Bounds* dialog box showing compression and autoload options. 3D smoke, boundary and slice files may be compressed using smokezip. All currently loaded files may be loaded automatically when smokeview first starts by selecting the autoload checkbox.

```
-d destdir - copies compressed files (and files needed by Smokeview
             to view the case) to the directory destdir
-demo - Creates the files (compressed and .svd ) needed by the
        Smokeview demonstrator mode.  Compresses files that are autoloaded,
        uses (20.0,620.0) and (0.0,0.23) for temperature and oxygen bounds and
        creates the .svd file which activates the Smokeview demonstrator mode.
-s sourcedir - specifies directory containing source files
-skip skipval - skip frames when compressing files
-no_chop - do not chop or truncate slice data.  Smokezip by default will compress
           slice data truncating data above and below values specified in the .ini file
-auto - compress only files that are auto-loaded by Smokeview
-c  - cleans or removes all compressed files
-h  - display this message

casename - Smokeview .smv file
Min and max bounds used to compress boundary files are obtained
from the casename.ini file or calculated by smokezip if casename.ini
does not exist.  See http://fire.nist.gov/fds for more information.
```

Smokezip either determines data bounds itself (if the -bounds option was specified) or uses min and max values found in the casename.ini file. These bounds are used to map four byte floating point data found in FDS data files to one byte color indices used by Smokeview. The algorithms for determining the data mappings used by Smokeview and Smokezip are identical so it should result in the same views.

Particle files may be converted to isosurface files using the `-part2iso` option as in `smokezip -part2iso casename`. The resulting isosurface file hilights particle boundaries (where particle density is 0.5 particles per grid cell). These isosurface files are accessible in the .smv file named `casename_smvzip.smv`.

17.2 Differencing - Using Smokediff to compare two FDS cases

Two FDS cases with the same geometry may be compared using the stand-alone program smokediff. Smokediff examines two .smv files files looking for boundary, slice and plot3d files containing the same type of data and located in the same region in space and/or time. Smokediff then subtracts the data in one file from the corresponding data in the other generating a new .smv file and new differenced boundary, slice and Plot3d data files. To compare the two .smv files, `casename1.smv` and `casename2.smv` one would use the command

```
smokediff -smv casename1 casename2
```

which opens smokeview to examine the differenced data after smokediff completes. Smokediff subtracts the data referenced in casename1 from the data referenced in casename2. For slice files, smokediff allows the grid in casename2 to be refined by a factor of 2. Other usage options for smokediff are detailed below

```
smokediff [options] smv_case1 smv_case2
  version: 1.0.3 (revision 6331) - Jun 15 2010

smokediff compares two FDS cases by subtracting data referenced in smv_case2 from
corresponding data referenced in smv_case1 (smv_case1 - smv_case2).  Slice, PLOT3d
and boundary files are supported.  Differenced results may be viewed by opening
smv_case1_diff.smv in Smokeview or by using the -smv option when running smokediff.

Mesh bounds must be identical for corresponsing meshes.  Mesh resolutions must be
identical when differencing boundary or PLOT3D files.  The x, y, and/or z mesh
resolution in smv_case1 must be an integer multiple of the corresponding x, y, z mesh
resolution in smv_case2 when differencing slice files.

-h  - display this message
-v  - display version information
-s1 dir1 - directory containing case smv_case1.smv
```

```
-s2 dir2 - directory containing case smv_case2.smv
-d  dir  - directory containing created differenced files
-nb      - do not difference boundary files
-np      - do not difference Plot3d files
-ns      - do not difference slice files
-smv     - view case in smokeview when differencing is complete
-type label - difference only data of type label (in boundary and slice files)
smv_case1,smv_case2 - Two smokeview cases to compare.
```

17.3 Background - A utility to run multiple Windows programs simultaneously

This section explains the use of the utility named *background.exe*, what it is and how it might be useful to FDS users. It is included with the Windows and Linux FDS/Smokeview bundles. The Windows *start* command can be used to run Windows programs in the background. *background.exe* has the additional feature of checking the current CPU usage level and only starting new programs when the usage level is below a specified level. This enables one to submit a long list of FDS cases without saturating the CPU, since only a small number (depending on the maximum usage level specified) will be running at any one time.

MPI is a message passing software library used to enable implement parallel processing at the program *i.e.* FORTRAN source code level. This enables one to make use of multiple CPUs thereby speeding up a calculation. *background.exe* allows parallel processing to occur at the program level. It is often the case that one is doing a parameter study or running a long list of cases to verify the use of FDS. Typically you would create a windows batch file (.bat) containing a list of commands like

```
fds5 casename_1.fds
....
fds5 casername_n.fds
```

On a Windows system, each entry in the above list will not start until the previous entry has completed, even if the computer has multiple cores or CPUs.

Unix/Linux based systems have the capability of putting computer jobs in the background, meaning that when a job is run, control returns immediately allowing the next job in the list to start running. With computers that have multiple cores or CPUS, one can then run more than one job simultaneously.

Here is how one might use *background* with FDS

```
background -d 1.0 -u 90 fds5 casename.fds
```

This command runs "fds5 casename.fds" after waiting 1 s and ensuring that the CPU usage is less than 90 %. If the CPU usage happens to be more than 90 %, the program *background* waits to submit the fds5 command until the usage drops below 90 % . Once this occurs, it runs the command, `fds5 casename.fds`.

The purpose of the delay before submitting a job is to give windows a chance to update the usage level from the previous invocations. This feature is a fail safe to ensure that a large number of jobs are not submitted at once.

The background utility is designed to use in a windows batch file. For example, suppose you have a list of 5 FDS jobs you want to run in a windows batch file. On a windows computer you would have a batch file with the contents something like

```
fds5 case1.fds
fds5 case2.fds
fds5 case3.fds
fds5 case4.fds
fds5 case5.fds
```

Using background with a 2 second delay and 75 per cent maximum load level, you would change your script to something like

```
background -d 2 -u 75 fds5 case1.fds
background -d 2 -u 75 fds5 case2.fds
background -d 2 -u 75 fds5 case3.fds
background -d 2 -u 75 fds5 case4.fds
background -d 2 -u 75 fds5 case5.fds
```

Help information for background may be obtained at the command line by typing `background -h` which gives:

```
background 1.0(6084) - Apr 27 2010
  Runs a windows program in the background

Usage:

  background [-d delay time (s) -h -u max_usage -v] prog [arguments]

where

  -d dtime  - wait dtime seconds before running prog in the background
  -h        - display this message
  -u max    - wait to run prog until cpu usage is less than max (25-100%)
  -v        - display version information
  prog      - program to run in the background
  arguments - command line arguments of prog

Example:
  background -d 1.5 -u 50 prog arg1 arg2
    runs prog (with arguments arg1 and arg2) after 1.5 seconds
    and when the CPU usage drops below 50%
```

Chapter 18

Summary

Often fire modeling is looked upon with skepticism because of the perception that eye-catching images shroud the underlying physics. However, if the visualization is done well, it can be used to assess the quality of the simulation technique. The user of FDS chooses a numerical grid on which to discretize the governing equations. The more grid cells, the better but more time-consuming the simulation. The payoff for investing in faster computers and running bigger calculations is the proportional gain in calculation accuracy and realism manifested by the images. There is no better way to demonstrate the quality of the calculation than by showing the realistic behavior of the fire.

Up to now, most visualization techniques have provided useful ways of analyzing the output of a calculation, like contour and streamline plots, without much concern for realism. A rainbow-colored contour map slicing down through the middle of a room is fine for researchers, but for those who are only accustomed to looking at real smoke-filled rooms, it may not have as much meaning. Good visualization needs to provide as much information as the rainbow contour map but in a way that speaks to modelers and non-modelers alike. A good example is smoke visibility. Unlike temperature or species concentration, smoke visibility is not a local quantity but rather depends on the viewpoint of the eye and the depth of field. Advanced simulators and games create the illusion of smoke or fog in ways that are not unlike the techniques employed by fire models to handle thermal radiation. The visualization of smoke and fire by Smokeview is an example of the graphics hardware and software actually computing results rather than just drawing pretty pictures. A common concern in the design of smoke control systems is whether or not building occupants will be able to see exit signs at various stages of a fire. FDS can predict the amount of soot is located at any given point, but that doesn't answer the question. The harder task is to compute on the fly within the visualization program what the occupant would see and not see. In this sense, Smokeview is not merely a *post-processor*, but rather an integral part of the analysis.

The purpose of Smokeview is to help one gain insight into the results of fire modeling simulations. Some areas of future work pertaining to the technical aspects of Smokeview include improving the visual modeling of smoke and fire and improving Smokeview's ability to handle larger cases. General strategies for improving Smokeview's ability to visualize cases and therefore to improve the understanding of computed fire flow are discussed in more detail in the Smokeview Technical Guide [20].

Bibliography

[1] National Institute of Standards and Technology, Gaithersburg, Maryland, USA, and VTT Technical Research Centre of Finland, Espoo, Finland. *Fire Dynamics Simulator, Technical Reference Guide*, 5th edition, October 2007. NIST Special Publication 1018-5 (Four volume set).

[2] W. W. Jones, R. D. Peacock, G. P. Forney, and P. A. Reneke. CFAST, Consolidated Model of Fire Growth and Smoke Transport (Version 5. technical reference guide. NIST Special Publication 1030, National Institute of Standards and Technology, Gaithersburg, Maryland, October 2004.

[3] K.B. McGrattan, S. Hostikka, and J.E. Floyd. Fire Dynamics Simulator (Version 5), User's Guide. NIST Special Publication 1019-5, National Institute of Standards and Technology, Gaithersburg, Maryland, October 2007.

[4] D. Madrzykowski and R.L. Vettori. Simulation of the Dynamics of the Fire at 3146 Cherry Road NE, Washington, DC May 30, 1999. Technical Report NISTIR 6510, Gaithersburg, Maryland, April 2000. URL: http://fire.nist.gov/6510.

[5] D. Madrzykowski, G.P. Forney, and W.D. Walton. Simulation of the Dynamics of a Fire in a Two-Story Duplex, Iowa, December 22, 1999. Technical Report NISTIR 6854, Gaithersburg, Maryland, January 2002. URL: http://www.fire.nist.gov/bfrlpubs/duplex/duplex.htm.

[6] R.L. Vettori, D. Madrzykowski, and W.D. Walton. Simulation of the Dynamics of a Fire in a One-Story Restaurant – Texas, February 14, 2000. Technical Report NISTIR 6923, Gaithersburg, Maryland, October 2002.

[7] R.G. Rehm, W.M. Pitts, Baum H.R., Evans D.D., K. Prasad, K.B. McGrattan, and G.P. Forney. Initial Model for Fires in the World Trade Center Towers. Technical Report NISTIR 6879, Gaithersburg, Maryland, May 2002.

[8] Brian W. Kernighan, Dennis Ritchie, and Dennis M. Ritchie. *C Programming Language (2nd Edition)*. Prentice Hall PTR, March 1988.

[9] T. M. Ellis, Ivor R. PHilips, and Thomas M. Lahey. *Fortran 90 Programming*. Addison-Wesley, 1994.

[10] OpenGL Architecture Review Board, Dave Shreiner, Mason Woo, Jackie Neider, and Tom Davis. *OpenGL Programming Guide - The Official Guide to Learning OpenGL, Version 2.1*. Addison-Wesley, Stoughton, Massachussets, 6 edition, 2007.

[11] Mark J. Kilgard. *OpenGL Programming for the X Window System*. Addison-Wesley Developers Press, Reading, Massachussets, 1996.

[12] Thomas Boutell. *CGI Programming in C & Perl*. Addison-Wesley Publishing Company, Reading, Massachussets, 1996.

[13] Thomas Boutell. GD version 2.0.7, http://www.boutell.com/gd/, November 2002.

[14] Guy Eric Schalnat, Andreas Dilger, and Glenn Randers-Pehrson. libpng version 1.2.5, http://www.libpng.org/pub/png/, November 2002.

[15] JPEG version 6b, http://www.ijg.org/.

[16] Jean loup Gailly and Mark Adler. zlib version 1.1.4, http://www.gzip.org/zlib/, November 2002.

[17] Paul Rademacher. GLUI version 2.1, http://www.cs.unc.edu/ rademach/glui/.

[18] Tomas Akenine-Moller and Eric Haines. *Real-Time Rendering*. A K Peters, Ltd., Natick, Massachusetts, 2nd edition, 2002.

[19] Pamela P. Walatka and Pieter G. Buning. PLOT3D User's Manual, version 3.5. NASA Technical Memorandum 101067, NASA, 1989.

[20] G.P. Forney. Smokeview (Version 5), A Tool for Visualizing Fire Dynamics Simulation Data, Volume II: Technical Reference Guide. NIST Special Publication 1017-2, National Institute of Standards and Technology, Gaithersburg, Maryland, May 2009.

Part IV

Appendices

Appendix A

Command Line Options

Smokeview may be run from a command shell. Furthermore, command line options may be invoked in order to alter Smokeview's startup behavior. Normally these options are not necessary. However, they may be used for cases with very large particle files or to generate a preference or customization file. To obtain a list of command line options, type:

```
smokeview -help
```

without any arguments which results in output similar to:

```
Smokeview 5.6 - Oct 29 2010
Visualize fire/smoke flow simulations.  All parameters are optional.

Usage:

smokeview casename -points m -frames n -ini -ng_ini -part -nopart -stereo -demo
            -runscript -script scriptname

where

  casename = project id (file names without the extension)
         m = maximum number of particles.  Default=50000000
         n = maximum number of particle frames.  Default=5001
     -demo = activate demonstrator mode of Smokeview
     -help = display this message
      -ini = output default smokeview parameters to smokeview.ini
   -ng_ini = same as -ini .  Used when console does not have graphics setup
     -part = load particle file if present
   -nopart = do not load particle file
   -stereo = activate stereo mode (if supported)
  -version = display version information
-runscript = run the script file, casename.ssf, at startup
-script scriptfile = run the script file, scriptfile, at startup
    -build = show pre-preprocessing directives used to build smokeview
```

The `-nopart` option is used to prevent a particle file from being loaded at startup. The `-points` and `-frames` options are used to load more than the default 5,000,000 points or 500 frames where a frame is data for one time step. To load up to 6,000,000 points and 1000 frames then type:

```
smokeview casename -points 6000000 -frames 1000
```

where in both cases `casename` is the basename of the FDS output files. The same effect may be achieved by using:

```
MAXPOINTS
6000000
MAXFRAMES
1000
```

in the `smokeview.ini` or `casename.ini` file. This file may be created with the `-ini` option and contains many other customizable Smokeview parameters. The `-benchmark` option is used to measure the performance of Smokeview. The `-benchmark` option causes Smokeview to produce precise timings by outputting frame rates based upon one cycle through the timing loop rather than using moving averages. The `-stereo` option may used to access stereo hardware (often called quad buffering) if it is available.

Appendix B

Menu Options

The design philosophy used to develop Smokeview has been to avoid complicated, non-portable user interfaces that are costly to implement. As a result, most of the development effort has gone into the visualization (display of particle flow, contour plots *etc*) rather than user interface design and implementation. Smokeview's pop-up menus are implemented with GLUT [11], the graphics library utility toolkit. The user interacts with Smokeview via 1) menus, 2) keyboard shortcuts and 3) the preference file (`smokeview.ini` or `casename.ini`).

A *pop up* menu is displayed when the right mouse is clicked anywhere within the scene. The main menu options as illustrated in Figure B.1 are: `Load/Unload` `Show/Hide`, `Options`, `Dialogs` `Tours`, `View` and `Help`. Several of these menu options have sub-menus. These menus are described in the following sections.

B.1 Main Menu Items

Load/Unload This menu option allows one to load or unload particle, isosurface, vector slice, slice, Plot3D or boundary files. These time dependent files may be viewed simultaneously, but not concurrently with the time independent Plot3D files. However, one boundary or one Plot3D file per mesh may be viewed at a time. Multiple slices for the same variable may be viewed simultaneously. This menu may also be used to load and create preference files `.ini files` and to re-read the `.smv` file. For more details see Appendix B.2.

Show/Hide This menu item allows one to show or hide the loaded data files and various scene attributes such as time/color bars, internal blockages *etc*. As a file type is shown or hidden (or loaded and unloaded), the color and time bars are changed to reflect the currently visible data files. More details are given in Appendix B.3.

Options This menu allows one to specify various smokeview options such as specifying frame rates, rendering the screen to a PNG or JPEG file, changing font sizes, selecting dialog boxes *etc*.

Dialogs This menu allows one to open/close various dialog boxes for setting data bounds, controlling the *look* of the 3D smoke, specifying clip planes *etc*.

Tour This menu displays a list of tours stored in the `casename.ini` preference file. The `manual` tour gives control back to the user. Tours may be defined using the *Tour* dialog box.

View Resets the simulation scene to an alternate view. The three choices are 1) exterior view, 2) interior view or a 3) user defined view. A viewpoint may be saved by using this menu or by

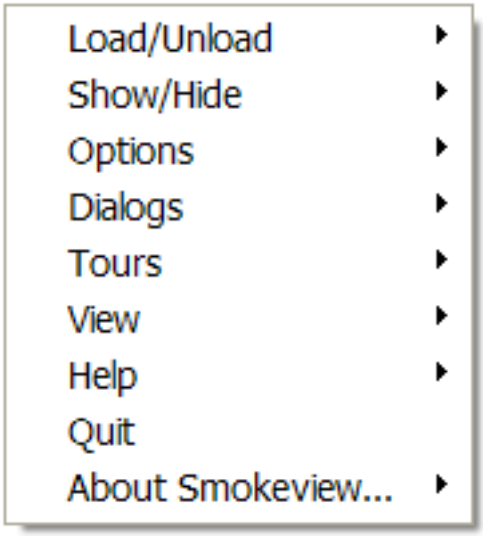


Figure B.1: Main Menu.

using the `Viewpoint` sub-menu of the `Options` menu. If a time file is visible then two sub-menus occur allowing one to reset the view back to the original position or the time bar back to the initial time.

