

3M™ Service Life Software – United States

Introduction to Select and Service Life Software

3M™ Service Life Software is designed to help you estimate the service life of 3M gas/vapor respirators and cartridges. This help information is for the 3M Service Life Software.

3M™ Select Software is designed to help you choose the appropriate 3M respirator for your work environment. Help information for Select Software is available from within the Select Software program.

By using the links in the left margin, you may also do any of the following:

- use the 3M Service Life Software
- go to the 3M Occupational Health and Environmental Safety Division website
- download a pdf file of a respirator selection guide
- select a different country
- or contact 3M OH&ESD

Service Life Software

Gas and vapor cartridges consist of a container filled with a sorbent. Typically this sorbent is activated carbon or activated carbon with a chemical treatment. The sorbent will adsorb specific gases and vapors for a period of time until the gas or vapor begins to exit (break through) the outlet side of the cartridge. Service life is the time until breakthrough of a specified concentration occurs. Service life of the cartridge will depend on many factors including the type of sorbent, amount of sorbent, specific chemical(s), chemical concentration, temperature, humidity, atmospheric pressure, and flow rate through the cartridge.

Because cartridges have a limited service life, an appropriate cartridge change schedule must be implemented. The U.S. Occupational Safety and Health Administration (OSHA) requires employers to change cartridges based on objective data instead of relying on subjective warning properties (e.g. odor or irritation) as an indication of gas or vapor breakthrough. If a chemical cartridge change schedule can not be established, a supplied air respirator or other atmosphere supplying respirator must be used instead. Please see OSHA standard 29 CFR 1910.134 for more information.

This software is designed to help estimate service life for 3M gas/vapor respirators. It can help determine if the service life is sufficient for your application and if so, aid in establishing a cartridge change schedule. Where two or more chemical cartridge respirators are appropriate, a service life estimate may help determine which chemical cartridge would be the best choice.

WARNING! Misuse of this software may cause sickness or death!

- This software cannot be used to make respirator selection. Prior to using this software, you must determine if a specific cartridge or respirator is appropriate. Please see 3M Select Software or contact 3M at 1-800-243-4630 for assistance.

- The service life estimates in this software apply only to specified 3M respirators and must not be used for non-3M respirators.
- The uncertainty in the service life estimate made by this software may be as much as $\pm 50\%$. Accurate input data from the user is essential. Appropriate safety factors should be used to account for any sources of uncertainty.

This software is not for particle filters. Instead, these are changed according to physical damage, increased breathing resistance, or time limitations in the presence of oily aerosol. Please see respirator or filter user instructions for more information.

The general process to estimate cartridge service life using this software tool is as follows:

- enter one or more contaminants,
- enter the exposure levels for the contaminants,
- select your cartridge,
- enter temperature, relative humidity, atmospheric pressure,
- and select work rate or type of headgear used with powered air purifying respirators (PAPRs).

You can navigate through the software by answering the questions and selecting “continue”. **Do not use the Back and Forward arrows on your browser.** The remainder of this help document explains each successive screen.

Contaminants

SELECTING A CONTAMINANT:

The software contains a database of chemical names, chemical abstract service registry numbers (CAS #s) and occupational exposure limits (OELs). The CAS numbers were established by the American Chemical Society to harmonize chemical identification regardless of the synonym used or differences in spelling. The OELs are the maximum airborne contaminant concentration allowed in the breathing zone of the worker. However, an OEL is not a fine line between safe and unsafe conditions for all workers, and must be used with caution.

There are different types of OELs depending on the duration of the exposure: 8 hour time weighted average (TWA) exposure limits, 15 minute short term exposure limits (STEL) and/or ceiling (instantaneous) exposure limits. The OELs used in this system are the lowest value of either the ACGIH® Threshold Limit Values (TLVs®), OSHA Permissible Exposure Limits (PELs), or American Industrial Hygiene Association Workplace Environmental Exposure Levels (AIHAWHEELs). TLVs are from ACGIH®, 2009 TLVs® and BEIs® Book. Copyright 2009. Reprinted with permission. The OEL units are either parts of contaminant per million parts of air (ppm) or milligrams per cubic meter of air (mg/m^3).

You may select one or more contaminants to estimate service life. To select a contaminant, click in the "Search" box and then begin to type either the name or CAS number. You will be taken to the contaminant as you type. Click on the “+” button next to a contaminant to add it to your list

of “selected contaminants” in the bottom half of the screen. To restore the complete list of contaminants in the top half of the screen, click the "Clear" button.

UNLISTED CONTAMINANTS

Chemicals without established occupational exposure limits or other required data are not included in the software. Chemicals that are mainly used as pesticides are not included since respirator information should be provided by the pesticide manufacturer per Environmental Protection Agency (EPA) regulations.

