RESPIRATOR MEDICAL EVALUATION

I. GENERAL INFORMATION

A. Medical evaluations are required for personnel who wear respirators to ensure that they are physically able to wear their assigned respirator while performing their work. The preamble to the Occupational Safety and Health Administration (OSHA) Respirator Standard (reference 1) describes in greater detail the purpose for respirator medical evaluations as follows:

1. Medical evaluation to determine whether an employee is able to use a given respirator is an important element of an effective respiratory protection program and is necessary to prevent injuries, illnesses, and even, in rare cases, death from the physiological burden imposed by respirator use.

2. The purpose of a medical evaluation program is to ensure that any employee required to use a respirator can tolerate the physiological burden associated with such use, including the burden imposed by the respirator itself (e.g., its weight and breathing resistance during both normal operation and under conditions of filter, canister, or cartridge overload); musculoskeletal stress (e.g., when the respirator to be worn is an SCBA),[1] limitations on auditory, visual, and odor sensations; and isolation from the workplace environment.

B. Types of respirator medical evaluations include medical questionnaires, such as the OSHA medical evaluation, medical examination, or a combination of these two methods, such as conducted by the Navy. Special evaluations, such as spirometry,[2] are only performed on a case-by-case basis at the discretion of the physician. Per reference 2, spirometry or exercise stress testing (testing the effect of exercise on the heart) may be used if the physician or other licensed health care professional (PLHCP) needs information in addition to a medical history (medical questionnaire) and medical examination. Reference 2 further states that results of these special evaluations do not in themselves indicate fitness or lack of fitness to wear respirators.

II. REGULATORY REQUIREMENTS AND STANDARDS

A. **OSHA medical evaluation policy.** OSHA respirator medical evaluation policy is in paragraph (e) of 29 CFR 1910.134 (reference 1). OSHA requires medical evaluation (not necessarily a medical examination) before wearing respirators in the workplace and prior to fit testing. The employee completes the questionnaire in Appendix C of 29 CFR 1910.134, which is reviewed by a PLHCP. Alternatively, employers may provide respirator users with a medical examination instead of medical evaluation as long as the medical examination obtains the same information as the medical questionnaire. Employers providing physical examinations need not also administer the OSHA medical questionnaire although the PLHCP would likely administer a medical history questionnaire as part of the medical exam process.

[1] SCBA is the acronym for self contained breathing apparatus.

[2] Spirometry measures the amount of air exhaled and measures how fast breath can be exhaled to help in diagnosing lung disorders such as asthma, chronic obstructive pulmonary, chronic bronchitis, emphysema, and pulmonary fibrosis.

1. OSHA requires follow-up medical examinations for employees who give a positive response to any question 1 – 8 on the questionnaire or whose initial medical evaluation indicates a need for follow-up medical examination.

a. Follow-up medical examinations include any medical tests (e.g., spirometry), consultations, or diagnostic procedures that the PLHCP considers necessary to make a final determination.

2. OSHA DOES NOT require periodic respirator medical evaluations. However, employees may be medically reevaluated if:

a. The employee reports medical signs or symptoms related to wearing the respirator,

b. There is a change in workplace conditions that substantially increase physiological stress on the employee,

c. A need for medical recertification is determined during implementation of the respirator program, such as observations made during fit testing and observations made during program audit/evaluation, or

d. The employer determines that an employee needs medical reevaluating for any reason.

3. Per paragraph (e)(5) of reference 1, employers must provide the PLHCP with information about the operation and the respirator to be worn, including:

a. The type and weight of the respirator to be used by the employee,

b. The duration and frequency of respirator use (including use for rescue and escape),

c. The expected physical work effort,

d. Other protective clothing and equipment to be worn, and

e. Temperature and humidity extremes that may be encountered.

4. Employers must also provide the PLHCP with a copy of their written respiratory protection program and a copy of 29 CFR 1910.134.

5. The PLHCP must provide the employer a written medical recommendation regarding the following:

a. Whether or not the employee is medically able to use a respirator,

b. Any limitations on respirator use related to the medical condition of the employee or relating to the workplace conditions, and

c. Any follow up medical evaluations that are required, and

d. The PLHCP must also provide the employee with a copy of the written recommendation.

6. Although OSHA does not require periodic medical evaluations, the PLHCP can specify that an employee return for follow-up medical evaluation for a specific medical reason.

7. If the PLHCP finds a medical reason that an employee cannot wear negative pressure air-purifying respirators then the employer must provide that employee with a powered air purifying respirator (PAPR) as long as it provides adequate protection.

8. If employees' work tasks change in a way that might adversely affect their ability to wear the selected respirators, then additional medical evaluations must be performed.

9. OSHA states that there is no medical evaluation necessary for voluntary use of filtering facepiece respirators. All other respirator use requires medical evaluation.

B. **American National Standards Institute (ANSI).** *ANSI Z88.6-2006, Respirator Use-Physical Qualifications for Personnel* (reference 2) presents a respirator medical evaluation process that meets, and in many areas exceeds, the minimum requirements of the OSHA respirator standard. Although the Navy is not required to follow this standard, it contains excellent information for health care providers. The following is a summary of what was revised from the 1984 version of this standard:

1. Includes all the questions required by the OSHA respirator questionnaire as well as additional questions to assess the risk of cardiac disease, which is more commonly a disqualifier than pulmonary disease.

2. Recommends physician review of all cases that fall outside certain parameters.

3. Any medical professional authorized to evaluate respirator use should be required to know the physiologic demands associated with various types of respirators.

4. A periodic medical questionnaire prior to annual respirator fit testing should be administered.

5. Specific blood pressure, body weight, and pulmonary function values will require physician consideration, and/or evaluation, and/or medical testing.

6. Workers using contact lenses and workers with perforated tympanic membranes should not be routinely excluded.

7. A concise statement regarding facial hair should be included.

C. **Navy Instructions.** OPNAVINST 5100.23*series* is the Navy occupational safety and health instruction for shore-based civilian and military respirator wearers. OPNAVINST 5100.19*series* is the shipboard occupational safety and health instruction governing industrial respirator use in the fleet. Both of these Navy instructions will be discussed under the sections concerning the specific respirator populations that the instructions govern.

