CritView User's Guide

Rev. 2

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ACRONYMS

DOE	U.S. Department of Energy
MCNP	Monte Carlo N-Particle
NCSP	Nuclear Criticality Safety Program
SRNS	Savannah River Nuclear Solutions

1.0 INTRODUCTION

1.1 Overview

This document serves as a user's guide for the CritView code, version 1.05. It supersedes the previous revision (Rev. 1), which was applicable to version 1.04 of CritView. This release of CritView also includes version 1.09 of the database, which replaces version 1.08.

The CritView code is used as an electronic equivalent of a nuclear criticality handbook (e.g., ARH-600). This code takes an electronic data library and allows the user to plot data as needed. This approach has two distinct advantages over a paper handbook. First, the database can be easily expanded to include additional data sources (e.g., other handbooks, configurations, or modeling techniques). Secondly, the code provides flexibility by allowing the user to easily change the units and parameters of the plots.

CritView provides the ability to quickly and easily change the axis parameters and units of the plot. For example, a plot showing the relationship between critical sphere radius and concentration can be converted to show the relationship between critical mass and concentration. Similarly, if the plot shows concentration in units of g/cc (for example) it can be changed to g/L. Other major functionality includes the ability to compare curves, to list out the curve data in tabular form, and to export the plot to a graphics file for use in a document.

The CritView code is intended to support evaluating the behavior of various fissile configurations (e.g., minimum critical mass, minimum critical diameter, etc.). The data included in the associated database (like the data in ARH-600 itself) is typically a best estimate of critical (i.e., $k_{eff} = 1.0$) and does not include accommodation for uncertainty or bias. As such it can be somewhat non-conservative and should not be considered as providing subcritical limits. The code is primarily intended as a scoping tool for estimating minimum critical configurations, and for determining potential areas of interest in a criticality safety parametric study. It is not intended to supplant analysis of specific configurations. In general, it is recommended that the code not be used to directly set limits or controls for criticality safety.

CritView was originally developed at Hanford under charter from the DOE NCSP for use by the nuclear criticality safety community. It is distributed through the NCSP's web site (ncsp.llnl.gov). At the time of this document, the code is being maintained by SRNS under contract to the NCSP.

At the time of this document, the current version of CritView is 1.05, and the associated database is version 1.09. The database is encapsulated in two files: CritViewDB.ar and CritViewDB.txt. The "ar" file is a binary version of the database and is the recommended file for normal use (it is loaded by default if present). The "txt" file is an ascii text version and can be used to recreate the binary file (which is done automatically if the binary file is not present). The current version of CritView should not be used with older versions of the database file. Similarly, the current database should not be used with older versions of the code. Later versions of the database, if/when released, may be used with this version of CritView unless the release document associated with the new database file indicates otherwise. Additional details pertaining to the database file can be found in Appendix C and Appendix D.

Use of the CritView code is supported by the NCSP CritView code custodian, as indicated on the NCSP web site (http://ncsp.llnl.gov/analytical-methods/critview). For any questions or issues associated with the use of the code, including bug reports, the user should contact the code custodian.

1.2 Changes with this Revision

Revision 1.05 of CritView represents a substantial rewrite of the underlying code to improve efficiency and simplify future work. Most of the changes, however, are largely transparent to the user. The major changes to the functionality are:

The addition of all LA-10860 curves to the database.

The addition of SCALE6.1 curves to the database.

Improvements to the database filtering process to allow curves with non-standard parameters to be selected. This facilitates the use of LA-10860 data.

Addition of several new parameters to the filtering capability

Refinements to the isotopic content filtering capability

Improvements to the labeling consistency in the database file

Minor bug fixes and improvements to aesthetics.

This revision of the code also introduces a new version the database, which includes some significant changes. The database is discussed further in Appendix C.

2.0 SYSTEM REQUIREMENTS

This version of CritView is intended for installation on a desktop PC running a Microsoft Windows operating system (Windows 10 or newer). At least 16 MB of free disk space are required.

Any additional requirements for use of this code are identified on the NCSP web page.

There are no specific training requirements for use of this code; however, a working knowledge of Microsoft Windows and some familiarity with criticality safety handbooks (e.g., ARH-600 and LA-10860) is recommended.

3.0 INSTALLATION

This software is a "console"-type application and does not require a formal installation (i.e., no changes are made to the Windows registry). Installation consists of copying the executable file and the database files to an appropriate folder on the computer where it will be used. The executable file is named CritView_v###.exe where the "###" is the code version number (e.g., CritView_v105.exe). There are two database files that will normally be present (although the

code can be used with just one). The first is the text version of the database and is named CritViewDB.txt. The contents of this file are in text format and begin with comment lines identifying the version number. The second file is the binary formatted version of the database. It is named "CritViewDB.ar". Note that the binary file can be recreated from the text file but that the text file cannot be regenerated from the binary file.

When first using the software on a given computer, the user should run the example case given in Appendix A and confirm the results are correct. This practice serves as installation testing for the code.

4.0 CODE USE

This section describes some of the basic functions that the user is likely to need. Additional, more detailed, descriptions are provided in Section 5.

4.1 USER INTERFACE

The CritView code is a Windows-based software package that uses menus and on-screen selections as its user interface.

Most code actions are initiated by selecting a menu option. The menu is available through a menu bar across the top of the window (just above the plot). This bar provides the basic menu options, each of which will bring up a small sub-menu window that provides access to various operations. A detailed description of the various menu options available is provided in Section 5.

Additional user options are available by left clicking elements of the plot. Most elements of the plots are clickable (e.g., the curves, individual data points, axis numbers, labels, etc.). Left clicking on an element once will (typically) highlight it and double clicking will bring up a format window for that element.

A curve can be selected either by left clicking on it directly or by left clicking on its representation in the legend box. Selecting a curve will cause the individual data points in that curve to be selected (i.e., highlighted). Left clicking anywhere on a selected curve will cause the X and Y values of the nearest point to be displayed on the screen.

4.2 GETTING STARTED

The code is normally started by double clicking the CritView icon from Windows Explorer. The code will first check for the presence of the default binary database file (CritViewDB.ar). If it is found, it will read the file and proceed. If the binary file is not found, it will attempt to read the default text database file (CritViewDB.txt). If the text version is found, it will be read and a corresponding binary file will be created. Note that reading the text file can take a significant amount of time – up to several minutes – depending on the size of the file and the speed of the computer. If neither the binary file nor the text file is found, the code will bring up a pop-up that allows the user to select a database file for processing.

After the code has read in the database file it will select available curves from the database, based on the default filter values (e.g., ^{239}Pu, sphere). These selected curves will then be plotted onto the screen. It will then display an 'About CritView' box that identifies the code and database versions and requires the user to click on "ok" before proceeding. After the user clicks "ok", the welcome box will close and the user may begin using the code to select new curves or to alter the display of the default curves.

4.3 SELECTING CURVES

The database files may contain data for hundreds or thousands of curves. Typically, it is not desirable to plot them all at once. CritView provides tools for filtering the data so that only the curves the user actually wants to see are displayed. There are two tools available: "Quick Select" and "Advanced Select". The advanced select tool allows the user to specify any combination of parameter values that are available in the database. The quick select tool limits the choices to a subset that includes the most common parameter combinations. This reduces the options available but is easier to use and more intuitive for some people. Additional details of these two tools are discussed in Section 5.

The user can activate the quick select tool by pressing the ctrl-Q keys. Alternately, either tool can be activated by clicking on the Select Data menu option, followed by clicking on either "Quick Select" or "Advanced Select". Either option will bring up a Windows dialog box (specific to the selected tool) from which the user can select any of several different available parameter values of interest (these selections are referred to as "filters"). A typical filter selection would be:

- Geometry: sphere;
- Critical material: Pu;
- Moderator material: H20;
- Nuclide: Pu240 = 0.0 wt%;
- Reflector thickness: = 0.0 cm;
- Data source: ARH600 primary

If this still produces too many curves, additional filters can be applied, or the Hide Curve option (see below) could be used to eliminate unwanted curves from the plot.

The actual filters (and filter values) available are dependent on the curves included in the database. Appendix B provides a description of the filters available with the current version of the database.

