Cartridge Change
Frequently Asked Questions (FAQs)

Q. What is the definition of Chemical Cartridge?

Chemical cartridges are used on respirators to help remove and lower worker exposures to harmful gases and vapors in the workplace. There are several types of chemical cartridges: organic vapor, ammonia, formaldehyde, mercury vapor and acid gas, such as hydrogen chloride, chlorine and sulfur dioxide.

Q. What is the definition of Cartridge Change Schedule?

Change schedule is a specified time period after which the chemical cartridge will be replaced. This time period may be established after consideration of the service life estimate, workplace conditions such as contaminant concentration, relative humidity, temperature, work activities, respirator use pattern (e.g., continuous or intermittent use), presence of other materials, potential for contaminant migration/desorption, health effects of the gas or vapor, and quality of warning properties, if any.

Q. What is the definition of Service Life?

Service life is the measured or estimated period of time before breakthrough of a contaminant (gas or vapor) for a specific chemical cartridge under specified conditions of the test or estimate.

Q. Why can't I use warning properties to determine chemical cartridge change-out?

When OSHA revised 1910.134, it changed the standard requiring that change-out schedules be determined using objective data. In the past, warning properties such as odor, eye irritation, and respiratory irritation were relied on almost completely for indicating when chemical cartridge breakthrough was starting. In fact, organic vapor chemical cartridges were only approved by NIOSH for those organic vapors with good warning properties. However, warning properties rely upon human senses that are not foolproof. The 1987 NIOSH Respirator Decision Logic described the typical wide variation of odor threshold in the general population (greater than two orders of magnitude). Other problems exist: shift in odor threshold due to extended low exposures, shifts due to simple colds and other illnesses, and failure to recognize odor because of distraction of the workplace competing for worker attention. Given the variability among people with respect to detection of odors and differences in measuring odor thresholds, a better practice is to establish cartridge change-out schedules even for chemicals with "adequate warning properties". Because of this fact, when OSHA revised its respiratory protection standard, it prohibited the reliance on warning properties as the primary means for indicating when it was time to change the chemical cartridges. Instead, OSHA requires that a change schedule be established that identifies how long a chemical cartridge can be used in a particular workplace before being replaced. OSHA has indicated that if an effective change-out schedule can be established for chemicals with poor warning properties, chemical cartridges could be used for these chemicals as well.

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Q. Can I use the 3M Service Life software to calculate service life for chemicals such as benzene or formaldehyde that have their own standard?

No. The change-out schedule requirement from 1910.134 does not apply to these chemicals. Instead the change schedule from the specific standard must be followed. Therefore the software doesn't allow a service time to be calculated for organic chemicals regulated by a specific OSHA standard and that require the use of an organic vapor cartridge. If someone were to establish a change schedule longer than that allowed by the one of these standards based upon a calculation using the 3M software, they would be out of compliance with the standard. This could result in misuse of the respirator and make them subject to a citation from OSHA. Obviously the user can establish a shorter change schedule than that required by the standard. Since there is no guarantee how the data will be used, 3M's current policy is to not include information on those substances for which OSHA has established the change schedule. Formaldehyde is a different issue. Organic vapor cartridges are not acceptable for use with formaldehyde. The organic vapor model in the software is only for liquid chemicals whose vapors are removed by adsorption. Formaldehyde cartridges use treated carbon, and it is removed through the process of chemisorption (actually it is via complex formation). The organic vapor formula does not predict formaldehyde service life for formaldehyde cartridges. Since formaldehyde cartridges are required by the standard, this software cannot be used to calculate formaldehyde service life. (You do not want to use an organic vapor cartridge for formaldehyde because the service life can be so short under so many conditions.) The formaldehyde cartridge has great capacity for formaldehyde and will easily meet the time requirements in the OSHA standard. Generally, increased relative humidity is not detrimental to the service life of the formaldehyde cartridge like it is to the organic vapor cartridge respirator.

Q. Do I need to establish a change schedule for particulate respirators?

Service life determination for particulate filters is not required under 1910.134; it is only required for gases and vapors. Often the particulate filtration efficiency will improve during use as the filter loads and a "cake" layer forms on the surface of the filter. We suggest therefore that respirators or filters be changed if they become damaged, soiled, or an increase in breathing resistance becomes noticeable. In addition to these considerations, N series filters should not be used against oily aerosols, R series filters should be changed every 8 hours if used against oily aerosols; and P series filters used in environments containing oily aerosols should be limited to 40 hours of use or 30 days, whichever is first.

