Title: **XTV USERS GUIDE**

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# XTV USERS GUIDE

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by

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## ABSTRACT

XTV is an X-Windows based Graphical User Interface for viewing results of Transient Reactor Analysis Code (TRAC) calculations. It provides static and animated color mapped visualizations of both thermal-hydraulic and heat conduction components in a TRAC model of a nuclear power plant, as well as both on-screen and hard copy two-dimensional plot capabilities. XTV is the successor to TRAP, the former TRAC postprocessor using the proprietary DISSPLA graphics library. This manual describes Version 2.0, which requires TRAC version 5.4.20 or later for full visualization capabilities.

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## 1.0.  INTRODUCTION

XTV is a simple, intuitive, postprocessing Graphical User Interface (GUI) to the complex database generated by a Transient Reactor Analysis Code (TRAC)[1] calculation. It provides static and animated color-mapped visualizations of both thermal-hydraulic and heat-conduction components in a TRAC model of a nuclear power plant, as well as both on-screen and hard copy two-dimensional (2D) plot capabilities.

XTV is written in clean, modular ANSI C, and utilizes the Xlib library for low-level graphics, and the Xt and Motif libraries for implementation of high-level, user-interface, graphical objects (widgets). It requires a UNIX operating system running X Windows and a high-resolution color monitor. XTV specifies its own default resources so that the usual X resource file is optional.

The code version described in this document is XTV Version 2.0, which defines the completion of the XTV Enhancements task for the United States Nuclear Regulatory

Commission, Office of Nuclear Regulatory Research. It reads graphics files written by TRAC version 5.4.20 or later.

A standard ASCII text version of this documentation is shipped with XTV as the file README.XTV. This file can be opened and displayed at the GUI with the Users Manual control under the Help menu item.

A good measure of the effectiveness of a GUI is how little back-up documentation is necessary. It was our goal to keep this document as small as possible.

## 2.0.    CREATION OF XTV GRAPHICS FILES

TRAC automatically runs write output files named xtvgr.t and xvtgr.b, with time edits at the intervals specified for the old DISPLAY-based TRCGRF files. The first file (xtvgr.t) is a text header file containing: (1) time-independent identification, (2) node and geometric information about the thermal-hydraulic and Heat-Structure components used in the TRAC run, and (3) name and type information for the variables associated with each component. The binary file xtvgr.b contains the times and the time-dependent values of each of the variables specified by xtvgr.t at the times specified for graphics edits in the TRAC input file. Each of the equal-sized time edits contains the time, followed by variable data organized by component, written in standard 32-bit binary. There is no format information (user or compiler generated) in this file.

To avoid system crashes caused by filled hard disks on the workstation, the default maximum allowed size for xtvgr.b is 100 MB. This may be reset by providing a file named xtvtin in the directory in which TRAC executes, the first and only line that contains the maximum file size in megabytes.

## 3.0.    GUI STARTUP

XTV is run by typing 'xtv' on a command line. It will display information read from the graphics input files before switching to the Xt event handler, which responds to user input at the GUI. The file names for the TRAC-generated graphics input files are <root>.t and <root>.b, where the default value of <root> is xtvgr, giving the filenames as written by TRAC. The value of <root> may be changed with

the -i command line option, as in 'xtv -i sbloca'. Here XTV would look for files sbloca.xtvt and sbloca.xtvb. If these were not found, it would look for sbloca.t and sbloca.b We recommend using the xtvt and xtvb suffixes when using nondefault <root> names for clarity.

Binary files from sequential TRAC runs may be concatenated with the command 'xtv -c'. This will concatenate files named according to one of four conventions: <root>.xtvb.n, <root>n.xtvb, <root>.b.n, or <root>n.b. Here n is the file sequence number, as in 1, 2, 3, 4, n; and root is xtvgr if not specified on the command line with the -i option, as in 'xtv -i <root> -c'. The resultant concatenated file is named <root>.<ext>.new, where <ext> is the same extension that was used for the input file names, either 'xtvb' or 'b'. The file xtvgr.t must be present, and must be applicable to all the data files. That is, the concatenated data files must be output from sequential runs using the same TRAC input component database. The concatenated files may have overlaps caused by restarting TRAC from a time edit that is not the last in the calculation. Sequential data files with no overlaps may also be concatenated using the UNIX 'cat' command.

