CONTROLLING DPM EXPOSURE WITH ENVIRONMENTAL CABS AND PPE

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INTRODUCTION

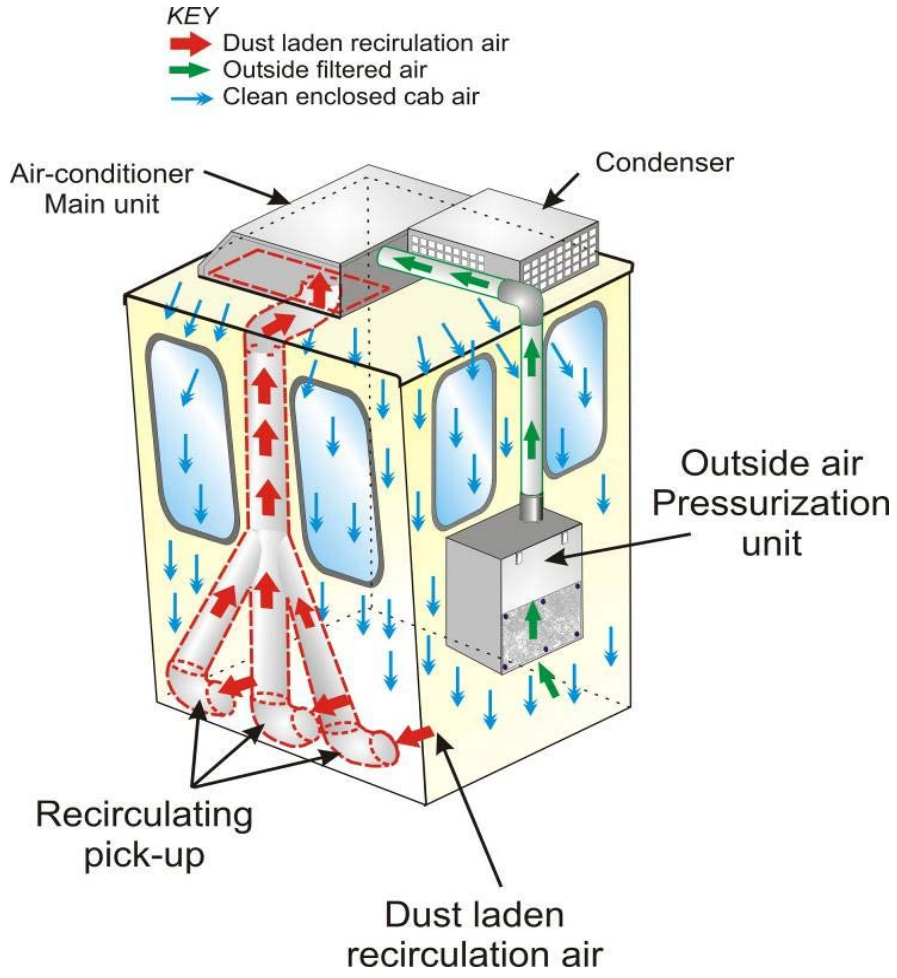
Underground miners can be exposed to the highest concentrations of DPM of any occupation

In 2001, MSHA promulgated rule
interim : 400 µg/m^3 TC
final : 160 µg/m^3 TC

ENVIRONMENTAL CABS

- Recognized as an engineering control used to reduce exposure of mobile equipment operators to DPM in underground mines
- Available from OEMs on new equipment
- Available as retrofit on existing equipment

ENVIRONMENTAL CABS



- Typical designs of environmental cabs include;
  - Filtration
  - Pressurization
  - Air-conditioning system
- Walls, doors and windows must be tightly sealed
- Must maintain positive pressure inside cab

THREE TYPES OF FILTRATION SYSTEMS ARE USED ON ENVIRONMENTAL CABS

- Pre-filtration system
  - Used to prevent the penetration of coarse, mechanically generated aerosols from surrounding atmosphere into cab
- Main filtration system
  - Used downstream of pre-filtration and re-circulation filters
  - Remove smaller mechanically generated and combustion aerosols
- Recirculation filtration system
  - Reduces entrainment of dust from miners clothes and cab floor into the cab atmosphere
  - Creates an order of magnitude increase in protection factor when filters with filtration efficiency in excess of 85% are used in the recirculation system

WHAT FILTRATION ELEMENT SHOULD I USE?