4.4 HIDING CURVES

Specific curves can be removed from the plot (without the use of filters) by selecting the Hide/Show Curves option under the Format menu. This will bring up a Windows dialog that

will list all the curves currently on the plot. Clicking any of the curve titles will move it from the Show list to the Hide list (clicking it again will move it back to the Show list). When the dialog is closed the plot will be redrawn with only those curves in the Show list.

4.5 CHANGING THE PLOT AXES

The parameters associated with the plot axes (e.g., mass, radius, concentration), as well as the corresponding units (e.g., grams, kg, pounds) can be changed using the Select Axis Parameter menu option. Note that not all curves can have the parameter changed. Some changes are illegal (e.g., changing from critical radius to critical volume is not allowed for an infinite cylinder) and some changes are possible only if all necessary data is included in the database. For example, a plot showing mass vs. concentration of a sphere can be converted to a volume vs. concentration plot but only if the database includes the volume data for that curve (or other data, such as radius, that allows the volume to be calculated).

There is also a Swap Axes option that will swap the X axis parameter with the Y axis parameter (e.g., a mass vs. diameter plot becomes a diameter vs. mass plot).

4.6 CHANGING THE PLOT APPEARANCE

Most aspects of the plot appearance can be changed as desired. The plot title and the axes titles can be changed by double clicking on them. The axes labels can be changed (as well as the scale, log vs. normal, and other plot settings) by double clicking on the desired axis or by using the "Format" menu option. The appearance of the individual curves can be changed by double clicking on them (or on the matching line in the legend box). This allows the user to change the line style and color, and to specify the curve title to be used in the legend. The general appearance of the legend box can be changed by double clicking on it (or using the "Format" menu option). All options can be restored to their original values by selecting the Reset Plot option under the Tools menu.

The legend box can also be moved or resized using the standard windows move and resize cursors.

4.7 VIEWING NUMERICAL DATA

The numerical values of the underlying data points plotted on the screen can be viewed in two different ways.

The first option is to use the "View" tab (see Section 5.2). Typically, the user would select a curve of interest by clicking on it (it will highlight) then selecting the "View" tab followed by the "View Data from Selected Curve" option. This will bring up a menu, which will provide several ways to select the specific curve you want to look at. Once a curve is selected, the code will bring up a dialog box showing the key curve parameters and a point-by-point listing of the plotted data. Note that this is the raw data in the database, not necessarily the parameters or units selected for plotting.

The second method is through querying the plot directly. Clicking on a point on a curve will result in the X and Y values for that point being displayed on the screen. Note that this is the

plotted data, not the raw data. The raw data may have been converted to conform to the selected axes parameters and units to generate the plots.

4.8 EXPORTING A PLOT TO A FILE

A plot may be saved as a standard graphics file by selecting the "Export Plot to File" option under the "File" menu option. This will bring up a standard "Save File" dialog with the default file type set as JPEG. Other file types can be selected as discussed in Section 5.1. Note that it is important to use the correct suffix in the file name or else leave it blank; if the file named entered does not include a suffix, then the code will add the appropriate suffix.

4.9 PRINTING THE PLOT

The CritView code includes a print feature that may be utilized by selecting the File menu option followed by the Print option.

4.10 COMPARING CURVES

The difference between any two curves on the plot may be examined by selecting the Compare Curves option under the Tools menu. This will bring up a Windows dialog box that lists all the curves on the plot. From here, the user may select two of these curves for comparison. CritView then creates a new curve by subtracting (on a pointwise basis) the second curve from the first. This function is described further in Section 5.6.

5.0 CODE OPTIONS

This section provides a detailed description of all the available CritView menu options. The CritView commands are available through a menu system located on the menu bar at the top of the code window. This section is broken down into subsections for each option on the menu bar, and then further broken down to describe submenus and options underneath each top-level option.

5.1 FILE

Selecting the "File" tab brings up a menu that offers the following commands:

- Print Preview — Displays the plot on the screen as it would appear printed.
- Print Setup — Selects a printer and printer connection.
- Print — Prints the current plot.
- Export Plot to File — Creates a graphics file containing the current screen image.
- Exit — Exits CritView.

Most of these are self-explanatory, but the "Export Plot to File" option deserves some additional discussion. Selecting this option will bring up a dialog that allows the current plot to be saved to a standard graphics file. This dialog allows the user to specify a directory, a file name, and a type. The type indicates the type of graphics compression that will be used in saving the file. Note that each type has an implied suffix for the name. If the user does not specify a suffix when specifying the file name, the code will automatically add the suffix associated with the selected type.

The supported file types and suffixes are shown below. The quality of the resulting image and the size of the file will vary with the file type selected. Note: the resulting plot file will have the same resolution and aspect ratio as the plot displayed on screen.

Available file types and suffixes:

JPEG	.jpg	Highly compatible but not lossless; smallest sized file. Recommended.
Bitmap	.bmp	Highly compatible and accurate (lossless) but produces the largest file.
PNG	.png	Less compatible, but smallest file for lossless method.
TIFF	.tif	Reasonably compatible and lossless; intermediate file size.

5.2 VIEW

The "View" tab brings up a menu that offers the following commands:

- Status Bar — Shows or hides the status bar.
- View Data from Selected Curve — Lists parameter values and data points for currently selected curve.
- List Curves Selected by Filter — Provides a means to list curve(s) currently selected by the filter.
- List of All Curves in Database — Provides a means to list any curve in the database.

The last three options warrant some additional discussion.

The "View Data from Selected Curve" option will produce a dialog window with a listing of the pertinent details from the currently selected curve. The listing provides the curve title and other parameters specified in the database, and the raw curve data (not necessarily the data in the plot).

The "List Curves Selected by Filter" option will produce a dialog window with a listing of all the curves (by title) that are currently selected by the filter. One or more of these curves may be selected (use the ctrl-click to select multiple curves), then viewed by clicking on the "View Curve" button. This will list the data for each of the selected curves just as if they had been highlighted and the "View Data from Selected Curve" option had been used.

The "List of All Curves in Database" option will produce a dialog window with a listing of all the curves (by title) in the database. Note that there are typically thousands of curves in the database. One or more of these curves may be selected, then viewed by clicking on the "View Curve" button. This option will also list the data for each of the selected curves just with the above options.

5.3 SELECT DATA

The "Select Data" tab brings up a menu that offers the following commands:

- Quick Select
- Advanced Select

These two options each bring up a different data selection dialog. These dialogs allow the user to filter the database so only the curves of interest are plotted. If no filters are specified all curves in the database will be plotted. This could be many thousands of curves, which would be time consuming to plot and not very useful; therefore, the user should take care to select appropriate filters.

The "Quick Select" dialog includes an assortment of the most common parameters (e.g., geometry, fissile element, reflector thickness), each of which is presented on a separate tab. When a specific tab is selected then a dialog is brought up for that parameter and certain default settings are activated. Once this dialog is activated, a corresponding filter is implemented. The user can change the settings (by clicking the various boxes or buttons) but cannot leave all the settings blank. If the user attempts to uncheck all of the boxes, the code will automatically check the predefined default box. It is not possible (using the Quick Select tool) to eliminate the filter once it is created in this manner. This tool provides a quick and reasonably intuitive manner of selecting the parameters of interest, resulting in a set of curves to be plotted. The tool is limited, however, to specific predefined options. It may not be useful if the user desires to look at some of the more esoteric data, or if the user has added their own data to the database.

The "Advanced Select" dialog allows the user to specify filters based on all the various parameters and parameter values that exist in the current database. This is a very flexible tool but is less intuitive to use. It is recommended only for advanced/experienced users or non-standard data.

The filters available in the advanced tool depend on the curves present in the database; any parameter specified in the database will show up as a potential filter. For example, if any curve in the database specifies a value for "Volume," uses volume as a variable, or provides sufficient information to calculate the volume, then "Volume" will appear in the list of potential filters. If the volume is not available for any of the curves in the database, it will not appear as a potential filter.

In the advanced tool, a filter is selected by clicking on its name under the available filter list and then clicking the "Add" button, or by just double clicking on its name. This will bring up a dialog box specific to the filter type. In the filter dialog the user will be able to specify a valid

value or range of values for the parameter. Once this filter has been added, only curves having one of the selected values (or falling within the specified range) will be plotted. After clicking the OK button, the filter dialog will close, and the filter selection dialog will reappear (with the new filter in the "Current Filters" list). A filter may be modified or deleted by selecting it from the list of current filters and clicking on the appropriate button. The "Delete All" button will delete all current filters without the need to first select them.