Component identification numbers may be specified on the command line, as in 'xtv 11 12 13 14'. These components will be displayed on startup.

As an X Windows application, XTV may be run over the network using the -display command line option, or by setting the DISPLAY environment variable. For example, to run XTV on machine alpha while sitting in front of machine beta, first type xhost alpha on machine beta, then log onto machine alpha and set the display environment variable (using C Shell syntax) with either of the following options:

    setenv DISPLAY beta:0

or execute XTV with the display command line option:

    xtv -display beta:0

The ':0' indicates the first screen on machine beta.

## 4.0.　GUI DESCRIPTION

On startup, XTV finds the size of the user's (screen server's) screen and fills it entirely, scaling its component widgets appropriately. There are three main interface areas: a menu bar and view control bar at the top, three global selection widgets at the bottom, and a graphics display area in between. The graphics display area is initially tiled with eight display objects (DOs, pronounced "Dee-Ohs") that can show color-mapped visualizations. The menu bar hides most user selectable options; these will be discussed in detail later. The global selection widgets at the bottom allow quick selection of time edit, component, and variable. Components may be thermal-hydraulic components, heat structures, or global components. Time-dependent spatial rezoning of heat structures is accounted for and can be visualized. The global components are signal variable and control block, whose variables are all the user-specified signal variables and control blocks in the TRAC input.

The DOs allow simultaneous viewing (static or animation) of different components, different cross-sections of the same three-dimensional (3D) component, or of different color maps of different variables for the same component. The component display is generated by filling the component geometry (defined in the TRAC input) with cell-specific color maps of selected fluid variables. For those variables with no associated geometry (signal variables or the global properties of heat structures, for example) a rectangle comprising most of the display area is the DO filled with the mapped color.

The graphics display area may be toggled with the button on the far right of the menu bar to show graphs, each containing up to six line plots. These graphs may have either space or time as their independent variable; the plots on graphs using space may be animated in time. The procedure for generation, saving, and retrieval of graphs will be described later.

### 4.1. Menu and View Control Bars

Along the top of the display is a menu bar that hides many of the user-controlled options of XTV. The visible items will be described here; the hidden items will be described as their functions are encountered later in this report. The syntax for a

hidden menu item will be A/B/C, where A is the visible menu item, B is an item on that menu, and C is an item on B's menu. From left to right, the visible menu bar items are as follows.

- File contains the item Quit, the normal exit control for XTV.

- Color Maps contains various controls that affect the appearance of the objects drawn in the Color Map Display area.

- Graphs contains items that control the creation, saving, and retrieval of graphs containing line plots.

- TRAC is a place holder for future control of executing TRAC runs.

- HELP contains a single item that brings up a scrollable window containing this documentation.

Directly below the menu bar is the view control bar, consisting of the following four buttons that control what is displayed in the graphics display area.

- View Line Plots toggles the graphics display area to the line plot mode.

- View Color Maps switches the graphics display area to color-mapped DOs.

- Single Color Map enlarges the selected DO, if occupied, to fill the entire graphics display area.

- Tiled Color Maps returns to the multiple DO mode, with the specified tiling (Color Maps/Tiling).

## 4.2. Time Edit Selection

Frames of data (time edits) may be selected manually or automatically (animated) using these controls. Manual selection is accomplished by 'grabbing' and moving the time edit slider, or by clicking within the slider bar to the right or left side of the slider control, which will change the selected edit by one increment up or down. The time edit number is shown above the slider control, and the selected time is

shown above the slider bar. Manual selection changes the time edit for data shown in the color map display area, and selects the time for the next space plot created if graphs are in static mode (Section). If graphs are in dynamic mode and the current graph contains space plots, changing the time edit changes the data plotted. Static and dynamic graph modes are toggled with the buttons under Graphs/Mode.

