Selection, Use & Limitations of Respiratory Protection Devices

WORLD CLASS HEALTH & SAFETY EVENT
Michigan Safety Conference

Selection, Use and Limitations of Respiratory Protection Devices

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94 Years - Find Your Safety _____!

Recognizing the Need for Respiratory Protection

In the 16th Century, Leonardo da Vinci described a simple protective mask to protect sailors against a toxic powder weapon he designed:

. . . have your nose and mouth covered over with a fine cloth dipped in water . . .

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Respiratory Protection Circa 1721 – Black Plague

Plague Doctor's Mask
Copper engraving of Dr. Schnabel, a plague doctor in 17th century Rome.

3

1ST Gas/Vapor APR Industrial Revolution

John Stenhouse, of Glasgow, Scotland, designed a mask in 1850 that used wood charcoal as a filtering material. The facepiece was velvet lined for a tight fit and used an elastic head band. Stenhouse did not patent his mask but gave it to the public. Within a few years, chemical manufacturers in London were supplying their workmen with charcoal respirators.

From Edward L. Youmans' Class-Book of Chemistry, New York, 1858

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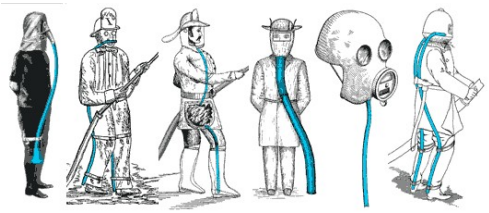
Atmosphere Supplying Respiratory Protection

- **Hanging-Tube Masks** designs by, from left to right: Robertson; Nelson (1857); Elliot (1885); Hurd (1887); Richet (1889); and Moran (1893). This type of device became obsolete in the early 20th century.



- Refs: R.H. Davis, *Breathing in Irrespirable Atmospheres* (1947); U.S. patents #16863, #334360, #396161, #409428, #518822

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Healthcare Respiratory Protection

Healthcare workers in "anti-plague masks" during the 1911 Manchurian plague. [Photo: courtesy University of Cambridge/Centre for Research in the Arts, Humanities and Social Sciences (CRASSH, The University of Cambridge)/The University of Hong Kong Libraries]

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Selection, Use & Limitations of Respiratory Protection Devices

Respiratory Protection
responds to Market Demands

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Medical Evaluation

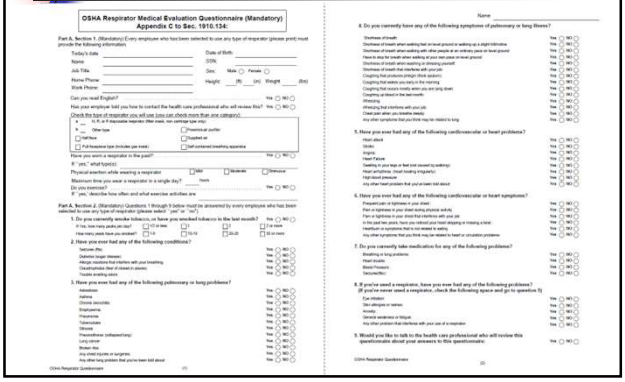
- Medical Questionnaire & Exams shall be:
  - Confidentially during work hours
  - At a convenient time and place

Table H–1.—Suggested frequency of medical fitness determinations*

Type of working conditions	Worker age (yr)		
	<35	35 to 45	>45
Most work conditions requiring respirators	Every 5 yr	Every 2 yr	1–2 yr
Strenuous working conditions with a SCBA†	Every 3 yr	Every 18 mo	Annually

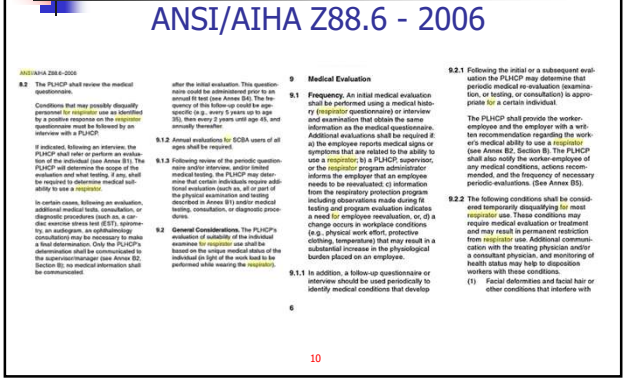
*Interim testing would be needed if changes in health status occur.
†SCBA = self-contained breathing apparatus.

Respirator Medical Evaluation Questionnaire
Appendix C of 29 CFR 1910.134



OSHA Respirator Medical Evaluation Questionnaire (Mandatory)
Appendix C to Sec. 1910.134

Physical Qualifications
for Personnel
ANSI/AIHA Z88.6 - 2006



9 Medical Evaluation

9.1 Frequency. An initial medical evaluation shall be performed using a medical history (respirator questionnaire) or interview and examination that obtain the same information as the medical questionnaire. Additional evaluations shall be required if: a) the employee reports medical signs or symptoms that are related to the ability to use a respirator; b) a PLHCP, supervisor, or the respirator program administrator informs the employer that an employee needs to be reevaluated; c) information from the respiratory protection program including observations made during fit testing and program evaluation indicates a need for employee reevaluation, or; d) a change occurs in workplace conditions (e.g., physical work effort, protective clothing, temperature) that may result in a substantial increase in the physiological burden placed on an employee.

9.1.1 In addition, a follow-up questionnaire or interview should be used periodically to identify medical conditions that develop after the initial evaluation. This questionnaire could be administered prior to an annual fit test (see Annex B4). The frequency of this follow-up could be age-specific (e.g., every 5 years up to age 35), then every 2 years until age 45, and annually thereafter.

9.1.2 Annual evaluations for SCBA users of all ages shall be required.

9.1.3 Following review of the periodic questionnaire and/or interview, and/or limited medical testing, the PLHCP may determine that certain individuals require additional evaluation (such as, all or part of the physical examination and testing described in Annex B1) and/or medical testing, consultation, or diagnostic procedures.