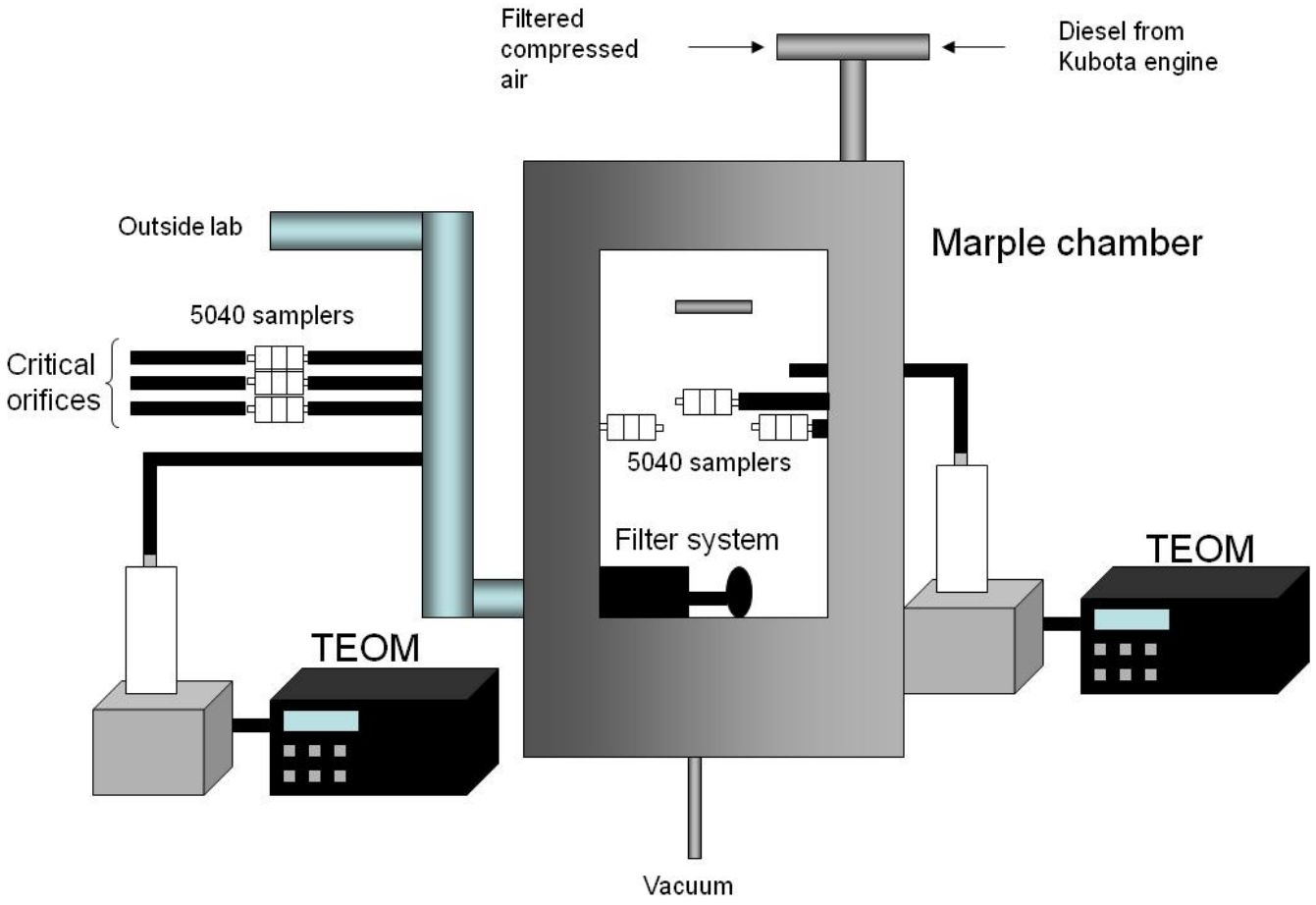
- Choice of a filtration element is specific to the application and depends on;
  - The type of aerosols present in the environment and cab
  - Desired level of protection
  - Cost

- Filters used in the U.S. are rated by the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)
  - Effectiveness of filters in removing dust is reported in terms of minimum efficiency reporting values (MERV)

WHAT DOES MERV RATING TELL ME?

- Filters with higher MERV ratings are more efficient in capturing particles
- MERV ratings of 12 and higher are suitable for filtering respirable dust.
- MERV ratings of 14 and higher might be used for filtration of submicron aerosols, such as diesel particulate matter
- High efficiency particulate air (HEPA) filters have efficiencies higher than those published for MERV-rated filters
  - All HEPA filters should remove at least 99.97% of airborne particles that are 0.3 microns in diameter

EXPERIMENTAL SETUP



NIOSH EVALUATED EFFECTIVENESS OF FILTERS ON EC AND TC REMOVAL?