III. NAVY RESPIRATOR USE POPULATIONS

A. **Navy Shore-based Civilian Respirator Wearers.** According to paragraph 1508 of reference 3, activities shall not fit test personnel or assign them to work in, or permit them to enter, areas requiring respiratory protection unless they have been medically evaluated per the Medical Surveillance Procedures Manual/Medical Matrix (reference 4).

1. The civilian medical requirements of paragraph 1508 primarily address Navy industrial respirator wearers. However, there are other populations of civilian respirator wearers, including the following categories:

a. Health care providers. Per paragraph 1507.f., health care providers who wear respirators must comply with Chapter 15 respirator program requirements.

b. CBRN[3] first responders. Per paragraph 2606 of reference 3, first responders must comply with medical evaluation requirements of Chapter 15.

c. Occupations requiring *Specialty Examinations*. The *Specialty Examinations*, such as the annual *Comprehensive Firefighter Exam, Program 707*, fulfill requirements of several medical examinations including the *Respirator User Certification Exam 716*.

d. Voluntary respirator use. Medical evaluation is not required for voluntary respirator use when respirators are NOT required to control exposures and when the contaminant of concern is a particulate and filtering facepiece respirators are issued and controlled by the respiratory protection program manager.

e. See section III.C. of this document for a discussion on the DoD[4] Civilian Expeditionary Workforce.

2. Paragraph (e) of reference 1 states that OSHA requirements are the **minimum** medical evaluation requirements that employers must implement to determine employees' medical ability to wear respirators. Both OSHA (paragraph (e)(2)(ii) of reference 1) and DoD (paragraph C4.13.2.2 of reference 5) state that equivalent questionnaires or combination of questionnaires and/or medical examinations are permissible as long as they obtain the same information as the OSHA medical questionnaire.

3. The *Respirator User Certification Exam 716* in the Medical Surveillance Procedures Manual/Medical Matrix is more comprehensive than the OSHA medical questionnaire. In addition, the *Respirator User Certification Exam 716* includes a physical examination along with completing a medical history. The *Respirator User Certification Exam 716* medical questionnaire is reproduced in Appendix A. Appendix B is a chart comparing the OSHA and Navy respirator medical evaluation methods.

4. Per paragraph 1313.b.(1) of reference 3, the following personnel may conduct the respirator medical evaluation:

a. Physician or a nurse practitioner,

b. Occupational health nurse,

c. Physician's assistant,

d. Preventive medicine technician,

[3] CBRN is the acronym chemical, biological, radiological, and nuclear.
[4] DoD is the acronym for Department of Defense.

e. Independent duty hospital corpsman (IDC) under the supervision of a physician (note that IDCs can only evaluate active duty military personnel).

5. The frequency of Navy respirator medical evaluations is age dependent and the schedule for recurring medical evaluations is reproduced below[5].

(under 35)	(35-45)	(over 45)
5 years	2 years	1 year

Reference 4, *Respirator User Certification Exam 716*, states that SCBA users require annual medical evaluation.

6. *Appendix 15-A* of reference 3 is filled out by the respirator wearer's supervisor to provide the cognizant BUMED occupational medicine provider with information needed to identify the type of respirator and understand the conditions in which it will be worn.

a. *Appendix 15-A* is to be replaced with the electronic *Respirator Use Questionnaire*, *OPNAV Form 5100/35* in OPNAVINST 5100.23H. This form is available on the Naval Safety Center's Medical Surveillance Toolbox webpage.

b. Both *Appendix 15-A* and *OPNAV Form 5100/35* provide Navy health care providers with information about each individual's workplace operations and the type of respirator(s) required to be worn. However, neither form describes the physiological stress associated with wearing respirators.

i. Appendix C of this document provides a discussion of the physiological stress resulting from wearing respirators.

ii. Appendix D of this document ranks classes of respirators from the most to the least physiologically challenging to wear.

iii. Appendix E is a quick reference respirator ranking guide for health care providers performing respirator medical evaluations.

7. *Appendix 15-A* and *OPNAV Form 5100/35* are also used by the healthcare professional to document medical evaluation of the individual's physical ability to perform his or her duties while wearing the respirator(s) and to indicate when the respirator wearer shall return for the next medical evaluation. The medical recommendation provides the following information:

a. The worker's ability to wear the respirator,

b. Any limitations on respirator use, or recommendations for a different respirator based on the worker's medical condition or relating to the workplace conditions,

c. The time to report back for their next respirator physical, and

d. A statement that the health care professional has provided the worker with a copy of the written recommendation.

[5] These intervals may be superseded/reduced based on employee specific medical anomalies/qualifiers.

B. **Military Respirator Users.** Per sections 1508 and 2602 of reference 3, military personnel who have been confirmed as "Fit for Full Duty" and who have a current annual Periodic Health Assessment (PHA) are deemed medically qualified to wear all types of respirators. The phrase "Fit for Full Duty" is interpreted as having no deployment-limiting conditions. This is consistent with a "fully or partially medically ready status" of the Individual Medical Readiness (IMR) classification described in reference 6.

1. Questionable cases will be referred to the MTF for a *Respirator User Certification exam (Medical Matrix Program 716).*

2. Industrial hygienists who need to verify military respirator qualifications during their industrial hygiene surveys can check with the IMR point of contact for the command or the local medical treatment facility.

3. Shipboard military respirator medical evaluations are addressed in paragraph B0602.d(1) of reference 7, which states that the medical department representative (MDR) shall,

   a. "*Confirm that personnel, who are issued respirators have no deployment limiting medical conditions, and have a current annual Preventive Health Assessment per reference B6-3* [OPNAVINST 6120.3][6] *(see paragraph B0613).*"

   b. Paragraph B0613 states that, "*Military personnel, who have been confirmed by the MDR as having no deployment limiting medical conditions, and with a current annual PHA per reference B6-3 [OPNAVINST 6120.3][6] are considered qualified to wear any type of respiratory protection.*"

   c. Questionable cases, per paragraph B0613, will have further medical evaluation, "*Special evaluations shall be performed after prolonged absences from work for medical reasons or whenever a potential respirator-related medical problem has been identified.*"

4. Per reference 4, military personnel, who have been confirmed by their region or activity as "Fit for Full Duty" based on their current periodic military physicals (references 8 and 9) are considered qualified to wear any type of respiratory protection. As all active duty Navy personnel must be able to wear military gas masks and SCBA escape respirators in order to be fit for duty and deployable, active duty fitness for duty medical standards are considered to be equivalent to, or surpass, the OSHA respirator medical standards. Since military personnel are medically fit to wear these respirators, which are the most physiologically challenging respirators, they are fit to wear any type of respirator (see paragraph 6 for a detailed discussion).