Help Displays a list and explanation of keyboard equivalent commands.

B.2 Load/Unload

Six types of files may be visualized with Smokeview. These files are loaded using the `LOAD/UNLOAD` menus as illustrated in Figure B.2. They are particle, vector slice, slice, boundary, isosurface and Plot3D files. Note that vector slice animations use two or more slice files to display the animated vector slices. The format of the data contained in these files is described in the FDS User's Guide [3]. A sub-menu is present under `Load/Unload` for each file type generated for the simulation. Selecting one of the files appearing in the sub-menu causes it to be loaded and then displayed. The data may be unloaded or freed by selecting an `Unload` menu item appearing under the file list. Selecting `Unload All` as expected will unload all files. To hide a data file, select the `Show/Hide` menu option corresponding to the file type to be hidden.

The Smokeview `.smv` file contains information about all data files appearing in the `Load/Unload` menu item. The FDS field modelling software creates this file. (See Appendix D.4 for documentation on the format of this file).

The character "$\star$" occurring before a file name in one of the sub-menus indicates that the file has already been loaded. If the file below is loaded but not visible, then use the appropriate `Show/Hide` option to make it visible.

Open Smokeview (`.smv`) This menu item allows one (on the PC) to use an open file dialog box to open a Smokeview scene (file with `.smv` extension). This menu is only active when one starts up

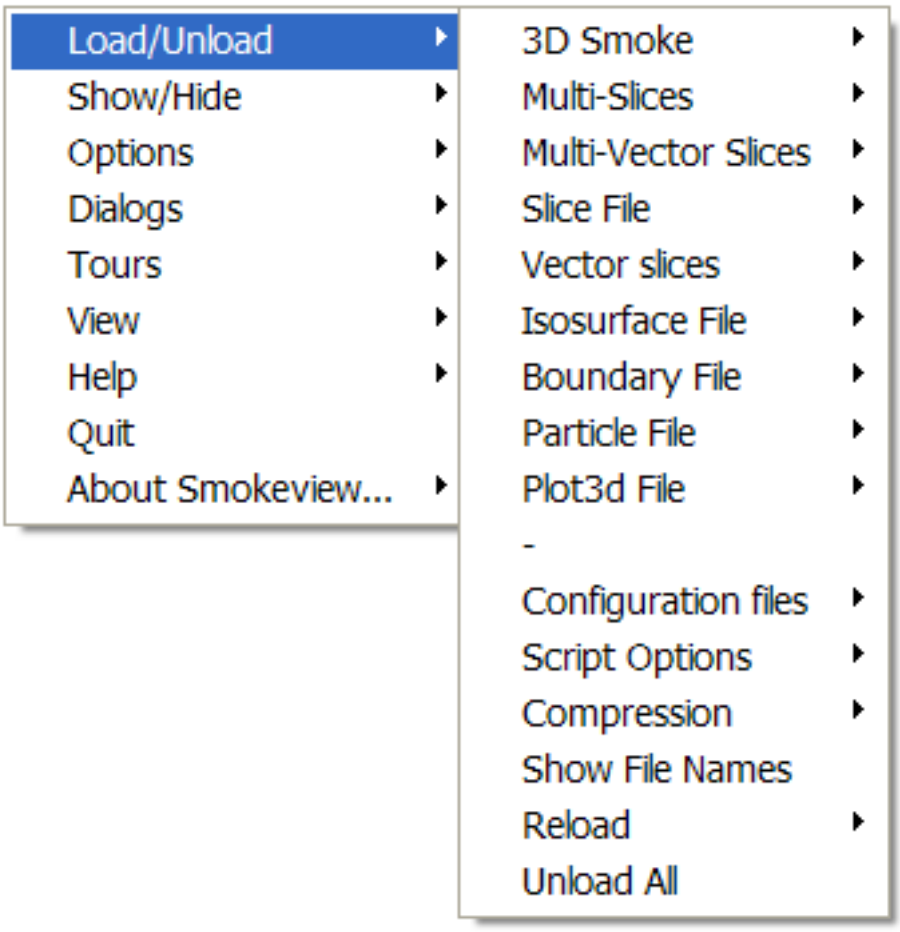


Figure B.2: Load/Unload Menu.

Smokeview without first specifying a file. (One cannot open a new Smokeview file after one has already been opened.)

3D Smoke File (`.s3d`) This menu item allows one to load realistic smoke, fire or water spray files.

Slice File (`.sf`) This menu item gives the name and location of all available slice files and also the option to unload the currently loaded slice files.

Multi-Slice File (`.sf`) This menu item allows one to load all slices occurring in one plane (within a grid cell) simultaneously. It also gives the option to unload the currently loaded multi-slices.

Vector Slice File (`.sf`) This menu item gives the name of all slice files that have one or more associated U, V and/or W velocity slice files. These slice files must be defined for the same region (or slice) in the simulation.

Multi-Vector Slice File (`.sf`) This menu item allows one to load all vector slices occurring in one plane (within a grid cell) simultaneously. It also gives the option to unload the currently loaded multi-slices.

Isosurface File (`.iso`) This menu item gives the name of all isosurface files and also the option to unload the currently loaded isosurface file.

Boundary File (`.bf`) This menu item gives the name of all boundary files and also the option to unload the currently loaded boundary file.

Particle File (`.part`) This menu item gives the name of all particle file and also the option to unload the currently loaded particle file.

Plot3D File (`.q`) This menu item gives the name of all Plot3D files and also the option to unload the currently loaded Plot3D file.

Preference File (`.ini`) The INI or preference file contains configuration parameters that may be used to customize Smokeview's appearance and behavior. This menu item allows one to create (or overwrite) a preference file named either `smokeview.ini` or `casename.ini`. A preference file contains parameter settings for defining how Smokeview visualizes data. This file may be edited and re-read while Smokeview is running.

Compression 3D smoke and boundary files may be compressed using this menu item.

Show File Names Load and Unload menus by default are specified using the location and type of visual to be displayed. This menu item adds file names to the Load and Unload menus.

Reload This menu item allows one to reload files at immediately or at intervals of 1, 5 or 10 minutes. The `u` key may used to reload files from the keyboard. This is useful when using Smokeview to display a case that is currently running in FDS.

Unload All This option causes all data files to be unloaded.

B.3 Show/Hide

The `Show/Hide` menu item allows one to show or hide various parts of the simulation. This menu item contains sub-menus for Particles, Boundary, Animated Slice, Plot3D 2D and 3D contours, sensors

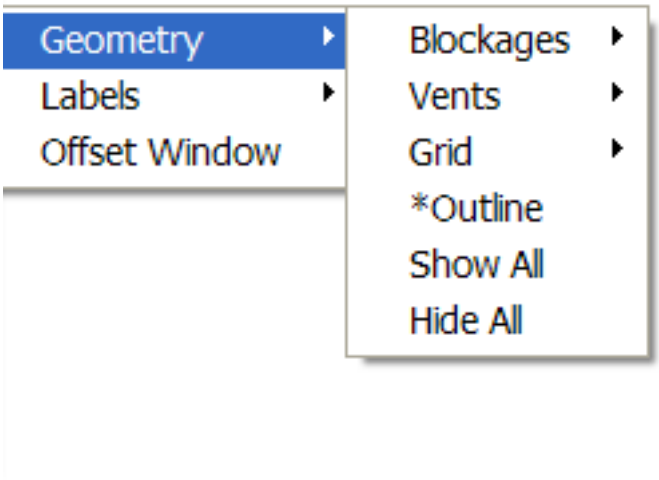


Figure B.3: Geometry Menu.

(thermocouples, heat detectors and sprinklers), Color and time Bars and Geometry. These menu items only appear if they pertain to the simulation. For example the `Particles` sub-menu only appears if a particle file has been loaded. Similarly, the `Plot3D contouring` sub-menus only appear if a Plot3D file has been loaded. The "$\star$" character is used to indicate whether the visualization feature corresponding to the menu item is set or active.

B.3.1 Geometry Options

The `Geometry` menu is illustrated in Figure B.3.

Blockages Blockage sub-menus are divided into two groups. The first group allows the user to change how blockage appear (`Defined in Input File`, `Normal`, `Outline`, `Hidden`).

The second group allows the user to change where blockages are located (actual or requested). The `Actual` sub-menu positions blockages as computed by FDS (along grid lines). The `Requested` sub-menu positions blockages at locations as specified in the input file. If the `dx2dxf` conversion program was used to convert a CAD drawing to input compatible with FDS and Smokeview then a third menu option appears, `CAD`. This option displays the Smokeview scene in a form similar to the original CAD drawing.

Grid This option allows one to visualize the grid used to perform the numerical calculations. One selects `xy plane`, `xz plane` or `yz plane` to visualize a single plane or `Show All`, `Hide All` to show or hide all grids. (Keyboard shortcut: `g`)

Outline Show or hide the outline that frames the simulation scene.

Show All Show all geometric features described above.

Hide All Hide all geometric features described above.

B.3.2 Animated Surface

This menu allows one to control the way isosurfaces are displayed. An isosurface is represented in Smokeview as a collection of triangles. Each triangle consists of three edges and three vertices.

Solid Display the isosurface by shading the triangles.

Outline Display the isosurface by only showing the triangle edges.

Points Display the isosurface by only showing the triangle vertices.

***quantity* levels** Display the desired isosurface level (when more than one isosurface is stored in an isosurface file).

Smooth Display the isosurface using smoothed vertex normals.

B.3.3 Particles

Smoke (tracer) Toggle the visibility of the particles. If water/sprinkler droplets are present in the particle file then sub-menus exist for both smoke and water to allow one to show or hide smoke and water droplets independently.

Sprinkler Toggle the visibility of sprinkler (water droplets).

B.3.4 Boundary

Exterior Show or hide all data contained in a boundary (`.bf`) file pertaining to the exterior walls.

Interior Show or hide all data contained in a boundary (`.bf`) file pertaining to interior blockages.

Front, Back, Left, Right, Up, Down Toggle the visibility of whatever exterior boundary surface is selected. Note an exterior boundary menu option only appears if its data is present in the boundary file.

B.3.5 Animated Vector Slice

Toggle the visibility of the animated vector slice file.

B.3.6 Animated Slice

Toggle the visibility of the animated slice file.

B.3.7 Plot3D

2D Contours

Solution Variables A Plot3D data file contains five solution variables. If one or more of the velocity components denoted u, v and w are present in the Plot3D file then speed, calculated using $\sqrt{u^2+v^2+w^2}$, appears in the menu. Any velocity components missing from the Plot3D file are set to 0.0 when calculating speed. This menu item allows one to select the Plot3D solution variable to be visualized. (Keyboard shortcut: `p`)

xy, xz, yz planes These three menu items, appearing beneath the Solution Variables menu item, allow one to select which plane (xy, xz or yz) is displayed. (Applicable keyboard shortcuts: space bar, -, left/right cursor, up/down cursor, page up/down, `1...9`)

Flow vectors Toggle visibility of flow vectors. The magnitude and direction of the vectors are determined by the U, V and W components of velocity. The vector color is determined by the solution variable selected. (Applicable keyboard shortcuts: `a, s, v`)

Continuous Display contours as smooth continuous shades or as stepped constant shades. (Keyboard shortcut: `c`)

Show All Show all three (xy, xz and yz) Plot3D planes at once.

Hide All Hide all three Plot3D planes.

Plot3D 3D Contours

Solution Variables Same as for 2D contours. This menu item allows one to select the solution variable used to generate the 3D or iso-contour to be displayed.

Solution Value Select the 3D contour level to display. The axis label shown in red corresponds to the 3D contour level displayed.

Block Size To increase the drawing speed, adjacent grid cells may be combined when viewing 3D contours. Selecting 1 will result in highly resolved contours but may take longer to draw. Selecting 5 will have the opposite effect.

Hide Hide the 3D contour.

B.3.8 Heat detectors, Sprinklers, Thermocouples

Toggle the sensor visibility. The currently implemented sensors are heat detectors, sprinklers and thermocouples.

B.3.9 Textures

Toggle the visibility of each or all textures.

B.3.10 Labels

The label menu is illustrated in Figure B.4

Color Bars, Time Bars, Title, Axis, Frame Rate, Time Label, Frame label, Mesh label, Memory Load, Text Labels Show or hide the individual scene element.

Show All Show all scene elements.

Hide All Hide all scene elements.

B.4 Options

The option menu is illustrated in Figure B.5 and detailed below.

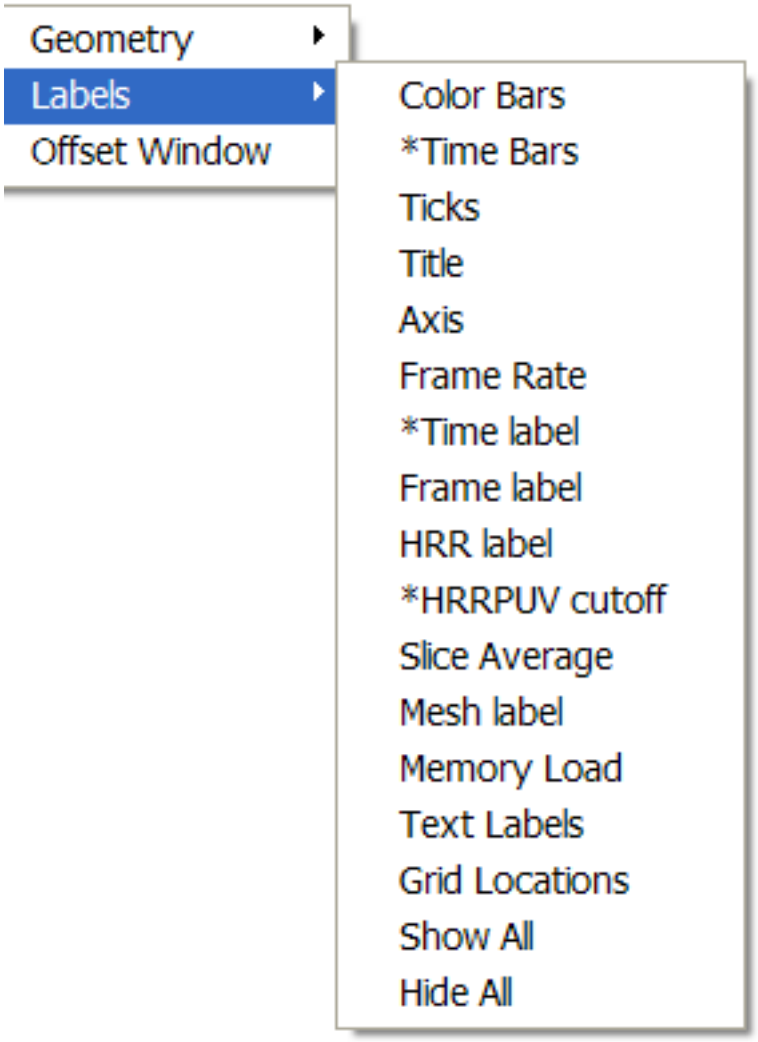


Figure B.4: Label Menu.

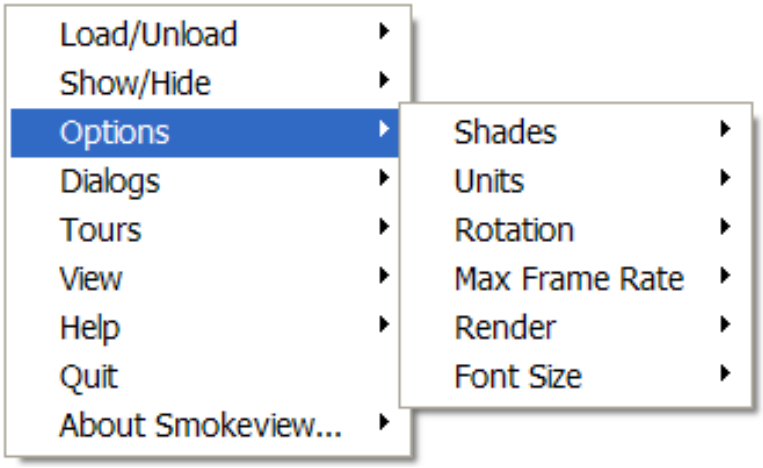


Figure B.5: Option Menu.