9.2 General Considerations. The PLHCP's evaluation of suitability of the individual examinee for respirator use shall be based on the unique medical status of the individual (in light of the work load to be performed while wearing the respirator).

9.2.1 Following the initial or a subsequent evaluation the PLHCP may determine that periodic medical re-evaluation (examination, or testing, or consultation) is appropriate for a certain individual.

The PLHCP shall provide the worker-employee and the employer with a written recommendation regarding the worker's medical ability to use a respirator (see Annex B2, Section B). The PLHCP shall also notify the worker-employee of any medical conditions, actions recommended, and the frequency of necessary periodic-evaluations. (See Annex B5).

9.2.2 The following conditions shall be considered temporarily disqualifying for most respirator use. These conditions may require medical evaluation or treatment and may result in permanent restriction from respirator use. Additional communication with the treating physician and/or a consultant physician, and monitoring of health status may help to disposition workers with these conditions.

(1) Facial deformities and facial hair or other conditions that interfere with

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MAKE SURE THE RESPIRATOR FITS SNUGLY ON YOUR FACE

29 CFR 1910.134 Appendix A
Facial Hair required for Fit Testing

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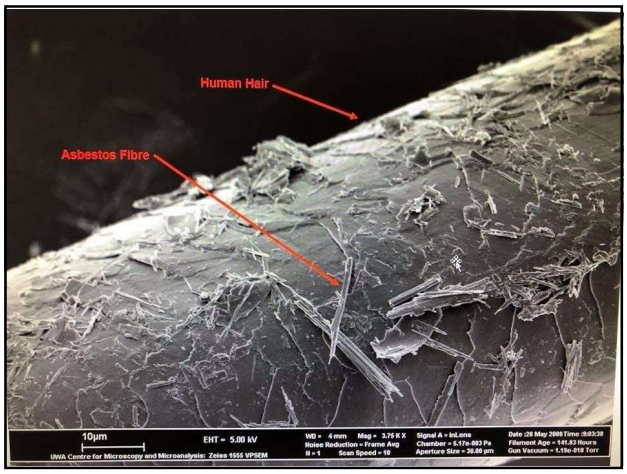


Facial Hair Restriction Tight Sealing Facepieces

Acceptable vs Unacceptable

Universal Limitations for APR/PAPR

- **Concentrations** are **Unknown**
- **Contaminant Concentrations ≥ IDLH**
- **Atmosphere contains <19.5% Oxygen**
- **Limited by available sorbent materials**
- **Gas/Vapor Contaminant has Poor Warning (odor/ irritation) Properties***

*Unless Provided with Service Life Calculations (1998)

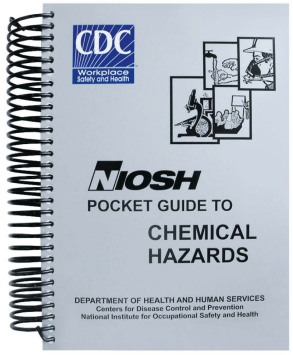
Maintenance & Care Requirements

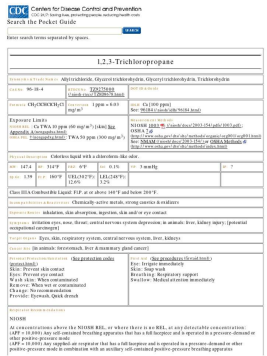
- Provide each user with a respirator that is clean, sanitary and in good working order
- Clean and disinfect at the following intervals:
  - As Often As Necessary When Issued for Exclusive Use
  - Before Being Worn by Different Individuals When Issued to More Than One Employee
  - After Each Use for Emergency Respirators and Those Used in Fit Testing and Training

Immediately Leave the Area & Remove the Respirator If

1) Breathing becomes difficult
2) Dizziness or other distress occurs
3) Wearer senses Irritation, Odors or Tastes the Contaminants
4) Air-Purifying Element Is Equipped With an End-of-Service-Life Indicator Which Has Changed Color to Indicate Expiration
5) Respirator becomes physically damaged

Respirator Selection Aides





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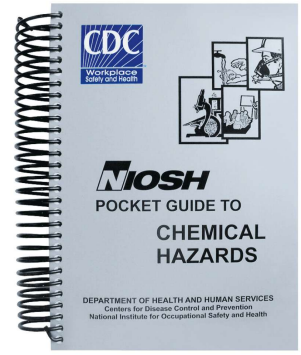
Respirator Selection Aides



Manufacturers Respirator Selection Guide

NOTE: See important warnings, definitions, and explanation of column headings and abbreviations starting on page 1. For occupational exposure limits, please see your local regulatory authority. In the US, please see https://www.osha.gov/annotated-pels.

Contaminant	CAS #	Synonym	Skin?	Respirator	Comments
Acetone cyanohydrin	75-86-5	2-Cyano-2-propanol, 2-Hydroxy-2-methyl propanenitrile, 2-Methyllactonile, 2-Propane cyanohydrin, a-Hydroxy isobutyronitrile	Y	OV	
Acetonitrile	75-05-8	Cyanomethane, Ethane nitrile, Ethyl nitrile, Methanecarbonitrile, Methyl cyanide	Y	OV	3M Organic Vapor Monitors
Acetophenone	98-86-2	1-Phenylethanone, Acetyl benzene, Benzoyl methide, Methyl phenyl ketone		OV	See comment E in Introduction. 3M Organic Vapor Monitors.
Acetylsalicylic acid	50-78-2	Aspirin		N95	
Acrolein	107-02-8	Acrylaldehyde, Acrylic aldehyde, Allylaldehyde, Propenal	Y	(F)OV	Short service life

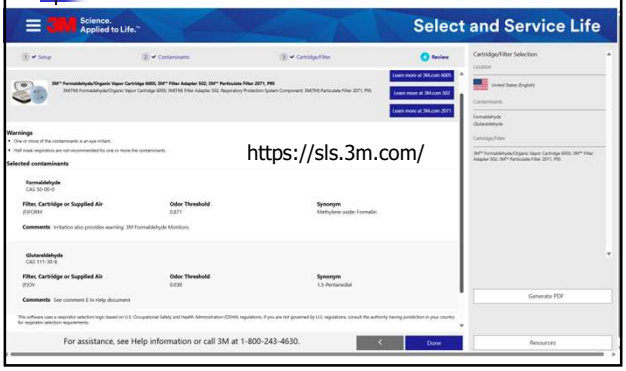
3M Respirator Selection Guide
https://multimedia.3m.com/mws/media/639110O/3m-respirator-selection-guide.pdf?fn=Respirator%20Selection%20Guide%20Final

