DoD IH Forum 2005:

Estimating Service Life for Chemical Respirator Cartridges ...An Overview...

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Why do we need to estimate chemical cartridge service life ??

- Respirator cartridges don't last forever…
- Because OSHA says so !!
  - ✓ Per 29 CFR 1910.134 (d)(3)(iii)
  - ✓ Can no longer rely on warning properties…
  - ✓ Does allow use of chemical cartridges against contaminants that don't have warning properties…

When do we change the cartridges ??

- Two options for determining when to change respirator cartridges:
  - ✓ End of service life indicator
  - ✓ Change out schedule

End of Service Life Indicators

- **There are very few NIOSH-approved ESLI's:**
  - ✓ Ammonia
  - ✓ Carbon monoxide
  - ✓ Ethylene oxide
  - ✓ Hydrogen chloride
  - ✓ Hydrogen fluoride
  - ✓ Hydrogen sulfide
  - ✓ Mercury
  - ✓ Sulfur dioxide
  - ✓ Toluene-2,4-diisocyanate
  - ✓ Vinyl chloride

Cartridge Change-out Schedules

- Base the schedule on available objective info and data
- Include in your written program:
  - ✓ Data or information that was used to develop the schedule
  - ✓ The basis for your use of that data
- The best source of info is the manufacturer's test data

Cartridge Change-out:

Methods for determining service life

- Estimate with rules of thumb
- Test in laboratory using simulated workplace
- Test cartridge in workplace
- Test cartridge after use
- Use respirator carbon tube

- Calculate using breakthrough equations (or use manufacturers' software)

Cartridge Change-out Rules of Thumb

- Service life should be at least 8 hours if:
  - ✓ Contaminant has BP > 70 C (158 F)
  - ✓ Concentration is < 200 ppm
  - ✓ Relative humidity < 50%
- Flow rate
  - ✓ Service life is inversely proportional to flow

Cartridge Change-out Rules of Thumb

- **Concentration**
  - ✓ Reducing the concentration by a factor of 10, increases service life by a factor of 5
- **Humidity**
  - ✓ Humidity greater than 85% reduces service life by 50%