Table 2: Efficiency of Cab Filters Using NIOSH 5040 Data						
	after filtration		in chamber		EC	TC
Filter Type	EC ($\mu g/m^3$)	TC ($\mu g/m^3$)	EC ($\mu g/m^3$)	TC ($\mu g/m^3$)	% efficiency	% efficiency
no filter	501	568	513	602	2	5
HEPA	< 3	< 6	625	706	> 99	> 99
Merv 8	310	371	528	604	41	39
Merv 16	20	42	574	668	96	94
Merv 16 long	11	19	690	803	98	98
HEPA low resistance	< 3	< 6	660	742	> 99	> 99

NIOSH EVALUATED EFFECTIVENESS OF FILTERS ON TOTAL DPM REMOVAL?

Table 3: Cab Filter Efficiency Using TEOM Data			
	TEOM mass ($\mu g/m^3$)		
Filter Type	**chamber**	**after filtration**	**% efficiency**
no filter	682	570	16
HEPA	814	< 8	> 99
Merv 8	772	355	54
Merv 16	641	26	96
Merv 16 long	861	7	99
HEPA low resistance	801	< 8	> 99

NIOSH EVALUATED FILTERS

- MERV 8 filters show moderate efficiency in removing elemental carbon, total carbon and total DPM mass
  - 41% for EC
  - 39% for TC
  - 54% for total mass

- Two types of MERV and two types of HEPA filters demonstrated high efficiencies (> 95%) at removing diesel aerosols.

CONCLUSIONS FROM NIOSH EVALUATION

- HEPA and MERV 16 capture DPM at high efficiency
  - HEPA (99%) better than MERV 16 (96-99%)
  - MERV16 may be cheaper and less restrictive to cab air flow
  - MERV 16 filters allow for high protection factor but cost less, have a longer life expectancy and are less restrictive to cab air flow.
- HEPA had efficiency greater than 90% in most cases in field studies.

ISSUES WITH USING HEPA FILTERS

- Price of filter increases with efficiency
  - HEPA filters can be more costly
- Life expectancy decreases with efficiency
  - HEPA filters will need replaced more often

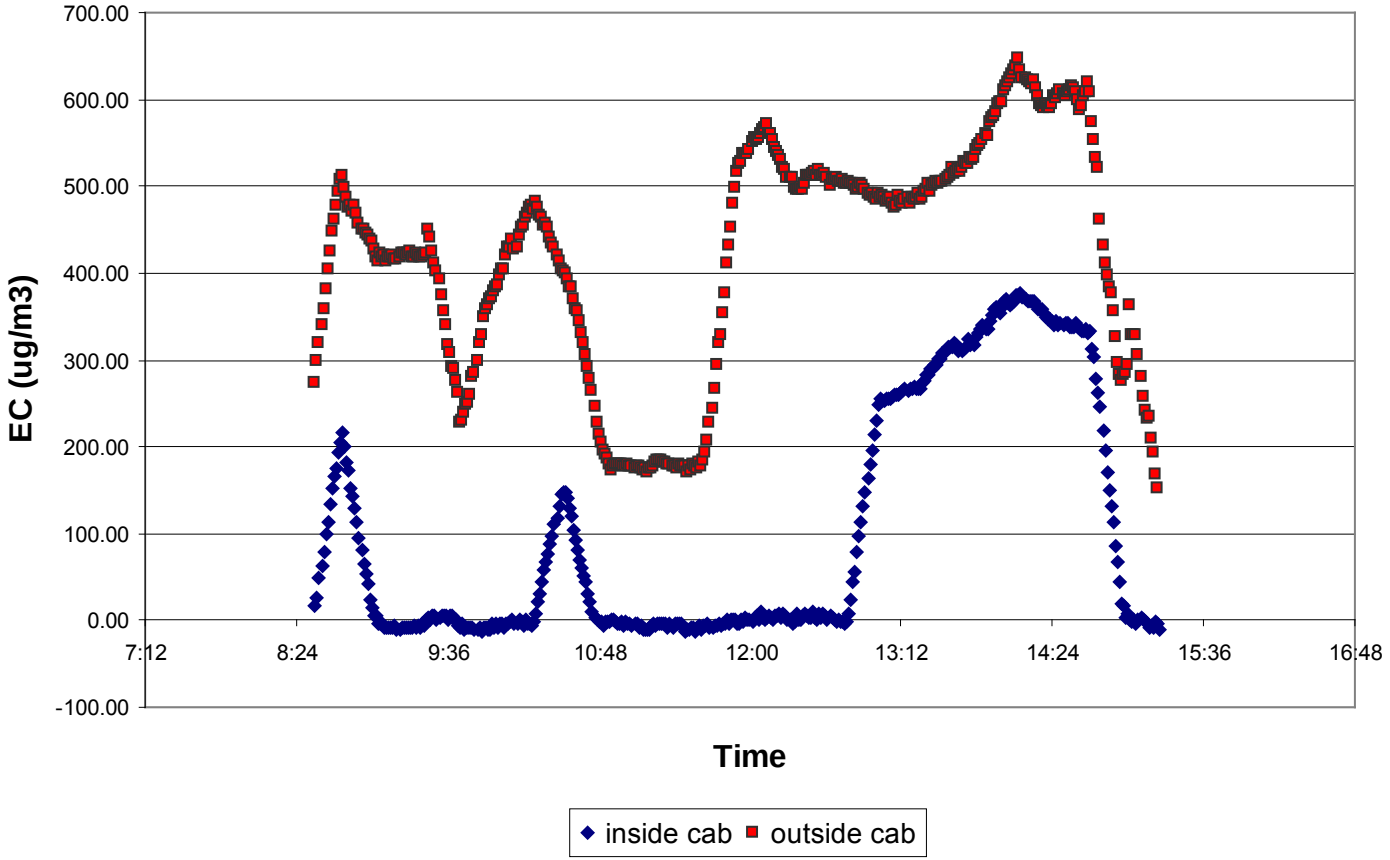
DETAILS FOR IMPLEMENTING ENVIRONMENTAL CABS