5. For clarification, the Navy does not need to request an alternate standard from OSHA concerning military respirator medical evaluation policy. The following discussion addresses this issue.

[6] OPNAVINST 6120.3 was canceled by SECNAVINST 6120.3 CH-1. Note that these instructions address only the PHA – they do not discuss medical qualification for respirators. It is OPNAVINST 5100.19*series* and OPNAVINST 5100.23*series* that establish the policy that physically fit for duty military personnel are medically qualified to wear any type of respirator.

a. Paragraph (e) of the *OSHA Respirator Standard*, *29 CFR 1910.134*, states that the OSHA requirements are the minimum requirements for medical evaluation that employers must implement to determine the employee's ability to use a respirator. Both the OSHA Respirator Standard, in paragraph (e)(2)(ii), and paragraph C4.13.2.2 of *DoDI 6055.05M* state that equivalent questionnaires or combinations of questionnaires and/or medical examinations are permissible as long as they obtain the same information as the OSHA medical questionnaire. The military entrance exam qualifies as a respirator-related medical exam and will identify respirator-incompatible conditions. Personnel serving in the military are medically qualified to wear all respirators, since passing the military entrance exam qualifies personnel to wear military gas masks, which are the most physiologically challenging respirators.

b. After the initial respirator medical clearance, OSHA does not require annual or even regularly scheduled periodic medical evaluations. In contrast, in order to continue to serve in the Navy, military personnel are required to pass an annual PHA medical evaluation to be classified as "Fit for Full Duty." Personnel who pass the PHA and who are "Fit for Full Duty" are deemed medically qualified: (1) for deployment; (2) to wear military gas masks; and (3) to wear any type of respirator.

c. Since OSHA does not require regularly scheduled periodic respirator medical evaluations, there is no need to request an alternate standard from OSHA. Regularly scheduled periodic respirator medical evaluations are Navy policy requirements, NOT OSHA requirements, so it is left up to the Navy to establish those policies. OSHA's permission for a waiver is not required for a policy that OSHA does not regulate.

6. The following discussion provides the historical background, which was the basis and justification for allowing military personnel, who are physically fit for duty and deployable, to be considered medical qualified to wear any type of respirator.

a. Military personnel, who are fit for full duty, are expected to carry field equipment in excess of 50 pounds for hours under forced marches, which greatly exceed the weight of the heaviest respirators. In industrial circumstances where a heavy respirator such as a self-contained breathing apparatus is to be used, personnel will not be carrying field packs. In comparison, during wartime conditions, military personnel will be required to use respirators under battlefield conditions indefinitely as protection against some of the most toxic materials known.

b. Military gas masks are the most physiologically challenging respirators because of the increased exhalation resistance. Additionally, military personnel are also required to wear MOPP[7] gear, which further increases their physiological challenge.

[7] MOPP is the acronym for Mission Oriented Protective Posture, the protective ensemble worn by warfighters in combat for protection against chemical warfare agents and other toxic chemicals and materials.

c. Therefore, military personnel who are fit to wear military gas masks are considered fit to wear any respirator.

C. **DoD Civilian Expeditionary Workforce.** References 10 and 11 authorize Department of Defense (DoD) civilians and contractors to be trained, medically cleared, equipped, and ready to deploy in support of combat operations by the military. These individuals may be required to wear MOPP gear, including wearing military gas masks. In anticipation of this emerging issue, the following recommendation has been proposed to amend Section 2603 of OPNAVINST 5100.23*series,* entitled *Personal Protective Equipment, d. Notable Exemptions.*

1. Section 2603.d.(2) of OPNAVINST 5100.23*series*: *It is permissible for Navy civilians in the DoD Civilian Expeditionary Workforce, who deploy in support of military combat operations, to be issued MOPP gear. DoD Directive (DoDD) 1404.10 (reference 25-XX) requires that members of the DoD Civilian Expeditionary Workforce shall be organized, trained, cleared, equipped, and ready to deploy in support of military combat operations. This includes medical evaluation to ensure these DoD civilians are medically fit for deployment and shall include medical evaluation for wearing any type of respiratory protection, including military gas masks (e.g., MCU-2A/P and M40). Medical evaluation for Navy civilians in the DoD Civilian Expeditionary Workforce are established in the OCONUS Deployment Medical Examination (program #798) of reference 25-3* [NMCPHC – TM OM 6260 Medical Surveillance Procedures Manual and Medical Matrix]. *For personnel needing vision correction, a written prescription shall be provided to the supporting military medical component so that eyeglass inserts for use in a compatible military gas mask can be prepared.*

2. Section 2603.d.(3) (b) of OPNAVINST 5100.23*series*: *Certain contractors are authorized to accompany the force (CAAF) in order to provide support to deployed military contingency operations (e.g. transporting munitions and other supplies, performing maintenance functions for military equipment, and providing private security services, etc.). Per DoDI 3020.41 (reference 25-YY) under the terms and conditions of their contracts, defense contractors shall provide medical examination and clearance (i.e., certification) to ensure that CAAF personnel are medically and physically qualified to perform duties, in applicable contingency operations, including wearing MOPP gear, when necessary. This medical and physical qualification shall follow the guidelines established in the OCONUS Deployment Medical Examination (program #798) of reference 25-3* [NMCPHC – TM OM 6260 Medical Surveillance Procedures Manual and Medical Matrix] *and shall include medical evaluation for wearing any type of respiratory protection, including military gas masks (e.g., MCU-2A/P and M40). For personnel needing vision correction, reference 25-YY* [DoDI 3020.41] *requires that a written prescription shall be provided to the supporting military medical component so that eyeglass inserts for use in a compatible military gas mask can be prepared.*

IV. REFERENCES

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http://www.gpo.gov/fdsys/pkg/FR-1998-01-08/pdf/97-33843.pdf

2 American National Standards Institute (ANSI): American National Standard for Respiratory Protection-Respirator Use-Physical Qualifications for Personnel (ANSI Z88.6). New York: ANSI, 2006.

