MultiVapor TUTORIAL
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(Tutorial Section One - Opening Window)

Welcome to the MultiVapor Tutorial. MultiVapor is a computer tool for estimating breakthrough times and service lives of air-purifying respirator cartridges manufactured to remove toxic organic vapors from breathed air. It can also be used for larger filters and for carbon beds of any size prepared for laboratory studies. MultiVapor replaces the program, Breakthrough, which performs the same function for only one organic vapor at all humidities.

A breakthrough time is the time following the first and continuous use of a cartridge after which the user of the cartridge could be exposed to a selected concentration of a harmful vapor. This is the consequence of the cartridge being used up. Service life is the breakthrough time with, possibly, a safety factor applied.

MultiVapor is intended to help an industrial hygienist or other qualified person to set cartridge change-out schedules. It is **not** a substitute for regulatory requirements or professional judgments.

Users must assume full responsibility for any application of the MultiVapor computer software. No warranties related to the software are expressed or implied by the National Institute for Occupational Safety and Health or its contractors. This software is intended to provide estimates based on the latest scientific information. The accuracies of any such estimates will depend in part on the accuracy and validity of the data entered by the user.

This tutorial will now guide us through the steps of using the MultiVapor computer program. We will see the windows as they appear when using the program and we will learn how to interact with those windows to enter the required data and get results.

Let's begin by clicking on the **[About]** button in the upper left hand corner of this window.

(Tutorial Section Two – About Window)

The About window summarizes the research leading to the mathematical model and MultiVapor computer program. The basis and description of the model can be found in the publication cited here.

Now let's return to the opening window of the program by clicking on **[Return]**.

Pressing the **[Continue]** button takes us to the Data Input window.

(Tutorial Section Three – Data Input Window)

This window shows the three categories of input information that are required to estimate a breakthrough time.

The first input category (in green) includes information about the respirator cartridge and the activated carbon it contains for removing organic vapors.

The second input category (in blue) includes information about the organic vapors of concern.

The third input category (in pink) includes data related to respirator use conditions.

Let's begin the data entry process by clicking on the **[Organic Vapor Cartridge]** button which will take us to the Cartridge or Carbon Bed Data window.

(Tutorial Section Four– Cartridge or Carbon Bed Data Window)

The eight parameters that appear in this window are required to characterize the cartridge or carbon bed. They should be available from the cartridge, filter, or carbon manufacturer. After entering a cartridge description, the parameters can be entered and saved in the database for easy future retrieval by pressing **[Save Entry in Database]**.

The **[Clear Data]** button clears all fields and allows a new cartridge description and its parameters to be entered.

For this tutorial we've been provided with a set of sample cartridge parameters. They are saved in the program database under the cartridge name, "Typical OV Cartridge." We choose this name from the drop-down list-box and press the **[Search for Data]** button to automatically fill all eight parameter fields.

To continue, we click on the **[Return]** button which takes us back to the Data Input window.

(Tutorial Section Five – Vapor Data Window)

Next, we need to specify the properties of the vapors.

Pressing **[Organic Vapor #1]** takes us to the Organic Vapor Data window.

We see that this window looks like the Cartridge or Carbon Bed Data window. User interactions in both windows work the same. The four buttons on the right all have the same labels and perform the same functions.

In the Organic Vapor Data window, we can select the first chemical vapor of concern from the drop-down list-box. Optionally, we could type in the chemical name in the box above or type its Chemical Abstract Services (CAS) number in the box below. A CAS number always has three numbers separated by dashes.

For this tutorial we select "Cyclohexane" from the chemical names by scrolling down the list-box past those chemicals with numerical prefixes. We need to be careful to avoid selecting a chemical with a similar name.

By pressing the **[Search for Data]** button, we can retrieve most of the data fields that are needed to estimate the breakthrough times. The CAS number is also displayed to confirm that the desired chemical has been selected.

As an exercise, let's press **[Clear Data]** and search the database using the CAS number 110-82-7. The chemical name we get is "Hexanaphthene," not "Cyclohexane." Searching by a CAS number finds all the synonyms for the chemical name and inserts them in the list box. From the drop-down list-box, let's choose the name we prefer, "Cyclohexane."