Service life for unlisted organic vapors may be estimated by choosing a chemical of similar molecular weight and/or vapor pressure. This option is often necessary for organic liquid mixtures of variable composition, such as gasoline, mineral spirits and petroleum distillates. Appropriate caution and safety factors must be used with this method.

Sulfur dioxide can be used as a surrogate to provide a conservative service life estimate for hydrogen chloride, hydrogen fluoride, hydrogen sulfide, chlorine or chlorine dioxide.

ENTERING A “USER-DEFINED ORGANIC VAPOR”

If you do not see the organic vapor you are looking for, you may enter it yourself by clicking on the “Enter User-Defined Organic Vapor” button at the top of the page. However, to use this function, the contaminant must be an organic liquid at your temperature of interest, and you must enter the following information:

- Contaminant name
- CAS number (optional)
- Exposure limit
- Molecular weight (grams/mole)
- Index of refraction (nD)
- IDLH (optional) - This is the concentration considered Immediately Dangerous to Life or Health. For chemicals that do not have an established IDLH level, a lower explosive limit (LEL) may be used.
- Liquid density (gm/cm³)
- Saturated vapor pressure (mm Hg). Vapor pressure varies by temperature. Please enter the saturation vapor pressure for the temperature where the respirator is used.
- Temperature (degrees C or F) – This is the temperature where the respirator is used.
- Exposure - The exposure is the contaminant concentration in air measured in the breathing zone of the worker. It is NOT the concentration (e.g. % by weight) listed on a material safety data sheet. For more information on sampling worker exposure levels, please call 3M at 1-800-243-4630 or contact an industrial hygienist. For a list of certified industrial hygienist consultants, please see www.aiha.org. You must input your contaminant concentration in either ppm (parts per million) or mg/m³ (milligrams per cubic meter). If your concentration is in other units you must first convert it into either ppm or mg/m³. Change between ppm and mg/m³ by clicking on the window displaying the unit.

Some of the information required above may be found in handbooks of chemistry and physics or from chemical suppliers. After all required fields have been entered, select the “Add New User-Defined Organic Vapor” button.

REMOVING A CONTAMINANT:

To remove a contaminant from the list of “selected contaminants” in the bottom half of the screen, click on the “-“ button next to the contaminant.

ENTERING EXPOSURE LEVELS:

You must enter an exposure level for each of the contaminants that you have selected. To enter an exposure, click on the box next to the contaminant and enter the exposure concentration.

Note: The exposure level is the contaminant concentration in air measured in the breathing zone of the worker. It is NOT the concentration (e.g. % by weight) listed on a material safety data sheet. For more information on sampling worker exposure levels, please call 3M at 1-800-243-4630 or contact an industrial hygienist. For a list of certified industrial hygienist consultants, please see www.aiha.org.

The units for exposure levels are either parts per million (ppm) or milligrams per cubic meter of air (mg/m^3). In some cases, you may also change the units used for the exposure. To change units, select the desired unit of measure from the units drop-down list. If your concentration units are not one of the options, you must convert your exposure value to one of the options available. When you have entered all exposures click the "Continue" button.

Environment and Cartridge Selection

A list of chemical cartridges will be displayed depending on the contaminants that you have entered. Click on the drop down arrow to find your cartridge. 3M has not tested all possible combinations of contaminants and cartridges for this software. If you can't find your cartridge, or if no cartridges are listed, please contact 3M technical service at 1-800-243-4630. If more than one cartridge will be used, a separate service life estimate must be determined for each. For cartridges that are combined with particulate filters, use the number from the chemical cartridge itself (use of a particulate filter in combination with a cartridge does not affect gas or vapor service life).

RELATIVE HUMIDITY

Relative humidity (RH) greater than 65% can dramatically reduce service life of organic vapor cartridges. The effect depends on the relative humidity level, the chemical concentration, volatility of the chemical and the chemicals miscibility (ability to dissolve) in water. If you select $\text{RH} > 65\%$ (e.g. 65, 75, 85 or 90%), the software will automatically correct for organic vapor service life using testing done with water immiscible (insoluble) solvents to demonstrate worst-case RH effects.

The service life estimates for acid gases, ammonia, methylamine and formaldehyde are based on testing done at 50% relative humidity. In contrast to organic vapor service life, relative humidity greater than 50% may increase the service life for these chemicals. Service life at lower relative humidity for these materials may be shorter than the software estimates. **The software does not adjust service life for these chemicals at various relative humidities.**

ATMOSPHERIC PRESSURE

Enter the atmospheric (barometric) pressure at your facility. The pressure must be between 0.8 and 1.2 atmosphere (ATM). Your barometric pressure can be obtained by calling the local weather station or airport and requesting the unadjusted barometric pressure.