Q. Do I need to establish a change schedule for cadmium and lead?

Cadmium and lead require particulate filters. Service life determination for particulate filters is not required under 1910.134; it is only required for gases and vapors. Often the particulate filtration efficiency will improve during use as the filter loads and a "cake" layer forms on the surface of the filter. We suggest therefore that respirators or filters be changed if they become damaged, soiled, or an increase in breathing becomes noticeable. In addition to these considerations, N series filters should not be used against oily aerosols, R series filters should be changed every 8 hours if used against oily aerosols; and P series filters used in environments containing oily aerosols should be limited to 40 hours of use or 30 days, whichever is first.

Q. Do I need to establish a change schedule for welding fumes?

No. The main respiratory hazard during welding is particles, i.e., tiny welding fumes. Service life determination for particulate filters is not required under 1910.134; it is only required for gases and vapors. Often the particulate filtration efficiency will improve during use as the filter loads and a "cake" layer forms on the surface of the filter. We suggest therefore that respirators or filters be changed if they become damaged, soiled, or an increase in breathing resistance becomes noticeable. In addition to these considerations, N series filters should not be used against oily aerosols, R series filters should be changed every 8 hours if used against

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oily aerosols; and P series filters used in environments containing oily aerosols should be limited to 40 hours of use or 30 days, whichever is first. Some of our particulate filters/respirators have small amounts of carbon for nuisance relief from gases that may be present during welding, but are generally at concentrations below the exposure limit. Since, the respirator is not being worn for protection from these gases, only nuisance relief, service life determination is not required.

Q. How does 3M Service Life Software work on chemicals such as nitroglycerin?

Chemicals such as nitroglycerin are interesting cases. The model used in the software is applicable only to liquid chemicals. Chemicals such as nitroglycerin have two interesting properties: a freezing point encountered in the possible temperature range of some workplaces and low vapor pressures with respect to the OEL. At temperatures below the freezing point, nitroglycerin is a solid and the model is not applicable for solids. If an air concentration above the saturated vapor concentration (SVC) for the temperature chosen is entered, the model will not calculate it either because it is impossible to have a vapor concentration exceeding the SVC. If a concentration is reported to you that is higher than the SVC it is most likely present in both particulate and vapor form. (In these situations we recommend a particulate filter be used in addition to the organic vapor chemical cartridge.) If you do pick a concentration (e.g., 0.05 ppm) at an appropriate temperature, then you find the service life is very long. The software tells you 999 hours (not minutes). The software rounds all values greater than or equal to 1000 hours as 999 hours. We figured at this point the actual service life is not going to be the critical issue in establishing your change schedule. This is equivalent to about one half year of 40 hour work weeks. This is how long the cartridge will last when used against nitroglycerin continuously at this concentration. This long service life is supported by data published in the literature (Am. Ind. Hyg. Assoc. J 54:432-439 1993). Chemical cartridges work quite well and have a great capacity for nitroglycerin. While the cartridge lasts a long time factors such as storage relative humidity and possible desorption after long storage times will probably be the main factors for establishing the change schedule.

Q. What is the status of developing end of service life indicators for organic vapor cartridges?

3M has been looking at ESLIs for organic vapors for a long time. In fact in the early 1980s, 3M came out with an organic vapor respirator with an ESLI for several organic vapors. Due to many reasons it was discontinued. The technical challenges still remain. They include developing ESLIs that eliminate interference, have good durability and longevity and be economical. We continue to work on ESLIs.

Q. How is cartridge service life affected by humidity?

The Relationship Between Relative Humidity and Service Life

Relative humidity (RH) greater than 50% (especially greater than 65%) can have a dramatic effect on the service life of organic vapor chemical cartridges. The effect of relative humidity on service life of organic vapor cartridges will depend on the relative humidity level, the chemical concentration, volatility of the chemical and the chemical's miscibility (ability to dissolve) in water. Table 1 illustrates the volatility differences of five chemicals. The solvents were chosen to represent a wide range of chemical volatility. Experiments with these five chemicals at various concentrations illustrate how dramatic the effect of relative humidity on organic vapor cartridges and its impact on the service life estimates may be. This impact must be considered when establishing your change schedule. The graph in Figure 1 shows the correction factor necessary to adjust the service life estimate from the 3M Service Life Software for relative humidity of 85%. The calculated service life from the software must be divided by the correction factor on the y-axis to get the actual service life to 1% breakthrough at 85% RH.