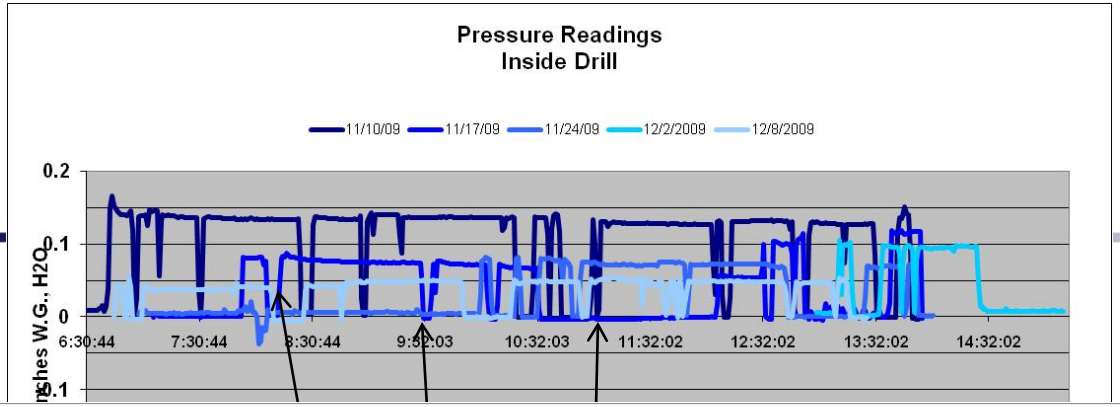
- The effectiveness of the environmental cabs in reducing concentrations of diesel aerosols depends on;
  - Efficiency of deployed filtration element
  - Design and integrity of the cab and filtration system