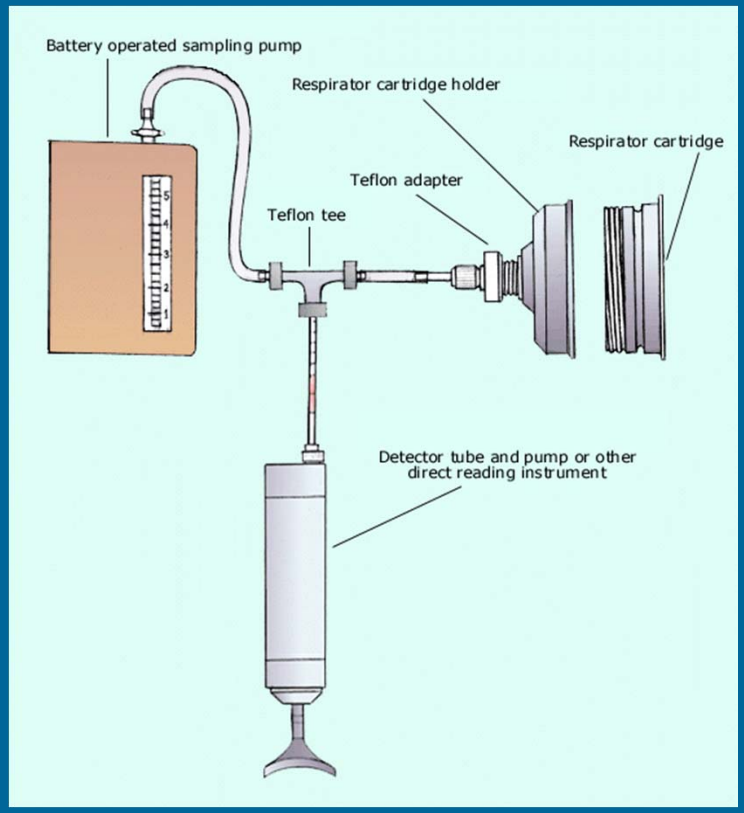
Experimental Testing in Lab or Field

+ Most reliable & accurate, especially for mixtures

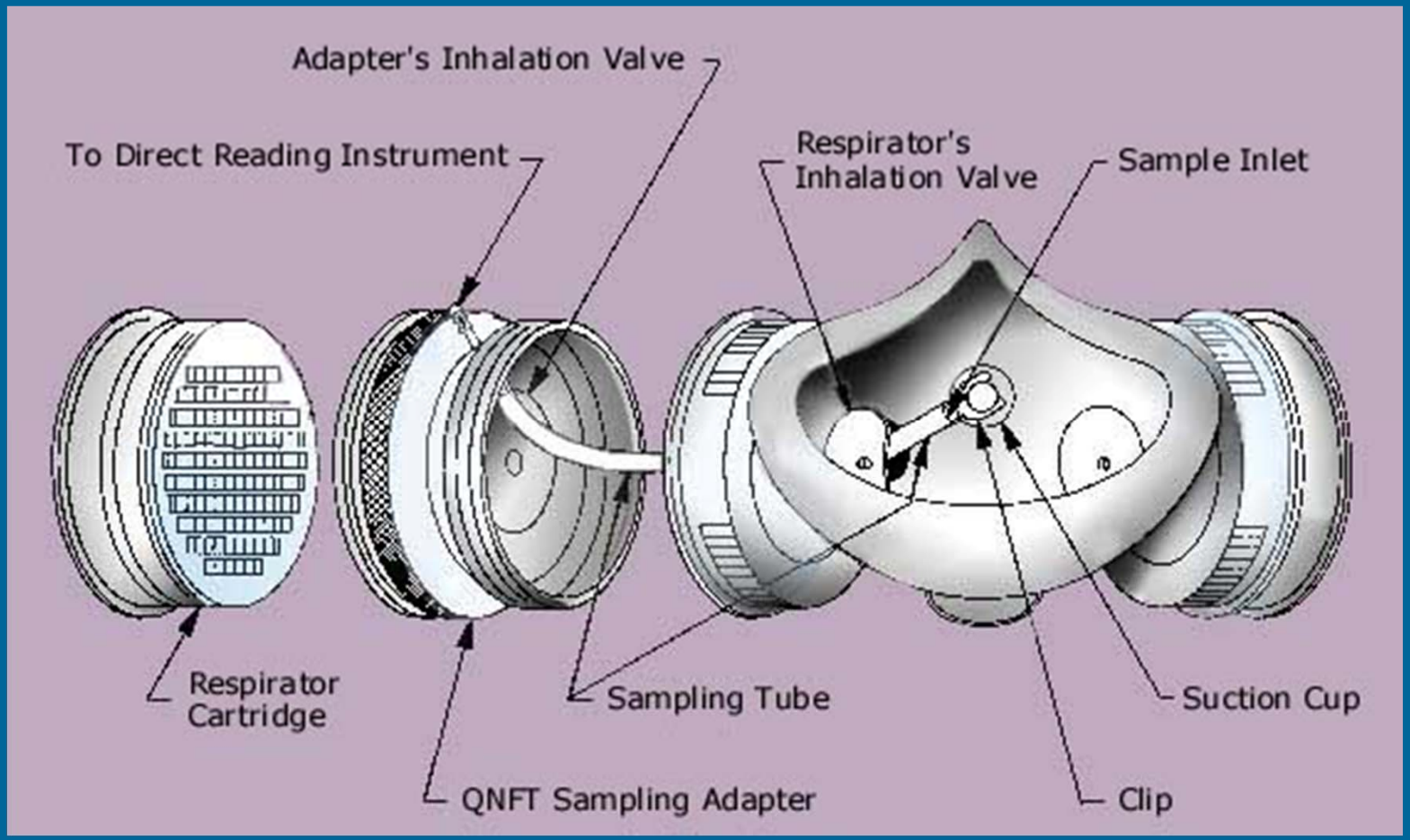
+ Can be used to validate existing change schedule

- Is equipment, labor, & time intensive

- Can be $$$



Experimental Testing in Field
(for remaining service life)



