CALCULATING CHEMICAL CARTRIDGE CHANGE OUT SCHEDULES FOR MIXTURES

Encl: (1) RESPIRATOR MANUFACTURER SERVICE-LIFE SOFTWARE
(2) OSHA RULES OF THUMB FOR COMPUTING BREAKTHROUGH TIMES FOR MIXTURES
(3) CARTRIDGE CHANGE OUT SCHEDULE WORKSHEET
(4) INSTRUCTIONS FOR CARTRIDGE CHANGE OUT SCHEDULE WORKSHEET

Both Occupational Safety and Health Administration (OSHA) and Navy policy no longer allow reliance on odor thresholds and other warning properties solely as the basis for changing respirator chemical cartridges. OSHA and the Navy require implementing change out schedules for respirator cartridges based on objective data. This objective data along with the logic used for relying on this data must be described in the written respirator program. If this is not accomplished, both OSHA and Navy policy require using atmosphere supplying respirators or respirators with end-of-service-life indicators for protection against gases and vapors.

Enclosure (1) lists several free respirator manufacturers' service-life software calculators for their cartridge respirator users. Workplace exposures and environmental conditions must first be determined and then entered into the service-life software to calculate breakthrough times. Most service-life software calculators are based on exposure from a single contaminant; however, most workplace exposures are from mixtures of chemicals. Some manufacturers, like 3M (Minnesota Mining and Manufacturing Company) have software that calculates change out schedules for chemical mixtures using OSHA's rules of thumb for computing breakthrough times for mixtures, as described in Enclosure (2).

Change out schedules must still be calculated for mixtures when using service-life software that calculates breakthrough for only single contaminants. A spreadsheet to help simplify this process is provided in Enclosure (3). This spreadsheet calculates breakthrough time for each mixture component relative to its proportion of the mixture. This is based on the mixture components' mole fractions. This spread sheet is part of a form that can be printed as a permanent record describing the objective data and logic used to establish the change out schedule. Be sure to first read the instructions for this spreadsheet found in the last paragraph of Enclosure (4). A fresh copy of the spreadsheet should be used for each breakthrough calculation to ensure the equations are intact.

For more detailed information on respirator cartridge change out schedules, including a method for validating estimated change out schedules, see the article entitled "Chemical Cartridge Change Out Schedules," which can be found under the NAVMCPUBHLTHCEN "Industrial Hygiene" homepage.

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RESPIRATOR MANUFACTURER SERVICE-LIFE SOFTWARE

3M Respirator Service Life Software
http://solutions.3m.com/wps/portal/3M/en_US/Health/Safety/Resources/Four/

MSA Cartridge Life Expectancy Calculator:
http://webapps.msanet.com/cartlife/

AO Safety Merlin Cartridge Change Out Program Software & Respirator Selection Guide
http://www.aosafetyproducts.com.mx/Admin/files/20070305153243.pdf

Survivair Cartridge Service Life Software
http://www.survivair.com/support/cartridge.asp and
http://www.survivair.com/support/downloads.asp

North Safety Products - Selection Guide for Respiratory and Hand Protection calculates estimated cartridge service life.
http://www.northsafety.com/

Encl (1)

OSHA RULES OF THUMB
FOR COMPUTING BREAKTHROUGH TIMES FOR MIXTURES

Pages 13 - 14 of OSHA CPL 2-0.120 - *Inspection procedures for the Respiratory Protection Standard*, provide the following rules of thumb for establishing cartridge service-life for exposure to chemical mixtures:

> If mixture component breakthrough times are within two magnitudes (100 times), add concentrations and assume entire mixture behaves like the contaminant with the shortest breakthrough time.
>
> If mixture component breakthrough times vary by two orders of magnitude (100 times) or more, use the shortest breakthrough time.

Example of mixture component breakthrough times within two orders of magnitude.

The following breakthrough times for mixture components were calculated using respirator manufacturer service-life software.

Component A = 100 ppm; estimated service life = 10 hr Component B = 200 ppm; estimated service life = 100 hr Component C = 300 ppm; estimated service life = 50 hr

In this mixture, the breakthrough times of the mixture components are within two orders of magnitude of each other. Therefore, add the component concentrations and recalculate breakthrough for the component with the shortest breakthrough time using this sum.