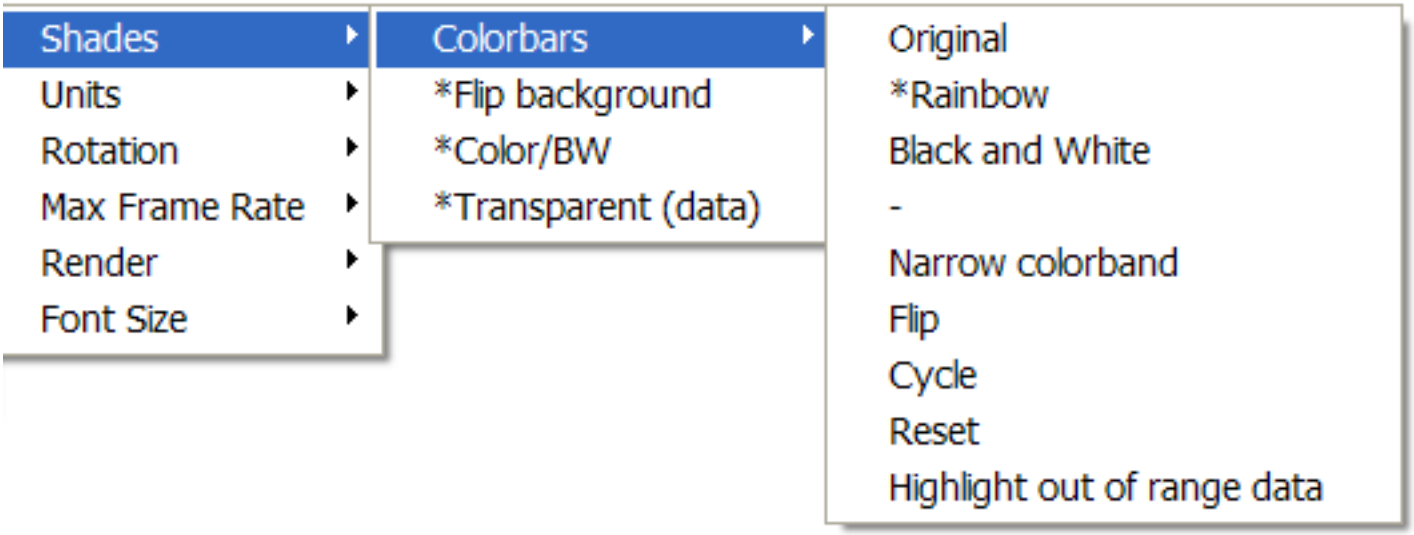


Figure B.6: Shades Menu.

B.4.1 Shades

The shades menu is illustrated in Figure B.6.

Colorbars A sub-menu which allows the user to choose and manipulate colorbars.

Flip Background Flip the background color between a dark and light shade. A dark background shade looks better on a computer monitor while a light shade looks better on the printed page.

Color Toggle scene colors between color and shades of grey. This option currently does not convert all scene colors to shades of grey. Contours and blockages are the most important Smokeview objects to convert.

Transparent Toggle contours between opaque and transparent. Transparent colors allow one to view the scene behind the contours giving the user a better sense of scale. Transparent colors, however, may make the scene look too confusing when the geometry is complex.

Colorbars

Narrow colorband Causes a narrow (one pixel high) region of the colorbar to be changed to black when selected by the mouse. Allows one to highlight data of interest.

Flip Reverse the order of the colors displayed in the colorbar.

Cycle Cycle the colors in the colorbar.

Reset Return the colorbar to the original display.

Highlight out of range data When activated causes data when out of range to be highlighted.

B.4.2 Units

Select alternate temperature or velocity units. The `UNIT` keyword described in Appendix D.3 may be used to incorporate additional unit changes into Smokeview.

B.4.3 Rotation

Eye Centered Rotate and move the scene relative to the observer's *eye*. Eye centered views make it easier to move around within the scene itself as in modern computer games. (Keyboard shortcut: `e`. The "`e`" keyboard shortcut toggles the view between an *eye centered* and a *world centered* perspective.)

World Centered Rotate and move the scene relative to the scene's center. (Keyboard shortcut: `e`. The "`e`" keyboard shortcut toggles the view between an *eye centered* and a *world centered* perspective.)

World Centered - Level Rotation As expected, this is the same as `World Centered` but with level rotations.

B.4.4 Max Frame Rate

This option controls the rate at which image frames are displayed. The sub-menus allow one to specify a maximum frame rate. The actual frame rate may be slower if the scene is complex and the graphics card is

unable to draw the scene sufficiently fast. The unlimited menu item allows one to display frames as rapidly as the graphics hardware permits. The Real Time menu item allows one to draw frames so that the simulation time matches real time. The step menu item allows one to step through the simulation one time step at a time. This menu item may be used in concert with the Render menu item described below to create images at the desired time and view orientation for inclusion into reports. This is how figures were generated in this report.

B.4.5 Render

The Render menu, illustrated in Figure B.7, allows one to create PNG or JPEG image files of the currently displayed scene. The graphics library, GD 2.0.15, was used to create the rendered versions. GD 1.0 is documented in reference [12, Appendix 4]. GD 2.0.7 now creates images using *full color* allowing for more realistic scene representations eliminating the color banding that occurred with the previous version because of the limited number (256) of colors used to represent images. Due to patent disputes, GD 2.0.15 has dropped support for the GIF file format and uses JPEG or PNG instead.

The Render sub-menus allow one to specify an integer between 1 and 20 indicating the number of frames between rendered images. This allows one to generate images encompassing the entire time duration of the simulation which in turn can be converted into movie files (`mpeg, mov, avi` *etc*) using software available on the internet. Rendering may be stopped by selecting Cancel.

The keyboard shortcut for the render option is `r`.

B.4.6 Font Size

This option allows one to display text in either a normal or a large font.

B.4.7 Zoom

This menu item allows one to change the perspective by altering the magnification used to display the scene.

B.5 Dialogs

The Dialogs menu, illustrated in Figure B.8, allows one to select dialog boxes for setting various Smokeview features.

Clip Geometry Open the dialog box for clipping the geometry allowing one to see past exterior portions of the scene.

Compression/Smokezip Open the dialog box for compressing the FDS case being visualized using the external program Smokezip.

Display Open the dialog box for setting various parameters that control how the Smokeview scene appears.

Edit Geometry Open the dialog box for editing FDS blockages.

File/Bound/Script Settings Open the dialog box for specifying data bounds.

Motion/View/Render Open the dialog box for controlling scene movement. To use the movement arrows, click and hold the mouse in one of the arrows then move the mouse to achieve the desired movement.

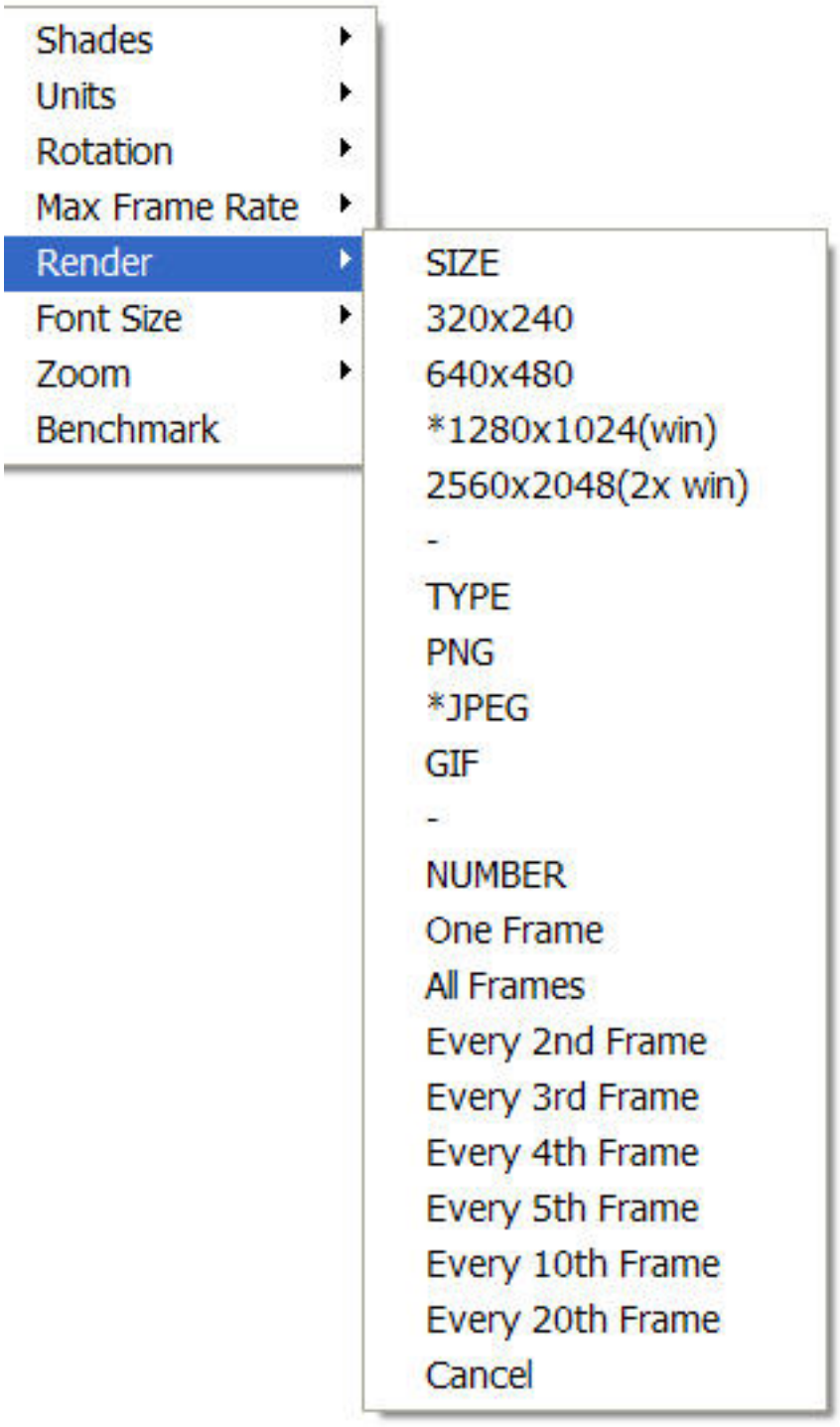


Figure B.7: Render Menu.

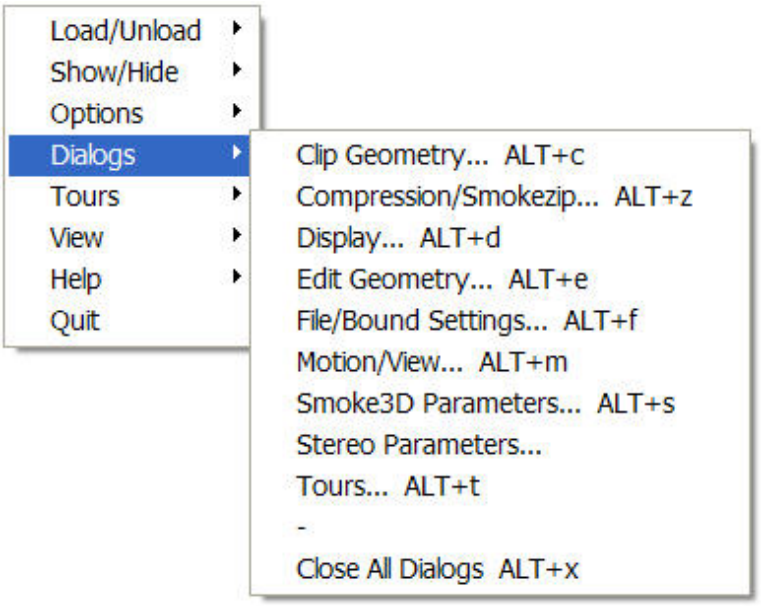


Figure B.8: Dialogs Menu.

Smoke3D Parameters Open the dialog box for specifying controlling the look of the 3D smoke.

Stereo 3-D Provides stereo 3-D output on systems equipped with supported video cards. Stereo 3-D requires a computer graphics card, monitor, software drivers and shuttered glasses. This option only appears if Smokeview is started from the command line using the `-stereo` command line option and if a video card supporting quad buffering (left and right front buffer, and left and right back buffer) is supported.

Tours This menu item opens up the *Edit Tour* dialog box and shows the path over which the tours occur.

B.6 Tours

The Tour menu illustrated in Figure B.9 allows one to show and hide available tours.

Manual This menu item turns *touring* off, allowing the user to control the scene with the mouse.

Default This menu item activates the original *tour* used in previous versions of Smokeview.

List of tours Each tour defined in the `.ini` file is listed under the `Tour` menu. A *circular* tour is defined automatically by Smokeview.

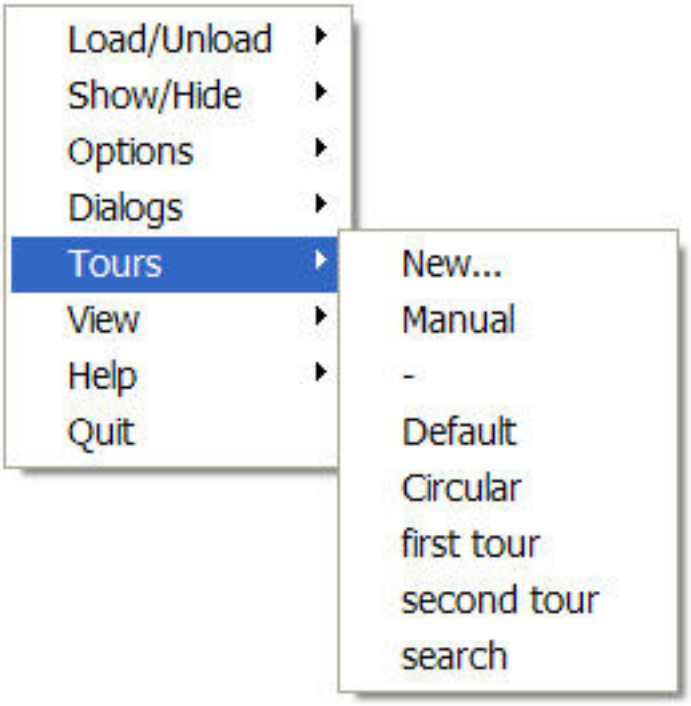


Figure B.9: Tour Menu.

Appendix C

Keyboard Shortcuts

Many menu commands have equivalent keyboard shortcuts. These shortcuts are described here and are also briefly described under the Help menu item from within Smokeview.

C.1 alphanumeric shortcuts

a Alter the arrow size used to display velocity vectors.

a Slide left when in **eye centered** movement mode.

b Used to increment the number of grid cells combined (between one and five) to generate PLOT3D iso-contours.

c Toggle the Plot3D 2D contour display between solid banded contours and continuously shaded contours.

d Slide right when in **eye centered** movement mode.

e Toggle how the scene is manipulated between an *eye view* where scene motion is relative to the observer and a *world view* where the scene motion is relative to the scene center.

g Toggle the grid visibility. When the grid display option is active, the x, y and z keys may be used to show or hide the grid perpendicular to the x, y and z axes respectively.

h Toggle window indentation, for use with window capturing.

i Toggle the visibility of PLOT3D iso-contours (3D surface contours).

k Toggle the visibility of the time bar.

m Switch between blocks in a case that has more than one mesh.

M Switch the behavior of the right mouse button between activating smokeview menus and moving the scene vertically.

o Switch between outline viewing modes. The modes are

1. outline of the current mesh
2. outline of the entire case
3. no outline

This option may be used with the *m*] key to highlight all meshes in sequence of a case.

p Show the next variable in the Plot3D data set.

P The cursor keys and the page up/down keys are needed to both move grid and Plot3D planes around the scene and to move through the scene while in *eye centered* mode. The upper case "P" key is then used to switch the way these keys are used between grid/Plot3D movement mode and scene movement mode.

q Switch between blockage views. These views are blocks that are aligned on grid lines, blocks as specified by the user (in the FDS input file) and blocks as generated by a CAD (computer aided drawing) package.

r,R Render the current scene as a JPEG or a PNG file which can be viewed in a web browser or inserted into a word processing document. If the upper case `R` key is selected then the scene is rendered in with double the screen resolution.

s Increment the number of vectors skipped. This is useful for making vector displays more readable when grids are finely meshed.

s Move backwards when in **eye centered** movement mode.

t Toggle the time stepping mode. Time stepping mode allows one to step through the simulation one time step at a time.

T Toggle the method for interpolating colors when drawing slice and boundary files.

u Reload files from the keyboard. This is useful when using Smokeview to display a case that is currently running in FDS.

v Toggle vector visibility. This option is only active when there are U, V and/or W velocity components present in the Plot3D data set.

w Move forwards when in **eye centered** movement mode.

x, y, z Toggle the visibility of the Plot3D data planes perpendicular to the x, y and z axes respectively (parallel to the yz, xz and xy planes).

0 Reset a time dependent animation to the initial time.

1-9 Number of frames to skip when viewing an animation.

C.2 ALT shortcuts

ALT d Open the Display dialog box.

ALT e Open the Edit Blockage dialog box.

ALT f Open the File/Bounds dialog box.

ALT m Open the Motion/View dialog box.

ALT s Open the 3D Smoke dialog box.

ALT t Open the Edit Tours dialog box.

ALT u Toggle option to draw a coarse portion of a 2D slice file within an imbedded mesh.

ALT v Toggle projection method used to visualize scene between size preserving and perspective.

ALT x Close all dialog boxes.

ALT y Toggles the interpolation method used to display cell centered slice file (draw cells as one color or interpolate colors smoothly between cell centers.

ALT z Open the Compress Files portion of the File/Bounds dialog box.

C.3 Special character short cuts

! Snap scene to nearest 45 degree rotation angle.

Save smokeview settings to the casename.ini file.

& Toggle line anti-aliasing. When active, this option draws line smoothly without *jaggies*.

$ Toggle trainer or demonstrator mode. When active, displays a dialog box that provides a simple set of controls for controlling the scene.

Left/Right Cursor When the *eyeview* mode is **eye centered** then these keys rotate the scene to the left or right otherwise they increment/decrement the Plot3D plane location displayed in the xz plane.

Page Up, Page Down Increment/decrement the Plot3D plane location displayed in the xy plane.

Up/Down Cursor Increment/decrement the Plot3D plane location displayed in the yz plane.

- Decrement Plot3D data planes, Plot3D iso-contour levels or time step displayed.

space bar Increment Plot3D data planes, Plot3D iso-contour levels or time step displayed.