Mathematical Model : Wood's Equation

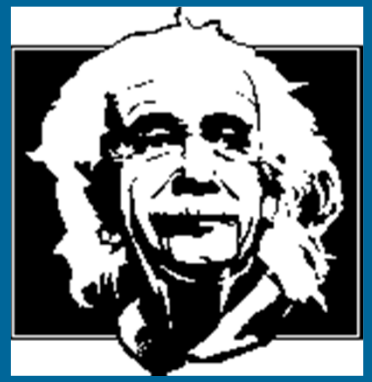
$$t_b = \left(\frac{W_e W}{C_o Q}\right) - \left(\frac{W_e \rho_\beta}{k_v C_o}\right) \ln\left[\frac{C_o - C_x}{C_x}\right]$$

t_b = breakthrough time (min)
C_x = exit concentration (g/cm^3)
C_o = inlet concentration (g/cm^3)
Q = volumetric flow rate (cm^3/min)
W = weight of carbon adsorbent (g)
ρ_β = bulk density of the packed bed (g/cm^3)
W_e = equilibrium adsorption capacity (g/g carbon)
k_v = adsorption rate coefficient (min^{-1}).

Service Life Calculator

- **Use on-line or download "Advisor Genius" program at www.osha.gov/SLTC/etools/respiratory/advisor_genius_wood/ advisor_genius.html**

- **Will need manufacturer's cartridge information**
  - ✓ Number of cartridges used by respirator
  - ✓ Weight of sorbent in each cartridge (in grams)
  - ✓ Carbon micropore volume (in cm^3/gm)
  - ✓ Density of packed bed (in gm/cm^3)



- **Other information needed**
  - ✓ Max temperature & humidity expected in workplace
  - ✓ Max concentration of contaminants in workplace (in ppm)
  - ✓ Work-rate (volumetric flow rate or breathing rate – in LPM)

Manufacturers' Service Life Calculators

Use on-line or download "3M Service Life" program at csrv.3m.com/csrv/

Use on-line at www.msanet.com/msanorthamerica/msaunitedstates/cartlife/

Download "Cartlife" program at www.survivair.com/support/cartridge.asp

Manufacturers' Service Life Calculators

Download "EZGuide" program at www.northsafety.com/usa/en/bs_sproduct.html?GID=3693

Email Scott Technical Support directly at techsupport.scotths.us@tycoint.com

Download "Merlin" program at www.aosafety.com/aosafety.com/industrial/resp_main.htm

Dealing with Mixtures . . . ?

- If breakthrough times for individual chemicals are within one order of magnitude (10X), add concentrations together and assume entire mixture behaves like the component with shortest individual breakthrough time.
- If breakthrough times for individual chemicals vary by two orders of magnitude (100X) or more, base service life on component with shortest individual breakthrough time.

OSHA Method for Mixtures

- Employees are exposed to following:
  - ✓ **Chemical A = 100 ppm**
  - ✓ **Chemical B = 100 ppm**
  - ✓ **Chemical C = 75 ppm**
- Service life software predicts the following service times for each substance:
  - ✓ **Chemical A = 3770 minutes**
  - ✓ **Chemical B = 3290 minutes**
  - ✓ **Chemical C = 2480 minutes**

OSHA Method for Mixtures

- Breakthrough times are within one order of magnitude
- Add concentrations (= 275 ppm)
- Assume mixture behaves like component with shortest individual breakthrough time (Chemical C)
- Recalculate service life for Chemical C at 275 ppm = **989 minutes**

Mole Fraction Method for Mixtures

- Total ppm of mixture = 275 ppm
- Mole fractions:
  - ✓ **Chemical A: 100 ppm ÷ 275 ppm = 0.36**
  - ✓ **Chemical B: 100 ppm ÷ 275 ppm = 0.36**
  - ✓ **Chemical C: 75 ppm ÷ 275 ppm = 0.27**
- For each chemical, multiply the mole fraction by the single component breakthrough time...

Mole Fraction Method for Mixtures

Chemical	Mole Fraction	Single Substance Breakthrough Time	Breakthrough Time in Mixture
Chemical A	0.36	3770 minutes	1357 minutes
Chemical B	0.36	3290 minutes	1184 minutes
Chemical C	0.27	2480 minutes	**670 minutes**

Other Sources of Information

- Navy Environmental Health Center at www-nehc.med.navy.mil/ih/Respirator/Resp_index.htm

- OSHA Respiratory Protection eTool at www.osha.gov/SLTC/etools/respiratory/ index.html

The End !!

Questions

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