100 + 200 + 300 = 600 ppm

Using manufacturer service-life software, recalculate Component A at 600 ppm. In this example, recalculation of Component A at 600 ppm estimated the service-life to be six hours. Therefore, use six hours as the mixture breakthrough time.

Example of mixture component breakthrough times exceeding two orders of magnitude.

The following breakthrough times for mixture components were calculated using respirator manufacturer service-life software.

Component A = 100 ppm; estimated service life = 10 hr **[shortest]** Component B = 2 ppm; estimated service life = 10,000 hr Component C = 30 ppm; estimated service life = 500 hr

In this mixture, the differences between breakthrough times of mixture components are greater than two orders of magnitude. Therefore, use the breakthrough time of the component with the shortest breakthrough time as the change out schedule for the mixture.

Encl (2)

CARTRIDGE CHANGE OUT SCHEDULE WORKSHEET

Operation:_____ Location: _____
Respirator Model: _____ Cartridge:_____

Chemical	Exposure Limit	Concentration	Boiling Point*

*Chemicals with boiling points less than 65^{o} C (149^{o} F) may be desorbed from sorbent during periods of non-use.

OPERATION PARAMETERS:

Frequency per week:_____ Duration of respirator wear: _____

Estimated work rate: [ ] Light [ ] Moderate [ ] Heavy

ENVIRONMENTAL DATA:

Highest temperature:_____ Highest humidity:_____

CALCULATE BREAKTHROUGH TIME OF COMPONENTS BASED ON THEIR PROPORTION OF THE MIXTURE

Mixture Component	$UTL_{95\%, 95\%}$ Concentration (ppm)	Mole Fraction[1]	Cartridge Service Life Calculator Estimated Breakthrough Time for Single Component (Hours)	Breakthrough Time of Components Based on Mixture (Hours)
		0.0		0
		0.0		0
		0.0		0
		0.0		0
		0.0		0
		0.0		0
Total ppm	0			

[1]Mole Fraction = ppm contaminant / total ppm of the mixture components

Change out schedule including safety factor of ten percent:
[ ] Every_____ hours[ ] After each shift [ ] Weekly [ ] Other (specify): _____

Encl (3)

INSTRUCTIONS FOR
CARTRIDGE CHANGE OUT SCHEDULE WORKSHEET

The following information is provided as guidance for using the using the mole fraction method to calculate change out schedules for respirator cartridges worn as protection against multiple organic vapor contaminants.

* Provide environmental data concerning workplace temperature, humidity, and worker breathing rate.

* Provide the boiling points of the chemicals of concern.

  Chemicals with boiling points less than 65^{o} C (149^{o} F) may be desorbed from cartridge sorbent material during periods of non-use or be replaced by chemicals with higher boiling points.

* Calculate mole fractions of the mixture components.

  Mole fraction is calculated by dividing concentrations of each organic mixture component in parts per million (ppm) by total ppm of the mixture.

* Calculate the breakthrough time for each mixture component using the respirator manufacturer's service life software.

* Multiply the mole fraction of each mixture component by its estimated breakthrough time to calculate individual breakthrough times based on each component's proportion in the mixture.

* Base change out schedule on the shortest mixture component breakthrough time. Incorporate a safety factor, by establishing a change out schedule that is at least 10% less than the shortest mixture component breakthrough time.

EASY METHOD

These calculations are performed automatically using the built-in spread sheet in Enclosure (3) entitled "*Calculate Breakthrough Time Of Components Based On Their Proportion Of The Mixture*.**"** First, make a copy of this spreadsheet and use a fresh copy for each breakthrough calculation. Fill in the columns for "*$UTL_{95\%,\ 95\%}$ Concentration*" and "*Cartridge Service Life Calculator Estimated Breakthrough Time for Single Component*." Then block the "*$UTL_{95\%,\ 95\%}$ Concentration*" column and **press F9** - this calculates the total parts per million. Next, block the whole table, and then **press F9** to complete the mole fraction calculations and breakthrough time calculations.

Encl (4)