Below the slider bar are buttons that control the animation. Start and Stop are self-explanatory; Reset will reset the time edit to that selected before the most recent animation was started. If the animation is allowed to reach the last time edit, the animation will stop by displaying the first time edit.

### 4.3. Component Selection
Components may be selected by finding, pointing, and clicking on them in the scrollable list, or by entering a known identification number in the small text entry box to the right of 'Component Selection' (the user must first direct keyboard focus to the text entry box by pointing and clicking within it.) Selected components will be automatically drawn in the currently selected DO. Selectable components include thermal-hydraulic components, heat structures, signal variables and control blocks. Heat structures include a labeled global component and the individual rods and slabs defined by the heat structure. When the selected component is changed to another type, a warning message advises the user to reselect the variable. Warning messages must be dismissed by clicking on OK before more user interaction is permitted.

### 4.4. Variable Selection
Variables are selected by clicking on them in the scrollable list. Selecting a variable causes it to be color mapped in the currently selected DO and selects it for the next generated line plot. The variable selection list will be empty if no components have been selected.

### 4.5. Color Map Display
To visualize a specific variable at a specific time, the user first selects the desired DO by pointing and clicking within its boundary. The selected DO's boundary turns red. Then the desired component is selected from the component selection list, either by scrolling through the list and identifying it by name, or by typing a known component identification number in the small box following "Component

Selection." Then the desired variable is selected by name from the Variable Selection list. Finally, the desired time is selected using the time edit selection widget. The selected DO can be enlarged to fill the entire graphics display area by pointing and clicking with the right mouse button within its boundary. The same operation will return to the multiple-DO viewing mode. A component may be deleted from a DO by pointing and clicking within the DO while holding down the "SHIFT" key. The tiling of simultaneously visible DOs can be set to 1 x 2, 2 x 4, and 3 x 6 using buttons under Visuals/Tiling. The DOs can be animated in time by selecting "Start" from the "Animation" menu on the menu bar.

Each DO has a text information (turquoise) area and a color map display (tan) area. Within the latter variables are color mapped over the finite difference grid, with small white circles ("node icons") at mass and energy conservation cell centers in fluid-dynamic components or the locations of nodes in heat structures. Pointing and clicking the left mouse button on a node icon selects that cell for text output in the text information area and locates the independent variable for the next selected plot. For variables that are associated with cell faces rather than cell centers (in fluid-dynamic components), the effect of selecting a node icon is different, depending on whether the component is one-dimensional (1D) or 3D. For 1D components, the value at the cell face between the selected node icon and the cell center with a lower index is selected. Clicking on the node icon with the middle mouse button will select the value at the cell face between the selected node icon and the cell center with a higher index. For 3D components, the value at the cell face between the selected cell center and the cell center with a higher index is always selected.

The visualizations of Heat Structures correspond to Figs. IV-5 in Vol. 1 of Ref. 1, and Figs. 2.7 and 2.8 of Vol. 2 of Ref. 1. Heat transfer nodes may be located on surfaces, and the interfaces between finite-difference cells are located midway between nodes. The x (horizontal) coordinate in XTV's color maps and line plots corresponds to the Heat-Structure coordinate that is normal to the fluid interface, and the y (vertical) coordinate corresponds to the Heat-Structure coordinate that is parallel to the fluid interface.

At normal size, the DO's text display area shows the component's name and identification number on the top line, the color-mapped variable name on the

second line, the range of values for that variable over all time edits within than component on the third line, and the value of the color-mapped variable in the selected cell. When enlarged, the text display area also shows the color mapping used with a 10-segment color bar. There are two choices of color map for each DO, shades of blue (Water Colors) and red (Hot Colors). These are toggled using the buttons under Visuals/Color Maps.

Effective wall temperatures are shown by small icons in the center of the cells of a 3D component that are coupled to a heat structure. These temperatures represent the average surface temperatures of all the heat structures that are coupled to the cell. The icons are either small circles or small diamonds, depending on whether the Heat Structure is a heat sink or source to the fluids in the cell. The icon's color is determined by the heat-structure color map (shades of red), which is displayed in the text area when the DO is expanded to full size. Also shown in this text area is the effective wall temperature (wt) of the currently selected cell  The visibility of the wall temperature icons can be toggled on/off with the buttons under Visuals/Wall Temperatures.