If these sources are unavailable, atmospheric pressure at sea level is about 1 atmosphere (760 mm or 29.92 inches Mercury - Hg). A general rule of thumb is to decrease barometric pressure by 0.033 ATM (1 inch Hg) for every 1000 feet of elevation, since barometric pressure is mostly affected by altitude (feet above sea level). (Ness, S. A.: Air Monitoring for Toxic Exposures. New York: Van Nostrand Reinhold. 1991. p. 508.)

TEMPERATURE

The software calculations for organic vapors are limited to a temperature range of 32°F to 122°F (0°C to 50°C). The temperature range is further limited to ensure that all of the organic vapors selected are liquids and vapor pressure data is available.

Select a temperature by clicking on the temperature and unit pull-down windows. Choose the temperature closest to your work environment in degrees Celsius or Fahrenheit. Higher temperatures may result in a shorter service life for organic vapors. Therefore, if your temperature is in between the options listed, you may wish to choose the higher temperature to give a conservative estimate.

For acid gases, ammonia, methylamine or formaldehyde, temperature is only used, if necessary, to convert between exposure level units (ppm and mg/m³). It is not otherwise used in the calculation of service life.

WORK RATE OR PAPR TYPE

Service life estimates are dependent on the airflow rate through the respirator. For negative pressure respirators, airflow through the respirator increases with increasing work rate (breathing rate). Select the most appropriate work rate for your work environment from those listed. Light, medium and heavy are defined as 20, 40 or 60 liters per minute, respectively (Nelson, G.O. and Correia, A.N., Respirator Cartridge Efficiency Studies VIII. Summary and Conclusions. Am. Ind. Hyg. Assoc. J. 36:514-525 [1976]). Higher breathing rates may occur for a short duration for certain intense activities. Appropriate safety factors should be applied.

Powered air purifying respirator (PAPR) airflow depends on whether the device is tight fitting or loose fitting. Tight fitting means either a half facepiece or a full facepiece. Loose fitting means a

helmet, hood or loose fitting facepiece. This software uses flow rates of 185 Lpm and 250 Lpm for 3M tight fitting and loose fitting systems, respectively.

Solution

Organic vapor service life estimates are calculated using a model presented by Wood (Wood, G.O.: Estimating Service Lives of Organic Vapor Cartridges, American Industrial Hygiene Association Journal 55[1], January 1994, p. 11-15.) The Wood model was modified for the characteristics of 3M cartridges, and some of the experimentally determined values were refined.

Service life for acid gases, ammonia, methylamine and formaldehyde is estimated using laboratory test data for each specific chemical. Service life was measured at concentrations within a range of approximately 10 to 100 ppm or 50 to 1000 ppm depending on the cartridge, and then a curve was fitted to the data.

BREAKTHROUGH CONCENTRATION

Service life is the time required for a stated breakthrough concentration of a contaminant to be detected on the downstream side of a cartridge. For organic vapors, the breakthrough concentration used in this software depends on the exposure level. If the exposure level is greater than the occupational exposure limit, then service life will be estimated until the breakthrough concentration reaches $\frac{1}{2}$ the occupational exposure limit. If the exposure level is less than the occupational exposure limit, service life will be estimated until the breakthrough concentration reaches 10% of the exposure level.

For acid gases, formaldehyde, ammonia or methylamine, the breakthrough concentration is from the laboratory testing. It does not change depending on the exposure concentration that you have entered.

MIXTURES

Service life estimates for organic vapor and non-organic vapors (acid gases, ammonia, methylamine and formaldehyde) mixtures are calculated separately and the shortest service life is chosen.

The method of estimating service life for mixtures of organic vapors is taken from OSHA CPL2-0.120, "Inspection Procedures for the Respiratory Protection Standard" September 25, 1998.

- 1) Service life for each of the organic vapors is calculated individually, and the organic vapor with the shortest service life is noted.
- 2) Concentrations are summed for all organic vapors with service life within a factor of 100 of the shortest service life.
- 3) Service life is estimated using the organic vapor with the shortest service life and the summed concentration.
- 4) Organic vapor service life is reported as whichever is shorter between step 1 and step 3. (Note: for certain volatile organic vapors, service life will actually increase with increasing concentration within a limited concentration range, hence the need to consider both step 1 and step 3.)

A different method is used for the non-organic vapor mixtures.

- 1) All of the acid gas and formaldehyde concentrations are summed.
- 2) Service life is estimated for each of the acid gases and formaldehyde using the summed acid gas/formaldehyde concentration.
- 3) All of the ammonia and methylamine concentrations are summed.
- 4) Service life is estimated for ammonia, methylamine and using the summed ammonia/methylamine concentration.
- 5) Non-organic vapor service life is reported as whichever is shorter between step 2 and step 4.