5.4 SELECT AXIS PARAMETER

This option brings up a menu that provides three options:

- X axis
- Y axis
- Swap Axes

If either of the first two options is selected, it will produce a dialog box providing a list of possible parameters for the axis, along with a list of valid units for the selected parameter. Initially the current parameter and units are selected. If a new parameter is selected, the units will default to the first one in the list. If a new parameter and/or new units are selected, the plot will be regenerated with the new axis parameter and/or units. Note that, in some cases, it is possible to select parameters that are not valid for all the curves in the plot. In this case the affected curves will not be plotted.

If the "Swap Axes" option is selected, then the current parameter and units on the X axis will be applied to the Y axis and vice versa.

5.5 FORMAT

The **Format** option brings up a menu that provides the following options:

- X axis
- Y axis
- Legend Box
- Hide/Show Curves

Each of these options are described further in the following subsections.

5.5.1 Format Axis (X or Y)

This option will produce a dialog box allowing the user to set various scale and style options for the axis as described below. Note that this dialog can also be activated by double clicking on the given axis of the plot. [The values in this dialog may be entered as decimal numbers (0.01, 10) or may be entered using scientific notation (1e-2, 1e1), etc.]

Log Scale

Checking this box will result in the axis being plotted as a log scale rather than a linear scale. This will affect many of the other options below. Note that a log scale may not ever cross the zero point on the axis. Only positive ranges are allowed for log scale plots in CritView.

Minimum Axis Value

This is the minimum point on the resulting axis. For a log scale axis, it is typically a power of 10 (e.g., .001, 1.0, 1000.0, etc.).

Maximum Axis Value

This is the maximum point on the resulting axis. It must be greater than the Minimum Axis Value. For a log scale axis, it is typically a power of 10 (e.g., .001, 1.0, 1000.0, etc.).

Major Tic Delta

For a linear scale axis this is the increment between primary tic marks on the resulting axis. This can be any number greater than 0 but typically will not be less than about 5% of the difference between the maximum and minimum axis values. If this value is too small the plot will likely be unreadable due to the large number of tic marks and corresponding grid lines.

For a log scale axis, this value is not used.

Minor Tic Delta

For a linear scale axis this is the increment between secondary tic marks on the resulting axis. This can be any number greater than 0, but typically it would be a value that divides evenly into the major tic delta value. It would typically not be less than 5% of the major tic delta value. If this value is equal to, or greater than, the major tic delta value then no secondary tic marks will be placed on the axis.

For a log scale axis, this value is not used.

1st Major Tic > Min Axis Value

Checking this box, for a linear scale axis, will result in the minimum point on the axis not defaulting to the first primary tic mark. If this box is checked then a value must be specified for the First Major Tic Mark.

This option has no effect on a log scale axis.

First Major Tic Mark

This value should only be entered if the "First Major Tic Not Min Axis Value" box is checked. This value specifies where on the axis the first primary tic mark will occur. Subsequent primary

tic marks will be offset by a multiple of the "Major Tic Delta" value set above. This value must be in the range of Minimum Axis Value <= x <= Maximum Axis Value.

This value has no effect on a log scale axis.

Show Major Gridlines

If this box is checked gridlines corresponding to the primary tic marks will be drawn on the plot.

Show Major and Minor Gridlines

If this box is checked gridlines corresponding to both primary and secondary tic marks will be drawn on the plot. If this box is checked the Show Major Gridlines box has no effect.

Show Minor Tic Labels

If this box is checked the values will be printed for the secondary tic marks (in addition to the labels for the major tic marks).

Exponential Labels

If this box is checked then axis labels will be printed in exponential format (e.g., 1.0E+1), otherwise they will be printed in standard format (e.g., 10.0).

Decimal Places

This value assigns the number of digits after the decimal point that will be printed in the tic mark labels. This must be a non-negative integer. If zero is entered, then no decimal point will be printed.

Font

Clicking this button will bring up the font selection dialog and allow typical font parameters (style, size, color, etc.) to be applied to the tic mark labels.

Default

Clicking this button will reset all values on this dialog to the default values (which, in some cases, are calculated based on the curves in the plot).

5.5.2 Legend Box

This option will produce a dialog allowing the user to set various style options for the legend box as described below. Note that this dialog can also be activated by double clicking on the legend box.

Background Color

Clicking this button will activate the color selection dialog box, which will allow the user to set the background color for the legend box. The default color is white.

Font

Clicking this button will activate the font selection dialog and allow typical font parameters (style, size, color, etc.) to be applied to the text in the legend box.

Change Curve Order

Clicking this button will activate the curve order dialog, which allows the user to specify the ordering of the curves in the legend box.

Background Transparent

Checking this box results in a transparent legend box background; the text will be visible but underlying plots and gridlines will show through. Note that this option overrides any background color that may be selected.

Hide Legend

Checking this box results in the legend box not appearing on the plot. If this option is selected then the legend box may only be restored by activating this dialog through the Format – Legend Box menu option (i.e., you can no longer double click on the legend box to bring up the dialog).

5.5.3 Hide/Show Curves

This option activates the Hide/Show curve dialog. This dialog provides a list of visible curves and a list of hidden curves (initially all curves on the plot are visible). Clicking on a curve in one list will switch it to the other. Any or all the curves in the plot may be hidden in this manner. This provides an alternate method for limiting the curves in the plot (as opposed to setting additional filters). Once curves are hidden they can only be restored by using the Hide/Show curve dialog.

Modifying the data filters (using either the quick select or advanced select tool) cancels the "hidden" property even if the same curves are selected.

5.6 TOOLS

The Tools option brings up a menu that offers the following options:

- Compare Curves
- Reset
- Load New Database File

Compare Curves

This option provides a means for comparing two curves. It brings up a dialog that lists all the curves in the current plot. Any two of these may be selected for comparison. The second curve selected will be subtracted from the first on a point-by-point basis. The resulting curve will be added to the plot. This new curve has the same units as the originals but may have a radically different magnitude, so the range of the Y axis may need to be adjusted before this curve is visible. The order of selecting the two curves will determine whether the resulting curve is positive or negative, so the larger curve is typically selected first. Note that the Y axis extents may need to be changed to show the resulting curve, and negative value curves won't show up at all on a log plot. If the data filters, or axis parameters, are changed then any new curves created through this tool will be deleted. Note that the two curves selected as a basis for the new curve must both be monotonic with respect to the X axis.

Reset Plot

This option resets all plot parameters and options to initial conditions. This includes fonts, axis parameters and ranges, hidden curves, and filters.

Load New Database File

This option allows users to load (or re-load) an existing CritView database file. Selecting this option brings up a Windows file selection window from which the user can select a new database file. The selected file can be either a standard ascii file (typically with a ".txt" suffix) or a binary database file (typically with a ".ar" suffix). The selected file must have a format compatible with the CritView code version.

Loading a new database will replace any existing filters (or plot settings) with the default values. It may be necessary to modify the default filters and settings to be consistent with the new database file.

Note that loading a new ascii database file will result in the code overwriting any existing binary database file. Users are advised to maintain a backup copy of any needed database files.

5.7 HELP

The Help option brings up a menu with the following option:

About CritView

Selecting this option will bring up a window that displays the version number of the code and of the currently loaded database file.

6.0 CODE WARNINGS AND ERROR MESSAGES

This section describes some warning messages that may be encountered by CritView users. These warnings show up in a Windows pop-up text box when certain conditions occur. The situations where they are typically encountered, and the appropriate user actions in response, are described below.

- "No Curves Selected! – Current filter settings exclude all curves!"

  This message appears when the user selects filters that are contradictory or otherwise exclude all the curves in the database. If the indicated filter is applied then the CritView plot (i.e., the axes) will be displayed but there will be no curves on the plot. When this warning is encountered the user should modify the selected filters. The current version of CritView prevents most such filter contradictions but it can still occur if inappropriate ranges are selected for one of the real valued parameters (e.g., reflector thickness).

- "Curves not monotonically changing in x direction - cannot calculate difference"

  This warning can occur when the user activates the "Compare Curves" function (under the "Tools" menu option). If either of the curves selected for comparison is not monotonically changing in the X direction, the comparison cannot be performed. This pop-up message will occur and, after clicking "ok," the user will be returned to the same plot as was shown before the comparison was attempted. Note that "monotonically changing in the X direction" means that curve increases or decreases over the entire curve. For example, monotonically increasing means that every data point in the curve (from first to last) must have an X value greater than the X value of the preceding data point.