3 OPNAVINST 5100.23*series*.
http://doni.daps.dla.mil/Directives/05000%20General%20Management%20Security%20and%20Safety%20Services/05-100%20Safety%20and%20Occupational%20Health%20Services/5100.23G%20w%20CH-1.pdf

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10 DoD Directive 1404.10, DoD Civilian Expeditionary Workforce of 23 Jan 2009.
http://www.dtic.mil/whs/directives/corres/pdf/140410p.pdf

11 DoDI 3020.41, Operational Contract Support (OCS) of 20 Dec 2011.
http://www.dtic.mil/whs/directives/corres/pdf/302041p.pdf

APPENDIX A
Respirator User Certification Exam 716

NMCPHC-TM OM 6260

RESPIRATOR USER CERTIFICATION EXAM **716**

Program Frequency	By Age
15 to 34 years	Every 5 years
35 to 44 years	Every 2 years
45+ years	Annual
SCBA user	Annual

EXAM ELEMENT	**BASE**	**PERI**	**TERM**
Medical history: have you ever had:			
Personal history of:			
Is your work exposure history current (OPNAV 5100/15)	Yes	By Age	No
Has anything about your health status changed since your last examination	Yes	By Age	No
Have any medications changed since your last examination	Yes	By Age	No
Major illness or injury	Yes	By Age	No
Hospitalization or surgery	Yes	By Age	No
Cancer	Yes	By Age	No
Back injury	Yes	By Age	No
Do you drink 6 or more drinks per week (beer, wine, liquor)	Yes	By Age	No
Have you ever smoked?	Yes	By Age	No
Do you currently smoke? # of packs per day _____	Yes	By Age	No
Heart disease, high blood pressure, stroke or circulation problems	Yes	By Age	No
Current medication use (prescription or OTC)	Yes	By Age	No
Medication allergies	Yes	By Age	No
Any reproductive health concerns	Yes	By Age	No
Allergies (asthma, hay fever, eczema)	Yes	By Age	No
Skin disease, rash, erosion, ulcer, eczema, abnormal pigmentation or other skin abnormality	Yes	By Age	No
Lung/respiratory disease (for example: COPD, emphysema, asthma, bronchitis, pneumonitis, asbestosis, silicosis, pneumothorax/collapsed lung)	Yes	By Age	No
Wheezing	Yes	By Age	No
Tuberculosis	Yes	By Age	No
Chest surgery or injury (including broken ribs)			
Use of eye glasses	Yes	By Age	No
Contact lens use	Yes	By Age	No
Loss of vision in either eye	Yes	By Age	No
Color blindness	Yes	By Age	No
Eye irritation	Yes	By Age	No
Any other eye or vision problem	Yes	By Age	No

EXAM ELEMENT	BASE	PERI	TERM
Inability or reduced ability to smell	Yes	By Age	No
Any injury to your ears	Yes	By Age	No
Ruptured ear drum	Yes	By Age	No
Loss or change in hearing	Yes	By Age	No
A need to wear a hearing aid	Yes	By Age	No
Any other hearing or ear problem	Yes	By Age	No
Chest pain, angina, heart attack, irregular heart beat (arrhythmia), or other heart problem	Yes	By Age	No
Repeated episodes of loss of or near loss of consciousness	Yes	By Age	No
Frequent pain or tightness in your chest	Yes	By Age	No
Swelling in legs or feet (not caused by walking)	Yes	By Age	No
Shortness of breath	Yes	By Age	No
Cough (dry or productive)	Yes	By Age	No
Current pregnancy (females only)	Yes	By Age	No
Epilepsy or seizures	Yes	By Age	No
Problems with balance and coordination	Yes	By Age	No
Numbness, tingling, or weakness in hands or feet	Yes	By Age	No
Diabetes (sugar disease) or other endocrine disorder (thyroid, parathyroid, pituitary, adrenal gland)	Yes	By Age	No
Mental/emotional illness	Yes	By Age	No
Claustrophobia	Yes	By Age	No
Muscle or joint problems, rheumatism, or arthritis	Yes	By Age	No
Any other muscle or skeletal problem that may interfere with using a respirator	Yes	By Age	No
Work history of:			
Prior respirator use	Yes	By Age	No
If yes, any problems that interfered with use	Yes	By Age	No
Comments on medical history:	Yes	By Age	No
Physical examination:			
Vital signs	Yes	By Age	No
Height	Yes	By Age	No
Weight	Yes	By Age	No
Special attention in examination to:			
Cardiovascular system	Yes	By Age	No
Eyes	Yes	By Age	No
Respiratory system	Yes	By Age	No
Ears (tympanic membrane defect)	Yes	By Age	No
Skin (rash, erosion, ulcer, pigment, eczema, etc)	Yes	By Age	No
Other appropriate examination (specify)	Yes	By Age	No
Comments on physical examination:	Yes	By Age	No
Is surveillance/PPE consistent with exposures	Yes	By Age	No
Are any abnormalities related to exposures/occupations	Yes	By Age	No
Recommendations:	Yes	By Age	No

APPENDIX B
Comparison of OSHA and Navy Respirator Medical Evaluations

OSHA Respirator Medical Evaluation Questionnaire	Navy Respirator User Certification Exam 716
1. Do you currently smoke tobacco, or have you smoked tobacco in the last month:	Medical history: have you ever had: Personal history of: Have you ever smoked? Do you currently smoke? # of packs per day_____, Do you drink 6 or more alcohol drinks per week?
2. Have you ever had any of the following conditions? Seizures → Diabetes (sugar disease) → Allergic reactions that interfere with your breathing → Claustrophobia (fear of closed-in places) → Trouble smelling odors: →	Medical history: have you ever had: Personal history of: Epilepsy or **seizures**, **Diabetes (sugar disease)** or other endocrine disorder, Allergies (asthma, hay fever, eczema), Claustrophobia, Inability or reduced ability to smell.
3. Have you ever had any of the following pulmonary or lung problems? Asbestosis Asthma Chronic bronchitis → Emphysema Pneumonia Tuberculosis → Silicosis Pneumothorax (collapsed lung) → Lung cancer → Broken ribs Any chest injuries or surgeries → Any other lung problem that you've been told about	Medical history: have you ever had: Personal history of: Lung/respiratory disease (for example: COPD, **emphysema**, **asthma**, **bronchitis**, pneumonitis, **asbestosis**, silicosis, pneumothorax/collapsed lung), Allergies (**asthma**, hay fever, eczema), Tuberculosis, Lung/respiratory disease (for example: COPD, emphysema, asthma, bronchitis, pneumonitis, asbestosis, **silicosis**, **pneumothorax/collapsed lung**), Cancer, **Chest surgery or injury** (including **broken ribs**).
4. Do you currently have any of the following symptoms of pulmonary or lung illness? Shortness of breath Shortness of breath when walking fast on level ground or walking up a slight hill or incline Shortness of breath when walking with other people at an ordinary pace on level ground Have to stop for breath when walking at your own pace on level ground Shortness of breath when washing or dressing Shortness of breath that interferes with your job	Medical history: have you ever had: Personal history of: Shortness of breath,

