Comparison of Methods Suggested in 29CFR1910.134 for Determining Change Schedules for Air Purifying Respirators

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Respirator Change Schedules

(from OSHA web-site)

Did you know that employers are now required to provide a respirator cartridge change schedule?

Respirator cartridges don't last forever!

A change schedule is the part of the written respirator program which says how often cartridges should be replaced and what information was relied upon to make this judgment. A cartridge's useful service life is how long it provides adequate protection from harmful chemicals in the air. The service life of a cartridge depends upon many factors, including environmental conditions, breathing rate, cartridge filtering capacity, and the amount of contaminants in the air.

Situation

- Need to remove certain toxic organic vapors (OVs) from breathed air.
- Select a certain (manufacturer and model) air-purifying respirator with cartridges.
- Characterize the environment: Identity of vapors and concentrations; Temperature, %RH, and Pressure; Average breathing air flow.

Situation (cont'd)

- <u>**Identify**</u> **the maximum acceptable breakthrough concentrations (MACs) allowed in breathed air.**

- <u>**Recognize**</u> **that cartridge change schedules are required as part of an overall respirator use program.**

- <u>**Question:**</u> **How does one get breakthrough times needed for setting change schedules?**

Resolution: Try Recommendations in 29CFR1910 and on the OSHA Website

1) Review manufacturer's recommendations;
   (Use the manufacturer's Service Life Calculator)
2) Use the Service Life Table on the OSHA website;
3) Search literature for measured breakthrough times;
4) Use the NIOSH MultiVapor service life calc'n program;
5) Measure cartridge breakthrough times in a laboratory.

Specifics of the Situation

- An MSA Safety Works half-mask with pairs of Multi-Purpose cartridges was selected and Purchased from an online supplier for use

- Against 1000 ppm hexane (MAC=50 ppm) or

- Against 500 ppm chloroform (MAC=10 ppm)

- At conditions of 23 ºC, 1.0 atm, and 50% RH for an average worker breathing rate of 30 L/min based on level of work effort.

Attempt 1: Manufacturer's Website

- **Found a similar half-mask and cartridge (different part numbers and identifications).**

- **Tried Manufacturer's Service Life Calculator**
  - **Inputted desired vapor, concentration, air flow rate (Low = 30 L/min), and breakthrough concentration (100% of OEL)**

- **Resulting breakthrough times:**
  - **1000 ppm hexane → 191 min @ 50 ppm**
  - **500 ppm chloroform → 326 min @ 10 ppm**

Attempt 2 : OSHA Website

- Used the Wood Math Model Table
  - Based on an older (1994) model
  - Uses small cartridges (52 g carbon/pair) at high flow rates (53.3 L/min)
  - Reports 10% breakthrough times only
  - For selected challenge concentrations only

- Resulting breakthrough times:
  - 1000 ppm hexane → 48 min @ 100 ppm
  - 500 ppm chloroform → 87 min @ 50 ppm

Attempt 3a : Literature Search

- Found Nelson, et al. (1974-1976) publications
  - They used small cartridges (52 g carbon/pair) at a high air flow rate (53.3 L/min)
  - Reported 10% breakthrough times only
  - For selected challenge concentrations only

- Resulting breakthrough times:
  - 1000 ppm hexane → 70 min @ 100 ppm
  - 1000 ppm chloroform → 52 min @ 100 ppm (no 500 ppm data available)

Attempt 3b : Literature Search (continued)

- Found Nelson (1980) correlations of breakthrough times with concentrations
  - Allow extrapolations to desired concentration.
  - Used larger single cartridge (80 g carbon) at lower air flow rate (40 L/min).
  - For 10% breakthrough times only.

- Resulting breakthrough times:
  - 1000 ppm hexane → 87 min @ 100 ppm
  - 500 ppm chloroform → 178 min @ 50 ppm

Attempt 4a : Use MultiVapor Service Life Estimation Model

- On the CDC/NIOSH/NPPTL Website
- Recommended on the OSHA Website

- First Try: Use the default cartridge size and carbon property input parameters for a "Typical Organic Vapor Cartridge."
- Resulting breakthrough times:
  - 1000 ppm hexane → 182 min @ 50 ppm
  - 500 ppm chloroform → 388 min @ 10 ppm

Attempt 4b : Use MultiVapor Service Life Estimation Model (Continued)

- Second Try: Input parameters for a "Typical Organic Vapor Cartridge," but using measured cartridge bed size (2.54 cm deep and 8 cm average diameter) and total carbon weight (144 g/pair) parameters.