- Various "aborting" error messages

  The CritView code has additional built in error messages indicating that an error has occurred, and the program will shut down. These errors typically indicate a problem with the database file but could represent an actual bug in the code. None of these should be encountered during normal use of the code. If such an error does occur, the user should note the filter options and axis parameters in use at the time the error occurred. The user should report the error to the code custodian as indicated on the NCSP web page.

7.0 REFERENCES

ARH-600, 1968, *Criticality Handbook*, R.D. Carter, G.R. Kiel, and K.R. Ridgeway, 1980 Revision, Atlantic Richfield Hanford Company, Richland, Washington.

Appendix A Example Problem

This appendix presents a sample exercise with the CritView code. This serves as both a simple case to acquaint the user with the code and as an installation test case to confirm the code is working properly on a given computer.

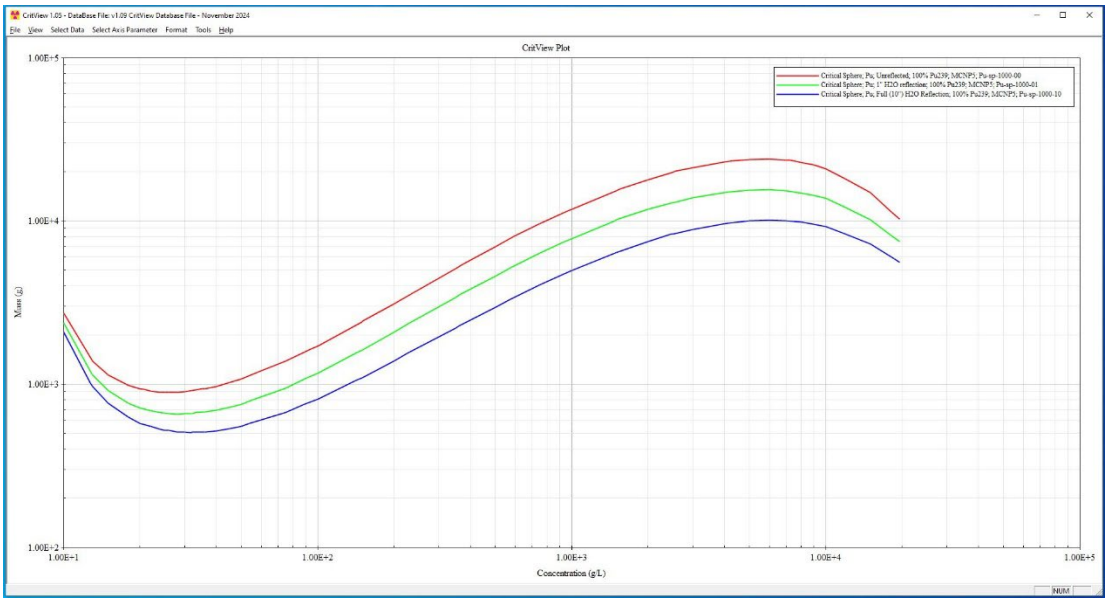
For this example, the user will plot curves representing critical mass vs. concentration for plutonium spheres reflected by water. A series of manipulations will then be performed on these curves to test the functionality of the code.

The first step in the test is to start up the code. The test should always be performed with a fresh instance of CritView; this simplifies the setup required for the test.

After starting the code, click "ok" on the welcome window to close this window (and accept the default filters).

The resulting screen should look like the plot shown in Figure 1.

Figure 1

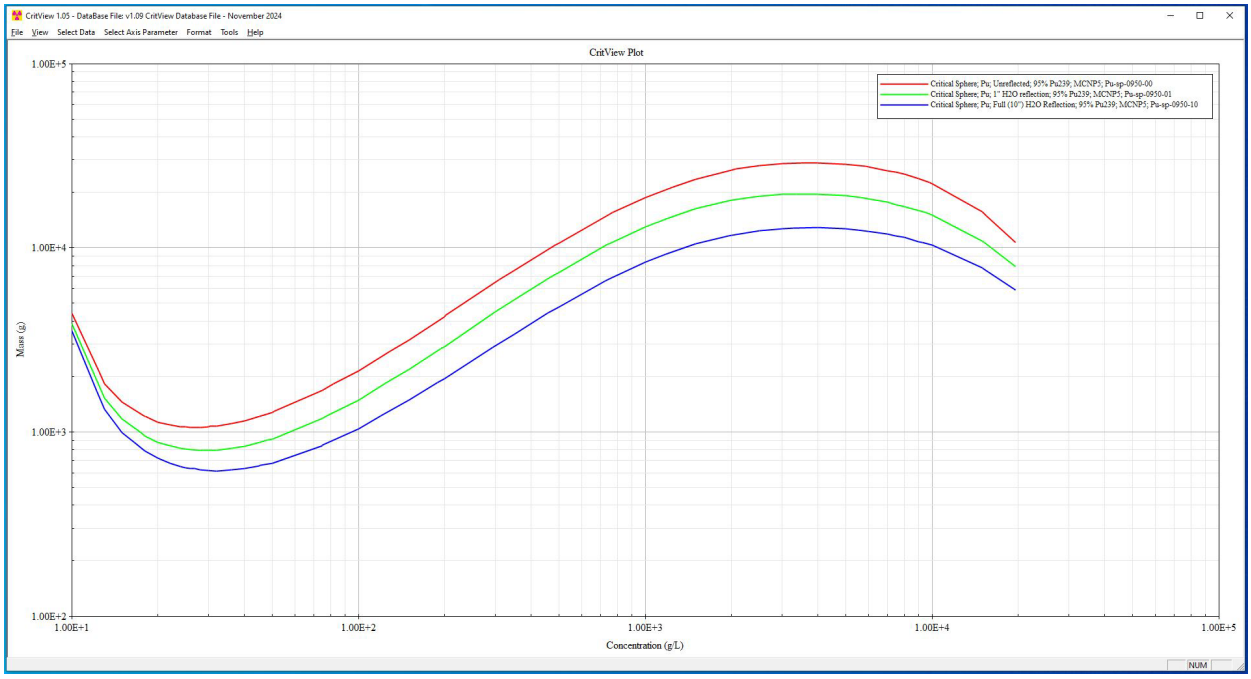


This is the default CritView plot. It shows three curves based on a pure ^{239}Pu sphere: an unreflected sphere; a sphere with 1″ of water reflection; and a sphere with full (10″) water reflection, all taken from the MCNP data set in the database file.

Next, to the user should look at the corresponding curves with 5% ^{240}Pu. To accomplish this, it is necessary to modify the default filters. The filters can be modified using the "Quick Select" tool. Open the Quick Select tool by clicking on the "Select Data" tab and then clicking on "Quick Select". On the "Isotopics" tab of the Quick Select tool, click on the "Set Range" button for ^{240}Pu. This will bring up a dialog box that allows the user to set the desire value or range. First, click on the radio button labeled with the "=" symbol, then enter "95.0" in the box after the "=" sign and select "wt%" in the units box. Next, click the "ok" button to close the isotopics dialog and again to close the quick select dialog.