APPENDIX B
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4. Do you currently have any of the following symptoms of pulmonary or lung illness? **(Continued)**	
Coughing that produces phlegm (thick sputum) Coughing that wakes you early in the morning Coughing that occurs mostly when lying down Coughing up blood in the last month	Cough (dry or productive),
Wheezing Wheezing that interferes with your job	Wheezing,
Chest pain when you breathe deeply	Chest pain, Frequent pain or tightness in your chest.
Any other symptoms that you think may be related to lung problems	
5. Have you ever had any of the following cardiovascular or heart problems?	Medical history: have you ever had: Personal history of:
Heart attack, High blood pressure, Stroke Angina, Heart arrhythmia (heart beating irregularly) Heart failure	**Heart disease**, high **blood pressure**, **stroke** or circulation problems, Chest pain, **angina**, **heart attack**, irregular heart beat (**arrhythmia**), or other heart problem,
Swelling in your legs or feet (not caused by walking)	Swelling in your legs or feet (not caused by walking),
Any other heart problem that you've been told about	Other heart problem.
6. Have you ever had any of the following cardiovascular or heart symptoms?	Medical history: have you ever had: Personal history of:
Frequent pain or tightness in your chest	Frequent pain or tightness in your chest,
Pain or tightness in your chest during physical activity Pain or tightness in your chest that interferes with your job In the past two years, have you noticed your heart skipping or missing a beat Heartburn or indigestion that is not related to eating	**Chest pain**, angina, heart attack, irregular heart beat (arrhythmia), or other heart problem, **Heart disease**, high blood pressure, stroke or **Circulation problems**,
Any other symptoms that you think may be related to heart or circulation problems	Other heart problem.
7. Do you currently take medication for any of the following problems?	Medical history: have you ever had: Personal history of:
Breathing or lung problems Heart trouble Blood pressure Seizures (fits)	Have any medications changed since your last examination, Current medication use (prescription or OTC), Medication allergies.
8. If you've used a respirator, have you ever had any of the following problems?	Medical history: have you ever had: Personal history of:
Eye irritation	Eye irritation,
Skin allergies or rashes	Skin disease, rash, erosion, ulcer, eczema, abnormal pigmentation or other skin abnormality,
Anxiety	Mental/emotional illness,
General weakness or fatigue	
Any other problem that interferes with your use of a respirator	Any problems interfering with respirator use?

APPENDIX B **Comparison of OSHA and Navy Respirator Medical Evaluations**	
Questions 10 to 15 must be answered for full facepiece respirator or SCBA use.	
10. Have you ever lost vision in either eye (temporarily or permanently)	Medical history: have you ever had: Personal history of: Loss of vision in either eye.
11. Do you currently have any of the following vision problems? Wear contact lenses → Wear glasses → Color blind → Any other eye or vision problem →	Medical history: have you ever had: Personal history of: Contact lens use, Use of eye glasses, Color blindness, Any other eye or vision problem.
12. Have you ever had an injury to your ears, including a broken ear drum: →	Medical history: have you ever had: Personal history of: Ruptured ear drum, Any injury to your ears.
13. Do you currently have any of the following hearing problems? Difficulty hearing → Wear a hearing aid → Any other hearing or ear problem →	Medical history: have you ever had: Personal history of: Loss or change in hearing, A need to wear a hearing aid, Any other hearing or ear problem.
14. Have you ever had a back injury?	Medical history: have you ever had: Personal history of: Back injury.
15. Do you currently have any of the following musculoskeletal problems? Weakness in any of your arms, hands, legs, or feet Back pain Difficulty fully moving your arms and legs Pain or stiffness when you lean forward or backward at the waist Difficulty fully moving your head up or down Difficulty fully moving your head side to side Difficulty bending at your knees Difficulty squatting to the ground Climbing a flight of stairs or a ladder carrying more than 25 lbs Any other muscle or skeletal problem that interferes with using a respirator →	Medical history: have you ever had: Personal history of: Numbness, tingling, or weakness in hands or feet, Back injury, Muscle or joint problems, rheumatism, or arthritis, Problems with balance and coordination, Any other muscle or skeletal problem that may interfere with using a respirator.

APPENDIX B Comparison of OSHA and Navy Respirator Medical Evaluations	
OSHA Respirator Medical Evaluation Questionnaire	**Navy Respirator User Certification Exam 716**
OSHA allows the medical questionnaire to suffice and does not require physical examination.	**Physical examination:** Vital signs, **Special attention in examination to:** Cardiovascular system, Eyes, Respiratory system, Ears (tympanic membrane defect), Skin (rash, erosion, ulcer, pigment, eczema, etc.), Other appropriate examination (specify). **Comments on physical examination:** Is surveillance/ PPE consistent with exposures? Are any abnormalities related to exposures/ occupations?
OSHA question 9 requires employers to provide the employee with an opportunity to discuss the questionnaire and examination results with the PLHCP.	Health care providers interview each employee about their medical history. The Navy omits detailed questions on the Certification Exam 716 questionnaires, such as OSHA's series of questions on "musculoskeletal problems" and "shortness of breath." Instead, the Navy questionnaire lists general questions, which are discussed with each employee during an interview offering the possibility of discerning more detailed medical information.
Medical Determination: The employer shall obtain a written recommendation regarding the employee's ability to use the respirator from the PLHCP, including: Any limitations on respirator use related to the medical condition of the employee, or relating to the workplace conditions in which the respirator will be used, including whether or not the employee is medically able to use the respirator; The need, if any, for follow-up medical evaluations; and A statement that the PLHCP has provided the employee with a copy of the PLHCP's written recommendation.	**Medical Recommendations, including:** The worker's ability to wear the respirator, Any limitations on respirator use, or recommendations for a different respirator based on the worker's medical condition or relating to the workplace conditions, The time to report back for their next respirator physical, A statement that the health care professional has provided the worker with a copy of the written recommendation. Note: The above health care providers' recommendations are from *Appendix 15-A of OPNAVINST 5100.G* and *OPNAV Form 5100/35*.
OSHA requires follow up medical examinations if: 1) an employee who gives a positive response to questions in the medical questionnaire; or 2) if an initial medical examination was performed, which indicated the need for a follow up medical examination.	Navy requires specific age related periodic respirator medical evaluations as follows: Program Frequency By Age: 15 to 34 years Every 5 years 35 to 44 years Every 2 years 45+ years Annual SCBA user Annual