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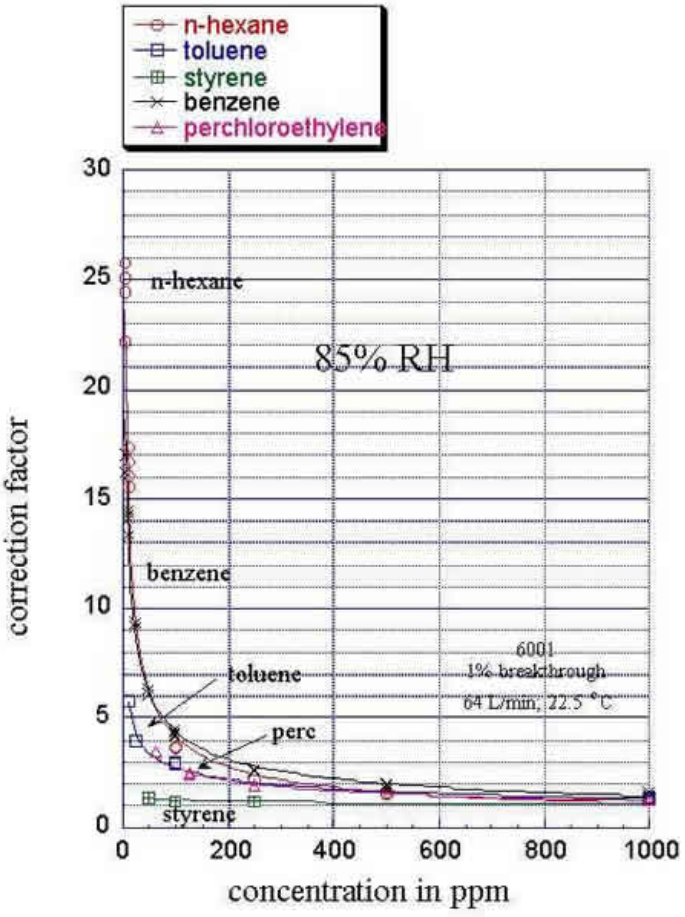
Table 1. Vapor pressure and boiling point for five solvents.

Solvent Vapor Pressure	mmHg Boiling point	degrees C
n-hexane	124	69
benzene	75	80
toluene	21	110.6
perchloroethylene	14	121
styrene	5	145-146

Figure 1. Correction factor versus solvent concentration at 85% relative humidity and for 1% breakthrough



For chemicals with low volatility such as styrene, the effect of high relative humidity is small. At 85% RH a correction factor of about 1.5 seems appropriate through the styrene concentration range tested. For the more volatile chemicals tested, the most significant RH effect is at low concentrations. Using n-hexane as an example, at high concentrations (~ 400 ppm) the necessary correction factor for 85% RH is about 2, whereas at low concentrations (~ 10 ppm) the service life estimate should be reduced by a factor of about 16.

Acid Gases and Ammonia/Methylamine

The service life of acid gas, ammonia/methylamine and other chemical cartridges that work by chemisorption, typically increase with increasing relative humidity. Most service life data is generated at 50% RH. Therefore, the service life will be shorter than expected for relative

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humidity levels less than those used in the testing. The change schedule should be adjusted to account for this RH effect.

Q. Can chemical cartridges be used for more than one shift?

Organic vapors are removed by the process of adsorption. Weak physical forces hold the organic vapor on the activated carbon. Since these forces are weak, the process can be reversed and the organic vapor can be desorbed. Desorption during storage or nonuse periods can result in the migration of the chemical through the cartridge. Migration is mainly a concern only for organic vapor cartridges. Organic vapors adsorbed on an organic vapor cartridge can migrate through the carbon bed without airflow. Desorption of very volatile contaminants can occur after a short period (hours) without use (e.g., overnight). Partial use of the chemical cartridge and subsequent reuse could potentially expose the user to the contaminant. This is most significant for the most volatile and poorly retained organic vapors (e.g., boiling point < 65°C). For organic vapors with a boiling point less than 65°C, it is recommended that the organic vapor cartridge never be used longer than one shift even if the estimated service life is greater than 8 hours and the cartridge is used for only a short time during the shift.

However, a boiling point of 65°C is not a fine line between chemicals that migrate and those that do not. Chemicals with boiling points greater than 65°C can still migrate, but the nonuse period of concern may be longer than above. For chemicals with boiling points greater than 65°C, nonuse or storage periods of a few days, like over a weekend, may be the concern. For these chemicals, (e.g., ethyl acetate, boiling point 77°C), reuse should not be allowed after two days of nonuse even if the service life estimate would suggest it. As the volatility decreases migration will become less of a concern. Your reuse pattern should still be carefully evaluated even for these less volatile chemicals. Chemicals with low volatility will give long service lives, but even in these situations use should probably not extend beyond a week or two even if the service life estimate is longer.

For workers that use their respirators intermittently and perhaps in different environments, such as a maintenance worker or inspector, the organic vapor cartridges should never be reused.

The user can conduct desorption studies, mimicking the work conditions of use and nonuse, to determine acceptable patterns of reuse. The ANSI Z88.2-1992 American National Standard for Respiratory Protection recommends that organic vapor cartridges be changed daily unless desorption studies support longer use.

For more detail on chemical bed migration reference 3M Technical Data Bulletin #142 “Reuse of Organic Vapor Chemical Cartridges.”

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