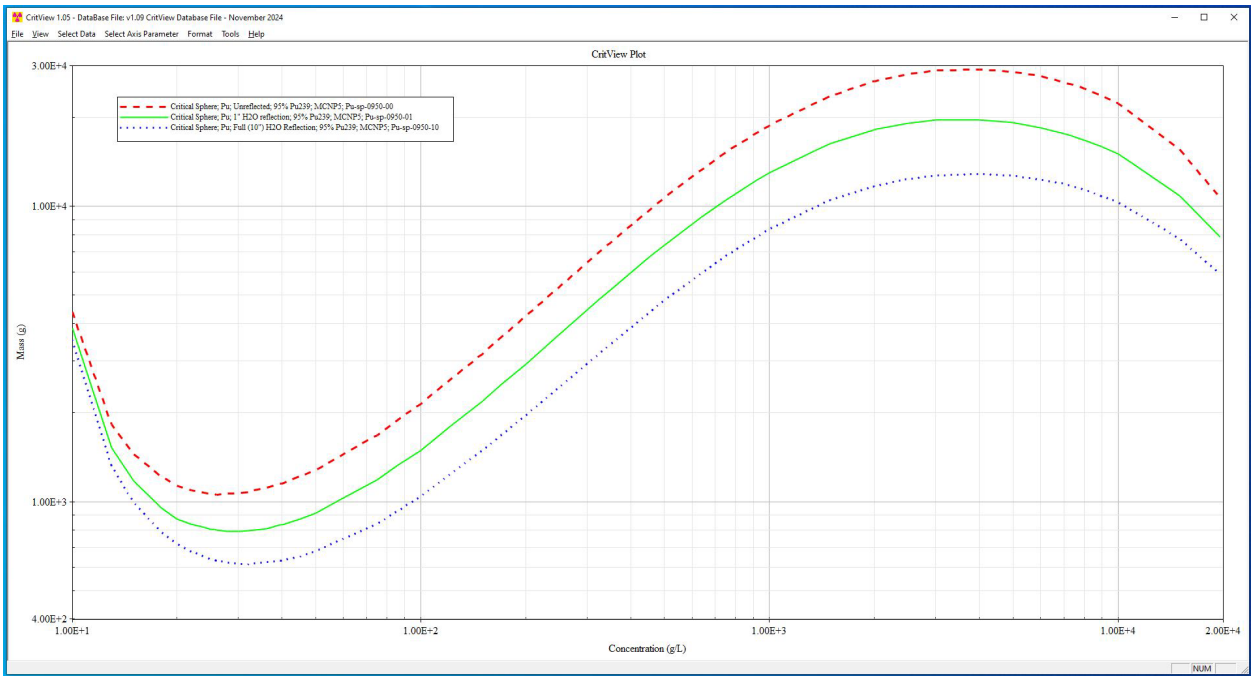
CritView should now show the plot seen in Figure 2.

Figure 2



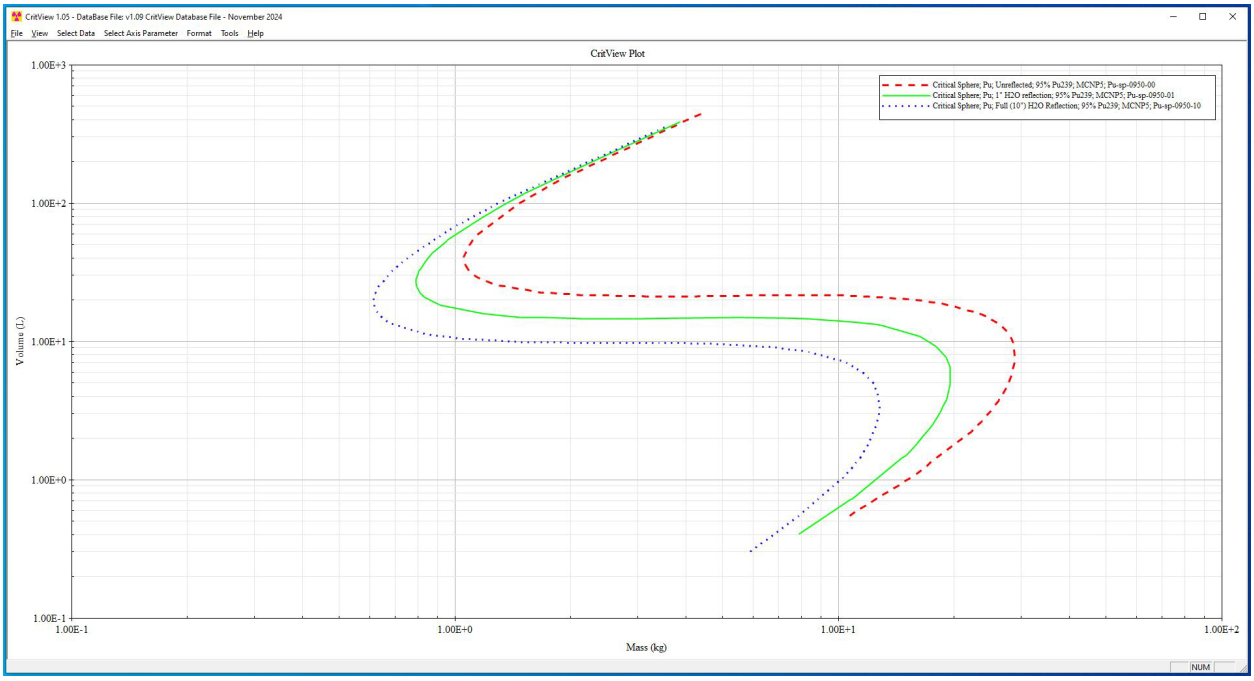
The next task is to change the look of plot. The lines will be changed so that they are easier to distinguish should a black and white copy be made. To do this, first double click on the top line, either on the plot or in the legend box. This will bring up a "Line Style" format box. Find the entry for "Line Style" and change it from solid to dash, also change the line width from "2" to "3", then click ok. Repeat this for the bottom curve, changing its style from solid to dot. Next, we are going to change the scale of the plot. First double click on the X axis; this will bring up an X axis settings box. Change the maximum axis value from 100,000 to 20,000 and click ok. Next, repeat this process for the Y axis, changing the minimum axis value from 100 to 400, and the maximum axis value from 100,000 to 30,000. Now the plot has zoomed in on the curves. Note, however, that the legend box now covers some of the data. Click and drag on the legend box and move it to the upper left portion of the plot so it doesn't cover any data. The resulting plot should now look like Figure 3.

Figure 3



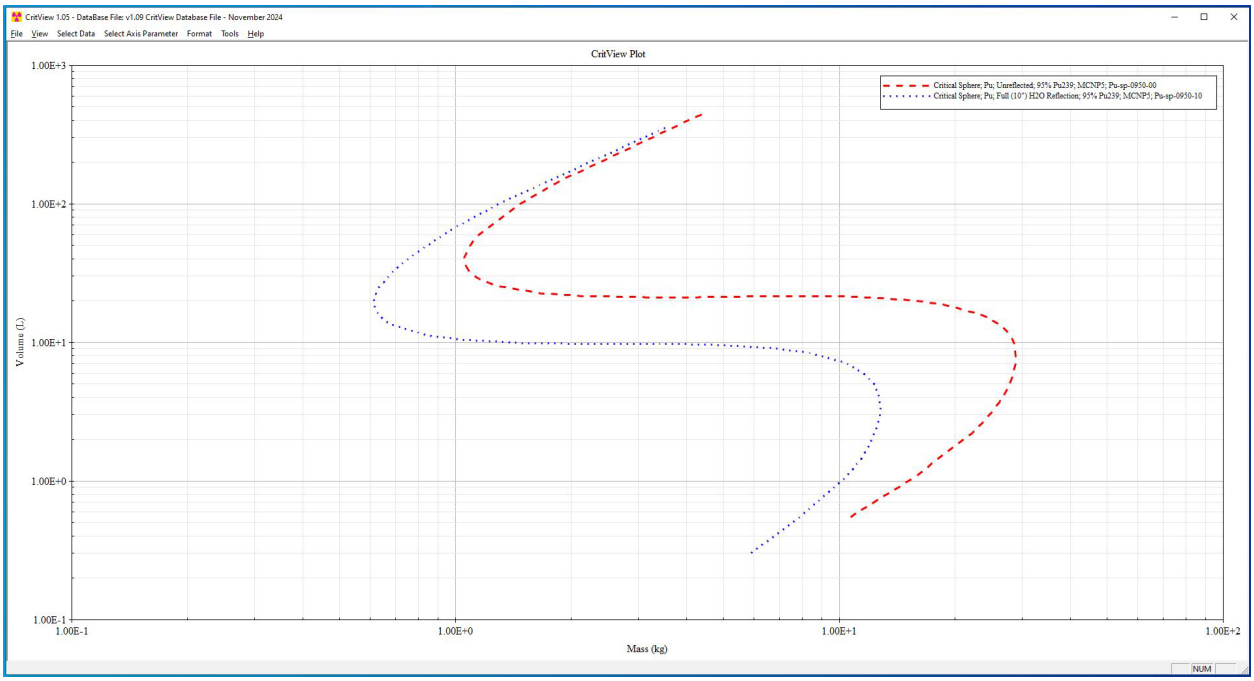
The next step is to convert the plot from mass vs. concentration to volume vs. mass. In addition, the mass axis will be changed from units of grams to units of kilograms. Click on the "Select Axis Parameter" menu option and select "Y Axis." Change the parameter from mass to volume and the units to liters and click on the "ok" button. Repeat this process for the X axis, changing the parameter from fissile concentration to fissile mass, and setting the units to kilograms. The resulting plot should look like Figure 4.