APPENDIX C

RESPIRATOR PHYSIOLOGICAL EFFECTS

I. INTRODUCTION

A. *Appendix 15-A* of reference 1 provides health care providers with information on the conditions under which the respirator will be worn, including the anticipated work effort while wearing the respirator, the frequency and duration of respirator wear, other personal protective equipment worn with the respirator, the work environment including temperature and humidity, and any special work conditions, such as working in confined spaces. However, no information is provided on the physiological effort required to wear respirators. The purpose of this appendix is to inform health care providers about the physical stress resulting from wearing respirators.

II. RESPIRATOR PHYSIOLOGICAL EFFECTS

A. Anatomical dead air space ("dead space") is that part of the respiratory tract not involved with gas exchange: the trachea and bronchi, which serve to conduct air (Figure C-1). Reference 2 discusses why the increased dead air space added by wearing respirators lowers oxygen intake during inhalation:

When someone breathes in normal air at 21% oxygen, part of the oxygen is absorbed to be used by the body. However, on exhalation, the breath will at first consist of this same inspired air, since there is little oxygen/carbon dioxide exchange in the airways (trachea and bronchi) of the lung. As a person continues to exhale, the last portion of the breath is from the alveoli (where exchange of oxygen and carbon dioxide occur) and may contain 5% carbon dioxide and 16% oxygen. When a worker wears a respirator, a portion of the worker's exhaled breath remains in the respirator. This exhaled air has a lowered oxygen percentage because of the oxygen removed by the lungs, and the similar amount of carbon dioxide added. Thus, on inhalation, the percentage of oxygen inhaled is reduced by including this rebreathed air.

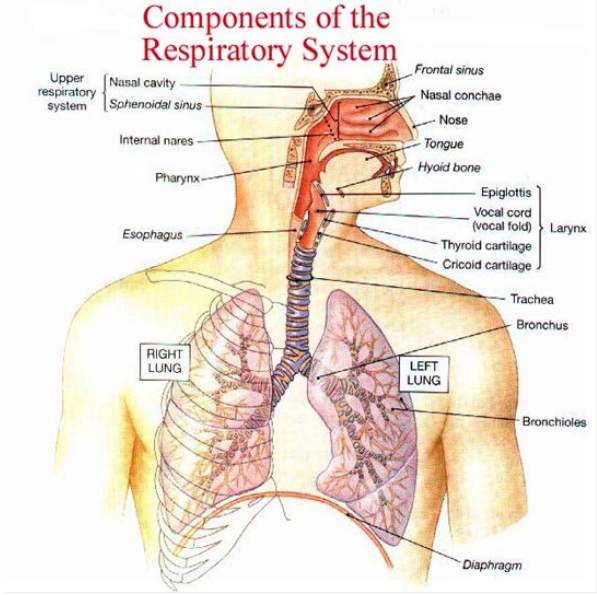

Figure C-1
Respiratory System

1. The volume of the respiratory tract anatomical dead air space is about 150 cc. Since normal inhalation is 500 cc air, and 150 cc remains in the dead air space, only 350 cc fresh air reaches the alveoli (for gas exchange) with each breath. When exhaling, some air stays in these air passageways and fills the anatomical dead air

space. Wearing a respirator increases the anatomical dead air space because some exhaled air is held inside the respirator, effectively increasing dead air space within the respiratory tract as illustrated in Figure C-2.