Appendix D

File Formats and Extensions

D.1 FDS and Smokeview File Extensions

D.1.1 FDS file extensions

.bf File containing boundary file data.

.end File containing endian information.

.fds File containing the FDS input file.

.iso File containing iso-surface data

.out File containing FDS output.

.prt File containing particle file data using FDS 4 and earlier.

.prt5 File containing particle file data using FDS 5 and later.

.q File containing PLOT3D data.

.sf File containing slice file data.

.s3d File containing 3D smoke, HRRPUV data.

D.1.2 Smokeview file extensions

.bini File containing percentile and global data bounds for boundary files in referenced casename.smv.

.ini File containing Smokeview configuration settings.

.smv File containing Smokeview keyword data.

.ssf File containing a Smokeview script.

.svz File containing compressed boundary, slice or 3D smoke/fire data. The .svz extension is appended to the .bf, .sf or .s3d extension respectively.

.sz File containing sizing information for uncompressed data files. The .sz files contain information about each data frame used by Smokeview to allocate memory.

.szz File containing sizing information for compressed .svz files (files compressed with Smokezip with a .svz extension).

D.2 Smokeview Bound File Format (.bini files)

The first time a user views a boundary file, Smokeview computes data bounds by inputting all boundary file data of the same type. Smokeview records the bound computations result in a casename.bini file so that it does not need to be performed a second time. The .bini file is then used in subsequent Smokeview sessions for displaying boundary file data. The .bini file contains one or more B_BOUNDARY keywords .

B_BOUNDARY defines the global minimum and maximum and percentile minimum and maximum boundary data bounds used to convert boundary data values to color indices. The `B_BOUNDARY` keyword also has a parameter allowing one to specify the data type. The format is given by

```
B_BOUNDARY
 global_min percentile_min percentile_max global_max data_type
```

D.3 Smokeview Preference File Format (.ini files)

Smokeview uses preference files to set input parameters not settable by using menus or the keyboard and to save the *state* of a visualization. Smokeview looks for preference files in three locations in the following order:

1. a file named `smokeview.ini` in a global directory defined by the `SMOKEVIEWINI` environment variable. On the PC, the directory `C:\Program Files\ FDS\FDS5\bin\smokeview.ini` is the default location for this preference file. The `SMOKEVIEWINI` environment variable may be defined on the PC to specify the location of the smokeview.ini file. This step is performed automatically by the Smokeview installation program.

   This environment variable may be defined on a UNIX workstation by adding the line:

   ```
   setenv SMOKEVIEWINI dir
   ```

   to a `.login` or `.cshrc` start up file again where `dir` is the directory containing the global preference file. Changes to this `smokeview.ini` file apply to all cases visualized on the computer unless overridden by preference files named or located in directories named in steps 2. and 3.

2. a file named `smokeview.ini` in the directory containing the case being visualized. Changes to this `smokeview.ini` file apply to all cases in the current directory unless overridden by the `casename.ini` file contained in this directory.

3. a file named `casename.ini` in the directory containing the case being visualized where casename is the name of the case.

The `smokeview.ini` file may be created by typing:

```
smokeview -ini
```

from the command line or by selecting the `smokeview.ini` menu item. The `casename.ini` preference file can be created via the menus or by copying a previously created `smokeview.ini` file.

Smokeview reads the global `smokeview.ini` file first (step 1. above), followed by the local `smokeview.ini` file (step 2. above), followed by the `casename.ini` file. The global `smokeview.ini` file is used to customize parameters for all Smokeview runs. The local `smokeview.ini` file is used to customize parameters for just those Smokeview runs contained in the local directory. The `casename.ini` file is used to customize parameters for only those Smokeview runs with the prefix casename.

All preference file parameters unless otherwise noted consist of a `KEYWORD` followed by a value, as in:

```
KEYWORD
value
```

D.3.1 Color parameters

All colors are specified using a 3-tuple: r g b where r, g and b are the red, green and blue components of the color respectively. Each color component is a floating point number ranging from 0.0 to 1.0 where 0.0 is the darkest shade and 1.0 is the lightest shade. For example the 3-tuple 1.0 0.0 0.0 is bright red, 0.0 0.0 0.0 is black and 1.0 1.0 1.0 is white.

AMBIENTLIGHT Sets the color used for specifying ambient light. (default: `0.6 0.6 0.6`)

BACKGROUNDCOLOR Sets the color used to visualize the scene background. (default: `0.0 0.0 0.0`)

BLOCKCOLOR Sets the color used to visualize internal blockages. (default: `1.0 0.8 4.0`)

BOUNDCOLOR Sets the color used to visualize floors, walls and ceilings. (default: `0.5 0.5 0.2`)

COLORBAR Entries for the color palette in RGB (red, green, blue) format where each color component ranges from 0.0 to 1.0 . The default values (rounded to 2 digits) are specified with:

```
COLORBAR
12
0.00 0.00 1.00
0.00 0.28 0.96
0.00 0.54 0.84
0.00 0.76 0.65
0.00 0.91 0.41
0.00 0.99 0.14
0.14 0.99 0.00
0.41 0.91 0.00
0.65 0.76 0.00
0.84 0.54 0.00
0.96 0.28 0.00
1.00 0.00 0.00
```

COLOR2BAR Miscellaneous colors used by Smokeview. The default values are specified using:

```
COLOR2BAR
8
1.0 1.0 1.0 :white
1.0 1.0 0.0 :yellow
0.0 0.0 1.0 :blue
1.0 0.0 0.0 :red
0.0 1.0 0.0 :green
1.0 0.0 1.0 :magenta
0.0 1.0 1.0 :cyan
```

```
0.0 0.0 0.0 :black
```

where the 8 indicates the number of colors defined and the character string after the ``:'' are ignored.

COLORBAND The data is displayed using 256 levels. The colorbar consists of one color for each level. The COLORBAND parameter specifies the width of the **black** region on the colorbar highlighted when selected by the left mouse button. Currently the colorband width may be either 1 level or 10. (default: 10)

COLORBARFLIP Specifies whether the colorbar is flipped (1) or not flipped (0) (default: `0`).

DIFFUSELIGHT Sets the color for specifying diffuse light (default: `0.5 0.5 0.5`).

FLIP Specifies whether to flip (1) or not to flip (0) the foreground and background colors. By default the background color is black and the foreground color is white. Setting FLIP to 1 has the effect of having a white background and black foreground. (default: `0`).

FOREGROUNDCOLOR Sets the color used to visualize the scene foreground (such as text labels). (default: `1.0 1.0 1.0`)

HEATOFFCOLOR Sets the color used to visualize heat detectors before they activate. (default: `1.0 0.0 0.0`)

HEATONCOLOR Sets the color used to visualize heat detectors after they activate. (default: `0.0 1.0 0.0`)

ISOCOLORS Colors and parameters used to display animated isocontours. Default:

```
ISOCOLORS
10.000000 0.800000 : shininess, transparency
0.700000 0.700000 0.700000 : specular
3
0.960000 0.280000 0.000000
0.750000 0.800000 0.800000
0.000000 0.960000 0.280000
```

SENSORCOLOR Sets the color used to visualize sensors. (default: `1.0 1.0 0.0`)

SETBW The parameter used to set whether color shades (0) or shades of grey (1) are to used for coloring contours and blockages. (default: `0`)

SPRINKOFFCOLOR Sets the color used to visualize sprinklers before they activate. (default: `1.0 0.0 0.0`)

SPRINKONCOLOR Sets the color used to visualize sprinklers after they activate. (default: `0.0 1.0 0.0`)

STATICPARTCOLOR Sets the color used to visualize static particles (particles displayed in frame 0). (default: `0.0 1.0 0.0`).

TIMEBARCOLOR Sets the color used to visualize the timebar. (default: `0.6 0.6 0.6`)

VENTCOLOR Sets the color used to visualize vents. (default: `1.0 0.0 1.0`)

D.3.2 Size parameters

The parameters described in this section allow one to customize the size of various Smokeview scene elements.

ISOLINEWIDTH Defines the width in pixels of lines used to draw animated iso-surfaces in outline mode. (default: 2.0)

ISOPOINTSIZE Defines the size in pixels of iso-surface particles. (default: 4.0)

LINEWIDTH Defines the width of lines[1] in pixels. (default: 2.0)

PARTPOINTSIZE Defines the size in pixels of smoke or tracer particles. (default: 1.0)

PLOT3DLINEWIDTH Defines the width in pixels of lines used to draw PLOT3D iso-surfaces in outline mode. (default: 2.0)

PLOT3DPOINTSIZE Defines the size in pixels of PLOT3D iso-surface particles. (default: 4.0)

SENSORABSSIZE Defines the sensor size drawn by smokeview using the same units as used to specify the grid coordinates. (default: 0.038)

SLICEOFFSET Defines an offset distance[2] animated slices are drawn from adjacent solid surfaces. (default: 0.10)

SMOOTHLINES Specifies whether lines should be drawn (1) or not drawn (0) using anti-aliasing (default: `1`).

SPRINKLERABSSIZE Defines the sprinkler size drawn by smokeview using the same units as used to specify the grid coordinates. (default: 0.076)

STREAKLINEWIDTH Defines the width of a streak line. (default: 1.0)

VECTORLENGTH Defines the length of Plot3D vectors. A vector length of 1.0 fills one grid cell. Vector lengths may also be changed from within Smokeview by depressing the "`a`" key. (default: 4.0)

VECTORPOINTSIZE Defines the size in pixels of the point that is drawn at the end of a Plot3D vector. (default: 3.0)

VENTLINEWIDTH Defines the width of lines used to draw vents in pixels. (default: 2.0)

VENTOFFSET Defines a distance used to offset vents drawn from adjacent surfaces. (default: 0.10 (units of fraction of a grid cell width))

WINDOWHEIGHT Defines the initial window height in pixels. (default: 480)

WINDOWWIDTH Defines the initial window width in pixels. (default: 640)

WINDOWOFFSET Defines a margin offset around the Smokeview scene for use when capturing images to video. (default: 45)

D.3.3 Time, Chop and value bound parameters

This section describes parameters used by Smokeview to 1) modify the time intervals used to load data (keywords beginning with T_), 2) eliminate or chop data from being displayed (beginning with C_) and 3) override the minimum and maximum data values (keywords beginning with V_) used to convert data to

[1] Except lines used to draw vents

[2] distance is relative to the maximum grid cell width

color values. By default, Smokeview reads in data for all time values and does not override minimum and maximum data values. Each time and data bound keyword (except for V_PLOT3D) has the format:

```
KEYWORD
minflag minvalue maxflag maxvalue
```

where `minflag` can be either 0 or 1. If it is 1 then, the subsequent number, `minvalue` is used by Smokeview to scale the data otherwise if `minflag` is 0 then `minvalue` is ignored. The next two parameters `maxflag` and `maxvalue` are defined similarly. The `V_PLOT3D` keyword contains data bound entries for each variable in the Plot3D data file. If a Plot3D *speed* variable was constructed by Smokeview then the `V_PLOT3D` keyword will contain six entries instead of five.

C_PARTICLES Defines the minimum and maximum values used to discard particle data in a visualization. To drop particle data below 70°C and above 200°C use:

```
C_PARTICLES 1 70. 1 200.
```

C_PLOT3D Defines the minimum and maximum data values used to drop or chop Plot3D. To cause Smokeview to set the minimum and maximum chop values for the first PLOT3D quantity (usually temperature) to 100 and 300 use:

```
C_PLOT3D 5
1 1 100.0 1 300.0
2 0 1.0 0 0.0
3 0 1.0 0 0.0
4 0 1.0 0 0.0
5 0 1.0 0 0.0
```

The integer "`1`" occurring before the "`100`" or "`300`" causes Smokeview to use the next number as a minimum or maximum chop value respectively.

C_SLICE Defines the minimum and maximum values used to discard slice file data in a visualization. To drop slice data below 70°C and above 200°C use:

```
C_SLICE 1 70. 1 200.
```

T_BOUNDARY Defines the minimum and maximum times used to include boundary frames in a visualization. To load boundary data between 20 and 150 seconds use:

```
T_BOUNDARY
1 20. 1 150.
```

(default: `0 1.0 0 0.0`)

T_ISO Defines the minimum and maximum times used to include isosurface frames in a visualization. To load isosurface data between 20 and 150 seconds use:

```
T_ISO
1 20. 1 150.
```

T_PARTICLES Defines the minimum and maximum times used to include particles in a visualization. To load particle data between 20 and 150 seconds use:

```
T_PARTICLES
1 20. 1 150.
```

T_SLICE Defines the minimum and maximum times used to include slice frames in a visualization. To load slice data between 20 and 150 seconds use:

```
T_SLICE
1 20. 1 150.
```

(default: `0 1.0 0 0.0`)

V_BOUNDARY Defines the minimum and maximum data bounds used to convert boundary data values to color indices. (default: `0 1.0 0 0.0`)

The `V_BOUNDARY` keyword has an optional parameter allowing one to specify to which type of data the bounds should apply. For example, to specify boundary file bounds for temperature (30.0 °C, 600.0 °C) use:

```
V_BOUNDARY
1 30.000000 1 600.000000 TEMP
```

where `TEMP` is the Smokeview colorbar labels displayed when showing the boundary file.

These suffixes are added automatically when the Bounds dialog box is used to set data bounds.

V_PARTICLES Defines the minimum and maximum data bounds used to convert particle data values to color indices. (default: `0 1.0 0 0.0`)

V_PLOT3D Defines the minimum and maximum data bounds used to convert Plot3D data values to color indices. The default values are given by:

```
V_PLOT3D
5
1 0 1.0 0 0.0
2 0 1.0 0 0.0
3 0 1.0 0 0.0
```

```
4 0 1.0 0 0.0
5 0 1.0 0 0.0
```

where the initial 5 indicates the number of subsequent entries, the first integer on each line indicates the Plot3D data variable being specified and all other parameters on each line are defined as above.

To cause Smokeview to set the minimum and maximum data values to for the first quantity (usually temperature) to 20 and 600 use:

```
V_PLOT3D
5
1 1 20.0 1 600.0
2 0 1.0 0 0.0
3 0 1.0 0 0.0
4 0 1.0 0 0.0
5 0 1.0 0 0.0
```

The integer "1" occurring before the "20" or "600" causes Smokeview to use the next number as a minimum or maximum value respectively otherwise if "0" is specified then Smokeview ignores the subsequent min/max value.

In addition to 0 and 1, the V_PLOT3D keyword may use 2 as a bound indicator. In the above example, if 2 rather than 1 is used to define Plot3D bounds, then Smokeview does not draw contour[3] levels smaller than 20 or contours greater than 600. The Plot3D bound line 1 2 360.0 1 420.0 indicates that temperatures below 360 °C are not drawn and that temperatures above 420 °C are drawn with the *highest* color (black in black and white mode, red in color mode). This bound line could also be implemented with the *File/Bounds* dialog box as illustrated in Figure **??** resulting in a contour plot as illustrated in Figure 10.3.

V_SLICE Defines the minimum and maximum data bounds used to convert slice data values to color indices. (default: 0 1.0 0 0.0)

The V_SLICE keyword has an optional parameter allowing one to specify to which type of data the bounds should apply. For example, to specify separate slice file bounds for temperature (30.0 °C, 600.0 °C) and the U component of velocity (-1.0 m/s and 1.0 m/s) use:

```
V_SLICE
1 30.000000 1 600.000000 TEMP
V_SLICE
1 -1.0 1 1.0 U-VEL
```

where TEMP and U-VEL are the Smokeview colorbar labels displayed when showing the slice file.

These suffixes are added automatically when the *File/Bounds* dialog box is used to set data bounds.

[3]This is true for *stepped* or discrete contours. If *continuous* contours are drawn, then "2" and "1" have the same effect.

D.3.4 Data loading parameters

The keywords in this section may be used to reduce the memory required to visualize FDS data. Keywords exist for limiting particles and frames. Other keywords exist for compressing particle data and skipping particles and frames.

BOUNDFRAMESTEP Defines the number of intervals or steps between loaded boundary file frames. (default: 1)

EVACFRAMESTEP Specifies the interval or steps between loaded evacuation frames. An evacuation frame consists of all the *people* loaded at one particular time step. For example, if `EVACFRAMESTEP` is set to 3 then every 3rd evacuation frame is read in. (default: 1)

ISOFRAMESTEP Defines the number of intervals or steps between loaded isosurface file frames (default: 1)

ISOZIPSTEP Defines the number of intervals or steps between isosurface file frames when compressed by smokezip. (default: 1)

MAXFRAMES Specifies the maximum number of particle frames that can be read in. (default: `501`)

MAXPOINTS Specifies the maximum number of particle points that can be read in from a particle file. (default: `5000000`)

NOPART Indicates that a particle file should not (1) or should (0) be loaded when Smokeview starts up. This option is used when one wants to look at other files besides the particle file. (default: 1)

PARTFRAMESTEP Specifies the interval or steps between loaded particle frames. A particle frame is all the particles loaded at one particular time step. For example, if `PARTFRAMESTEP` is set to 3 then every 3rd particle frame is read in. This and the `PARTPOINTSTEP` options may be used together to dramatically reduce the memory required to view particle files. These options should be used when displaying Smokeview files on computers with limited memory. (default: 1)

PARTPOINTCOMPRESS Specifies how Smokeview stores particle data. Each particle is represented using three position coordinates and one data value. Using full precision (`PARTPOINTCOMPRESS` value of 0), Smokeview uses four bytes per position coordinate and one byte for the data value or 13 bytes to represent each particle point. If this keyword is set to 1 then Smokeview uses one byte per position coordinate and one byte for the data value or 4 bytes per particle point. Finally if this keyword has value 2 then 2 bytes are used to store each position coordinate and one byte for the data value or 7 bytes per particle point. The recommended value is 2. Using 0 results in almost twice the memory usage without any extra precision in positioning particles. Using 1, though using less memory than the "`2`" option, results in granularity effects when displaying particles which the user may find annoying. (default: 2)

PARTPOINTSTEP Specifies the interval or steps between loaded particle points. For example, if `PARTPOINTSTEP` is set to 5 then every 5th particle or only 20 per cent of the particle file is read in. (default: `1`)

SCRIPTFILE Specifies the name of a script file either created by hand or created automatically by Smokeview using the script recorder.