Manufacturers Respirator Selection Guide

Chemical Name CAS #	Synonym	IDLH (ppm)	OEL (ppm)	Odor Threshold (ppm)	Respirator (to 10x OEL)	Comments
Cyanides (as CN)		50 mg/m³	TWA=5 mg/m³ (OSHA) -skin-		SA	
Cyanogen 460-19-5	Dicyan, Oxalonitrile	66000	TWA=10	231	MG	
Cyanogen chloride 506-77-4	CNCl		C=0.3	0.976	(F)SA	Short OV service life
Cyclohexane 110-82-7	Hexahydrobenzene, Hexamethylene	10000	TWA=100	83.8	(F)OV	Irritation also provides warning. 3M 3510 Monitor
Cyclohexanol 108-93-0	Anol, Cyclohexyl alcohol, Hexahydrophenol, Hexalin, Hydralin, Hydroxycyclohexane	3500	TWA=50 -skin-	0.068	OV	See comment E, page 9. 3M 3510 Monitor.
Cyclohexanone 108-94-1	Cyclohexyl ketone, Pimelic ketone	5000	TWA=20 STEL=50 -skin-	0.019	OV	3M 3510 Monitor
Cyclohexene 110-83-8	Benzene tetrahydride	10000	TWA=300	0.363	OV	3M 3510 Monitor

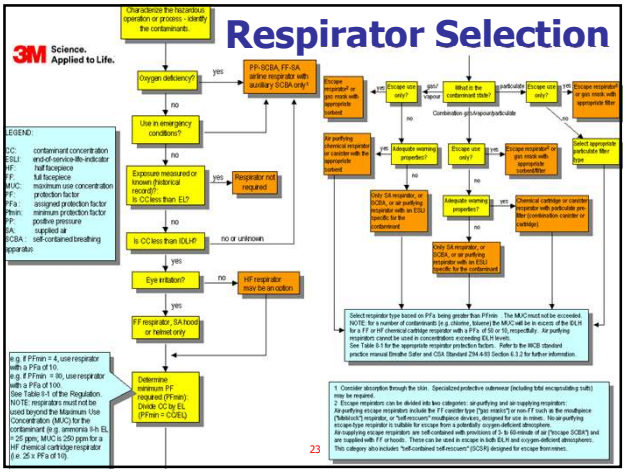
3M Respirator Selection Guide
OLDER VERSIONS

Respirator Selection Aides



https://sls.3m.com/

Respirator Selection



Hazard Ratios

Respirator Selection Form

Chemical Name	Air Concentration	IDLH	OEL	Hazard Ratio	Respirator Recommended
Respirator Selected:					

Hazard ratio = $\frac{\text{Exposure evaluation result *}}{\text{PEL *}}$

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Assigned Protection Factors

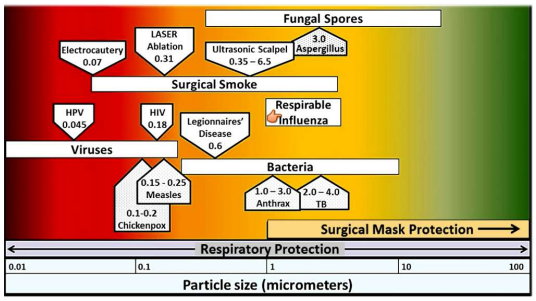
Respirator Type		CSA Z94.4-02	NIOSH 2004 Selection Logic	OSHA OSHA Nov. 2006 29 CFR 1910.134	CSA Z94.4-11 (Proposed Draft)
Air Purifying	Half Facepiece	10	10	10	10
	Full Facepiece	100 (QLFT – 10)	10[1] / 50[2]	50	50 (QLFT 10)
Powered Air Purifying	Loose-fitting facepiece	25	25	25	25
	Half facepiece	50	50	50	50
	Full facepiece	1000	50	1000	1000
	Helmet or hood	1000	25	25 / 1000[3]	25 / 1000[3]
Air Line Continuous Flow Supplied Air	Loose fitting facepiece	25	25	25	25
	Half facepiece	50	50	50	50
	Full facepiece	1000	50	1000	1000
	Helmet or hood	1000	25	25 / 1000[3]	25 / 1000[3]
Air Line Pressure Demand	Half facepiece	50	1000	50	50
	Full facepiece	1000	2000	1000	1000
	SCBA Full facepiece	----------	10000	10000	10000[4]
	SCBA tight fitting hood	----------	----------	10000	10000[4]

[1]APF of 10 with full facepiece respirators equipped with N/R/P 95 or 99 class filters.
[2]APF of 50 with a full facepiece equipped with a class 100 filter. Full facepiece with gas/vapour cartridge and/or equipped with a 100 class pre-filter.
[3] Manufacturer must demonstrate APF of 1000
[4] Must be QNFT

Maximum Use Concentration

- **Maximum Use Concentration (MUC):** the maximum atmospheric concentration of a hazardous substance from which an employee can be expected to be protected when wearing a respirator
- Determined by multiplying the **Assigned Protection Factor** (APF) for the respirator class by the NIOSH Recommended Exposure Limit (REL), OSHA Permissible Exposure Limit (PEL), Short Term Exposure Limit (STEL), Ceiling, or Peak Limit, or any other occupational exposure limit used for the hazardous substance

Healthcare Inhalation Hazards



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Healthcare Bioaerosol Hazards

- **Bioaerosols** include living or dead microorganisms, fragments, toxins, and particulate waste products from all varieties of living things. They are capable of causing infection, adverse or allergic response.
- **Liquid droplet** (generated by coughing, sneezing or a medical procedure such as bronchoscopy) or a **solid particle** (generated for example by sweeping, shoveling) suspended in the air.
- **Size Range:** <0.01 micron's to >100 microns in diameter.
- **Healthcare Precautions**: *Contact - **Droplet - Airborne***