Fluid velocity vectors can be displayed for thermal-hydraulic components. These can be turned off, set to liquid velocity, or set to vapor velocity using the buttons under Visuals/Vectors.

Two scale factors that affect the visualization in the selected DO can be set using the slider controls that pop up by clicking Visuals/Scales. The top slider adjusts the scale factor for the drawing, the second adjusts the scale factor used for vectors.

The control Visuals/Vessels pops up a window with 4 sliders that affect the appearance of a Vessel component in the selected DO. The first three set the x or radial (x-r), y or theta (y-t) and z coordinate planes, respectively, that are color mapped. Coordinate directions with only one plane can be selected by clicking on the slider (not grabbing and moving it). Slider widgets must have at least two positions, so it is possible in this case to move the slider to position "2," but this operation will be disallowed and an error message displayed. The fourth slider control changes the aspect ratio of the display by expanding/contracting the horizontal direction.

## 4.6.    Line Plots

The user may create any number of graphs, each containing up to six line plots, in any XTV GUI session.  Graphs can have independent variables of either space or time (denoted here as "space graphs" and "time graphs").  Space graphs may toggled as either "static" (the default)  or dynamic, using controls under Graphs/Mode.  In the static mode, the time selection widget is used to select the time at which space plots are made, and subsequent selection of time, using either the single-frame control slider or the animation controls will not affect displayed plots.  In the dynamic mode, the time selection controls change the time at which the displayed plots are evaluated  The animation controls function as in the color map mode.

**4.6.1.  GUI Plots.**  To create a line plot of desired data, the user first selects the component by pointing-and-clicking in the appropriate DO, or by loading the desired component into a selected DO.  The dependent variable is then selected from the variable selection list.  The independent variable, from the items listed under the Graphs/Plots/Set X Coordinate Plots (where Graphs is a menu item on the menu bar), is an item on the Graphs menu, and Set X Coordinate is an item on the Plots menu.  The choices are time, space coordinate for 1D components or x, z or z coordinate for 3D components, and Heat Structures (only the x and y coordinates are currently appropriate for Heat Structures).  For space plots, the independent variable is further specified by selecting the desired time.  The selection of the independent variable is completed by specifying a cell through which the selected coordinate passes by pointing-and-clicking on that cell in the selected DO.  For time plots, this specifies the cell whose selected dependent variable is plotted as a function of time.  For space plots, this fully specifies the cells whose dependent variable is plotted as a function of space at the selected time.  Items selected remain in effect until changed, so that only those items that change must be reselected when generating new plots.

After the desired plot has been specified, it can be either: (1) added to the current graph, (2) a new graph, or (3) one of the graphs that has been created previously during the current GUI session or read in from the database.  A new graph is created automatically for the first plot using Graphs/Plots/Add Specified Plot.  After that, new graphs can be created using Graphs/New, and new plots may be added to the current graph using Graphs/Plots/Add Specified Plot.  Independent variables (time and space) may not be mixed on the same graph. The current graph can be changed using  Graphs/Selected  Graph/Next,  Graphs/Selected  Graph/Previous,  or  be

selecting from the list that pops up with Graphs/All Graphs/List. Plots may be selected by pointing-and-clicking on the appropriate plot legend box, which will turn white. Selected plots may be deleted from the graph using Graphs/Plots/Delete Selected Plot, and the variable name may be changed with Graphs/Plots/Reset Variable Name.

The units used on the dependent-variable axis (y) may be reset using the control Graphs/Current Graph/Select Units. A selection widget pops up with the choices K, m/s, m**2, kg/m**3, W, kg, kg/s, s, and m.

A graph's title may be set with the control Graphs/Current Graph/Set Title. The selected plot's variable name may be reset with the control Graphs/Plots/Reset Variable Name.