SLICEFRAMESTEP Specifies the number of intervals or steps between loaded slice file frames. (default: 1)

SLICEZIPSTEP Specifies the number of intervals or steps between slice frames when compressed by smokezip. (default: 1)

SMOKE3DFRAMESTEP Specifies the number of interval or steps between loaded 3D smoke file frames. (default: 1)

SMOKE3DZIPSTEPxxx

SLICEDATAOUT When set to 1 will output data corresponding to any loaded slice files whenever the scene is rendered.

D.3.5 Viewing parameters

The keywords in this section define how a scene is viewed. Keywords exist for showing or hiding various scene elements and for modifying how various scene elements appear.

APERTURE Specifies the viewing angle used to display a Smokeview scene. Viewing angles of 30, 45, 60, 75 and 90 degrees are displayed when APERTURE has the value of 0, 1, 2, 3 and 4 respectively. (default: 2)

AXISSMOOTH Specifies whether axis numerical labels should be smoothed (`AXISSMOOTH set to 1`) or not smoothed (`AXISSMOOTH` set to 0). (default: 1)

BLOCKLOCATION Specifies the location or method used to draw blockages. Blockages are drawn either snapped to the nearest grid (5), drawn at locations as specified in the FDS input file (6) or drawn as specified in a compatible CAD package (7)[4]. (default: 5)

CLIP Specifies the near and far clipping plane locations. Dimensions are relative to the longest side of an FDS scene. (default: 0.001 3.000)

COLORBAND Specifies the width in pixels of the black colorband created when the colorbar is selected by the mouse. (default: 1)

COMPRESSAUTO Specifies that files that are to be auto-loaded by Smokeview (and no other files) should be compressed by smokezip.

CULLFACES Hide (1) or show (0) the back side of various surfaces.

EYEVIEW Specifies whether the scene should be rotated relative to the observer (`EYEVIEW` set to 1) or the scene center (`EYEVIEW`=0). (default: 0)

EYEX, EYEY, EYEZ The parameters `EYEX, EYEY, EYEZ` specify the x, y and z location respectively of the viewing origin (where your eyes are). (default: `0.5 -0.9 1.5`)

FONTSIZE Specifies whether small (0) or large (1) fonts should be used to display text labels. (default: 0)

FRAMERATEVALUE Specifies the maximum rate (frames per second) that Smokeview should display frames. This value is an upper bound. Smokeview will not display frames faster than this rate but may display frames at a slower rate if the scene to be visualized is complex. (default: 1000000 (essentially unlimited))

ISOTRANS Specifies transparency state for iso-surfaces. The choices are all iso-surface levels transparent (ALL_TRANSPARENT=1), minimum iso-surface level solid (MIN_SOLID=2), maximum

[4]There are various third party tools that have been developed to help process obstruction data for FDS. See the FDS/Smokeview website, http://fire.nist.gov/fds/ , for details.

iso-surface level solid (MAX_SOLID=3) and all iso-surface levels transparent (ALL_TRANSPARENT=4) (default: 3)

MSCALE Specifies how dimensions along the X, Y and/or Z axes should be scaled. (default: 1.0 1.0 1.0)

PROJECTION Specifies whether a perspective (0) or orthographic (1) projection is used to draw Smokeview scenes. (default: 0)

P3CONT2D The parameter `P3CONT2D` may be set to 0, 1 or 2. If P3CONT2D is set to 0 then Plot3D color contours are drawn by coloring each node and letting OpenGL interpolate colors between nodes. If P3CONT2D is set to 1 then discrete or stepped shaded contours are drawn. If P3CONT2D is set to 2 then contour lines are drawn. (default: 1)

P3DSURFACETYPE Specifies how Plot3D isosurfaces should be drawn. If P3DSURFACETYPE is set to 1 then Plot3D isosurfaces are drawn using shaded triangles. If P3DSURFACETYPE is set to 2 or 3 then Plot3D isosurfaces are drawn using triangle outlines and points respectively. (default: 1)

P3DSURFACESMOOTH When drawing Plot3D isosurfaces using shaded triangles, this option specifies whether the vertex normals should be averaged (P3DSURFACESMOOTH set to 1) resulting in smooth isosurfaces or not averaged resulting in isosurfaces that have sharp edges (P3DSURFACESMOOTH set to 0). (default: 1)

RENDERFILETYPE Specifies whether PNG (RENDERFILETYPE set to 0) or JPEG (RENDERFILETYPE set to 1) should be used to render images. (default: 1)

RENDEROPTION Records the option used to render images.

SBATSTART Specifies that if smooth blockages are present in a simulation that they should be smoothed when Smokeview starts up.

SENSORRELSIZE Specifies a scaling factor that is applied when drawing all sensors. (default: 1.0)

SHOWAXISLABELS Specifies whether axis labels should be drawn (1) or not drawn (0) drawn. (default: 0)

SHOWBLOCKLABEL Specifies whether a label identifying the active mesh should be drawn (1) or not drawn (0). (default: 1)

SHOWBLOCKS Specifies how a blockage should be drawn. A value of 0, 1 or 2 indicates that the blockages are invisible, drawn normally or drawn as outlines respectively. (default: 1)

SHOWCADANDGRID

SHOWCEILING Specifies whether the ceiling (upper bounding surface) should be drawn (1) or not drawn (0). (default: 0)

SHOWCOLORBARS Specifies whether the color bars should be drawn (1) or not drawn (0). (default: 1)

SHOWEXTREMEDATA Specifies whether data exceeding the maximum colorbar label value or less than the minimum colorbar label value should be colored with a different color (black). If SHOWEXTREMEDATA is set to 1 then extreme data is colored black, if SHOWEXTREMEDATA is set to 0 then extreme data is colored as indicated by the maximum and minimum region of the colorbar. (default: 0). .

SHOWFLOOR Specifies whether the floor (lower bounding surface) should be drawn (1) or not drawn (0). (default: 1)

SHOWFRAME Specifies whether the frame surrounding the scene should be drawn (1) or not drawn (0). (default: 1)

SHOWFRAMELABEL Specifies whether the frame number should be drawn (1) or not drawn (0). (default: 1)

SHOWFRAMERATE Specifies whether the frame rate label should be drawn (1) or not drawn (0). (default: 0)

SHOWGRIDLOC Specifies where grid location should be drawn (1) or not drawn (0). (default: 0)

SHOWHRRCUTOFF Specifies whether the HRRPUV cutoff label should be (1) or should not be (0) displayed. (default: 0)

SHOWISO Specifies how an isosurface should be drawn: hidden (0), solid (1), outline (2) or with points (3). (default: 1)

SHOWISONORMALS Specifies whether iso-surface normals are drawn (1) or not drawn (0). (default: 0)

SHOWIGNITION When drawing a temperature boundary file, this option specifies whether ignited materials (regions exceeding the materials ignition temperature) should be drawn (1) or not drawn (0). A second parameter specifies whether only the ignited regions should be drawn (1) or both the ignited regions and other regions should be drawn (0). (default: 0 0)

SHOWLABELS Specifies whether labels should be drawn (1) or not drawn (0). Labels are specified using the **LABEL** keyword described in subsection 16. (default: 0)

SHOWMEMLOAD Specifies (when run on a PC) whether a label giving the memory used should be drawn (1) or not drawn (0). (default: 0)

SHOWNORMALWHENSMOOTH Specifies that smooth blocks should be drawn as normal blocks (1) or drawn as smooth blocks (0). (default: 0)

SHOWOPENVENTS Specifies that open vents should be drawn (1) or not drawn (0). (default: 0)

SHOWDUMMYVENTS Specifies that dummy vents (vents created by FDS) should be drawn (1) or not drawn (0). (default: 0)

SHOWSENSORS Specifies whether sensors should be drawn (1) or not drawn (0). A second parameter specifies whether the sensor's orientation or normal vector should be drawn (1) or not drawn (0). (default: 1 0).

SHOWSLICEINOBST Specifies whether a slice file should be drawn (1) inside a blockage or not drawn (0) inside a blockage. Normally a slice file is not drawn inside a blockage but one would want to draw a slice file inside a blockage if the blockage disappears over the duration of a run. (default: 0).

SHOWSMOKEPART Specifies whether smoke or trace particles should be drawn (1) or not drawn (0). (default: 1)

SHOWSPRINKPART Specifies whether sprinkler droplet particles (if present in the particle file) should be drawn (1) or not drawn (0). (default: 1)

SHOWSTREAK Specify parameters that define streak properties. This keyword has four integer parameters with format:

```
SHOWSTREAK
streak5show,streak5step,showstreakhead,streakindex
```

The `streak5show` parameter may be 0 or 1 and indicates whether a streak is not (0) or is (1) shown. The `streak5step` parameter indicates number of streaks skipped or not displayed. The `showstreakhead` parameter may be 0 or 1 and indicates whether a streak head is not (0) or is (1) shown. The `streakindex` parameter indicates the length of the streak.

SHOWTERRAIN If terrain is present, specifies that terrain should be visualized as a *warped* sheet rather than as a set of FDS blockages.

SHOWTICKS Specifies whether labels should be drawn (1) or not drawn (0). Ticks are specified using the **TICK** keyword described in subsection 16. (default: 0)

SHOWTIMEBAR Specifies whether the timebar should be drawn (1) or not drawn (0). (default: 1)

SHOWTIMELABEL Specifies whether the time label should be drawn (1) or not drawn (0). (default: 1)

SHOWTRANSPARENTVENTS Specifies whether vents specified as being invisible should be shown (1) or not shown (0). (default: 0)..

SHOWHMSTIMELABEL Specifies whether the time label should be drawn (1) or not drawn (0) using the format "h:m:s" where "h" is hours, "m" is minutes and "s" is seconds. (default: 0)

SHOWTITLE Specifies whether the title should be drawn (1) or not drawn (0). (default: 1)

SHOWVENTS Specifies whether vents should be drawn (1) or not drawn (0). (default: 1)

SHOWALLTEXTURES If wall textures are defined in the input .smv file, this option specifies whether to draw (1) or not to draw (0) wall textures. (default: 0)

SHOWWALLS Specifies whether the four walls (four vertical bounding surfaces) should be drawn (1) or not drawn (0). (default: 1)

SMOKERTHICK When the GPU is used to visualize smoke, this parameter specifies a relative thickness scaling factor.

SMOOTHBLOCKSOLID Specifies that smooth blockages should be drawn as regular rectangular blockages: (default: 0)

STARTUPVIEW Used by Smokeview to record the view to be displayed at startup (as defined in a previous Smokeview run).

SURFINC Smokeview allows one to display two Plot3D isosurfaces simultaneously. The SURFINC parameter specifies the interval between displayed Plot3D surface values. (default: 0)

TERRAINPARMS Specifies various parameters used to characterize how terrain appears. The parameters are the color at the minimum depth, the color at the maximum depth and scaling factor used to vertically exaggerate the scene.

```
TERRAINPARMS
terrain_rgba_zmin[0],terrain_rgba_zmin[1],terrain_rgba_zmin[2];
terrain_rgba_zmax[0],terrain_rgba_zmax[1],terrain_rgba_zmax[2];
vertical_factor);
```

TIMEOFFSET Specifies that offset time in seconds added to the displayed simulation time. Along with the **SHOWHMSTIMELABEL** keyword, the **TIMEOFFSET** keyword allows one to display *wall clock* rather than simulation time. (default: 0.0)

TITLESAFE Amount in pixels to offset titles when displaying scene in *title safe* mode. (default: 0)

TRANSPARENT Specifies whether 2D and 3D contours should be drawn with solid colors (0) or transparent colors(1). (default: 1)

TWOSIDEDVENTS Specifies whether to draw vents so that they are visible from both sides (1) or visible from only one side (0). (default: 0)

USEGPU If the GPU is available, specifies whether it should be used. (default: 1)

VECLENGTH Specifies vector lengths.

VECTORSKIP Specifies what vectors to draw. For example, if this parameter is set to 2 then every 2nd vector is drawn when displaying vectors. (default: 1)

VIEWPOINT5 Specifies the internal Smokeview parameters used to record a scene's viewpoint and orientation. This parameter is set automatically by Smokeview when a .ini file is created. (default: none)

```
VIEWPOINT5
 eyeview,rotation_index,view_id
 eye\_x,eye\_y,eye\_z,zoom,zoomindex
 view_angle,direction_angle,elevation_angle,projection_type
 xcen,ycen,zcen
 angle_zx[0],angle_zx[1]
 mat[0],mat[1],mat[2],mat[3]
 mat[4],mat[5],mat[6],mat[7]
 mat[8],mat[9],mat[10],mat[11]
 mat[12],mat[13],mat[14],mat[15]
 xyz_clipplane,clip_x,clip_y,clip_z,clip_X,clip_Y,clip_Z
 clip_x_val,clip_y_val,clip_z_val,clip_X_val,clip_Y_valclip_Z_val
 name
```

- eyeview - view method type (0 - general rotations, 1 - first person movement, 2 - level rotations
- eye - coordinates of viewing position
- xcen, ycen, zcen - coordinates of view direction
- mat - viewing transformation matrix
- xyz_clipplane - global clipping flag (on=1, off=0)
- clip_x, clip_y, clip_z - min clipping plane flag ((on=1, off=0)
- clip_X, clip_Y, clip_Z - maxn clipping plane flag ((on=1, off=0)
- clip_x_val, clip_y_val, clip_z_val - min clipping plane values
- clip_X_val, clip_Y_val, clip_Z_val - max clipping plane values
- name - label appearing in Viewpoint menu

XYZCLIP Specifies clip planes in physical coordinates. There are six clipping planes, a minimum and maximum X, a minimum and maximum Y, a minimum and maximum Z. Each clipping plane may be used or not. The first parameter is 1 or 0 and specifies whether clipping is turned on or off. The next three lines specify clipping parameters for the X, Y and Z axes. Each line has the format

```
minflag min-clipval maxflag max-clipval
```

where the two flags, minflag and maxflag are 1 if turned on or 0 if turned off. Clipping is specified with the *Clipping* dialog box found under the Options menu item. (default:

```
0
0 0.0 0 0.0
0 0.0 0 0.0
0 0.0 0 0.0
```

ZOOM Specifies the zoom amount used to display a Smokeview scene using two parameters, an integer zoom index and a floating point zoom amount. If the zoom index is 0-¿4 then the zoom amount is 0.25, 0.5, 1.0, 2.0 and 4.0 respectively. If the zoom index is negative then the second parameter is used to specify the zoom amount. (default: 0 1.0)

D.3.6 Tour Parameters

GLOBALTENSION Specifies whether the tour spline tension parameter found in the dialog box should (1) or should not (0) be used for ALL tour keyframes. (default: 1)

SHOWPATHNODES Specifies whether the path nodes should (1) or should not (0) be drawn. This is a debugging parameter, not normally used. (default: 0)

SHOWTOURROUTE Specifies whether the tour route should (1) or should not (0) be drawn. (default: 0)

TOURS Keyword used to specify the tours. The format is

```
TOURS
ntours - number of tours
label for tour
nkeyframes - number of keyframes for first tour
time xpos ypos zpos 1 az elev bias continuity tension zoom localspeedflag
...
time xpos ... for last keyframe
nkeyframes for 2nd tour
...
...
```

If a cartesian view direction is specified then instead of `1 az elev` above use 0 xview yview zview where xview, yview, zview are the coordinates of the view direction. The *Circle* tour is not stored in the .ini file unless it has been changed by the user. The tour entry created by using the **Add** button in the *Tour* dialog box is given by

```
TOURS
1
```

```
Added Tour 1
2
0.0 -1.0 -1.0 -1.0 0 0.0 0.0 0.0 0.0 0.0 1.0  0
100.0 7.4 9.0 7.4 0 0.0 0.0 0.0 0.0 0.0 1.0 0
```

TOURCOLORS Keyword used to specify the tour colors. The colors as before consist of a red, green and blue component ranging from 0.0 to 1.0 . One can override Smokeview's choice for the path, the path knots for both the selected and un-selected case. One may also specify the color of the time labels and the location of the object or avatar on the tour at the current time. The foreground color is used when a color component less than 0.0 is specified. Default:

```
TOURCOLORS
1.000000 0.000000 0.000000   :selected path line
1.000000 0.000000 0.000000   :selected path line knots
0.000000 1.000000 0.000000   :selected knot
-1.000000 -1.000000 -1.000000   :path line
-1.000000 -1.000000 -1.000000   :path knots
-1.000000 -1.000000 -1.000000   :text
1.000000 0.000000 0.000000   :avatar
```

TOURCONSTANTVEL Specifies whether the avatar should (1) or should not (0) traverse the path with a constant velocity. (default: 1)

VIEWALLTOURS Specifies whether all (1) tours should be drawn. (default: 0)

VIEWTOURFROM Specifies whether the scene should (1) or should not (0) be observed from the selected tour.