If we press **[Return]** at this point we get an error message saying we aren't finished yet. Pressing **[Return]** in the Information Incomplete window takes us back to the Vapor Data window.

The blank data field relates to a condition that varies from workplace to workplace. Therefore, the database doesn't store a value for this. It's the average concentration, in parts-per-million units, of vapor measured in the workplace. This value is best obtained by an industrial hygienist or other air-measurement expert.

For this tutorial, let's enter 1200 parts-per-million as a sample measurement for cyclohexane.

We press **[Return]** to store the values for later calculations and take us back to the main Data Input window.

As we can see, the Data Input window now lists our cartridge and our first organic vapor.

MultiVapor has the capability of handling cases where there may be up to five organic vapors in the workplace. The other components of such mixtures in air are entered just as the first one was. The order of vapor entries doesn't matter, but the program may change the order when it calculates results.

Let's enter two more vapors: 500 parts-per-million of MIBK (methyl isobutyl ketone) and 800 parts-per-million toluene.

Returning to the Data Input window, we see the name of the cartridge and the three vapors we entered.

Now we need to specify the workplace environment itself. We press the **[Use Conditions]** button to take us to the Use Conditions window.

(Tutorial Section Six– Use Conditions Window)

It contains default values. These must be changed to reflect the actual temperature, atmospheric pressure, and relative humidity of the workplace environment. These values should be measured in the workplace with appropriate instruments.

The number of cartridges used with a particular respirator must be stated. This ranges from one or two cartridges for a negative-pressure, air-purifying respirator to up to five for a powered air-purifying respirator.

It's also important to specify the average breathing rate. For example **only**, the chart at the bottom of the window describes typical breathing rates for various work efforts. However, the actual breathing rate depends upon the size and physical condition of the person using the respirator. Again, an industrial hygienist should be consulted to specify this parameter.

For our example we will use the default values and click the **[Return]** button.

If we hadn't visited and filled in all the input windows, we couldn't proceed. Since we've done so, we can press the **[Continue]** button, which will take us to the final window.

(Tutorial Section Seven– Results Window)

The breakthrough time calculations now need one last category of data input. We must enter the breakthrough concentrations in parts per million in the appropriate boxes in this window. These values are the maximum concentrations the worker is allowed to breathe. They can be specified by a regulated standard, with or without a safety factor, or given as a professional judgment by an industrial hygienist. Let's enter 300 for the allowable breakthrough concentration of cyclohexane, 100 for MIBK, and 200 for toluene.

At this point, if all the necessary parameters have been appropriately entered, pressing the **[Calculate Results]** button at the bottom of the window causes the program to complete the calculation. The program reports the answers for the estimated breakthrough times in the top right of the window. In this case we see estimated breakthrough times of 52 minutes for cyclohexane, 86 minutes for MIBK, and 107 minutes for toluene.

The calculation also provides lower and upper bounds for the breakthrough times to give an idea about the uncertainty of the answers. These range estimates are based upon model limitations and testing. They do not take into account incorrect input parameters. For our example, the breakthrough time range for cyclohexane is 42 to 63 minutes.

Another calculation can be done by pressing **[Return to Data Inputs]** to go back and change the cartridge, the vapors of concern, or the use conditions. Ultimately, four of the Use Condition parameters can be changed on the final window. For example, let's increase the relative humidity to 80 per cent. This reduces the cyclohexane time to 48 minutes.

This Results window can be printed by clicking on the **[Print this Window]** button.

Notice the **[Exit]** buttons at the bottom of the Results window and in the Data Input window. They will terminate the program with the loss of results and any data that has not been saved in the databases with the **[Save Entry in Database]** buttons. However, a chance will be given to verify terminating the program. Let's confirm by pressing **[Yes]**.

This brings to an end the MultiVapor tutorial; we hope that this service life estimation computer program will be beneficial to you and your workers. Please contact us with any suggestions and comments so we can improve it.