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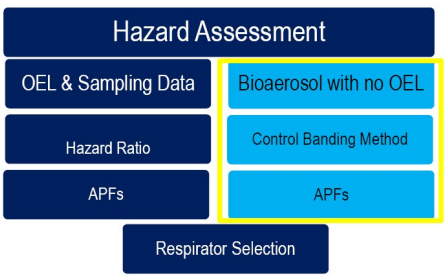
Healthcare Inhalation Hazards



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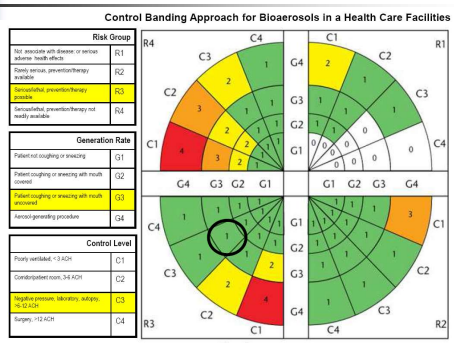
CSA Z94.4-18 Control Banding



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Selection, Use & Limitations of Respiratory Protection Devices

Mycobacterium tuberculosis (TB) Exposure

Acceptable level						Air-purifying options	APF	Atmosphere-supplying options
0	1	2	3	4	5			
					5	No air-purifying option available	10000	SCBA (pressure-demand) full-facepiece SCBA (pressure-demand) tight-fitting hood Multi-functional SCBA/airline
				4 to 5		Powered air-purifying full-facepiece Powered air-purifying helmet/hood with SWPF study	1000	Airline (continuous-flow) full-facepiece Airline (pressure-demand) full-facepiece Airline (continuous-flow) helmet/hood with SWPF study
			3 to 5			Powered air-purifying half-facepiece Air-purifying (negative-pressure) full-facepiece	50	Airline (pressure-demand) half-facepiece Airline (continuous-flow) half-facepiece
		2 to 5				Powered air-purifying loose-fitting facepiece/visor Powered air-purifying helmet/hood without SWPF study	25	Airline (continuous-flow) loose-fitting facepiece/visor Airline (continuous-flow) helmet/hood without SWPF study
	1 to 5					Air-purifying (negative-pressure) half-facepiece (including filtering facepieces)	10	No atmosphere-supplying option available
						No respiratory protection required	<1	No respiratory protection required

Notes:
(1) *See Tables 1 and 2 for fit test pass/fail criteria for tight-fitting respirators.*
(2) *Fit testing is not required for loose-fitting respirators.*

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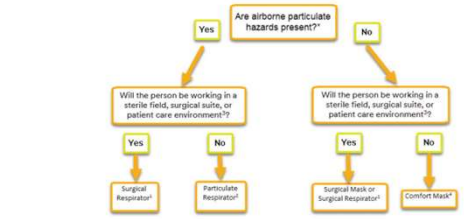
Respiratory versus Surgical Mask Decision Tree

Figure 1: Respirator versus Surgical Mask Decision Tree



1. In the U.S., surgical masks and surgical N95 respirators are cleared by the FDA for use in surgery. Surgical N95 Respirators are also approved by NIOSH.
2. In the U.S., particulate respirators are approved by NIOSH.
3. Patient care with potential exposure to high velocity streams of blood such as intravenous lines, surgery, emergency room, etc. Consult with your infection control manager.
4. Comfort masks are not designed to protect lungs from airborne hazards, are not NIOSH approved or FDA cleared.

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Respiratory versus Surgical Mask Decision Tree

Figure 1. Loose-fitting surgical mask

Figure 2. Tight-fitting N95 Filtering Facepiece Respirator (sealed against the skin)

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Classification of Respirators by Mode of Operation

I. **Air-Purifying Respirators**
- A. Vapor- and Gas-Removing Respirators
- B. Particulate-Removing Respirators
- C. Combination Particulate- and Vapor- and Gas-Removing Respirators
- D. Combination Atmosphere-Supplying and Air-Purifying Respirators

Classification of Respirators by Mode of Operation

II. **Atmosphere-Supplying Respirators**
- A. Self-Contained Breathing Apparatus (SCBA)
- B. Supplied-Air Respirators (SAR)

Elastomeric Half Facepiece Respirator

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Elastomeric Full Facepiece Respirator

Loose Fitting Hood, Helmet or Facepiece

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Emergency Egress Respirators

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3M Science. Applied to Life.™

https://multimedia.3m.com/mws/media/1833770O/filtering-of-bioaerosols-by-filtering-facepiece-respirators.mp4

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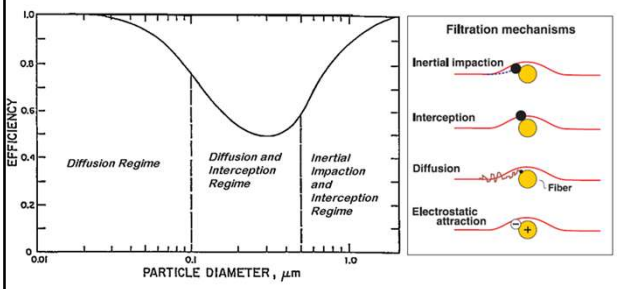
Aerosol Filtration Theory



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42 CFR Part 84 Minimum Filter Efficiency

42 CFR 84	Aerosol Test		
Minimum Efficiency	**NaCl** Non-oil Aerosols	**DOP** Includes Oil Aerosols*	**DOP** Includes Oil Aerosols
95%	N95	R95	P95
99%	N99	R99	P99
99.7%	N100	R100	P100

* May have a time use restriction on this filter series when oil aerosols are present. DOP = Dioctyl Phthalate NaCl = Sodium Chloride

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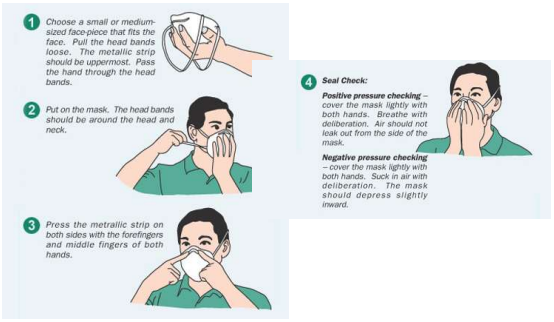
Filtering Facepiece (FFR)
Class 95-99-100 Dust Mask

A tight sealing negative pressure particulate respirator with a filter as an integral part of the facepiece or with the entire facepiece composed of the filtering medium.