Figure 4



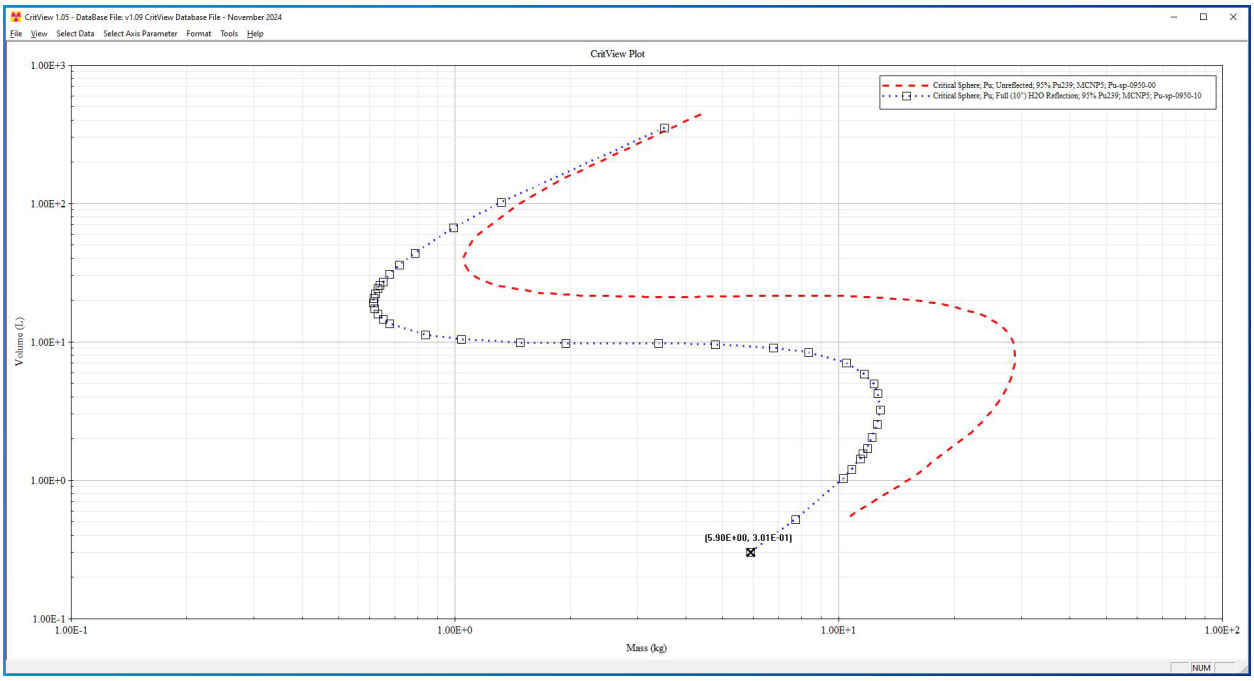
Next, remove the 1" reflection curve and just look at the unreflected and full reflected cases. To accomplish this, click on the Format tab, followed by the Hide/Show Curves menu option. Find the curve (corresponding to 1" reflection) in the left side box (visible curves) and click on it. The curve title should move from the left side box to the right side box (hidden curves), then click "ok". The resulting plot should look like Figure 5.

Figure 5



Finally, we want to test the data to be sure that all these calculations have worked correctly. Click on the left most curve (i.e., the fully reflected case) to highlight it. This will also highlight each of the individual points on that curve. Next, click on the bottom most (lowest volume) point on this curve. This will bring up the X and Y (i.e., mass and volume) values for that point. The result should look like Figure 6.

Figure 6



Confirm that the X and Y values are 5.90E+000 kg and 3.01E-001 L.

Now to double check those numbers, click on the "View" menu option and select the "View Data from Selected Curve" option. This will list pertinent details associated with the curve (e.g., the source and the reflector thickness). It will also list all of the X and Y values for this curve (showing more significant digits than the method above). The concentration (in g/cc) and the diameter (in inches) will be listed for each point. The last point in the list will be for the lowest diameter, which will correspond to the smallest volume point on the plot. This point should be concentration = 19.6 g/cc and diameter = 3.2737 inches. Using basic geometry, show that these values correspond to the above stated mass and volume.

A good follow-on exercise is to go back to the Select Data option and change the Data Source filter to include both the ARH600 and MCNP options. This will result in both sets of data being plotted on the same graph. Comparing the two sets of data one can see that they are in reasonably good agreement in most places, but there are some significant differences. In particular, note that the minimum critical mass calculated by MCNP is (in many places) about 5% lower than the corresponding ARH-600 value. Bear in mind, also, that the MCNP data is not adjusted for bias or uncertainty; if these factors were accounted for then the MCNP values would

be lower still. This demonstrates why the data in this code (and in ARH-600 in general) is not considered precise enough for setting critical limits.

Appendix B CritView Advanced Data Selection Filter Options

The filters available in the advanced data selection dialog of CritView are derived from the database file loaded when the code is run. Strictly speaking, these filters can be different for different versions of the database file but in practice there is generally little change. This section describes the various filter options deriving from the current version of the database file.

Each of the available filters, and their possible values, are described in the following subsections.

Unless otherwise indicated, filters can be set to any number of the available options. Units (when present) must be set to just one of the available options.

B.1 Acid Density

This filter allows the user to put restrictions on the acid density (e.g., g/L nitrate) of the critical material associated with the curves to be plotted. This applies only to nitrate solution curves. There are very few curves in this version of the database that have this parameter as a constant; therefore, this filter is not normally used.

B.2 Acid Molarity

This filter allows the user to put restrictions on the molarity associated with the curves to be plotted. Note that this parameter is only defined for acid solutions. In the current version of the database, the only values available are 0, 3, and 6.

B.3 Annulus Thickness

This filter allows the user to put restrictions on the annulus thickness for curves that are based on annular geometries.

B.4 Area

This filter allows the user to put restrictions on the area of the fissile geometry. This is most applicable to cylinders but can also be calculated for spheres.

B.5 B/X

This filter allows the user to put restrictions on the B/X ratio (i.e., the boron to fissile element ratio) in the fissile material. Only a few curves in the current database include B/X information, and none have this parameter as a constant, therefore specifying this filter will have limited usefulness.

B.6 Concentration

This filter allows the user to put restrictions on the concentration of the critical material associated with the curves to be plotted. There are very few curves in this version of the database that have this parameter as a constant (typically, it is a variable); therefore, this filter is not normally used.

B.7 Concentration - Areal

This filter allows the user to put restrictions on the areal concentration of an infinite slab (plane) in the curves to be plotted. There are no curves in this version of the database that have this parameter as a constant; therefore, specifying this filter will have limited usefulness.

B.8 Concentration - Linear

This filter allows the user to put restrictions on the linear concentration of the curves to be plotted. Note that this parameter is only defined for cylinders (typically only for infinite cylinders). There are no curves in this version of the database that this parameter as a constant; therefore, specifying this filter will have limited usefulness.

B.9 Cross-Section Library

This filter allows the user to put restrictions on the cross-section library used to model the various geometries (e.g., with MCNP or SCALE). Currently there are only two cross-section libraries represented in the database: ENDF/B-VI.6 (MCNP), and ENDF/B-VII.1 (SCALE).

B.10 Data Reference

The Data Reference filter provides a means to select curves based on their reference (e.g., document and page number) rather than on their physical characteristics (e.g., diameter, concentration, etc.). For example, if the (only) filter selected was "Data Reference" with a value of "ARH-600 III.A.3-1" then the resulting plot would show the curves from page III.A.3-1 of ARH-600. Any additional filters set would restrict which of those curves were plotted.

B.11 Data Set

This filter allows the user to limit the curves plotted to those from specific data sets. Note that these are subsets of the Data Source option (see below).