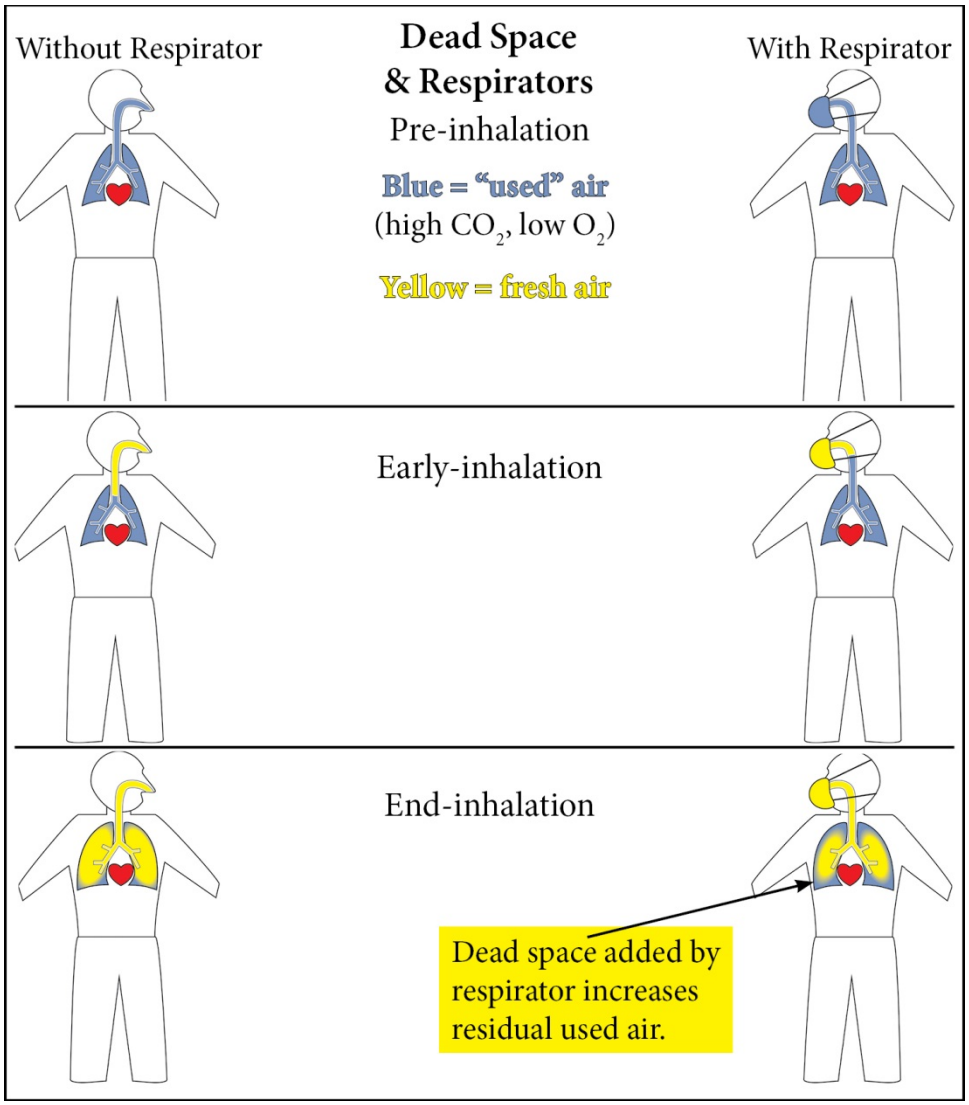

Figure C-2
Respirator Effect on Respiratory System Dead Air Space

2. Increase in dead air space varies from one respirator to another, but in general a half mask adds about 260 cc of dead air space to the respiratory system and a full-facepiece respirator adds 815 cc dead air space. Besides reduction in oxygen, another result of increasing dead air space by wearing respirators is the buildup of carbon dioxide, which is a respiratory stimulant. Inside the facepiece, CO_2 ranges in concentration from 2% to 5%. In contrast, CO_2 in normal fresh air varies between 0.03% and 0.06%.

B. Increasing dead air space (and, thus, "used" air) results in increased alveolar partial pressure of CO_2 (PCO_2) and decreases alveolar partial pressure of oxygen (PO_2).

Increased CO_2 concentration stimulates breathing more than the lack of O_2, at least initially for controlling respiration. Figure C-3, shows the peripheral chemoreceptor sensors in the carotid sinus of the carotid arteries, which supplies blood to the brain. According to reference 3, the peripheral chemoreceptors detect changes in both PO_2 and PCO_2. However, PO_2 must be reduced by about <u>half</u> before the carotid artery sensors send a message to the respiratory control center in the medulla to breathe harder. In contrast, an increase in CO_2 signals an increase in breathing much more quickly than the lack of oxygen.

1. The central chemoreceptors in the medulla detect changes in cerebrospinal fluid surrounding the brain and are much more sensitive to changes in respiration than the peripheral chemoreceptors. The central chemoreceptors monitor PCO_2 levels in the blood indirectly by monitoring hydrogen ion (H^+) concentrations.

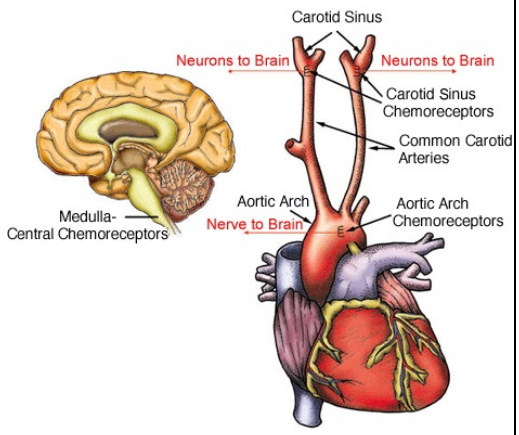

Figure C-3
Peripheral Chemoreceptors

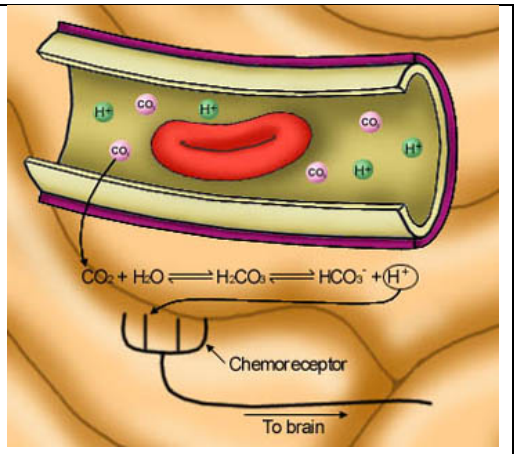

Figure C-4
Central Chemoreceptor

Illustrations are courtesy of reference 4.

2. Figure C-4, shows that most CO_2 in the blood is in the ionized form as bicarbonate and a hydrogen ion ($H^+ + HCO_3^-$). This illustrates, that the central chemoreceptors do not measure the CO_2 directly, but instead monitor the concentration of hydrogen ions associated with the ionized carbonic acid (H_2CO_3) in the cerebrospinal fluid.

3. When the hydrogen ion concentration changes, the central chemoreceptor sensors send messages to the respiratory control center almost instantaneously, so proper respiration is restored immediately. Therefore, **the CO_2 concentration is more crucial than the lack of O_2 for controlling respiration.**

<u>Note:</u> Some conditions, such as Parkinson disease, obesity, narcotic painkillers, and other conditions adversely affecting the brainstem can impair the ability to respond to increased CO_2 concentrations. Medical providers should be alert to those conditions when examining workers for respirator use.

C. Wearing respirators requires increased physical effort because of the increased physiological burden that wearing a respirator places on the human body. There are many physiological effects of wearing respirators, including:

1. Increasing the effort required to breathe. Wearing a respirator increases resistance to air flow, which increases the work required to breathe. Wearing an air-purifying respirator, for example, requires extra effort to open inhalation valves and draw air through filters and then to force the exhalation valve open to expel exhaled breath from the respirator. Consequently, the body must work harder to breathe because it takes more effort to obtain air. A simple air filter of very low resistance can increase the work of respiration by 20% to 30% and a standard closed-circuit SCBA can increase the breathing work load by 100%.

