

# Respirator Selection

November 29, 2004  
PUBH 5310

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## Objectives

- Understand basic respirator selection concepts
  - IDLH
  - Oxygen deficiency
  - Contaminant type and concentration
- Know how filters and cartridges work
- Be familiar with methods to determine cartridge change-out schedule

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## Respirator Selection Principles

- Select appropriate respirator based on the respiratory hazard
- The work atmosphere must be evaluated
  - Reasonable estimate of employee exposures
  - Identify contaminant chemical state and physical form
  - Atmosphere is considered IDLH where the employer cannot identify or reasonably estimate exposure

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## Respirator Selection Principles

- Respirators for IDLH
  - Full facepiece pressure demand SCBA , minimum 30 minute service life, or
  - Combination full facepiece pressure demand supplied-air respirator (SAR) with auxiliary self-contained air supply.
  - Escape-only respirators where appropriate

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## Respirator Selection Principles

- Oxygen Deficiency
  - Normal oxygen conditions
    - 20.9% “normal” @ sea level
    - 159 mm pO<sub>2</sub> partial oxygen pressure (.209x760mm)
  - ANSI limit based on pO<sub>2</sub>
    - 122 mm pO<sub>2</sub> = oxygen deficient
    - 95 mm pO<sub>2</sub> = IDLH
  - OSHA defines oxygen deficiency < 19.5%
    - IDLH range depends on altitude (16% O<sub>2</sub> at sea level):

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Table II (from 1910.134)

Altitude (ft.)	Oxygen deficient Atmospheres (% O <sub>2</sub> ) for which the employer may rely on atmosphere-supplying respirators
Less than 3001	16.0 - 19.5
3001 – 4000	16.4 - 19.5
4001 – 5000	17.1 - 19.5
5001 – 6000	17.8 - 19.5
6001 – 7000	18.5 - 19.5
7001 – 8000 <sup>1</sup>	19.3 - 19.5

Above 8,000 feet the exception does not apply. Oxygen-enriched breathing air must be supplied above 14,000 feet.

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## Respirator Selection Principles

- Respirators for non-IDLH
  - Atmosphere supplying respirators are suitable for gases, vapors or particulates
    - May be used for non-IDLH oxygen deficiency
  - Air-purifying respirators have more limitations
    - Not for oxygen deficiency
    - More information is needed about the contaminants
      - Cartridge selection and changeout is based on contaminant type and concentration

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## Respirator Selection Guidance

- Manufacturers
  - “User friendly” guide
  - For manufacturer’s product line
  - MSA Response® Respirator Selector
    - <http://www.msanet.com/response/index.html>
  - 3M, North, Willson
- NIOSH
  - “Pocket Guide to Chemical Hazards”
  - “Respirator Decision Logic”
    - <http://www.cdc.gov/niosh/87-108.html>

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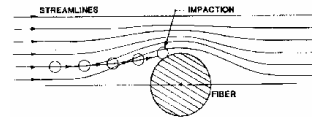
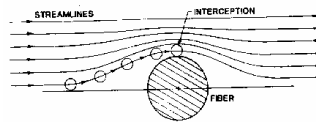
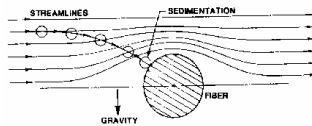


## Air-Purifying Respirators

- Filtration Mechanisms

- Larger particles

- Interception
- Sedimentation
- Impaction



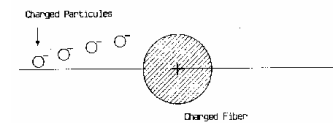
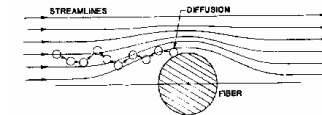
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## Air-Purifying Respirators

- Filtration Mechanism

- Smaller particles

- Diffusion “Brownian motion”
- Electrostatic attraction
- 0.3m “most penetrating” size



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## Air-Purifying Respirators

- Filter types

- Previously, particulate filters were classified by use and efficiency

- Dust, fume, mist
- High efficiency (HEPA)