The data sets available in the current version of the database are:

- ARH600 primary — A subset of the ARH-600 curves that represent all relevant data (for $k_{eff} = 1.0$) contained in the database.
- ARH600 secondary — All ARH-600 curves not included in the primary set. The data in these curves is generally duplicative of the data in "ARH600 primary" but is taken from different figures in ARH-600.
- ARH600 k=0.098 — A subset of the ARH-600 curves that include only curves defined with a k_{eff}=0.098.
- LA-10860 — All curves in the database that derive from LA-10860.

- MCNP5 primary — All curves generated with MCNP5; generally duplicates "ARH600 primary" curves.
- SCALE6.1 primary — All curves generated with SCALE6.1; generally duplicates "ARH600 primary" curves.
-

B.12 Data Source

This filter allows the user to limit the curves plotted to those from specific data sources.

The data sources available in the current version of the database are:

- ARH600 — All included curves originating from the ARH-600 handbook.
- LA-10860 — All curves in the database that derive from LA-10860.
- MCNP5 — All curves in the database that derive from MCNP5.
- SCALE6.1 — All curves in the database that derive from SCALE6.1.

B.13 Diameter

This filter allows the user to put restrictions on the diameter (e.g., of a sphere or a cylinder) associated with the curves to be plotted. There are no curves in this version of the database that have this parameter as a constant; therefore, specifying this filter will have limited usefulness.

B.14 Fissile Element

This filter allows the user to select which fissile elements will be included in the selected curves. The current version of the database includes the following three options: plutonium, uranium, and plutonium/uranium mix. Note that selecting just plutonium (or just uranium) will exclude all the curves that contain a plutonium/uranium mixture.

This filter, in conjunction with the fissile material form filter, accomplishes essentially the same function as the fissile material filter.

B.15 Fissile Material

This filter specifies the critical material (e.g., UO_2, Pu) of the curves to be plotted. There are many possible values for this filter in the database. This filter accomplishes essentially the same function as specifying both the fissile element and fissile material form filters.

Some of the more important fissile materials available in this version of the database are:

- Pu (elemental) Plutonium (typically in a metal-water mixture)
- U (elemental) Uranium (typically in a metal-water mixture)
- PuO2 Plutonium Oxide
- UO2 Uranium Oxide
- PuO2 + UO2 A mixture of plutonium oxide and uranium oxide. Note that specifying a filter value of PuO2 and/or UO2 will exclude curves identified as PuO2 + UO2.

In the case of solids (e.g., Pu or UO2) any given critical material applies to both pure materials and materials mixed with a moderator (if such are present in the database). For example, specifying UO2 may produce curves that include pure UO2 and curves representing UO2 mixed with water. Most often, the curves in the database represent a continuity of data ranging from unmoderated to highly over moderated.

This filter accomplishes essentially the same function as the fissile material filter in conjunction with the fissile element filter.

B.16 Fissile Material Form

This filter specifies the critical material form associated with the curves to be plotted.

In the current version of the database there are several fissile material forms available:

- Compound (e.g., oxide),
- Compound-water mixture,
- Metal
- Metal + solution
- Metal-water mixture
- Solution (e.g., nitrate),

B.17 Geometry

This filter specifies the geometry of the curves to be plotted.

There are several geometries available in the current version of the database, including:

- Annuli
- Various arrays

- Cylinders (finite)
- Infcyl (infinite cylinder)
- Infplane (infinite plane or slab)
- Lattice of rods (applies to only a single LA-10860 curve)
- Slab in Cylinder
- Sphere

B.18 H/X

This filter allows the user to put restrictions on the H/X ratio (i.e., the hydrogen to fissile element ratio) in the fissile material. Only a few curves in the current database include H/X information. Currently the code does not provide a means to convert between H/X and concentration, therefore usefulness of this filter is somewhat limited.

B.19 Height

This filter allows the user to put restrictions on the height of an infinite plane in the curves to be plotted. There are no curves in this version of the database that have this parameter as a constant; therefore, specifying this filter will have limited usefulness.

B.20 Isotopic Composition

This filter represents a family of filters that restrict the isotopic content of the various isotopes (e.g., pu239, u233). CritView creates a filter for each nuclide present in the database. These filters allow the user to put restrictions on the content of the specified nuclide. For example, the ^{240}Pu content could be limited (by selecting pu240) to 5 wt%.

B.21 Isotopic Mixtures

This filter allows the user to select specific isotopic mixtures that are present in the database. It accomplishes essentially the same function as the isomat filters but is more specific – rather than specifying ranges for each isotope the user just selects the specific isotopic compositions of interest. For example, the plot could be limited to standard 5 wt% ^{240}Pu curves by selecting the isotopic composition "Pu240 0.05 Pu239 0.95".

B.22 k-effective

This filter allows the user to put restrictions on the k_{eff} associated with the curves to be plotted. There are only a few curves (currently, only some infinite plane cases) in this version of the database where the k_{eff} has a value other than 1.0; therefore, this filter has limited usefulness.

B.23 Length

This filter allows the user to put restrictions on the length of certain geometries. This is only applicable to finite cylinders and slabs.

B.24 Mass

This filter allows the user to put restrictions on the mass of fissile material in the curves to be plotted. There are no curves in this version of the database that have this parameter as a constant; therefore, specifying this filter will have limited usefulness.

B.25 Moderator Material

This filter specifies the moderator material of the curves to be plotted. The most commonly used value here is "H2O."

B.26 Radius

This filter allows the user to put restrictions on the radius associated with the curves to be plotted. There are no curves in this version of the database that have this parameter as a constant; therefore, specifying this filter will have limited usefulness.

B.27 Reflector Material

This filter specifies the reflector material of the curves to be plotted. The most commonly used values here are "H2O" and "none." Some of the possible values include geometric aspects – such reflectors only apply to the corresponding geometries (e.g., "H2O 1 inch one side, full other side (slab geometry)" only applies to infinite planes).

B.28 Reflector Thickness

This filter allows the user to put restrictions on the reflector thickness associated with the curves to be plotted. In the current version of the database, the most common values for this parameter are 0", 1", and 10".

B.29 Volume

This filter allows the user to put restrictions on the volume associated with the curves to be plotted. There are no curves in this version of the database that have this parameter as a constant; therefore, specifying this filter will have limited usefulness.

B.30 Width

This filter allows the user to put restrictions on the width of certain geometries. This is only applicable to finite slabs. There are no curves in this version of the database that have this parameter as a constant; therefore, specifying this filter will have limited usefulness.

Appendix C CritView Database File

The CritView code requires a database file that contains all the data available for plotting along with associated parametric information. This file is named critviewdb.txt. Different versions of this database may be distributed using the suffix v###, where "###" represents the version number of the database.

The data included in the database consists of two types: data that has been acquired by digitization of existing handbook curves, and data that has been generated by computer modeling. All the data (of both types) has been documented in various reports (see the references at the end of this appendix).

The current version of the database is 1.09 (i.e., critviewdb.txt.v109).

This version includes the following data:

- ARH-600 data. The curves from Section III (which is the bulk of the handbook) are mostly present; it omits a few curves based on calculated parameters such as H/X, buckling, and migration area. The curves that are present represent more than 90% of the curves in ARH-600. This data was obtained by scanning and digitizing the plots from the original ARH-600 document.

- LA-10860 data. All of the curves from this handbook are included. This data was obtained by scanning and digitizing the plots from the LA-10860 document.

- MCNP data. Most of the ARH-600 data have been replicated with MCNP version 5.1.40 and included in this version of the database. This data set is considered the most reliable (having been constructed with modern techniques and peer reviewed and documented). Note, however, that even this data does not include any margin for bias, nor does it account for statistical uncertainty. In addition to the ARH-600 data, some MCNP curves have been included that are based on ARH-600 but have a lower k-effective (e.g., k=0.98).

- SCALE data. Many (though not all) of the MCNP curves have been reproduced with SCALE 6.1.

Note that ARH-600 includes a good deal of data that is essentially duplicative. Plots were constructed that showed the same basic data but used different axis parameters (e.g., critical mass vs. diameter and critical mass vs. concentration). For these cases, only a single MCNP plot was included so there are many more ARH-600 curves than MCNP curves.