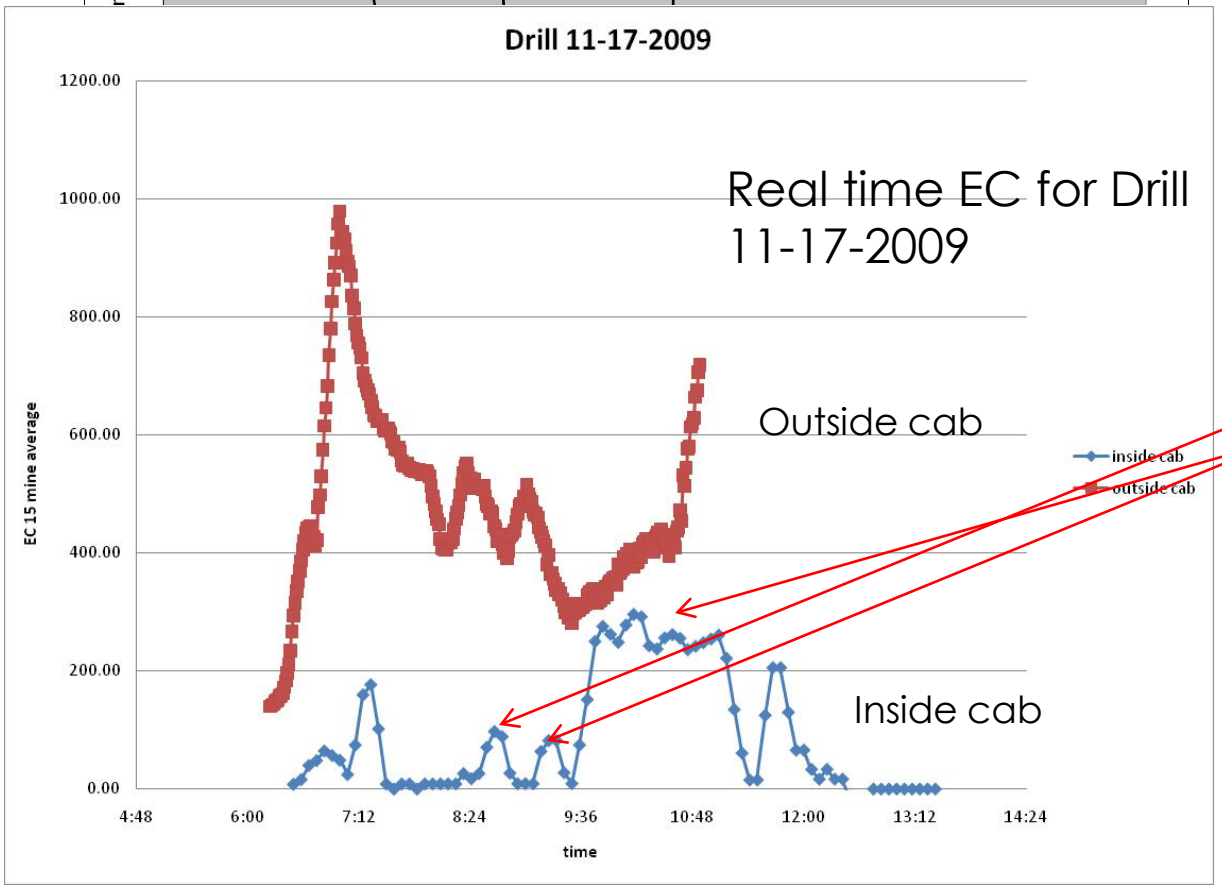
- Cabs provide protection only to workers who are spending most of their work time enclosed in cabs
  - Frequent opening of doors/windows, or leaving cab, reduces efficiency

- Cabs can also be used to reduce exposure of underground miners to noise.

POTENTIAL OPEN WINDOW







Real time EC for Drill 11-17-2009

Outside cab

Inside cab

Potential open door or window causing higher DPM concentration (coincides with drops in cab pressure)

INTEGRITY OF CAB IS IMPORTANT

- Verify integrity of cab using pressure measurements
- Pressurize the cab and measure pressure losses due to leaks

Importance of Keeping the Cab Properly Sealed

Mobile equipment operator should not have the ability to turn off the filtration/pressurization system. Operator should only be able to control fan speed and temperature.

RESPIRATORS

WHAT IS A RESPIRATOR?

- A personal protective device that is;
  - worn on the face,
  - covers at least the nose and mouth, and
  - is designed to reduce the risk of inhalation of hazardous aerosols, gases or vapors

WHEN SHOULD RESPIRATORS BE USED?

- **Only after all feasible engineering and administrative controls have been implemented and exposures have not been reduced to acceptable levels.**

RESPIRATORS ARE THE LAST LINE OF DEFENSE

- Approximately 5% of all U.S. workers wear respirators
- Respirators are worn in 20% of all work establishments
- **AT LEAST SOME OF THE TIME**

TWO TYPES OF RESPIRATORS ARE USED

- Air-purifying respirator (APR)
  - Protects the worker by removing the contaminants from the air
  - Widely used in workplaces
  - Do not supply oxygen and must never be used in environments with oxygen content below 19.5%

- Air-supplying respirator (ASR)
  - Protects the worker by supplying clean pollutant-free air from another source
  - Primarily used during entry into or escape from a hazardous atmosphere
  - Not technically or economically viable as a solution for reducing exposure of miners to DPM and gases