- Resulting breakthrough times:
  - 1000 ppm hexane → 288 min @ 50 ppm
  - 500 ppm chloroform → 571 min @ 10 ppm

Attempt 4c : Use MultiVapor Service Life Estimation Model (Continued)

- **<u>Third Try</u>: Input parameters for a "Typical Organic Vapor Cartridge," but using measured cartridge bed size and weight parameters and micropore volume and adsorption potential for a "typical multigas" carbon.**

- **Resulting breakthrough times:**
  - **1000 ppm hexane → 231 min @ 50 ppm**
  - **500 ppm chloroform → 485 min @ 10 ppm**

Attempt 4d : Use MultiVapor Service Life Estimation Model (Continued)

- **<u>Fourth Try</u>: Input parameters for a "Typical Organic Vapor Cartridge," but using measured cartridge bed size and weight parameters and micropore volume and adsorption potential reported for an MSA GME multiuse carbon.**

- **Resulting breakthrough times:**
  - **1000 ppm hexane → 250 min @ 50 ppm**
  - **500 ppm chloroform → 531 min @ 10 ppm**

Attempt 4e : Use MultiVapor Service Life Estimation Model (Continued)

- <u>Fifth Try</u>: Input parameters for a “Typical Organic Vapor Cartridge,” but using measured cartridge bed size and weight parameters and micropore volume and adsorption potential obtained from experimental breakthrough times for 20 tests converted to a D/R plot.

- Resulting breakthrough times:
  – 1000 ppm hexane → 268 min @ 50 ppm
  – 500 ppm chloroform → 456 min @ 10 ppm

Attempt 5: Laboratory Data

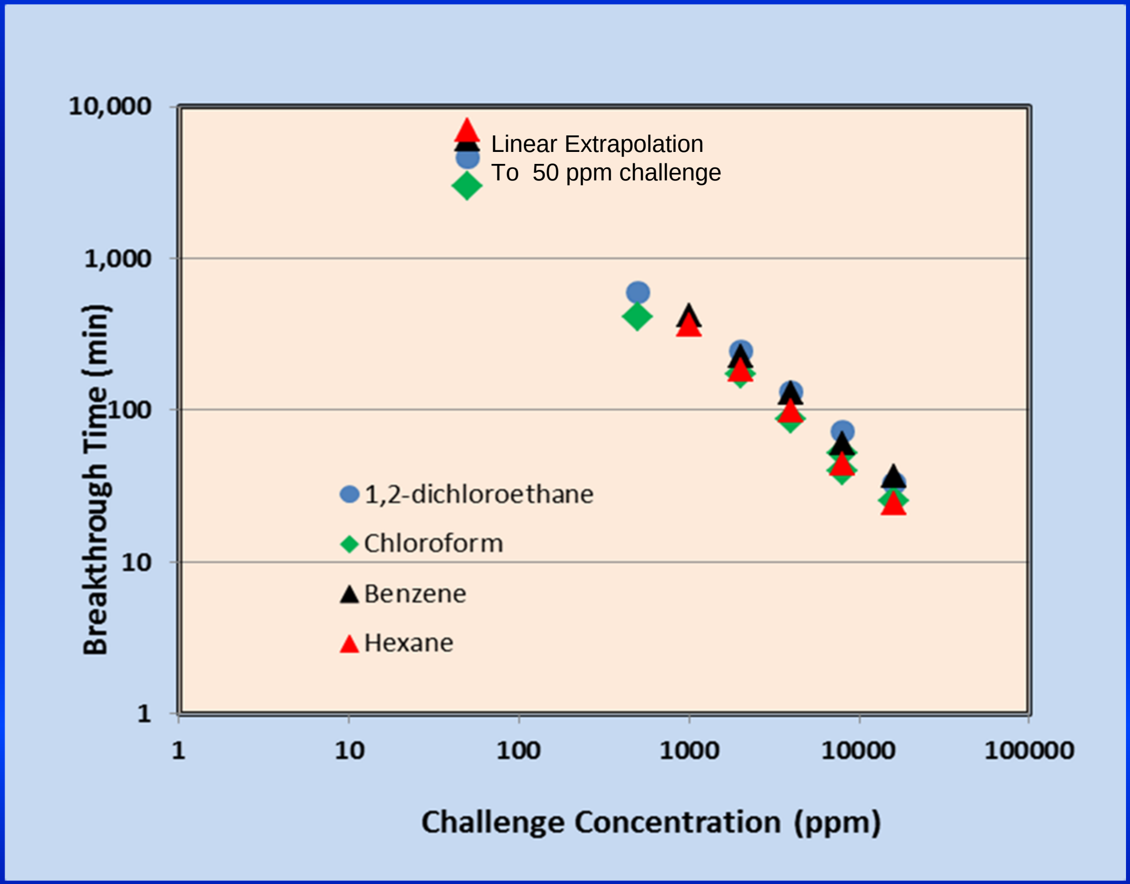
- Breakthrough times were measured for 3 hexane tests and 2 chloroform tests of the actual cartridges.