N95 Filtering Facepiece Respirators (FFR)



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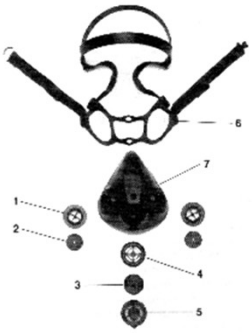
Service Life – Dust Filters

- In reality, Service Life of virtually all filters will be limited by hygiene considerations and increased breathing resistance due to filter loading
- Liquid particles will not cause filter caking, but will almost always be present with dusts or solids that do or will cake the filter

Full/Half Facepiece Air Purifying Respirators

Half Facepiece Respirator
APR Common Components



1. Inhalation Connector
2. Inhalation Valve
3. Exhalation Valve
4. Exhalation Valve Seat
5. Exhalation Valve Guard
6. Cradle Suspension
7. Silicone Half Facepiece

APR Daily Inspection Checklist

- **Proper Respirator Function**
- **Tightness of Connections**
- **Conditions of Parts**:
  - Facepiece, head straps, valves, connecting tube, cartridges, canisters, or filters
- Check of elastomer parts for pliability and signs of deterioration

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APR Daily Inspection Checklist

1. Check facepiece for cracks, tears and dirt. Be certain facepiece, especially face seal area, is not distorted.
2. Examine inhalation valves for signs of distortion, cracking or tearing.
3. Make sure that head straps are intact and have good elasticity.
4. Examine all plastic parts for signs of cracking or fatiguing. Make sure filter gaskets or seal areas are in good condition.
5. Remove exhalation valve cover and examine exhalation valve and valve seat for signs of dirt, distortion, cracking or tearing. Replace exhalation valve cover.
6. Inspect lens of full facepiece for any damage that may impair respirator performance or vision.

NIOSH Cartridge Color Coding

COLOR	TYPE OF PROTECTION
Black	Organic vapor cartridge
White	Acid gas cartridge
Yellow	Organic vapor and acid gas cartridge
Green	Ammonia and methyl amine cartridge
Olive Green	Organic vapor and formaldehyde cartridge
Purple (Magenta)	Dust, fumes, mists, asbestos, radionuclides, and highly toxic particulates (P100) filter
Black/Purple	Organic vapor and P100 combination
White/Purple	Acid gas and P100 combination
Yellow/Purple	Organic vapor/acid gas and P100 combination
Green/Purple	Ammonia/Methyl amine and P100 combination
Olive Green/Purple	Organic vapor/formaldehyde and P100 combination
Pre-filters	Use with dusts, fumes, mists, pesticides, and paints.

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Gas/Vapor Cartridges

- All chemical cartridges consist of a container filled with a *sorbent*.
- A chemical cartridge *sorbent* is a granular porous material that interacts with the gas or vapor molecule to remove it from the air.
- Typically this sorbent is *activated carbon* or activated charcoal. *Activated carbon* is an amorphous form of carbon characterized by high adsorptivity for many gases and vapors.
- The internal surface area of activated carbon averages 10,000 square feet per gram.

Gas/Vapor Cartridges

- The large surface area makes activated carbon ideal for removal of organic vapors by *adsorption*.
- ***Adsorption*** is the adherence of gas or vapor molecules to the surface of the activated carbon.
- The attractive force between the activated carbon and the chemical molecule is a relatively small, weak physical force. The strength of the attraction depends in part on the chemical.
- Since only weak physical forces are involved, the process can be reversed. This is called *desorption*.

Gas/Vapor Cartridges

- The more volatile the chemical the less strongly adsorbed, or the more likely it will undergo desorption
- Desorption during storage or nonuse times can result in *chemical migration*
- *Migration* is the movement of a previously adsorbed chemical through the chemical cartridge, even without air movement.

Variables That Appear to Impact Migration Include:

- **Vapor type**
- **Volatility** – the more volatile the chemicals, the greater the concern for migration;
- **Water Vapor** Co-adsorption [from use in atmospheres with RH >50%] can increase the migration effect;
- **Amount of material adsorbed** onto the cartridge in the first use;
- **Storage time**

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Gas/Vapor Cartridges

Chemical Cartridge Type	Removal Mechanism	Examples of Impregnant
Organic Vapors	Adsorption	N. A.
Ammonia/Methylamine	Chemisorption	Nickel chloride, Cobalt salts, copper salts, Acids
Acid Gases	Chemisorption	Carbonate salts, Phosphate salts, Potassium hydroxide, copper oxide
Formaldehyde	Chemisorption	Copper oxide + metal sulfates, Salts of sulfamic acids
Mercury Vapor	Chemisorption	Iodine, Sulfur
Hydrogen Fluoride	Chemisorption	Carbonate salts, Phosphate salts, Potassium hydroxide, copper oxide

OSHA Standard (HCHO) Specified Service Life:

- If air-purifying chemical-cartridge respirators are used, the employer must: 1910.1048(g)(2)(ii)(A)
- Replace the cartridge after three (3) hours of use or at the end of the work shift, whichever occurs first, unless the cartridge contains a end-of-service-life indicator (ESLI) to show when breakthrough occurs.

  1910.1048(g)(2)(ii)(B)
- Unless the canister contains a ESLI to show when breakthrough occurs, replace canisters used in atmospheres up to 7.5 ppm (10xPEL) every four (4) hours and industrial-sized canisters used in atmospheres up to 75 ppm (100xPEL) every two (2) hours, or at the end of the work shift, whichever occurs first.