The ARH-600 curves are divided into two groups: "primary" and "secondary." This is an attempt to avoid duplicate curves in CritView plots. All of the important curves are included in the primary set. The secondary set consists of curves that are equivalent to curves in the primary set (though they may not be identical). For example, one ARH-600 plot may show a series of curves representing a Pu sphere with varying degrees of reflection. Another plot might show unreflected spheres with varying ^{240}Pu content. Both plots might include a curve representing a

bare sphere with 0% ^{240}Pu. If the CritView user were to filter on bare spheres with 0% ^{240}Pu content (without distinguishing between primary and secondary curves) then both curves would show up on the plot. By arbitrarily labeling one curve as primary and any other equivalent curves as secondary, CritView allows the user to ensure that only unique curves are included in their plot. In addition to the preceding example (where the two curves are essentially identical), there are curves in the secondary set that are equivalent in the sense that they can be converted to the primary plot. For example, one ARH-600 plot might show curves, representing bare Pu sphere, in units of diameter vs. concentration. Another plot might show curves representing the same spheres but in units of mass vs. concentration. These curves would be equivalent because diameter can be converted to mass for a given concentration.

The desired set (e.g., "ARH600 primary") can be selected with the data filter "Data Source" (see Appendix B).

The MCNP plots are all labeled "primary". This has no special significance, it was just intended to be analogous to the ARH600 data set, and to allow for future development where an MCNP secondary data set might be desirable.

The development and peer review of the database is described in a group of Hanford and SRNS documents identified in the references shown below.

References

ARH-600, 1968, *Criticality Handbook*, R.D. Carter, G.R. Kiel, and K.R. Ridgeway, 1980 Revision, Atlantic Richfield Hanford Company, Richland, Washington.

CHPRC-01550, 2011, *Development of LA-10860 Database for CritView*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington.

CHPRC-01552, 2011, *MCNP5 Calculations Replicating ARH-600 Nitrate Data*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington.

CHPRC-01617, 2011, *CritView Database – Version 1.05*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington.

CHPRC-01905, Rev. 1, 2013, *MCNP5 Calculations Replicating Additional ARH-600 Data (2012 Subset),* Rev. 0, CH2MHILL Plateau Remediation Company, Richland, Washington.

LA-10860, 1987, *Critical Dimensions of Systems Containing ^{235}U, ^{239}Pu, and ^{233}U, 1986 Revision*, Los Alamos National Laboratory, Los Alamos, New Mexico.

PRC-NS-00009, 2013, MCNP Calculations Replicating ARH-600 Data, Rev. 1, CH2M HILL Plateau Remediation Company, Richland, Washington.

N-NCS-G-00191, 2022, *SCALE Calculations Replicating ARH-600 Data*, Rev. 0, Savannah River Nuclear Solutions, Aiken, SC.

N-NCS-G-00192, 2021, *Digitizing Curves from LA-10860 to be Used in CritView*, Rev. 0, Savannah River Nuclear Solutions, Aiken, SC.

Appendix D CritView Database File Format

This appendix provides an overview of the CritView database text file format. It is not intended to provide a complete description (adequate to create a new file) but rather a general guideline for users who may want to read the database file directly.

The database text file can be read by printing it or by loading it into a standard text editor. While it is also possible to edit the file, this is not recommended. At a minimum, if the file is changed in any way, the file should be given a new name and have the details of the change noted in the file comment lines.

The file begins with a title line, two meta commands, and a series of comment lines (which may be before, after or intermixed with the meta commands.

The first (non-comment) line is a title for the database file (e.g., "v1.08 CritView database file").

The two meta commands are:

- DBversion: *text*
- CVversion: *text*

The text string for DBversion is the version number of the database file (e.g., 1.09). The text string for CVversion is the minimum CritView version with which this database file is compatible. For example, the meta command "CVversion: 1.05" implies that the file can only be used with CritView version 1.05 or newer (note that newer versions might not be compatible – users will have to check with the user's guide for the specific version in question).

The comment lines can provide any desired information but typically provide a change history of the database. Note that any line that begins with an exclamation point ("!") is a comment (i.e., ignored by CritView).

Following the change history lines, the rest of the file consists of a series of curves. Each curve consists of header information followed by a number of data points. The header information is indicated by a keyword (e.g., "title") followed by a colon and a blank space, followed by the applicable data. The keywords are, for the most part, optional and may be presented in any order. There are, however, two exceptions: the keyword "reset" must always be present and must be the first line of each curve. The keyword "var" must be present at least twice (i.e., two distinct lines) and must be presented in the same order as the values in the data points (i.e., the first occurrence corresponds to the first column of data, the second occurrence corresponds to the second column, etc.). The "var" keyword will be discussed further below.

The data points must be presented after all of the keyword data. Each data point consists of two or more values on a single line, such that the first value forms the first column, the second value the second column, etc. The first two values typically represent the main variables associated with the curve and can be thought of as the X and Y axis values. Other values (if present) represent associated data (e.g., the statistical uncertainty at each point). There may be any

number of data points in a given curve; the data is considered complete when the next occurrence of "reset" is encountered.

Common keywords:

Reset	This keyword marks the beginning of a new curve. There is no data associated with this keyword (however the trailing colon is still required).
Title	The data on this line is an arbitrary alphanumeric string that describes the curve.
Reference	An alphanumeric string that identifies the reference document (and page number or figure) that the curve was taken from.
Created	The date that the curve was created or entered into the database.
Source	An arbitrary string used to group different curves together (e.g., "ARH600" or "MCNP").
Set	A second arbitrary string used to group different curves together. Typically, it is treated as a subset of the group identified with the "source" keyword (e.g., "ARH600 primary").
Geometry	A flag that identifies the geometry of the curve. Common values are "sphere," "infcyl" (infinite cylinder), and "infplane" (infinite plane or slab).
Modmat	The moderator material. Most often this is set as "H2O".
Critmat	The critical material. There are a number of different possible values, such as Pu (elemental), UO2, Pu – nitrate, etc. The actual name is arbitrary but must be the same as other curves that represent the same material.
Fiss-element	The element(s) included in the material represented by the curve (e.g., plutonium).
Fiss-form	The form of the material represented by the curve (e.g., metal water mixture).
Isomat	This keyword identifies the nuclide fraction of the fissile elements and isotopes represented by the curve. An example entry is "PU240 0.2 PU239 0.8", indicating plutonium with 20% ^{240}Pu and the rest ^{239}Pu.
Reflmat	The reflector material. The most common entries are "H2O" and "none."
Refthick:	The thickness of the reflector associated with the curve. The data on this line includes a numerical value followed by an alphanumeric units designator (e.g., "10.0 in").
k_{eff}	The k_{eff} value of the configuration associated with the curve. Most often this is 1.0.

Var	The var keyword must occur once for each value in the data points that make up the curve (most often there are two values, so the keyword must occur twice). The data on the "var" line is a name associated with the parameter represented by the value, and an associated units designation (which may be blank in some cases). Two of the most common values are "critconc g/cc" (indicating critical concentration in units of g/cc), and "Diameter in" (indicating diameter in inches).

Appendix E Known Issues and Error Reporting

The newest version of CritView represents a significant revision and all known bugs have been resolved. There are, however, still a few known issues that need improvement, and there are undoubtedly some bugs yet to be found. The known issues are listed at the bottom of this section. We always appreciate help in improving the code, including identifying errors and making suggestions. If you find errors or have suggestions, please send them to the code custodian as indicated on the NCSP web page.

Note: when a code crashes Windows typically produces an error message that includes the nature of the error, the module name, the line number, and sometimes the variable name. This information is of surprisingly little use when debugging Windows code because most often it only points to some internal Microsoft library function. Nevertheless, please include it with any bug report if you can. The most important information to provide is how to reproduce the error or, at least, what you were doing when it occurred. The particular version of the code (found in the About popup, accessible from the Help menu) and of the database (also found in the About popup) are also important information to include in any bug report.

Known Errors and Limitations:

- Nuclide content (e.g., percent ^{240}Pu**)** cannot currently be used as an axis parameter.
- File Export **-** jpeg option does not allow compression.
- Some fonts do not work for the Y-Axis label. In addition, some fonts will appear as designed on the screen but will not print correctly. This is primarily true for certain older non-True-Type fonts, in particular the WST fonts that were included with some versions of Microsoft Windows. Most common fonts work without issue.
- Curve Plotting Loop – Occasionally, mostly when attempting to plot a very large number of curves, Windows will go into a loop where it repeatedly draws the same curves over again. If this happens, it is best dealt with by placing the CritView window behind some other window (e.g., File Explorer) and allow CritView to finish drawing in the background.