VIEWTIMES Specifies the tour start time, tour stop time and number of points to specify a tour. (default: 0.0 100.0 1000)

D.3.7 Realistic Smoke Parameters

ADJUSTALPHA The ALPHA paramter in OpenGL/Smokeview is used to specify the transparency of an object. The ALPHA's are computed in FDS and adjusted in SMOKEVIEW according to value of the ADJUSTALPHA keyword. If ADJUSTALPHA is zero, then no adjustments to ALPHA are made. If ADJUSTALHPA is one, then ALPHA's are adjusted for non-orthogonal view directions (ALPHA is increased to account for longer path lengths along non-orthogonal view directions. If ADJUSTALPHA is two, then ALPHA's are adjusted as in the ADJUSTALPHA=1 case and are also set to zero on wall at blockage boundaries (this reduces graphical artifacts). (default: 1)

FIRECOLOR Specifies the color of the fire in red, green, blue coordinates. Each color component is an integer ranging from 0 to 255. (default: 255, 128, 0)

FIREDEPTH Specifies the depth at which the fire is 50 percent transparent. (default: 2.0)

SMOKECULL Cull (or do not draw) smoke if it is outside of the viewing frustum. (default: 1)

SMOKESHADE Grey level of smoke, may range from 0 to 255. (default: 255)

SMOKESKIP To speed up smoke drawing, spatial frames may be skipped. Allowable parameters are (0, 1, 2). (default: 0)

SMOKETHICK The ALPHA transparency parameter may be divided by a power of two ($2^{\texttt{SMOKETHICK}}$) to make the smoke thinner. Parameters may range from 0 to 7. (default: 0)

D.3.8 Zone Fire Modeling Parameters

SHOWHZONE Specifies whether upper layer temperatures should be (1) drawn horizontally or not (0). (default: 0)

SHOWVZONE Specifies whether upper layer temperatures should be (1) drawn vertically or not (0). (default: 1)

SHOWHAZARDCOLORS Specifies whether upper layer temperatures should be (1) drawn in terms of hazard or drawn in terms of a standard color scale (0). (default: 0)

D.4 Smokeview Parameter Input File (.smv file)

The FDS software outputs simulation results into the Smokeview input file with extension `.smv` and various output data files whose format is documented in the next section. A `.smv` file is a formatted ascii text file consisting of a set of KEYWORDs followed by DATA describing the FDS case's geometry, data file names and contents, sensor information *etc*.

D.4.1 Geometry Keywords

GRID This keyword specifies the number of grid cells in the `X`, `Y` and `Z` directions. For example,

```
GRID
10 20 30
```

specifies that there are 10, 20 and 30 grid cells in the `X`, `Y` and `Z` directions respectively.

OFFSET This keyword specifies signals to Smokeview that a new mesh has begun and also gives values for the front, left bottom corner of the mesh. For example,

```
OFFSET
xmin, ymin, zmin
```

Note that the xmin, ymin and zmin values must be identical to the corresponding values given in the `PDIM` keyword. The `OFFSET` keyword cannot be eliminated from the .smv file (it may seem logical to do this due to the presence of redundant data) because of its role in signalling new meshes.

PDIM This keyword specifies the region where a mesh is located using the same convention as is used in an FDS input file to specify a blockage location. PDIM also specifies a color to use for drawing grids. For example,

```
PDIM
xmin, xmax, ymin, ymax, zmin, zmax, r, g, b
```

where (xmin, ymin, ymax) and (xmax, ymax, zmax) represent opposite corners of a mesh and r, g and b represent the red, green and blue components (0.0 to 1.0) of grids drawn in the mesh.

Note that the xmin, ymin and zmin values must be identical to the values given in the OFFSET keyword.

SHOW_OBST(HIDE_OBST) This keyword specifies when a blockage should be shown(hidden). For example,

```
SHOW_OBST  2
  10 120.1
```

specifies that the tenth blockage in mesh 2 should be opened at 120.1 seconds. This keyword is automatically added to the .smv file by FDS.

OBST This keyword specifies internal blockages. A FORTRAN 90 code segment describing the format of OBST data is given by:

```
read(5,*)nb
do i = 1, nb
  read(5,*)x1(i),x2(i),y1(i),y2(i),z1(i),z2(i), id(i),
      ... s1(i),...,s6(i),tx(i),ty(i),tz(i)
end do
do i = 1, nb
  read(5,*)ib1(i), ib2(i), jb1(i), jb2(i), kb1(i), kb2(i),
         ... colorindex(i) blocktype(i),
         ...  red(i), green(i), blue(i), alpha(i)
end do
```

where the parameters are defined in Table D.1. The arrays x1, ..., z2 and ib1, ..., kb2 are required. All other arrays are optional and may be omitted.

TOFFSET The TOFFSET keyword defines a default texture origin, (x_0, y_0, z_0) . This origin may be overridden with data provided with the OBST keyword. For example,

```
TOFFSET
0.0 0.0 0.0
```

TRNX,TRNY,TRNZ The TRNX, TRNY, TRNZ keywords specify grid nodes in the X, Y, Z coordinate directions. A FORTRAN 90 code segment describing the format of TRNX data is given by:

Table D.1: Descriptions of parameters used by the Smokeview OBST keyword.

Variable(s)	type	Description
nb	integer	number of blockages or entries for the OBST keyword
x1, x2 y1,y2 z1,z2	float	floating point blockage bounds
id	integer	blockage identifier
s1, s2 s3, s4 s5, s6	integer	index of surface (SURF) used to draw blockage sides
tx, ty, tz	float	texture origin
ib1, ib2 jb1, jb2 kb1, kb2	integer	Indices used to define blockage bounds in terms of grid locations.
colorindex	integer	Type of coloring used to color blockage. -1 - default color -2 - invisible -3 - use red, green, blue and alpha to follow (values follow) n>0 - use n'th color table entry
blocktype	integer	Defines how the blockage is drawn. -1 - use surface to obtain blocktype 0 - regular block 2 - outline 3 - smooth
red, green, blue alpha	float	Each color value ranges from 0.0 to 1.0 . The alpha *color* represents transparency, alpha=0.0 is transparent, alpha=1.0 is opaque.

```
read(5,*)nv
do i = 1, nv
  read(5,*)idummy
end do
do i = 1, nv
  read(5,*)xplt(i)
end do
```

TRNY and TRNZ data entries are defined similarly. The first nx data items are not required by Smokeview.

VENT The keyword specifies vent coordinates. A FORTRAN 90 code segment describing the format of VENT data is given by:

```
read(5,*)nv
do i = 1, nv
  read(5,*)xv1(i), xv2(i), yv1(i), yv2(i), zv1(i), zv2(i), id(i)
      ... s1(i), tx(i), ty(i), tz(i)
end do
do i = 1, nv
  read(5,*)iv1(i), iv2(i), jv1(i), jv2(i), kv1(i), kv2(i)
end do
```

where the parameters are defined in Table D.2. The arrays xv1, ..., zv2 and iv1, ..., kv2 are required. All other arrays are optional and may be omitted.

OPEN_VENT(CLOSE_VENT) This keyword specifies when a vent should be opened(closed). For example,

```
OPEN_VENT 2
3 15.6
```

specifies that the third vent in mesh 2 should be opened at 15.6 S.

XYZ The XYZ keyword defines the .xyz or Plot3D grid file name. A FORTRAN 90 code segment describing the format of XYZ data is given by:

```
read(5,"(a)")xyzfilename
```

where xyzfilename is a character variable containing the name of the .xyz file.

D.4.2 File Keywords

BNDF The BNDF keyword defines the .bf file name along with character labels used to describe the data contents of the boundary file.

Table D.2: Descriptions of parameters used by the Smokeview VENT keyword.

Variable(s)	type	Description
nv	integer	number of vents or entries for the VENT keyword
xv1, xv2 yv1,yv2 zv1,zv2	float	floating point bounds
id	integer	vent identifier
s1	integer	index of surface (SURF) used to draw vent
tx, ty, tz	float	texture origin
iv1, iv2 jv1, jv2 kv1, kv2	integer	Indices used to define vent bounds in terms of grid locations.
ventindex	integer	Type of coloring used to color vent. -1 - default color -99 of +99 -n of +n - use n'th palette color < 0 - do not draw boundary file over vent > 0 - draw boundary file over vent
venttype	integer	Defines how the vent is drawn. 0 - solid surface 2 - outline -2 - hidden
red, green, blue alpha	float	Each color value ranges from 0.0 to 1.0 . The alpha *color* represents transparency, alpha=0.0 is transparent, alpha=1.0 is opaque.

HRRPUVCUT The HRRPUVCUT keyword defines the heat release rate per unit volume cutoff value. When displaying realistic smoke and fire, fire is displayed above this cutoff and smoke is displayed below.

INPF The INPF keyword specifies a file containing a copy of the FDS input file.

ISOF The ISOF keyword defines the .iso file name along with character labels used to describe the data contents of the isosurface file.

PART,PRT5 The PART and PRT5 keywords define the .part file name along with character labels used to describe the data contents of the particle file.

PL3D The PL3D keyword defines the .q file name along with character labels used to describe the data contents for each Plot3D variable.

SLCF,SLCT The SLCF and SLCT keywords define the .sf file name along with character labels used to describe the data contents of the slice file. The SLCT keyword is used for wildland urban interface fire simulations performed over terrains. Smokeview allows one to visualize slice files for these types of simulations that conform to the terrain.

D.4.3 Device (sensor) Keywords

DEVICE A *device* generalizes the notion of a sensor, sprinkler or heat detector. The DEVICE keyword defines the device location and name. This name is used to access the set of instructions for drawing the device. These instructions are contained in a file named objects.svo. The default location of this file on the PC is C:\Program Files\FDS\FDS5\bin\objects.svo . This file may be customized by the user by adding instructions for devices of their own design (*i.e.* custom devices may be added to a Smokeview visualization without re-programming Smokeview). See Chapter 4 for more information on how to do this. The format for the DEVICE keyword is

```
DEVICE
device_name
x y z xn yn zn 0 0 % PROP_ID
```

where device_name is the entry in the objects.svo file used to draw the device and (x,y,z) and (xn,yn,zn) are the location and direction vector of the device. The label PROP_ID (prepended by a %) is the PROP entry used to list of other properties used for drawing the device (see the PROP entry in this section for more details). Note, the two 0 0 numbers are used for backwards compatibility.

DEVICE_ACT The DEVICE_ACT keyword defines the activation time for a particular device. The format for the DEVICE_ACT keyword is

```
DEVICE_ACT
idevice time state
```

where time is the activation time of the idevice'th device. State is the state of the device, 0 for off or in-active and 1 for on or active. If the device may be drawn more than two ways then more than 2 states may be used with this keyword.

HEAT The HEAT keyword defines heat detector location data. A FORTRAN 90 code segment describing the format of HEAT data is given by:

```
read(5,*)nheat
do i = 1, nheat
  read(5,*)xheat(i),yheat(i),zheat(i)
end do
```

where nheat is the number of heat detectors and xheat, yheat, zheat are the x, y, z coordinates of the heat detectors.

HEAT_ACT The HEAT_ACT keyword defines heat detector activation data. A FORTRAN 90 code segment describing the format of HEAT_ACT data is given by:

```
read(5,*)iheat, heat_time
```

where heat_time is the activation time of the iheat'th heat detector.

PROP The PROP keyword specifies a list of general properties used by Smokeview to customize the drawing of devices defined in the objects.svo file. The format of the PROP keyword is

```
PROP
 prop_id           (character string)
 smokeview_id      (character string)
 number of keyword/value pairs  (integer)
 keyword1=value1   (character string)
 ..
 ..
 keywordn=valuen   (character string)
 number of texture files (integer) (0 or 1 for now)
 texture file 1
 ...
 ...
 texture file n
```

SPRK The SPRK keyword defines sprinkler location data. A FORTRAN 90 code segment describing the format of SPRK data is given by:

```
read(5,*)nsprink
do i = 1, nsprink
  read(5,*)xsprink(i),ysprink(i),zsprink(i)
end do
```

where nsprink is the number of sprinklers and xsprink, ysprink, zsprink are the

x, y, z coordinates of the sprinklers.

SPRK_ACT The SPRK_ACT keyword defines sprinkler activation data. A FORTRAN 90 code segment describing the format of SPRK_ACT data is given by:

```
read(5,*)isprink, sprink_time
```

where sprink_time is the activation time of the isprink'th sprinkler.

THCP The THCP keyword defines thermocouple location data. A FORTRAN 90 code segment describing the format of THCP data is given by:

```
read(5,*)ntherm
do i = 1, ntherm
  read(5,*)xtherm(i),ytherm(i),ztherm(i)
end do
```

where ntherm is the number of thermocouples and xtherm, ytherm and ztherm are the x, y and z coordinates of the thermocouples.

D.4.4 Miscellaneous Keywords

ALBEDO This keyword is not implemented yet. It will be used to specify the smoke albedo (0.0, 1.0).

ENDIAN The ENDIAN keyword defines whether a big or little endian[5] system is used to represent the data. The PC (both Windows and LINUX) uses the little endian system for representing numbers while most UNIX workstations use the big endian system. The PC version of Smokeview uses this keyword to determine whether data should be converted between these two systems before it is visualized. The valid ENDIAN parameters are BIG or LITTLE.

REVISION The REVISION keyword defines the SVN revision or build number for the version of FDS that ran the case currently being visualized. The FDS build number is displayed in the Help menu along with the Smokeview build number.

SYST The SYST keyword defines which system the FDS case was run on. The PC version of Smokeview uses this information (if the ENDIAN keyword is absent) to swap data bytes if the FDS case was run on a computer with a different *endian* format than the PC.

TITLE1/TITLE2 The TITLE1 and TITLE2 keywords allow one to specify extra information documenting a Smokeview case. These keywords and associated labels are added by hand to the smokeview (.smv) file using the format:

```
TITLE1
first line of descriptive text
```

[5]Big-endian and little-endian are terms that describe the order in which a sequence of bytes are stored in computer memory. Big-endian is an order in which the *big end* (most significant value in the sequence) is stored first (at the lowest storage address). Little-endian is an order in which the *little end* (least significant value in the sequence) is stored first. The terms big-endian and little-endian are derived from the Lilliputians of Gulliver's Travels, whose major political issue was whether soft-boiled eggs should be opened on the big end or the little end.

```
TITLE2
second line of descriptive text
```

D.5 CAD/GE1 file format

A program called DXF2FDS, written by David Sheppard of the US Bureau of Alcohol, Tobacco and Firearms (ATF), creates an FDS input file and a Smokeview geometric description file (.GE1) given a CAD description of the building being modelled. The CAD description must be in a *dxf* format and created using *3DFACE* commands. The .GE1 file has a simple text format and is described below. Details of this program can be found at the FDS/Smokeview website, http://fire.nist.gov/fds/ .

```
[APPEARANCE]
nappearances
string (material description)
index r g b twidth, theight, alpha, shininess, tx0, ty0, tz0
tfile
:
:   The above entry is repeated nappearances-1 more times
:
[FACES]
nfaces
x1 y1 z1 x2 y2 z2 x3 y3 z3 x4 y4 z4 index
The above line is repeated nfaces-1 more times.
```

nappearances Number of appearance entries to follow Each appearance entry has 3 lines.

string A material description is written out by DX2FDS but is ignored by Smokeview.

index An index number starting at 0.

r, g, b Red green and blue components of the CAD face used when a texture is not drawn. The values of r, g and b range from 0 to 255. If a color is not used then use -1 for each color component.

twidth, theight Textures are tiled or repeated. The characteristic width and length of the texture file is twidth and theight respectively.

alpha Opaqueness value of the cad element being drawn. Values may range from 0.0 (completely transparent) to 1.0 (completely opaque. (default: 1.0)

shininess Shininess value of the cad element being drawn. Values may be larger than 0.0 . (default: 800.0)

tx0, ty0, tz0 x, y and z values in physical coordinates of the offset used to apply a texture to a cad element. (default: 0.0, 0.0, 0.0)

tfile The name of the texture file. If one is not used or available then leave this line blank.

nfaces Number of face entries to follow. Each face entry has one line.

x1/y1/z1/.../x4/y4/z4 x,y,z coordinates of a quadrilateral. The four corners of the quad must lie in a plane or weird effects may result when Smokeview draws it. (This is a requirement of OpenGL). The four points should be in counter-clockwise order.

index Points to a material in the [APPEARANCE] section.

