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, and/or determine if a cartridge with end of service life indicator (ESLI) may be appropriate for your application. This help information is for the 3M Service Life Software.

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

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 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 cannot 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 respirators may cause sickness or death.

- 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 values generated by the software are estimates only. For example, the math model used to estimate organic vapor service life at <65% RH may have uncertainty of ± 50%.

- Estimated service life depends on the specific work environment. 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, particle filters should be changed according to physical damage, increased breathing resistance, or time limitations in the presence of oily aerosols. 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 and exposure levels
- select your cartridge
- enter temperature, relative humidity, atmospheric pressure
- select work rate or type of headgear used with powered air purifying respirators (PAPRs)

It is essential that your inputs into the software are accurate.

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 OELs are the maximum airborne contaminant concentration allowed in the breathing zone of the worker. 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 (AIHAWEELs). TLVs are from ACGIH®, 2019 TLVs® and BEIs® Book. Copyright 2019. 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).

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 U.S. 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 expertise, 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 the other acid gases on the NIOSH approval label.

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.

Some of the information required above may be found in handbooks of chemistry and physics or from chemical suppliers. If you have any questions, please call 3M Technical Service at 1-800-243-4630.

ENTERING EXPOSURE LEVELS:

You must enter an exposure level for each of the contaminants that you have selected. 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). To change units, select the desired unit of measure from the units drop-down list.

Cartridges

A list of chemical cartridges will be displayed depending on the contaminants that you have entered. 3M has not tested all possible combinations of contaminants and cartridges for this software. If you cannot 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 model number from the chemical cartridge (use of a particulate filter in combination with a cartridge does not affect gas or vapor service life).

The 3M™ Organic Vapor Service Life Indicator Cartridge 6001i and Organic Vapor/P100 Service Life Indicator Cartridge 60921i contain an end of service life indicator (ESLI) for certain

organic vapors and exposure levels. The ESLI is located inside the cartridge next to the activated carbon. As organic vapors move through the cartridge, they are also adsorbed into the ESLI. The vapor concentration moving through the cartridge that causes a noticeable change in the indicator is called the minimum indication level (MIL). The MIL is different for each organic vapor. The 6001i and 60921i will only be included as optional choices if the MIL has been defined for all of the organic vapors entered. If you have questions regarding the 6001i, 6092li, or ESLIs, please see below for further information or contact 3M Technical Service at 1-800-243-4630.

Environment

RELATIVE HUMIDITY

The service life of organic vapor cartridges may vary dramatically depending on the relative humidity level, the chemical concentration, volatility of the chemical and the chemicals miscibility (ability to dissolve) in water. If you select 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. At relative humidity less than 50%, service life 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.

Choose the temperature closest to your work environment. 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 provide a more conservative service life estimate.

For acid gases, ammonia, methylamine or formaldehyde, temperature is only used, if necessary, to convert between exposure level units (ppm and mg/m^3). 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 headgear 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.

Review

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 ½ 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 CPL 02-00-158, "Inspection Procedures for the Respiratory Protection Standard" (June 26, 2014).

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.

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 (CPL 02-00-158) 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 3M Technical Data Bulletin 142: Reuse of Organic Vapor Chemical Cartridges.

ESLI

The end of service life indicator (ESLI) is only appropriate for certain organic vapors and exposure levels. If organic vapor concentrations are too low, they will not be detected by the ESLI. This software may be used to determine if the ESLI is appropriate for your work environment. If the ESLI is not appropriate for the work environment, a cartridge change schedule must be established by an alternate method, such as 3M™ Service Life Software. If the ESLI is not appropriate, it may still be used to augment your current cartridge change schedule, i.e., change cartridge according to established cartridge change schedule or according to ESLI, whichever occurs first.

The vapor concentration moving through the cartridge that causes a noticeable change in the indicator is called the minimum indication level (MIL). The MIL is different for each organic vapor. Prior to use, airborne contaminants in the work environment must be identified and quantified. The applicability of the ESLI must be determined for all potential use scenarios, including both low and high exposure levels. The ESLI is only appropriate if both of the following are true:
1) MIL ≤ occupational exposure limit (OEL) for all intended applications (indicator bar will develop before vapor concentration moving through cartridge reaches exposure limit), and
2) Worker exposure levels ≥ MIL (exposure concentration is high enough to cause noticeable change in indicator).

Example:
MIL = 1 ppm, OEL = 25 ppm, worker exposure = 5 ppm.
MIL (1 ppm) is ≤ OEL (25 ppm), and
Worker exposure (5 ppm) is ≥ MIL (1 ppm),
ESLI is appropriate.

Mixtures
Organic vapors in a mixture will adsorb into the ESLI together to increase the likelihood of a visible change of the indicator bar. In order for the ESLI to be appropriate for a mixture of organic vapors, the ESLI must be appropriate for the individual organic vapor with shortest service life.

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.

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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