- Resulting average breakthrough times:
  - 1000 ppm hexane → 361 min @ 50 ppm
  - 500 ppm chloroform → 411 min @ 10 ppm

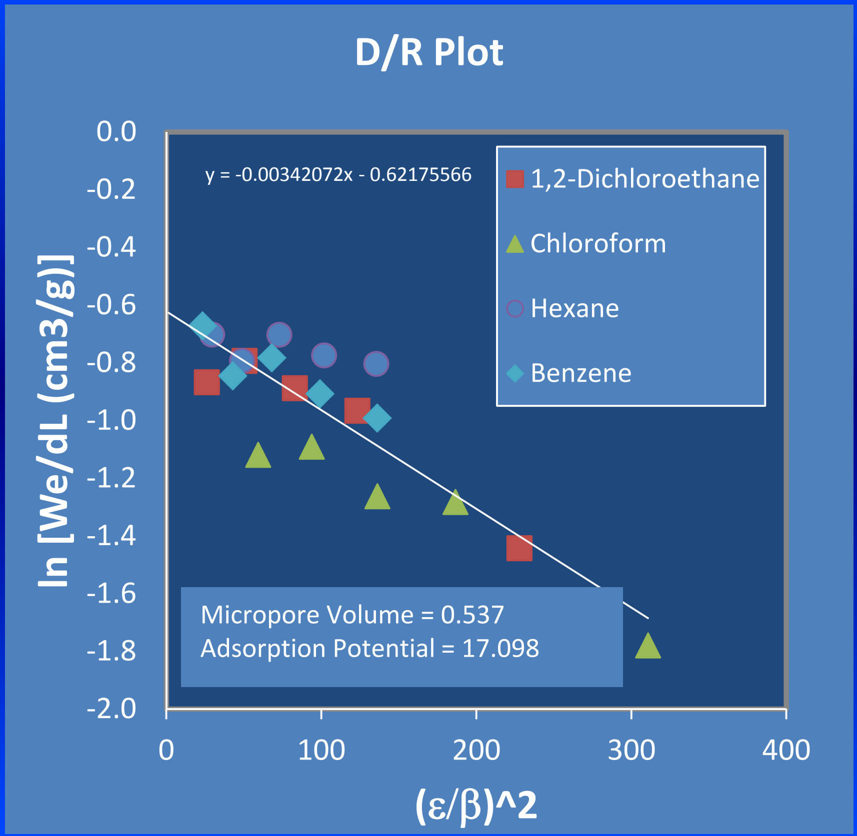
Service Life Extrapolation – Actual Data

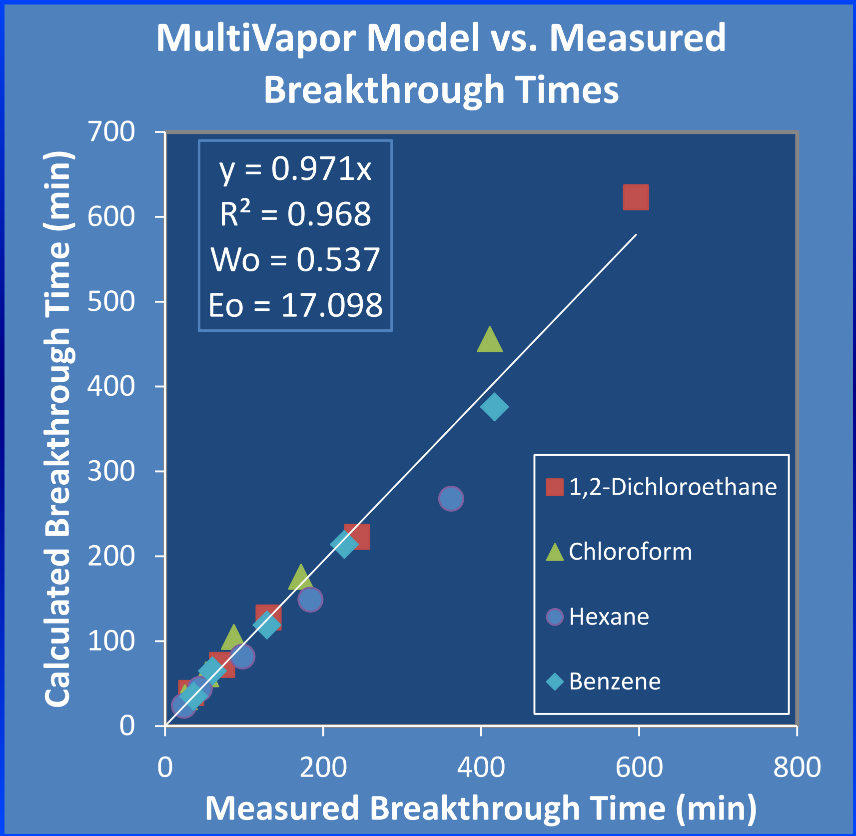
from Plot of Concentration vs Breakthrough Time