D.6 Objects.svo

```
// $Date: 2010-08-26 15:44:33 -0400 (Thu, 26 Aug 2010) $
// $Revision: 6655 $
// $Author: gforney $

// ************ object file format ********************

//  1. comments and blank lines may be placed anywhere
//  2. any line not beginning with "//" is part of the definition.
//  3. the first non-comment line after OBJECTDEF is the object name
//  4. an object definition may contain, labels, numerical constants
//     a number), string constants (enclosed in " ") and/or
//     commands (beginning with a-z)
//  5. a label begins with ':' as in :dx
//  6. the label :dx may be accessed afterward using $dx
//  7. An object may contain multiple frames or states.  A new frame within
//     an object is defined using NEWFRAME

// OBJECTDEF // OBJECTDEF begins the object definition

//   object_name // name or label for object
//   :var1 ... :varn  // a series of labels may be specified for use by
//                    // the object definition.  Data is copied to these
//                    // label locations using the SMOKEVIEW_PARAMETERS
//                    // &PROP keyword or from a particle file. The data
//                    // in :varn may be referenced  elsewhere in the
//                    // definition using $varn

//   // A series of argument/command pairs are specified on one or
//   // more lines.

//   arg1 ... argn command1 arg1 ... argn command2 ...

//   // An argument may be a numerical constant (e.g. 2.37), a string
//   // (e.g. "SKYBLUE"), a label (e.g. :var1),  or a reference to a
//   // label located elsewhere (e.g. $var1)

//  NEWFRAME    // beginning of next frame
//   more argument/command pairs for the next object frame
//   ....

   // ************ static object definitions - single frame/state ********************

OBJECTDEF
 debug_thermocouple
 "BLUE" setcolor
 push 0.00625 0.00625 0.075 scalexyz 1.0 1.0 drawdisk pop push 0.0 0.0 0.0375 translate 0.008 drawsphere pop
 "RED" setcolor
 push .075 0.00625 0.00625 scalexyz 1.0 1.0 drawdisk pop push 0.0375 0.0 0.0 translate 0.008 drawsphere pop
 "GREEN" setcolor
 push 0.00625  0.075 0.00625 scalexyz 1.0 1.0 drawdisk pop push 0.0 0.0375 0.0 translate 0.008 drawsphere pop

 0 0 0 setrgb
 90.0 rotatex
 0.005 0.005 0.005 scalexyz
 2.0 drawsphere
 153 153 153 setrgb
 push 3.4 0.0 3.5 translate 90.0 rotatey 0.5 5.0 drawdisk pop
 push  45.0 rotatey 0.5 5.0 drawdisk pop
 push 3.4 0.0 -3.5 translate 90.0 rotatey 0.5 5.0 drawdisk pop
 push  135.0 rotatey 0.5 5.0 drawdisk pop

OBJECTDEF
 thermocouple
 0 0 0 setrgb
 90.0 rotatex
 0.005 0.005 0.005 scalexyz
```

```
 2.0 drawsphere
 153 153 153 setrgb
 push 3.4 0.0 3.5 translate 90.0 rotatey 0.5 5.0 drawdisk pop
 push  45.0 rotatey 0.5 5.0 drawdisk pop
 push 3.4 0.0 -3.5 translate 90.0 rotatey 0.5 5.0 drawdisk pop
 push  135.0 rotatey 0.5 5.0 drawdisk pop

OBJECTDEF
 target
 153 153 153 setrgb
 0.0 0.0 -0.005 translate 0.2 0.01 drawdisk

OBJECTDEF  // used by smokeview to display smoke thickness
 smokesensor
 "WHITE" setcolor
 0.15 drawsphere

OBJECTDEF  // draw a plane intersecting through FDS meshes
 plane
 "GREEN" setcolor
 0.038 drawsphere

   // ************ static object definitions - multiple frames/states ********************

OBJECTDEF
 sensor
 "GREEN" setcolor
 0.038 drawsphere
 NEWFRAME
 "RED" setcolor
 0.038 drawsphere
 NEWFRAME
 "BLUE" setcolor
 0.038 drawsphere
 NEWFRAME
 "WHITE" setcolor
 0.038 drawsphere

OBJECTDEF
 heat_detector         // label, name of object

 // The heat detector has three parts
 //   a disk, a truncated disk and a sphere.
 //   The sphere changes color when activated.

 204 204 204 setrgb  // set color to off white
 180.0 rotatey 0.0 0.0 0.03 translate
 push 0.0 0.0 -0.02 translate 0.127 0.04 drawdisk pop
 push 0.0 0.0 -0.04 translate
 0.06 0.08 0.02 drawtrunccone pop
 "GREEN" setcolor
 push 0.0 0.0 -0.03 translate  0.04 drawsphere pop
 // push and pop are not necessary in the last line
 //   of a frame.  Its a good idea though to prevent
 //   problems if parts are added later.
 NEWFRAME  // beginning of activated definition
 204 204 204 setrgb
 180.0 rotatey 0.0 0.0 0.03 translate
 push 0.0 0.0 -0.02 translate 0.127 0.04 drawdisk pop
 push 0.0 0.0 -0.04 translate
   0.06 0.08 0.02 drawtrunccone pop
 "RED" setcolor
 push 0.0 0.0 -0.03 translate
   0.04 drawsphere pop

OBJECTDEF
 sprinkler_upright
 180.0 rotatey 0.0 0.0 -0.04 translate
```

```
 "BRICK" setcolor
 push  0.0 0.0 -0.015 translate 0.03 0.03 drawdisk  pop
 push  0.0105 0.0 0.055 translate -22 rotatey
   0.0085 0.004 0.05 scalexyz 1.0 drawcube pop
 push -0.0105 0.0 0.055 translate  22 rotatey
   0.0085 0.004 0.05 scalexyz 1.0 drawcube pop
 push  0.019 0.0 0.02 translate
   0.0085 0.004 0.03 scalexyz 1.0 drawcube pop
 push -0.019 0.0 0.02 translate
   0.0085 0.004 0.03 scalexyz 1.0 drawcube pop
 push 0.0 0.0 0.07 translate
   0.010 0.017 0.020 drawtrunccone pop
 push 0.0 0.0 0.089 translate
   0.064 0.002 0.004 -1.0 drawnotchplate pop
 "GREEN" setcolor
 push 0.00 0.0 0.04 translate
   0.4 0.4 1.0 scalexyz 0.03 drawsphere pop
 NEWFRAME
 "BRICK" setcolor
 180.0 rotatey 0.0 0.0 -0.04 translate
 push  0.0 0.0 -0.015 translate 0.03 0.03 drawdisk  pop
 push 0.0105 0.0 0.055 translate -22 rotatey
   0.0085 0.004 0.05 scalexyz 1.0 drawcube pop
 push 0.0190 0.0 0.020 translate
   0.0085 0.004 0.03 scalexyz 1.0 drawcube pop
 push -0.0105 0.0 0.055 translate 22 rotatey
   0.0085 0.004 0.05 scalexyz 1.0 drawcube pop
 push -0.0190 0.0 0.020 translate
   0.0085 0.004 0.03 scalexyz 1.0 drawcube pop
 push 0.0 0.0 0.07 translate
   0.01 0.017 0.02 drawtrunccone pop
 push 0.0 0.0 0.089 translate
   0.064 0.002 0.004 -1.0 drawnotchplate pop
 "BLUE" setcolor
 push 0.0 0.0 0.015 translate  0.015 drawsphere pop

OBJECTDEF
 sprinkler_pendent
 "BRICK" setcolor
 0.0 0.0 -0.04 translate
 push 0.0 0.0 -0.015 translate 0.03 0.03 drawdisk pop
 push 0.0105 0.0 0.055 translate -22 rotatey
   0.0085 0.004 0.05 scalexyz 1.0 drawcube pop
 push 0.019 0.0 0.02 translate
   0.0085 0.004 0.03 scalexyz 1.0 drawcube pop
 push -0.0105 0.0 0.055 translate 22 rotatey
   0.0085 0.004 0.05 scalexyz 1.0 drawcube pop
 push -0.019 0.0 0.02 translate
   0.0085 0.004 0.03 scalexyz 1.0 drawcube pop
 push 0.0 0.0 0.07 translate
   0.01 0.017 0.02 drawtrunccone pop
 push 0.0 0.0 0.089 translate
   0.064 0.002 0.008 1.0 drawnotchplate pop
 "GREEN" setcolor
 push 0.00 0.0 0.04 translate
   0.4 0.4 1.0 scalexyz 0.03 drawsphere pop
 NEWFRAME
 "BRICK" setcolor
 push
 0.0 0.0 -0.04 translate
 push 0.0 0.0 -0.015 translate 0.03 0.03 drawdisk pop
 push 0.0105 0.0 0.055 translate -22 rotatey
   0.0085 0.004 0.05 scalexyz 1.0 drawcube pop
 push 0.019 0.0 0.02 translate
   0.0085 0.004 0.03 scalexyz 1.0 drawcube pop
 push -0.0105 0.0 0.055 translate 22 rotatey
   0.0085 0.004 0.05 scalexyz 1.0 drawcube pop
 push -0.019 0.0 0.02 translate
```

```
   0.0085 0.004 0.03 scalexyz 1.0 drawcube pop
 push 0.0 0.0 0.07 translate
   0.01 0.017 0.02 drawtrunccone pop
 push 0.0 0.0 0.089 translate
   0.064 0.002 0.008 1.0 drawnotchplate pop
 "BLUE" setcolor
 push 0.0 0.0 0.015 translate 0.015 drawsphere pop
 pop

OBJECTDEF
 smoke_detector
 204 204 204 setrgb
 180.0 rotatey 0.0 0.0 0.02 translate
 push 0.0 0.0 -0.025 translate 0.127 0.05 drawdisk pop
 "GREEN" setcolor
 push 0.0 0.0 -0.02 translate 0.04 drawsphere pop
 26 26 26 setrgb
 push 0.0 0.0 -0.028 translate 0.10 0.11 0.02 drawring pop
 push 0.0 0.0 -0.028 translate 0.07 0.08 0.02 drawring pop
 push 0.0 0.0 -0.028 translate 0.04 0.05 0.02 drawring pop
 NEWFRAME
 204 204 204 setrgb
 180.0 rotatey 0.0 0.0 0.02 translate
 push 0.0 0.0 -0.025 translate 0.127 0.05 drawdisk pop
 "RED" setcolor
 push 0.0 0.0 -0.02 translate 0.04 drawsphere pop
 26 26 26 setrgb
 push 0.0 0.0 -0.028 translate 0.10 0.11 0.02 drawring pop
 push 0.0 0.0 -0.028 translate 0.07 0.08 0.02 drawring pop
 push 0.0 0.0 -0.028 translate 0.04 0.05 0.02 drawring pop


OBJECTDEF
 nozzle
 0.0 0.0 -0.041402 translate
 "BRICK" setcolor
 0.022225 0.0127 drawhexdisk
 push 0.0 0.0 0.0127 translate 0.01905 0.01905 drawdisk pop
 push 0.0 0.0 0.031751 translate 0.01905 0.009525 drawhexdisk pop
 204 204 204 setrgb
 push 0.0 0.0 0.035052 translate 0.00635 0.00635 drawdisk pop
 NEWFRAME
 0.0 0.0 -0.041402 translate
 "BRICK" setcolor
 0.022225 0.0127 drawhexdisk
 push 0.0 0.0 0.0127 translate 0.01905 0.01905 drawdisk pop
 push 0.0 0.0 0.031751 translate 0.01905 0.009525 drawhexdisk pop
 "BLUE" setcolor
 push 0.0 0.0 0.035052 translate 0.00635 0.00635 drawdisk pop
 push 0.0 0.0 0.035052 translate 0.00635 drawsphere pop
 push "BLUE" setcolor
   0.0 0.0 0.0414 translate 0.012 drawsphere pop

   // ************ object definitions used for FDS-EVAC ********************


OBJECTDEF
 evacbox
// draws a square "railings"
// smv file: xyz is the (min_x, min_y, z) corner
//           orientation vector (0,0,1)
// Red Green Blue  width(x) depth(y) diameter
 :R=0 :G=0 :B=0 :DX :DY :D
 $R $G $B setrgb
 push  0.0 0.0 0.0 translate -90.0 rotatex $D $D $DY scalexyz 1.0 1.0 drawdisk pop
 push  $DX 0.0 0.0 translate -90.0 rotatex $D $D $DY scalexyz 1.0 1.0 drawdisk pop
 push  0.0 0.0 0.0 translate  90.0 rotatey $D $D $DX scalexyz 1.0 1.0 drawdisk pop
 push  0.0 $DY 0.0 translate  90.0 rotatey $D $D $DX scalexyz 1.0 1.0 drawdisk pop
```

```
// push  $DX 0.0 0.0 translate -90.0 rotatex $D $D $DY scalexyz 1.0 drawcubec pop

OBJECTDEF
 evacdoor         // label, name of object
 :SX :SY :SZ :R=0 :G=0 :B=0 :DX :DY :DZ
 // Evacuation input: door or exit namelist
 push  $DX $DY $DZ translate -180.0 rotatex
    34 139 3 setrgb 0.0 0.0 -0.6 translate 0.4 0.6 drawcone pop // draw an arrow
 -90.0 rotatez -90.0 rotatex
 push  $SX $SY $SZ scalexyz $R $G $B setrgb
    0.0 -0.5 0.0 translate 1.0 drawcube pop // front half of door (user specified color)
 push  $SX $SY $SZ scalexyz 34 139 3 setrgb
    0.0 0.5 0.0 translate 1.0 drawcube pop // back half of door (forest green)
NEWFRAME
 :SX :SY :SZ :R=0 :G=0 :B=0 :DX :DY :DZ
 -90.0 rotatez -90.0 rotatex
 push  $SX $SY $SZ scalexyz $R $G $B setrgb
    0.0 -0.5 0.0 translate 1.0 drawcube pop // front half of door (user specified color)
 push  $SX $SY $SZ scalexyz "RED" setcolor
    0.0 0.5 0.0 translate 1.0 drawcube pop // back half of door (red)

OBJECTDEF
 evacincline         // label, name of object
 :SX :SY :SZ :R=0 :G=0 :B=0
 // Evacuation input: evss namelist
 -90.0 rotatez -90.0 rotatex
 push  $SX $SY $SZ scalexyz $R $G $B setrgb
    0.0 0.5 0.0 translate 1.0 drawcube pop // incline (user specified color)

OBJECTDEF
 evacentr         // label, name of object
 :SX :SY :SZ :R=0 :G=0 :B=0
 // Evacuation input: entr namelist
 -90.0 rotatez -90.0 rotatex
 push  $SX $SY $SZ scalexyz $R $G $B setrgb
    0.0 -0.5 0.0 translate 1.0 drawcube pop // front half of door (user specified color)
 push  $SX $SY $SZ scalexyz 135 206 235 setrgb
    0.0 0.5 0.0 translate 1.0 drawcube pop // back half of door (sky blue 135 206 235)
NEWFRAME
 :SX :SY :SZ :R=0 :G=0 :B=0
 -90.0 rotatez -90.0 rotatex
 push  $SX $SY $SZ scalexyz $R $G $B setrgb
    0.0 -0.5 0.0 translate 1.0 drawcube pop // front half of door (user specified color)
 push  $SX $SY $SZ scalexyz "RED" setcolor
    0.0 0.5 0.0 translate 1.0 drawcube pop // back half of door (red)

   // ************ dynamic particle object definitions ********************
   //          (modifable using data obtained from FDS)

OBJECTDEF // object for particle file sphere
 sphere
 :R=0 :G=0 :B=0 :D=0.1
 $R $G $B setrgb
 $D drawsphere

OBJECTDEF
 box
 :R=0 :G=0 :B=0 :DX :DY :DZ
 $R $G $B setrgb
 $DX $DY $DZ scalexyz 1.0 drawcubec

OBJECTDEF // object for particle file tube
 tube
 :R=0 :G=0 :B=0 :D=0.1 :L=0.1
 $R $G $B setrgb
 90.0 rotatey $D $L drawcdisk

OBJECTDEF // object for particle file tube
```

```
 cylinder
 :R=0 :G=0 :B=0 :D=0.1 :L=0.1
 $R $G $B setrgb
 90.0 rotatey $D $L drawcdisk

OBJECTDEF // object for particle "egg"
 egg
 :R=0 :G=0 :B=0 :D=0.1 :DX     // data obtained from an FDS input file
 $R $G $B setrgb
 $DX $D $D scalexyz 1.0 drawsphere

OBJECTDEF // object for particle file tube
 veltube
 :R=0 :G=0 :B=0 :D=0.1 :L=0.1 :U-VEL=1.0 :V-VEL=1.0 :W-VEL=1.0 :VELMIN=0.01 :VELMAX=0.2
 $R $G $B setrgb
 $U-VEL :UV abs $UV $VELMAX :U div $U 0.0 1.0 :CU clip
 $V-VEL :VV abs $VV $VELMAX :V div $V 0.0 1.0 :CV clip
 $W-VEL :WV abs $WV $VELMAX :W div $W 0.0 1.0 :CW clip