- Now, filters classified by efficiency and resistance to oil

- 42 CFR part 84
- Prompted by need to protect health care workers from TB
- Phase-in complete, July 1998

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## Air-Purifying Respirators

- 42 CFR part 84 Filter Classification

- Oil Resistance

- N = Not Oil Resistant
- R = Oil Resistant
- P = Oil Proof

- Efficiency (for “most penetrating” particle)

- 95 (95%)
- 99 (99%)
- 100 (99.97%), the same as HEPA

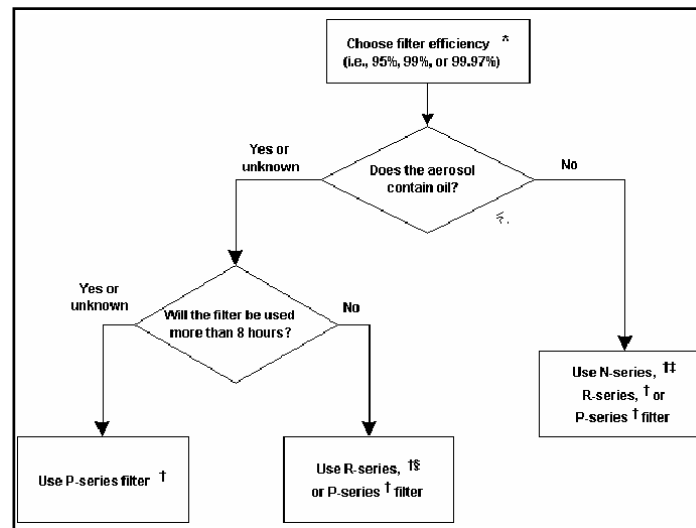
- Example

- N-95 = most filtering facepiece “dust masks” <sup>16</sup>

## Air-Purifying Respirators

### • Filter Selection

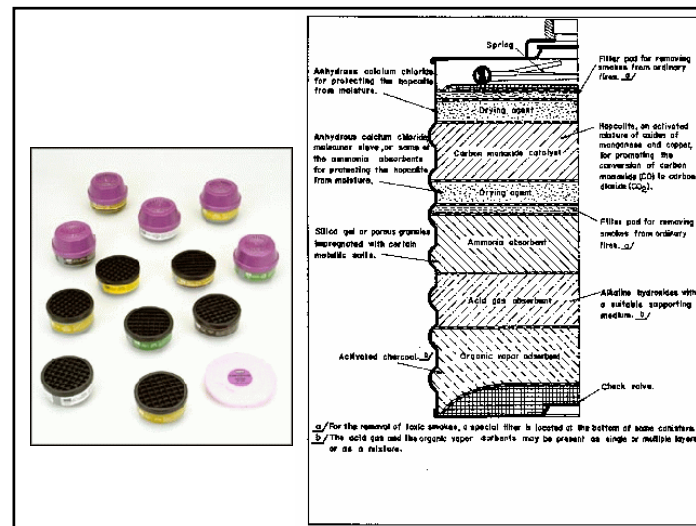
- Before 42 CFR 84, filters were selected according to particulate size
  - HEPA filters used for Mass Median Aerodynamic Diameter (MMAD) < 2 micrometers
- Now, select filters according to oil resistance
  - Specific OSHA standards may specify HEPA (P-100), although objective data suggests HEPA filters are not effective
    - Increased filtration efficiency does not compensate for increased facepiece leakage
    - All 42 CFR 84 are effective at removing small paraticles <sup>17</sup>



## Cartridge Selection

### • Cartridges for specific contaminants

- Acid gas, organic vapor, ammonia, mercury, etc.
  - Color coded
- Available in combination w/filters
- “Type N” Universal gas mask canister removes a wide range of contaminants

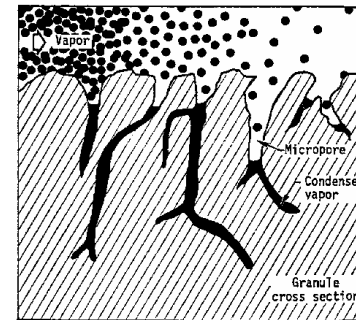


## Air-Purifying Respirators

- Gas and Vapor Removing Mechanisms
  - Adsorption
    - Contaminant molecules retained on surface
    - Activated charcoal, for organic vapors
    - May be treated with other substances
  - Absorption
    - Contaminant penetrates sorbent
    - Hydroxides with lime, for acid gases
  - Catalysis
  - Chemical reaction