1,2-dichloroethane, chloroform, hexane, and benzene



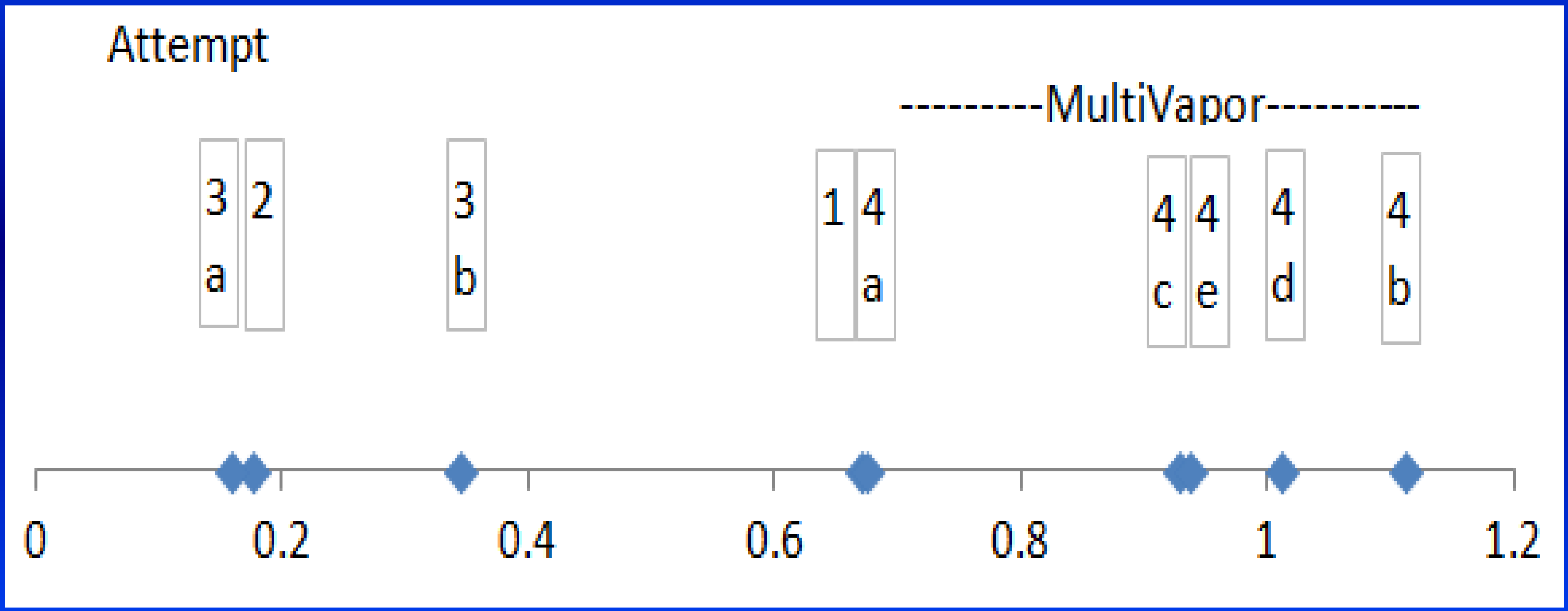
D/R Plot and Confirmation





Comparisons of Results

Measure of Accuracy = $\frac{\text{Calculated (Hexane BT + Chloroform BT)}}{\text{Measured (Hexane BT + Chloroform BT)}}$



(1) Mfr web-site
(2) OSHA web-site
(3) Literature Search
(4) NIOSH Multi-Vapor Model

Lessons Learned

- More effort (to obtain model parameters) was required to get more accurate breakthrough times.
- Literature values were few even for these common chemicals, and not always at the desired concentrations, air flow rates, or cartridge sizes.
- For rarer chemicals some resources and methods (literature values, manufacturer's recommendations and/or service life calculators) may not be available.

More Lessons Learned

- Manufacturer’s web-site calculators may provide safe predictions with shorter Service Life than actual Lab Tests
- New Multi-Vapor Model developed by NIOSH (Wood) is an improvement over earlier models
- Multi-Vapor model agreed well with Lab Values after some jiggering around
- Experimental Data remains the gold standard