 $CU $CV $CW rotatexyz $CU $CV $CW scalexyz $D $L drawcdisk

OBJECTDEF // color with FDS quantity, stretch with velocity
 velegg
 :R=0 :G=0 :B=0 :D=1.0 :U-VEL=1.0 :V-VEL=1.0 :W-VEL=1.0 :VELMIN=0.01 :VELMAX=0.2 // data obtained from an FDS inp
 $R $G $B setrgb
 $U-VEL :UV abs $UV $VELMAX :U div $U 0.0 1.0 :CU clip
 $V-VEL :VV abs $VV $VELMAX :V div $V 0.0 1.0 :CV clip
 $W-VEL :WV abs $WV $VELMAX :W div $W 0.0 1.0 :CW clip
 $CU $CV $CW rotatexyz $CU $CV $CW scalexyz $D drawsphere

OBJECTDEF // object for particle "egg"
 tempegg
 :R=0 :G=0 :B=0 :D=0.1 :DX :temp :rot_rate    // data obtained from an FDS input file
 $temp 700.0 :tempd28 div $tempd28 $G $B setrgb
 $rot_rate 0.0 :rotz multiaddt $rotz rotatez 0.2 $tempd28 0.2 scalexyz 1.0 drawsphere

OBJECTDEF
 block
 :R=0 :G=0 :B=0 :DX=1.0 :DY=1.0 :DZ=1.0
 $R $G $B setrgb
 $DX $DY $DZ scalexyz 1.0 drawcubec

OBJECTDEF
 cablerack
 :R=105 :G=105 :B=105 :D=0.1016 :DX=1.8292 :DY=1.21920 :DZ=0.3048
 $R $G $B setrgb
 0.057 offsetx
 push 0.0760 1.4478 0.6096 translate 1.8288 0.0762 0.0762 scalexyz 1.0 drawcubec pop
 push 0.0760 1.4478 2.1844 translate 1.8288 0.0762 0.0762 scalexyz 1.0 drawcubec pop
 push 0.0760 1.4478 3.4036 translate 1.8288 0.0762 0.0762 scalexyz 1.0 drawcubec pop
 push 0.0 1.2192 0.0 translate 0.1016 0.3048 3.6576 scalexyz 1.0 drawcubec pop
 push $DX 1.2192 0.0 translate 0.1016 0.3048 3.6576 scalexyz 1.0 drawcubec pop
 push -.057 0.0 0.0 translate 0.2286 1.6256 0.3048 scalexyz 1.0 drawcubec pop
 push 1.771 0.0 0.0 translate 0.2286 1.6256 0.3048 scalexyz 1.0 drawcubec pop
 0.4064 offsetz
 push -1.19348 rotatex $D $DY $D scalexyz 1.0 drawcubec pop
 push $DX offsetx -1.19348 rotatex $D $DY $D scalexyz 1.0 drawcubec  pop
 $DZ offsetz
 push -1.19348 rotatex $D $DY $D scalexyz 1.0 drawcubec  pop
 push $DX offsetx -1.19348 rotatex $D $DY $D scalexyz 1.0 drawcubec  pop
 $DZ offsetz
 push -1.19348 rotatex $D $DY $D scalexyz 1.0 drawcubec pop
 push $DX offsetx -1.19348 rotatex $D $DY $D scalexyz 1.0 drawcubec  pop
 $DZ offsetz
 push -1.19348 rotatex $D $DY $D scalexyz 1.0 drawcubec pop
 push $DX offsetx -1.19348 rotatex $D $DY $D scalexyz 1.0 drawcubec  pop
 $DZ offsetz
 push -1.19348 rotatex $D $DY $D scalexyz 1.0 drawcubec pop
 push $DX offsetx -1.19348 rotatex $D $DY $D scalexyz 1.0 drawcubec  pop
```

```
 $DZ offsetz
 push -1.19348 rotatex $D $DY $D scalexyz 1.0 drawcubec pop
 push $DX offsetx -1.19348 rotatex $D $DY $D scalexyz 1.0 drawcubec  pop
 $DZ offsetz
 push -1.19348 rotatex $D $DY $D scalexyz 1.0 drawcubec pop
 push $DX offsetx -1.19348 rotatex $D $DY $D scalexyz 1.0 drawcubec  pop

OBJECTDEF // object for a general ball
 ball
 :R=0 :G=0 :B=0 :DX :DY :DZ :D=-.1
 $D 0.0 :DGT0 GT
 $R $G $B setrgb
 $DGT0 IF
  $D drawsphere
  ELSE
  $DX $DY $DZ scalexyz 1.0 drawsphere
 ENDIF
 NO_OP

OBJECTDEF
 face_eye
  :R=0 :G=0 :B=0 :W :H
 $R $G $B setrgb
 rotateeye $W $H 1.0 scalexyz 1.0 drawsquare

OBJECTDEF // object for dynamic textured sphere
 movingsphere2
 :R=0 :G=0 :B=0  // sphere color
 :X0 :Y0 :Z0     // origin
 :VX :VY :VZ     // velocity
 :axis_x=0.0 :axis_y=0.0 :axis_z=1.0 // axis of rotation
 :ROTATE_RATE    // rotation rate
 :D=0.1          // sphere diameter
 :tfile          // texture file
 $R $G $B setrgb
 $VX $X0 :vvx multiaddt
 $VY $Y0 :vvy multiaddt
 $VZ $Z0 :vvz multiaddt
 $vvx $vvy $vvz gtranslate $ROTATE_RATE 0.0 :rotz multiaddt
   $rotz $axis_x $axis_y $axis_z rotateaxis 180.0 rotatey $tfile :textureindex gettextureindex $textureindex $D d
   push 255 0 0 setrgb 0.0 0.0 -1.0 translate 0.1 2.0 drawdisk pop

OBJECTDEF // object for dynamic textured sphere
 movingsphere
 :R=0 :G=0 :B=0  // sphere color
 :X0 :Y0 :Z0     // origin
 :VX :VY :VZ     // velocity
 :ROTATE_RATE    // rotation rate
 :D=0.1          // sphere diameter
 :tfile          // texture file
 $R $G $B setrgb
 $VX $X0 :vvx multiaddt
 $VY $Y0 :vvy multiaddt
 $VZ $Z0 :vvz multiaddt
 $vvx $vvy $vvz translate $ROTATE_RATE 0.0 :rotz multiaddt
   $rotz rotatez 180.0 rotatey $tfile :textureindex gettextureindex $textureindex $D drawtsphere

OBJECTDEF // object for a moving box
 movingbox
 :R=0 :G=0 :B=0 // box color
 :X0 :Y0 :Z0    // lower left front box corner
 :VX :VY :VZ    // box velocity
 :DX :DY :DZ    // box size
 $R $G $B setrgb
 $VX $X0 :vvx multiaddt
 $VY $Y0 :vvy multiaddt
 $VZ $Z0 :vvz multiaddt
 $vvx $vvy $vvz gtranslate $DX $DY $DZ scalexyz 0.0 0.0 0.5 gtranslate 1.0 drawcube
```

```
OBJECTDEF // object for dynamic textured sphere
 demosphere
 :R=0 :G=0 :B=0 :X0 :Y0 :Z0 :VX :VY :VZ :ROTATE_RATE :D=0.1 :XMAX :YMAX :ZMAX :tfile
 $R $G $B setrgb
 $VX $X0 :vvx multiaddt $vvx  0.0 $XMAX :CLIPX mirrorclip
 $VY $Y0 :vvy multiaddt $vvy  0.0 $YMAX :CLIPY mirrorclip
 $VZ $Z0 :vvz multiaddt $vvz  0.0 $ZMAX :CLIPZ mirrorclip
 $CLIPX $CLIPY $CLIPZ translate $ROTATE_RATE 0.0 :rotz multiaddt
   $rotz rotatez 180.0 rotatey $tfile :textureindex gettextureindex $textureindex $D drawtsphere

OBJECTDEF // object for dynamic textured sphere
 ttest
 :texture_file
 $texture_file :textureindex gettextureindex $textureindex 1.0 drawtsphere

OBJECTDEF // object to test IF, LE, GT and AND operators
 conditional_ball
 :DX :DY :DZ         // parameters passed from FDS in SMOKEVIEW_PARAMETERS array
 :time gett          // get the current time
 $time 3.0 :LE_L LE  // is time .le. 3
 $time 3.0 :GE_L GT  // is time .gt. 3
 $time 6.0 :LE_H LE  // is time .le. 6
 $time 6.0 :GT_H GT  // is time .gt  6
 $LE_L IF
   "RED" setcolor   // set the color to red if t .le. 3.0
 ENDIF
 $GE_L $LE_H :ANDTEST AND $ANDTEST IF
   "GREEN" setcolor   // set the color to green if t .gt. 3.0 and t .le.6
 ENDIF
 $GT_H IF
    "BLUE" setcolor  // set the color to blue if t > 6.0
 ENDIF
 $DX $DY $DZ scalexyz 1.0 drawsphere

OBJECTDEF
 fan
  :HUB_R=0 :HUB_G=0 :HUB_B=0 :HUB_D=0.1 :HUB_L=0.12
  :BLADE_R=128 :BLADE_G=64 :BLADE_B=32 :BLADE_ANGLE=30.0 :BLADE_D=0.5 :BLADE_H=0.09
  :ROTATION_RATE=360.0
 $HUB_L -2.0 :HUB_LD2 div
 $BLADE_H -2.0 :BLADE_HD2 div
 $HUB_R $HUB_G $HUB_B setrgb
 $ROTATION_RATE 0.0 :rotz multiaddt $rotz rotatez
 push
   0.0 0.0 $HUB_LD2 translate
   $HUB_D $HUB_L drawdisk
 pop
 push
   $BLADE_R $BLADE_G $BLADE_B setrgb
   0.0 0.0 $BLADE_HD2 translate
   $BLADE_ANGLE $BLADE_D $BLADE_H drawarcdisk
 pop
 push
  120.0 rotatez
  0.0 0.0 $BLADE_HD2 translate
  $BLADE_ANGLE $BLADE_D $BLADE_H drawarcdisk
 pop
 push
  240.0 rotatez
  0.0 0.0 $BLADE_HD2 translate
  $BLADE_ANGLE $BLADE_D $BLADE_H drawarcdisk
 pop

OBJECTDEF
 vent
  :R=0 :G=0 :B=0 :W :H :ROT=0.0
 $ROT rotatez $R $G $B setrgb
```

```
 $W $H 1.0 scalexyz 1.0 drawsquare
 NEWFRAME
  :R=0 :G=0 :B=0 :W :H :ROT=0.0
 $ROT rotatez $R $G $B setrgb
 $W $H drawvent

OBJECTDEF
 cone
  :R=0 :G=0 :B=0 :D=0.4 :H=0.6
 $R $G $B setrgb
 $D $H drawcone

OBJECTDEF // object for dynamic textured sphere
 tsphere
  :R=0 :G=0 :B=0 :AX0 :ELEV0 :ROT0 :ROTATION_RATE :D=0.1 :tfile
 $R $G $B setrgb
 90.0 rotatey $AX0 rotatex $ELEV0 rotatey
 $ROTATION_RATE $ROT0 :rotz multiaddt $rotz rotatez
   $tfile :textureindex gettextureindex $textureindex $D drawtsphere

   // ************ dynamic tree object definitions ********************

OBJECTDEF // object for tree trunk
 TREE
 :TRUNK_D :TRUNK_H :TRUNK_BASE_H   // trunk variables
 :TRUNK_R=138 :TRUNK_G=69 :TRUNK_B=18
 :CANOPY_D :CANOPY_H :CANOPY_BASE_H // canopy variables
 :CANOPY_R=25 :CANOPY_G=128 :CANOPY_B=0
 $TRUNK_R $TRUNK_G $TRUNK_B setrgb
 push 0.0 0.0 $TRUNK_BASE_H translate $TRUNK_D $TRUNK_H drawdisk pop
$CANOPY_R $CANOPY_G $CANOPY_B setrgb
 0.0 0.0 $CANOPY_BASE_H translate $CANOPY_D $CANOPY_H drawcone


OBJECTDEF // object for tree trunk
 TRUNK
 :TRUNK_BASE_H :TRUNK_D :TRUNK_H :R=138 :G=69 :B=18
 $R $G $B setrgb
 0.0 0.0 $TRUNK_BASE_H translate $TRUNK_D $TRUNK_H drawdisk

OBJECTDEF // object for tree canopy
 CANOPY
 :CANOPY_BASE_H :CANOPY_D :CANOPY_H :R=25 :G=128 :B=0
$R $G $B setrgb
 0.0 0.0 $CANOPY_BASE_H translate $CANOPY_D $CANOPY_H drawcone

   // ************ avatar object definitions ********************

AVATARDEF
 human_fixed          // label, name of avatar
 :DUM1 :DUM2 :DUM3 :W :D=0.1 :H1 :SX :SY :SZ :R=0 :G=0 :B=0 :HX :HY :HZ
 90.0 rotatez
 "TAN" setcolor // head color  TAN 210 180 140
 0.3 0.3 0.3 scalexyz
 0.0 0.0 0.0 translate
 push  0.0 0.0 5.2 translate 1.1 drawsphere
   "BLUE" setcolor // eye color BLUE
   push -0.25 -0.4 0.05 translate 0.2 drawsphere pop // eye
   push  0.25 -0.4 0.05 translate 0.2 drawsphere pop // eye
   pop // head
 28 64 140 setrgb  // body color
 push  0.0 0.0 3.55 translate 0.5 0.3 1.0 scalexyz 2.5 drawsphere pop // trunk
 "TAN" setcolor // arm color TAN 210 180 140
 push -0.9 0.0 3.5 translate  35.0 rotatey 0.2  0.2  1.0 scalexyz 3.0 drawsphere pop // arm
 push  0.9 0.0 3.5 translate -35.0 rotatey 0.2  0.2  1.0 scalexyz 3.0 drawsphere pop // arm
 39 64 139 setrgb // leg color ROYAL BLUE4: 39 64 139
 push -0.5 0.0 1.3 translate  30.0 rotatey 0.25 0.25 1.0 scalexyz 3.0 drawsphere pop // leg
 push  0.5 0.0 1.3 translate -30.0 rotatey 0.25 0.25 1.0 scalexyz 3.0 drawsphere pop // leg
```

```
AVATARDEF
 human_altered_with_data         // label, name of avatar
 :DUM1 :DUM2 :DUM3 :W :D=0.1 :H1 :SX :SY :SZ :R=0 :G=0 :B=0 :HX :HY :HZ
 90.0 rotatez
 "TAN" setcolor // head color  TAN 210 180 140
 $SX $SY $SZ scalexyz //  scale by data height
 1.0 1.0 0.579 scalexyz
 0.3 0.3 0.3 scalexyz
 push  0.0 0.0 5.2 translate 1.1 drawsphere
   "BLUE" setcolor // eye color BLUE
   push -0.25 -0.4 0.05 translate 0.2 drawsphere pop // eye
   push  0.25 -0.4 0.05 translate 0.2 drawsphere pop // eye
   pop // head
 $R $G $B setrgb  // body color
 push  0.0 0.0 3.55 translate $W $D $H1 scalexyz 1.334 1.33 1.0 scalexyz 2.5 drawsphere pop // trunk, scale by wi
 "TAN" setcolor // arm color TAN 210 180 140
 push -0.9 0.0 3.5 translate  35.0 rotatey 0.2  0.2  1.0 scalexyz 3.0 drawsphere pop // arm
 push  0.9 0.0 3.5 translate -35.0 rotatey 0.2  0.2  1.0 scalexyz 3.0 drawsphere pop // arm
 39 64 139 setrgb // leg color ROYAL BLUE4: 39 64 139
 push -0.5 0.0 1.3 translate  30.0 rotatey 0.25 0.25 1.0 scalexyz 3.0 drawsphere pop // leg
 push  0.5 0.0 1.3 translate -30.0 rotatey 0.25 0.25 1.0 scalexyz 3.0 drawsphere pop // leg

AVATARDEF
 ellipsoid         // label, name of object
 :DUM1 :DUM2 :DUM3 :W :D=0.1 :H1 :SX :SY :SZ :R=0 :G=0 :B=0 :HX :HY :HZ
 90.0 rotatez
 $HX $HY $HZ translate $SX $SY $SZ scalexyz $W $D $H1 scalexyz
  push 0.0 -1.0 0.0 translate 1.0 5.0 0.5 scalexyz "BLUE" setcolor 0.4 drawsphere pop
  $R $G $B setrgb 1.0 drawsphere

AVATARDEF
 disk         // label, name of object
 :DUM1 :DUM2 :DUM3 :W :D=0.1 :H1 :SX :SY :SZ :R=0 :G=0 :B=0 :HX :HY :HZ
 90.0 rotatez
 0.0 0.0 1.0 translate $W $D $H1 scalexyz
  push 0.0 -0.25 0.05 translate 0.3 2.5 0.3 scalexyz "CYAN" setcolor 0.2 drawsphere pop
  $R $G $B setrgb 1.0 0.05 drawdisk

   // ************ Elementary object definitions ********************

   //  These definitions are used to illustrate the basic building blocks
   //  used to create more complex objects

OBJECTDEF
 drawaxisxyz
 "RED" setcolor
 push  90.0 rotatey 0.05 0.05 0.4 scalexyz 1.0 1.0 drawdisk pop
 "GREEN" setcolor
 push -90.0 rotatex 0.05 0.05 0.4 scalexyz 1.0 1.0 drawdisk pop
 "BLUE" setcolor
 push 0.05 0.05 0.4 scalexyz 1.0 1.0 drawdisk pop

OBJECTDEF
 drawaxis2
 "BLACK" setcolor
 push 0.05 0.05 0.4 scalexyz 1.0 1.0 drawdisk pop
  "BLACK" setcolor
 push 90.0 rotatey 0.05 0.05 0.6 scalexyz 1.0 1.0 drawdisk pop

OBJECTDEF
 drawaxis
 "BLACK" setcolor
 push 0.00625 0.00625 0.075 scalexyz 1.0 1.0 drawdisk pop
 "BLACK" setcolor
 push 90.0 rotatey 0.00625 0.00625 0.075 scalexyz 1.0 1.0 drawdisk pop

OBJECTDEF
```

```
 drawcone
 "BRICK" setcolor
 0.50 0.30 drawcone

OBJECTDEF
 drawcube
 "BRICK" setcolor
 0.25 drawcube

OBJECTDEF
 drawdisk
 "BRICK" setcolor
 0.25 0.50 drawdisk

OBJECTDEF
 drawcdisk
 "BRICK" setcolor
 0.25 0.50 drawcdisk

OBJECTDEF
 drawhexdisk
 "BRICK" setcolor
 0.50 0.25 drawhexdisk

OBJECTDEF
 drawnotchplate
 "BRICK" setcolor
 0.5 0.1 0.2 1 drawnotchplate

OBJECTDEF
 drawnotchplate2
 "BRICK" setcolor
 0.5 0.1 0.2 -1 drawnotchplate

OBJECTDEF
 drawpolydisk
 "BRICK" setcolor
 5 0.35 0.15 drawpolydisk

OBJECTDEF
 drawring
 "BRICK" setcolor
 0.3 0.5 0.1 drawring

OBJECTDEF
 drawsphere
 "BRICK" setcolor
 0.25 drawsphere

OBJECTDEF
 drawtrunccone
 "BRICK" setcolor
 0.5 0.2 0.4 drawtrunccone

OBJECTDEF
 drawarcdisk
 "BRICK" setcolor
 60.0 0.6 0.2 drawarcdisk
```