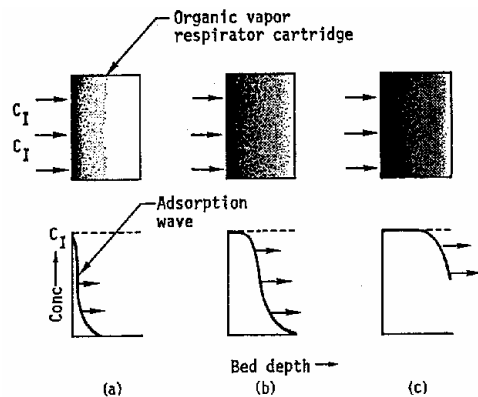
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## Adsorption



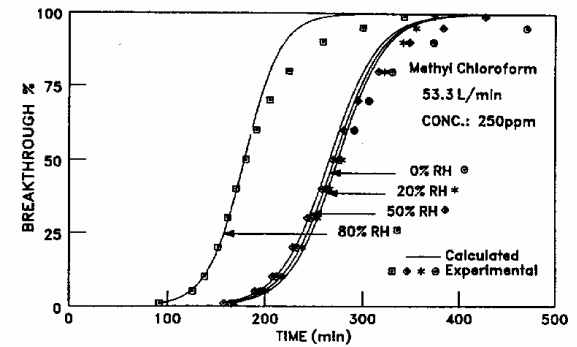
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## Breakthrough



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## Breakthrough and Humidity



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## Cartridge Changout

- Change filters when breathing resistance increases
- Previously, gas/vapor cartridges were changed when the user sensed “breakthrough”
  - Contaminant must have good “warning properties”
- Now, cartridges must be changed before breakthrough (OSHA 1910.134)
  - A few cartridges have an End-of-Service Life Indicator (ESLI)
  - Use a cartridge change schedule

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## Cartridge Changout

- Establishing a cartridge changeout schedule
  - Use experimental data
  - Use manufacturers data
  - Use mathematical modeling
  - Rule of Thumb

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## Cartridge Changout

- Establishing a CARTRIDGE change schedule
  - Experimental tests
    - Draw contaminated air through cartridges or glass tubes of charcoal or sample inside the respirator
    - Identify “breakthrough time”
  - Best method for mixtures of contaminants?
  - Guidance
    - Text, Chapter 36
    - <http://www.osha.gov/SLTC/etools/respiratory/oshafil es/evaluation.html>

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## Cartridge Changout

- Manufacturer’s recommendations
  - 3M service life computer program  
<http://www.mmm.com/market/safety/ohes2/html/cartridgechange.html>
  - MSA  
[http://www.msanet.com/msanorthamerica/msaunitedstates/USrespiratory\\_protection.html](http://www.msanet.com/msanorthamerica/msaunitedstates/USrespiratory_protection.html)
  - Other manufacturers

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## Cartridge Changout

- Mathematical models
  - “Predictive” models
    - Wood model
  - “Descriptive” models
    - Yoon-Nelson model
    - MSA
  - “Rule of Thumb”
  - OSHA Respiratory Protection Advisor
    - Wood “table” and “Genius”

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## Cartridge Changout

- Rule of Thumb is:
  - If the chemical's boiling point is  $> 70$  °C and the concentration is less than 200 ppm you can expect a service life of 8 hours at a normal work rate.
  - Service life is inversely proportional to work rate.
  - Reducing concentration by a factor of 10 will increase service life by a factor of 5.
  - Humidity above 85% will reduce service life by 50%
- From the “Text”, Chapter 36

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## Cartridge Changout

- OSHA
  - The Advisor Genius:  
Calculating the Wood Equation
    - [http://www.osha.gov/SLTC/etools/respiratory/advisor\\_genius\\_wood/advisor\\_genius.html](http://www.osha.gov/SLTC/etools/respiratory/advisor_genius_wood/advisor_genius.html)



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