The current list of graphs may be sent to the default printer using File/Graphs/Print All Graphs. For workstations that use commands other than 'lpr' to send files to the default printer, the environment variable XTV_PRINT_STRING can be used. For example, in the C Shell use

setenv XTV_PRINT_STRING "lp -d myprinter"

In the Bourne Shell, use

XTV_PRINT_STRING = "lp -d myprinter"; export XTV_PRINT_STRING;

The string within the double quotes is an example of an appropriate print command, minus the file name to be printed. The current graph can be sent to the printer with File/Graphs/Print Current Graph.

This hardcopy capability will be superseded by a much more sophisticated capability that utilizes line plot freeware.

**4.6.2. Graph Database.** XTV has a simple graph database used for saving the graphs generated during a GUI session to a file and retrieving that file later for display and comparison with new results. The file is saved with the name xtv2d.new, and retrieved with the name xtv2d.old. *Currently, only time graphs may be saved to the*

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*database.* Graphs may be saved in two modes, DATA and SPEC, using the controls under Graphs/All Graphs. The SPEC mode saves the specifications necessary to retrieve comparable data from future TRAC runs. The DATA format saves both the specification and the current plot data. Graphs saved in either mode can be used to specify either plots viewed at the GUI or hard copy plots in batch mode for new TRAC runs.

Graphs can be read from the file xtvgr.new at the GUI in DATA, SPEC, and COMPARE modes using the controls under Graphs/All Graphs. These graphs will be added to the end of the current list. Graphs read in DATA mode will display saved data, graphs read in SPEC mode will display data from the current TRAC calculation specified in xtvgr.new, and Graphs read in COMPARE mode will have two plots each—the first are data read from xtvgr.new, and the second are data specified in xtvgr.new from the current TRAC run .

**4.6.3. AUX File IO.** To maintain some backwards compatibility with previous TRAC graphics, XTV can read and write TRAP-generated "AUX" plot description files. The control File/Graphs/Read TRAP AUX File as New Plot will pop up a file selection widget. The selected AUX File will be plotted as a new plot on the current graph. Because AUX Files don't contain some of the information used by XTV, the current graph *must already contain at least one plot.*

The control File/Graphs/Write Selected Plot to TRAP AUX File will write in AUX file format the selected plot on the current graph to the file selected with the file selection widget. To protect it from accidental overwriting, this file must not already exist.

**5.0.   BATCH GRAPH HARD COPY**

XTV currently has some minimal batch hard copy capability. This capability will probably be superseded in the future (see Section 6 below) with features built around line-plot freeware.

The command 'xtv -b data' will send the graphs contained in xtv2d.old to the printer.

The command 'xtv -b spec' will get the data specified in xtv2d.old out of xtvgr.b, and send the graphs to the printer.

The command 'xtv -b compare' will get the data for each graph in xtv2d.old as plot 1, and the data specified in xtv2d.old out of xtvgr.b as plot 2, and send them to the printer.

## 6.0.    FUTURE WORK

XTV was meant to be a visualization tool to provide insight not possible from static line plots. Because the current TRAC line plot capability is archaic and dependent on commercial software, some custom X and Postscript line plot capability has been included in this version of XTV. We believe that the most cost-effective way of reproducing the TRAC documentation-quality hardcopy facility is to use XTV as in interface to the XMGR freeware line plot utility.

This version is limited to visualizing the system as individual components. An early version showed a 3D view of the entire system, but this required the user to specify additional geometric information. We plan to use an intermediate approach that allows 2D visualizations of multiple components, and/or intuitive controls for traversing the component network.

Analysis frequently requires composite quantities that are not part of TRAC's database. We intend to add the capability to specify and visualize algebraic composites at the GUI.

Finally, the current version operates exclusively in a postprocessing mode. We intend to add the ability to drive TRAC runs from the GUI with on-line visualization of the progress of the calculation.