THREE CLASSIFICATIONS OF APRS

- Particle-filtering facepiece (dust mask)
- Non-powered APRs (negative pressure)
- Powered air-purifying respirators (PAPRs) (positive pressure)

PARTICULATE-FILTERING RESPIRATORS

- Disposable
- The entire facepiece is discarded when it becomes unsuitable for use due to;
  - Impaired hygiene
  - Excessive resistance
  - Physical damage

- Only disposable filtering facepieces certified by NIOSH as P100 respirators are currently available to protect miners from DPM

NON-POWERED APRS

- Re-usable
  - The facepiece is cleaned and re-used
  - Filter cartridges are discarded and replaced when they become unsuitable for use
- When equipped with proper cartridges can also provide protection against gases
  - Components from one APR manufacturer should not be interchanged with components for another manufacturer
- Available as half-face or full-face

POWERED AIR PURIFYING RESPIRATOR (PAPRS)

- Motorized systems
  - Use of a blower helps reduce breathing resistance and results in less worker stress and fatigue
- Tight-fitting facepeice and hood covering head and neck
- Use HEPA-type particulate filters
  - Can be combined with gas and vapor cartridges

APRS AND PAPRS ARE CERTIFIED BY NIOSH

- Certified under 42 CFR 84
- Respirators certified under part 84 (After July, 1995) have a NIOSH DHHS label
- Respirators certified under 30 CFR 11 (before July 1995) have a NIOSH MSHA label

FOUR SERIES OF FILTERS

- N-series filters
  - Not resistant to oil
  - Because DPM contains oil aerosols N-series filters should not be used to protect miners from DPM
- R-series (somewhat resistant to oil) and P-series (strongly resistant to oil) filters can be used to protect against oil aerosols
  - Will not provide any protection from gaseous components of diesel emissions
- HEPA filters can be used in PAPRs to protect against oil aerosols

WHAT REGULATIONS AFFECT RESPITRATOR USE IN COAL MINES?

- The use of respirators cannot be considered a substitute for engineering and administrative controls

- Underground coal (30 CFR 70.300, 30 CFR 70.305 and 30 CFR 72.710)
  - Requires respiratory equipment approved by NIOSH under Part 84 be made available to all workers whenever they are exposed to concentration of DPM in excess of levels required to be maintained.

WHAT REGULATIONS AFFECT RESPITRATOR USE IN M/NM MINES?

- The use of respirators cannot be considered a substitute for engineering and administrative controls

- Underground M/NM (30 CFR 57.5005)
  - MSHA prohibits the use of PPE to comply with the DPM concentration limits.
  - Use of appropriate respirators is permited on a temporary basis where;
    - Effective engineering and administrative controls are not feasible,
    - Engineering and administration controls are being substituted,
    - During occasional temporary entry of workers into hazardous atmospheres to perform maintenance or investigations

WHAT ARE APPROPRIATE RESPIRATORS?

- The filters used in APRs and PAPRs to control exposure of underground M/NM miners to DPM should meet the following criteria;
  - Certified by NIOSH (30 CFR 11, 42 CFR 84) as HEPA filters
  - Certified by NIOSH (42 CFR 84) as R-series and P-series filters with 99.97% efficiency
  - Certified by NIOSH as filters for DPM

FILTER SELECTION

- Because of the nature of DPM aerosols only HEPA, R100 and P100 fitlers are recommended by industry experts for use in DPM respirators
  - Currently only P100 and HEPA filters are commercially available
  - List of P100 filters certified by NIOSH can be found at;
  - http://www.cdc.gov/niosh/npptl/topics/respirators/disp_part/

- Filter class should be clearly marked on filter, filter package or respirator box.
  - i.e. P100 filters are color-coded magenta

SERVICE LIFE OF FILTER CARTRIDGES

- Service life of R- and P-series filters is limited by considerations of;
  - Hygiene
  - Damage, and
  - Breathing resistance

- All filters should be replaced when they are damaged, soiled or cause noticeably increased breathing resistance (discomfort to wearer)

ASSIGNED PROTECTION FACTOR USED FOR GASEOUS CONTAMINANTS

- The minimum anticipated level of protection provided by each type of respriator worn
- APF of 10 means the respirator should reduce the airborne concentration of a contaminant by a factor of 10, or to 10% of the workplace concentration
- The maximum workplace concentration in which this respirator can be used is determined by multiplying the occupational exposure limit by the APF

QUESTIONS

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