Cartridge Change Schedules

- **Gases and Vapors**
  - Use of **Warning Properties** as the sole basis for determining change schedules is prohibited
    - Where an effective change schedule is implemented, air-purifying gas and vapor respirators may be used for hazardous chemicals, including those with few or no warning properties.

Cartridge Service Life:

- The **measured** or **estimated period of time** before breakthrough of a contaminant (gas or vapor) for a specific chemical cartridge under specified conditions of the test or estimated

Cartridge Change Schedule

- Is the employer/user specified time period after which the chemical cartridge will be replaced
- Established after consideration of the workplace conditions such as **contaminant concentration**, **relative humidity**, **temperature**, work **activities**, respirator **use pattern** (e.g., continuous or intermittent use), **presence of other materials**, **potential for contaminant migration/desorption**, **health effects of the gas/vapor** and quality of **warning properties**, if any.

The suggested Rule of Thumb:

- If a chemical's **boiling point is > 70 °C** & its concentration **< 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** increases service life by a factor of **5**.
- **Humidity above 85%** will reduce service life by **50%**

Service Life of Acid Gas, Ammonia/Methylamine and other chemical cartridge's that work by chemisorption, typically increase with increasing RH

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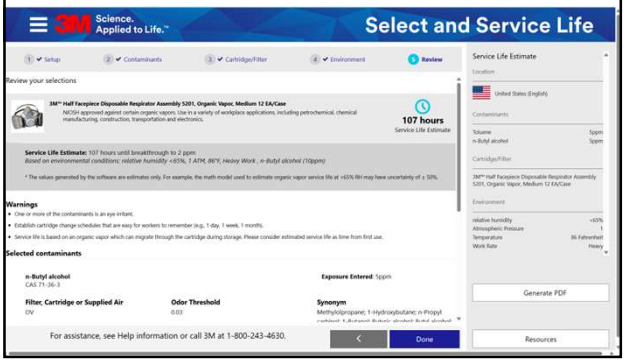
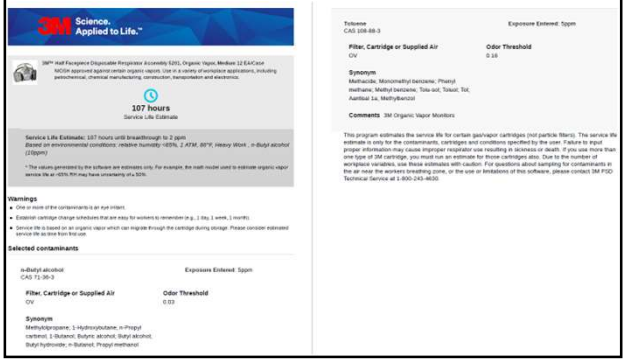
Selection, Use & Limitations of Respiratory Protection Devices

Manufacturers Service Life Software



Manufacturers Service Life Software



Powered Air Purifying Respirator

Protection against particulate, sparks, flying debris, chemical and molten metal splashes, including welding, cutting & grinding

Welding Fume, Ozone, Gas & Vapors PAPR

Powered Air Purifying Respirator

Infection Prevention, Pandemic Preparedness

Hazardous Drugs Spills

Advances in Design

Powered Air Purifying Respirators

Healthcare

First Receiver
TIC's & CBRN

Pharmaceutical

Active Pharmaceutical Ingredients - API

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Selection, Use & Limitations of Respiratory Protection Devices

Design Limitation
Powered Air Purifying Respirators

- Battery Status

Battery Storage

Storage of Li Polymer batteries is relatively easy. Unlike Nickel batteries, they lose a very small amount of power (less than 0.5% per day) and therefore can be charged and stored ready for use. If long-term storage is required, it is best to store the battery in a cool place with at least 40% charge still remaining.

NOTE

Discharging and re-charging the battery fully at least once every 3 months is suggested to ensure the longest possible life of the battery.

Temperature	40% charge level (recommended storage charge level)	100% charge level (typical user charge level)
0°C	98% after 1 year	94% after 1 year
25°C	96% after 1 year	80% after 1 year
40°C	85% after 1 year	65% after 1 year
60°C	75% after 1 year	60% after 3 months

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Cleaning & Disinfecting Procedures

Respirator Components should be immersed **2** - **4** minutes in one of the following:

1. Hypochlorite Solution (50 ppm of chlorine) made by adding one milliliter of laundry bleach to one liter of water at 43 deg. C (110 deg. F); or,
2. Aqueous Solution of Iodine (50 ppm iodine) made by adding 0.8 milliliters of tincture of iodine (6-8 grams ammonium and/or potassium iodide/100 cc of 45% alcohol) to one liter of water at 43 deg. C (110 deg. F); or,
3. Other Commercially Available Cleansers of equivalent disinfectant quality

If a respirator is...	Then...
issued for the exclusive use of an individual employee	the equipment must be cleaned and disinfected as often as necessary to be maintained in clean and sanitary condition.
used by more than one employee	the equipment must be cleaned and disinfected *before* being used by different individuals.
maintained for use in emergencies, testing, and training exercises	the equipment must be cleaned and disinfected *after* each use.

Store Respirators in Sealed Dry Containers

Supplied Air Respirator (SAR)

An atmosphere-supplying respirator for which the source of breathing air is not designed to be carried by the user

Also called Airline Respirator

Loose-Fitting Coverings

Classes of Atmosphere-Supplying Respirators

Continuous Flow

- Provides a continuous flow of breathing air to the respiratory inlet covering

Positive-Pressure Demand

- Admits breathing air to the facepiece when the positive pressure inside the facepiece is reduced by inhalation

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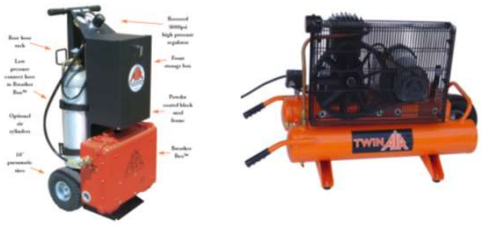
Selection, Use & Limitations of Respiratory Protection Devices

Atmosphere-Supplying Respirator

A respirator that supplies the user with breathing air from a source independent of the ambient atmosphere