## REFERENCES

1. TRAC-PF1/MOD2 Code Manual, Vols. 1–4, Los Alamos National Laboratory report LA-12031-M and NUREG/CR-5673 (1993)

# Appendix A
## Available Variables by Component Type

1D Components:

      volume fraction
      pressure
      saturation temperature
      liquid temperature
      vapor temperature
      liquid velocity
      vapor velocity
      flow area
      liquid density
      vapor density
      solute mass fraction
      noncondensible pressure
      total mass flow
      vapor mass flow
      mass phase change rate

3D components:

      volume fraction
      pressure
      saturation temperature
      liquid temperature
      vapor temperature
      liquid velocity (vector)
      vapor velocity (vector)
      solute mass fraction
      noncondensible pressure
      liquid mass flow (vector)
      vapor mass flow (vector)
      vessel water mass

core water mass
core liquid fraction

Heat-Structure Components:

max average rod temperature
max hot rod temperature
inner surface total power
outer surface total power

Heat-Structure Rod and Slab Components
axial position
structure temperature

(if inner heat transfer to fluid)
inner heat-transfer regime
inner Stanton number
inner liquid temperature
inner liquid heat-transfer coefficient
inner vapor heat-transfer coefficient

(if outer heat transfer to fluid)
outer heat-transfer regime
outer Stanton number
outer liquid temperature
outer liquid heat-transfer coefficient
outer vapor heat-transfer coefficient

Signal Variable Component:
All defined signal variables

Control Block Component:
All defined control blocks

## Appendix B
## Functional Description of Menu Bar User Controls

File
>    File IO controls

File/Graphs
>    File IO for XTV-generated graphs

File/Graphs/Read TRAP AUX File
>    Add plot specified in selected AUX file to current graph

File/Graphs/Write Selected Plot to TRAP AUX File
>    Write selected plot on current graph to selected file in AUX format

File/Graphs/Read as DATA
>    Read graphs in xtvgr.old into current graph list, plot saved data

File/Graphs/Read as SPEC
>    Read graphs in xtvgr.old into current graph list, plot new (xtvgr.b-specified) data

File/Graphs/Read as COMPARE
>    Read graphs in xtvgr.old into current graph list, plot saved data and new data as plots 1 and 2

File/Graphs/Write as DATA
>    Write time graphs on current list to xtvgr.new

File/Graphs/Write as SPEC
>    Write specifications for extraction of data on current list to xtvgr.new

File/Quit
>    Exit XTV

Visuals
>    Color map visualization controls

Visuals/Tiling
>    Options for tiling (number of rows x number of columns

Visuals/Vectors
>    Options for display of velocity vectors

Visuals/Color Maps

Optional color maps for selected DO

Visuals/Wall Temperatures

Show/Hide toggle for wall temperatures in Vessel components with Heat
Structures

Visuals/Scales

Pops up Scale Dialog

Visuals/Vessel

Pops up Vessels Dialog


Graphs

Line plot controls

Graphs/New

Create new blank graph

Graphs/List

Pops up scrollable selection list of graphs

Graphs/Mode

Toggle controls for static/dynamic graphs

Graphs/Current Graph

Controls that apply to current graph

Graphs/Current Graph/Delete

Delete current graph


Graphs/Plots

Controls that control line plots on graphs

Graphs/Plots/Add Specified Plot

Add the specified plot to the current graph

Graphs/Plots/Delete Selected Plot

Delete selected plot from current graph

Graphs/Plots/Reset Variable Name

Pops Reset Variable Name Text Entry

Graphs/Plots/Set X Coordinate

Options for X axis for next added plot

Graphs/Plots/Set X Coordinate/Time

Set X axis to time

Graphs/Plots/Set X Coordinate/1D Length

> Set X axis to length in 1D components

Graphs/Plots/Set X Coordinate/3D Length Along x-r

> Set X axis to length along X (Cartesian) or radial coordinate in Vessel
> components or Heat Structures

Graphs/Plots/Set X Coordinate/3D Length Along x-r

> Set X axis to length along X (Cartesian) or radial coordinate in Vessel
> components or Heat Structures

Graphs/Plots/Set X Coordinate/3D Length Along x-r

> Set X axis to length along z coordinate in Vessel components

TRAC

> Place holder for future on-line TRAC controller

Help

> Help Controls

Help/Users Guide

> Pops up a scrolling text widget containing this documentation

# APPENDIX C
## Source Listing of XTV Routines in TRAC

# APPENDIX D
## Source Listing of XTV