ESTABLISHING A CARTRIDGE CHANGE SCHEDULE

The estimated service life is only one piece of information to consider in establishing a change schedule. Cartridge change schedules must be practical and easy for workers to remember (e.g. 1 day instead of 1.3 days). One must also consider any local regulations and migration of the contaminant through the cartridge during storage.

US OSHA has mandatory cartridge change schedules for certain substances (acrylonitrile, benzene, formaldehyde and methylene chloride). If one of these contaminants is selected, a warning message will appear along with the reference to the specific OSHA standard.

MIGRATION

Migration is mainly a concern for organic vapors, and less so for acid gases, ammonia, methylamine and formaldehyde. Organic vapors can migrate through an organic vapor cartridge during periods of non-use. This is most significant for volatile organic vapors (e.g., boiling point <65° C). Partial use of the organic vapor cartridge, storage, and subsequent reuse the next day could potentially expose the user to organic vapors. Chemicals with boiling points greater than 65° C can still migrate, but as volatility decreases, migration becomes less of a concern.

For organic vapors with a boiling point less than 65° C, OSHA states that organic vapor cartridges must be changed at least every work shift unless the employer has data regarding contaminant migration. Laboratory or field studies may be conducted to determine acceptable patterns of reuse. An easier solution may be a “running clock”. In other words, the estimated service life starts when the cartridge is first used and continues whether the cartridge is being used or stored. For example, if the estimated service life is 40 hours, then the organic vapor cartridge may be used for 8 hours, stored 16 hours and used for 8 hours (total time 30 hours) before being discarded. The effective cartridge change schedule would be every 2 days, except when used prior to a weekend, holiday, etc.

For more information on contaminant migration, please see Technical Data Bulletin 142: Reuse of Organic Vapor Chemical Cartridges.

GENERATING A REPORT

You may also generate a report for your records. When you select the “generate report” button, a new window will open up to allow you to enter comments such as employee, task, location, etc. The report will contain the choices you have made including the selected contaminants, exposure concentrations, respirator chosen, etc.

The report will also contain the odor threshold for each contaminant if available. Odor and irritation can not be used as the primary indicator for changing gas and vapor cartridges per OSHA standard 29 CFR 1910.134. However, reported odor thresholds are still listed because odor can be useful as a secondary or backup indicator for cartridge change-out. It may also be useful in identifying situations where extra safety maybe needed in establishing a change schedule.

Values of reported odor thresholds have been obtained from a variety of publications (see below). The primary references for odor thresholds were VOCBASE and the American Industrial Hygiene Association (AIHA) publication, Odor Thresholds for Chemicals with Established Occupational Health Standards (1989). When an odor threshold value was not published in either of these two sources, the other odor threshold references were used. A few odor thresholds published in other documents were used when values were not listed in the references below (e.g., AIHA WEEL documentation). For a more thorough discussion of the determining of odor thresholds and an explanation of why ranges are sometimes reported, see the AIHA publication.

1. Jensen, B. and P. Wolkoff. VOCBASE: Odor Thresholds, Mucous Membrane Irritation Thresholds and Physio-Chemical Parameters of Volatile Organic Compounds . [Computer Software]. National Institute of Occupational Health, Denmark, 1996.
2. Odor Thresholds for Chemicals with Established Occupational Health Standards , American Industrial Hygiene Association, 1989.
3. Amooore, J. E., and E. Hautula . Odor as an Aid to Chemical Safety. J. Appl. Toxicol . 3(6): 272-290 (1983).
- 4 . Fazzuluri, F. A. Compilation of Odor and Taste Threshold Values Data. American Society for Testing and Materials (1978).
5. Verschueren, K. Handbook of Environmental Data on Organic Chemicals. pp 12-21 . Van Nostrand Reinhold, NY (1977).
6. Warning Properties of Industrial Chemicals - Occupational Health Resource Center , Oregon Lung Association.
7. Electrical Safety Practices, ISA Monograph #113 (1972).
8. Documentation of TLVs and BEIs. American Conference of Governmental Industrial Hygienists. 5th edition (1986).
9. Gemert, L. J. Van. Compilation of Odor Threshold Values in Air and Water. CIVO -TNO, Netherlands (1977).
10. Gemert, L. J. Van . Compilation of Odor Threshold Values in Air, Supplement IV, CIVO-TNO, Zeist, Netherlands (1982).

QUESTIONS?

If you have any further questions regarding this software or 3M respirators, please contact your local 3M representative or call 3M technical service at 1-800-243-4630.

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