Applications of Atmosphere-Supplying Respirators

- Abrasive Blasting
- Confined Space Entry
- Emergency Egress
- Emergency Response
- Entry in Unknowns
- Fire Fighting
- Oxygen Deficient Atmospheres
- Pharmaceutical Research and Manufacturing
- Spray Painting
- Water Jetting
- Welding in Enclosed Areas

Breathing Air Point-of-Attachment

Breathing Air Supplies require:

- Coupling or Quick-Disconnect
  Compatible to breathing air supply only
- Manifold
- Over Pressure Relief Valve – Max 125 psi
- Pressure Regulator
- Delivery Pressure Gauge
- Audible Alarm
  - Whistle, Bell or Electronic Alarm

Breathing Air Quantity

Four (4) Cubic Feet per Minute

- Tight fitting Full Facepiece or Half Facepiece atmosphere supplying respirators

Six (6) Cubic Feet per Minute

- Loose fitting Hood, Helmet or Facepiece assembly atmosphere supplying respirators

Maximum of 15 cfm for Vortex Cooling

Breathing Air Pressure

- Minimum 7 to 14 psi for Low Pressure Ambient Air Pump Systems
- 25 to 125 psi for High Pressure Plant Compressor or Manifold Air Bottle Supplies.
- Generally no more than three (3) lengths of breathing air hose
- Hose may require leak testing
- No more than 300' length of interconnected air supply hoses

Pressure Requirements

Hose and Pressure Requirements for 3M Compressed Air Systems (in psi)

Hose Length Feet	Meters	W-2862 Vortex Cooler	W-2863 Vortemp™ Heater	W-2907 Air Regulating Valve	W-9435 Hose, SA-1007 Air Regulating Valve	W-9435 Hose, W-3194 Connector	W-9435 Hose, W-3062 Valve	W-3020 Hose W-3018[2] Connector	W-3020 Hose SA-1027 Connector	W-3020 Hose W-3195 Connector
25	7.62	60-70	60-70	25-35	16-24	8-15	15-25	4-9	8-16	7-11
50	15.24	60-75	65-75	25-35	17-26	10-19	18-25	5-11	9-16	7-11
100	30.48	65-75	65-80	30-40	18-27	12-21	19-30	6-15	10-17	7-12
200	60.96	80-90	75-85	35-60	21-33	17-31	25-40	NA	NA	NA
300	91.44	85-90	85-90	40-70	25-38	21-36	25-55	NA	NA	NA
Maximum cfm Consumed		20	20	15	8	8	10	15	8	8

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Selection, Use & Limitations of Respiratory Protection Devices

NIOSH Approved Hose

- NIOSH approves SAR with all components from "Point of Attachment" out to the respirator
- Air hoses and Quick-Disconnect QD sets submitted by manufacturer must be used with respirator for product to remain approved
- Hoses can be directly connected by threaded couplings

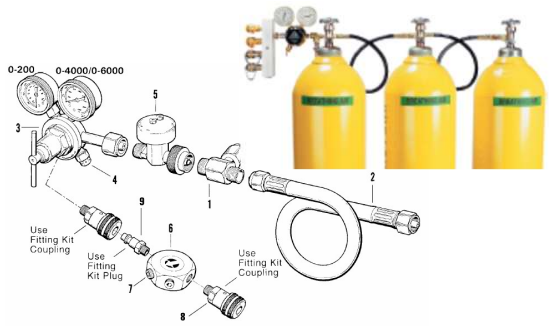
Plug - Is commonly referred to as the male end

Socket - Is commonly referred to as the female end

Ambient Air Breathing Air Pumps

- Generate Low Pressure Air
- Require Larger Diameter Air Hose
- Constant Flow SAR's
- Often Require Cooling
- Lower Initial Cost
- Limited Use Frequency or Durations

Breathing Air Manifold Systems



Breathing Air Manifold Systems

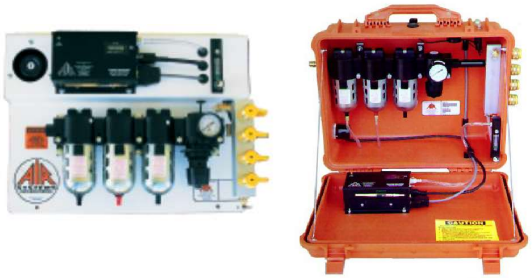
Breathing Air Compressor Systems

COMPLETE GRADE-D BREATHING AIR PACKAGES READY FOR PLANT INSTALLATION, (HORIZONTAL DESIGN PICTURED)

ELEMENTS OF A TYPE-C BREATHING AIR SYSTEM

Compressor	Filtration System	Air Distribution System	Respirator(s)
Compressed Air Source, Receiver Tank, Optional Air Dryer	Oil, Water, Particulate, Organic Vapor Removal, CO Monitor, Alarms	Manifold, Relief Valve, Regulator, Gauge, Hose Couplings	Maximum 300 Feet of NIOSH Approved Breathing Air Hose

Air Filtration/Distribution & Airline Monitors



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Selection, Use & Limitations of Respiratory Protection Devices

Breathing Air Quality and Use

- Compressed breathing air must meet at least the requirements for Type 1 - Grade D breathing air described in ANSI/CGA G-7.1-1989
- Compressors must be equipped with suitable in-line air-purifying sorbent beds/filters that are maintained and replaced or refurbished per manufacturer's instructions

Component	Symbol	Volume	
Nitrogen	N_2	78.084%	99.998%
Oxygen	O_2	20.947%	
Argon	Ar	0.934%	
Carbon Dioxide	CO_2	0.033%	
Neon	Ne	18.2 parts per million	
Helium	He	5.2 parts per million	
Krypton	Kr	1.1 parts per million	
Sulfur dioxide	SO_2	1.0 parts per million	
Methane	CH_4	2.0 parts per million	
Hydrogen	H_2	0.5 parts per million	
Nitrous Oxide	N_2O	0.5 parts per million	
Xenon	Xe	0.09 parts per million	
Ozone	O_3	0.07 parts per million	
Nitrogen dioxide	NO_2	0.02 parts per million	
Iodine	I_2	0.01 parts per million	
Carbon monoxide	CO	trace	
Ammonia	NH_3	trace	

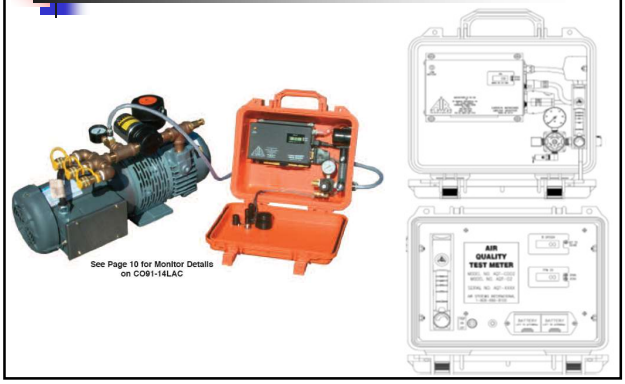
Compressed Gas Association G-7.1-1989

CGA Grade	Industrial Uses
A	Industrial compressed air
L	SCBA
D	OSHA breathing air
E	SCUBA
J	Specialty grade air, analytical applications
N	Medical/USP air

GRADE D AIR

AIR CONSTITUENT	ALLOWABLE CONCENTRATION
Oxygen content (v/v)	19.5%-23.5%
Oil (Condensed)	<=5 mg/m^3
Carbon monoxide	<=10 ppm
Carbon dioxide	<=1,000 ppm
Water content	See the discussion on water below
Odor	No pronounced odor

Airline Monitors

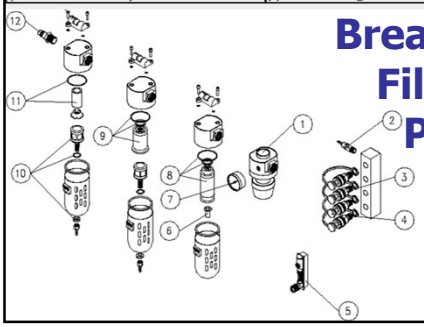


Breathing Air Quality and Use

- Compressors (not oil lubricated) CO levels in the Breathing Air must be <10 ppm (<5 PPM CSA)
- Oil-lubricated compressors, a high-temperature or CO alarm, or both, must be used to monitor CO levels
  - If only high-temperature alarms are used, the air supply must be monitored at sufficient intervals to prevent CO levels from > 10 ppm

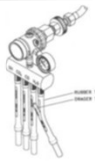
Filtration Efficiency All Models:	
1st Stage - Particulate/Bulk Liquid Separator	Auto Drain and Filter change indicator. 95% bulk liquids @ 5 microns
2nd Stage - Oil Coalescing	Auto Drain and Filter change indicator. 99.9998% @ 0.01 micron
3rd Stage - Activated Charcoal (Taste/odor removal)	Manual Drain and Filter change indicator. Less than 0.003 pp/wt remaining oil content

Breathing Air Filtration Panels



Colorimetric Test Kits

Air Component	Dräger Part No.
Water Vapor (H2O) 20/a-P	8103061
Oil PN* 100/A-P	8103111
Carbon Monoxide (CO) 5/A-P	6728511
Carbon Dioxide (CO_2) 100/A-P	6728521



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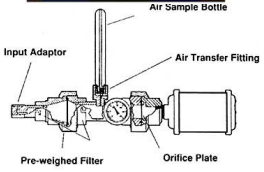
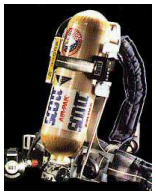
Selection, Use & Limitations of Respiratory Protection Devices

Analytical Sampling Kits



Self-Contained Breathing Apparatus (SCBA)

An atmosphere-supplying respirator for which the breathing air source is designed to be carried by the user.



Open Circuit available in 30, 45, 60 or 75 Minute Durations

Tight Fitting Respirators for IDLH Atmospheres

Full Facepiece Pressure Demand SCBA certified by NIOSH for a minimum service life of 30 minutes

Combination Full Facepiece Pressure Demand SAR with Auxiliary Self-Contained Air Supply

Self-Contained Breathing Apparatus (SCBA)

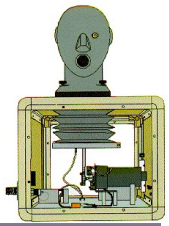
An atmosphere-supplying respirator for which the breathing air source is designed to be carried by the user.

1. Mask
2. Breathing connector
3. Exhalation breathing hose
4. Dust filter
5. CO_2 absorber
6. Breathing bag
7. Relief valve
8. Minimum valve
9. Cooler
10. Constant dosage
11. Inhalation breathing hose
12. Drain valve
13. Oxygen cylinder
14. Cylinder valve
15. Pressure reducer
16. Monitron basic unit
17. Monitron display unit

Closed Circuit operates up to 240 Minute Duration

SAR/SCBA Yearly Dynamic Flow Testing

- Mask Leak Check
- Exhalation Valve Opening Pressure
- Static Mask Pressure
- Breathing Resistance @ Std & Max Work Rate (40 & 100 LPM)
- Bypass Flow Rate
- Pressure Gauge Accuracy
- Low Pressure Alarm Activation
- Visual Inspection Record



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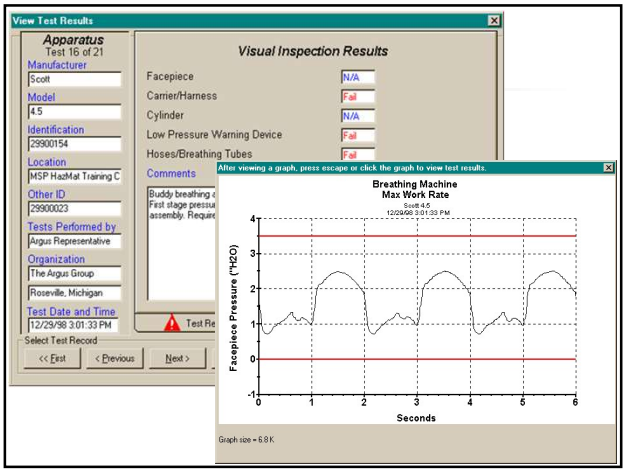

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