Note: Some diseases, especially those that restrict or constrict the lungs (such as asbestosis, silicosis, and chronic bronchitis), also increase the work of breathing.

2. Increasing cardiovascular stress. Ventilation (the exchange of air between the lungs and the ambient atmosphere) is more difficult when wearing a respirator, which burdens the heart to increase output, which adds stress to cardiovascular system and may lead to increased blood pressure.

3. Increasing Metabolic activity. Metabolic activity increases because it takes more energy (more calories) to breathe while wearing a respirator. To meet increased energy requirements, the body uses an alternate metabolic pathway. The body normally uses aerobic respiration - fueled by sugar and carbohydrates. Aerobic respiration is the most efficient energy producing pathway and operates when there is an ample supply of oxygen. When oxygen supply is low, the body uses anaerobic respiration, which produces lactic acid, making blood more acidic (decreases pH), which can be problem for diabetics.

4. Altering drug metabolism. Drug metabolism may be altered when wearing a respirator, affecting drug interactions because the clearance time (the time it takes the drug to get out of the system) may be extended.

5. Decreasing blood oxygen saturation. Oxyhemoglobin saturation decreases while wearing a respirator, which decreases the amount of oxygen in the blood.

6. Increasing heat stress. Wearing a respirator increases heat stress exposure by increased metabolic heat production from increased work of breathing and from heated exhaled air being trapped inside the dead space in the respirator.

a. Also, the inside of respirators may be heated from the sorption reaction in chemical cartridge respirators. For example, the Type N canister uses hopcalite to convert carbon monoxide to carbon dioxide. This is an exothermic (heat producing) catalytic reaction.

b. In addition, the body's ability to reduce heat load is decreased when a respirator is worn. The skin surface area available for cooling (from evaporation of perspiration) decreases by the amount of skin now covered by a respirator. For example, an abrasive blasting hood with a shroud produces a more significant heat load than wearing a half mask respirator because the shroud leaves much less skin surface area for evaporative cooling.

c. Due to residual exhaled air trapped in the respirator dead space, inhaled air will also be higher in humidity. If the relative humidity inside the respirator increases by 30%, the temperature perceived by the wearer increases by 10^{o}F.

III. PSYCHOLOGICAL PROBLEMS

A. Some people feel claustrophobic (dread or fear of small or confined spaces) when wearing a respirator. They may feel like they are suffocating in the facepiece, even though the respirator is providing air. For example, many people breathe harder when wearing an SCBA because they feel like they are not getting enough air.

B. Respirator wearers may complain of intense nose itching after donning a respirator, partly due to the uncomfortable feeling of increased pressure on the face.

C. Wearing respirators may affect decision-making abilities.

IV. SPECIAL MEDICAL CONSIDERATIONS

Most aspects of respirator medical evaluation are covered in guidance of the Medical Surveillance Procedures Manual/Medical Matrix (reference 5). However, there are two noteworthy medical aspects that are not covered, which deserve consideration. These special medical issues include the olfactory consideration of anosmia and possible personal exposure through perforated eardrums.

A. Anosmia is the inability to perceive smells. Prior to promulgation of the revised OSHA Respirator Standard (reference 6) in 1998, standard practice for replacing respirator cartridges was to change cartridges when the respirator wearer detected chemical warning properties signaling breakthrough of workplace contaminant(s) into the facepiece. Chemical warning properties are detected by smell or irritation when cartridge sorbent material is saturated and continued inhalation through the respirator cartridges results in contaminants breaking through the cartridges and into the respirator facepiece.

1. Before the 1998 OSHA Respirator Standard, personnel with the inability to perceive smells (anosmia) were not allowed to wear air-purifying gas/vapor removing respirators because they could not detect when chemical breakthrough occurred, at which point their respirator was no longer protecting them.

a. However, the revised, 1998 OSHA Respirator Standard states that warning properties are no longer permitted as the sole basis for determining that an air-purifying respirator will afford adequate protection against exposure to gas and vapor contaminants. This allows personnel with anosmia to wear air-purifying respirators as long as a cartridge change out schedule is developed and implemented or the respirator is equipped with a NIOSH approved end-of-service-life-indicator cartridge so that respirator cartridges are changed before chemical breakthrough occurs.

i. Individuals with anosmia must otherwise be medically qualified per paragraph 1508 of reference 1.

ii. This includes no existing conditions (e.g., claustrophobia or anxiety that would cause the worker to occasionally remove the respirator) or associated abnormalities (abnormal facial shape, lack of other senses, significant past exposure, etc.) that would limit respirator effectiveness or increase risk from minimal undetected exposure.

2. Another issue is fit testing respirator wearers who have anosmia. Most of the qualitative fit testing protocols require having to smell or taste the fit test challenge agent (e.g., smelling banana oil in the isoamyl acetate fit test protocol).

3. If health care providers identify individuals with anosmia on either Appendix 15-A of reference 1 or OPNAV Form 5100/35, respiratory protection program managers can avoid wasting time and effort on trying to fit test these individuals with qualitative fit test protocols that require fit test subjects to smell or taste the fit test challenge agent.

4. Alternatives to fit testing with odor dependent fit test protocols include:

a. Using any of the quantitative fit testing methods, in which respirator leakage is detected and measured by the fit testing equipment – and not by the person being fit tested, or

b. Using the irritant smoke qualitative fit test, which relies on irritation to detect respirator leakage.

B. Perforated tympanic membranes (eardrums) are a controversial area in respirator medical evaluation worthy of special consideration. The main concern with perforated eardrums is that while wearing negative pressure air-purifying respirators, the negative pressure produced during inhalation could draw contaminated workplace air into the perforation and then down the estuation tube and into the lungs. Intuitively, it seems that the larger the perforation, the greater the quantity of contaminated air that could be inhaled, and, thus the greater the potential exposure. As discussed below, the "bottom line" for issuing medical clearance for workers with perforated eardrums should be determined on a case-by-case basis.

1. OSHA does not address this issue in the final, 1998 OSHA Respirator Standard (reference 6). However, the 1994 OSHA proposed ruling (reference 7), which did not result in a new OSHA Respirator Standard at that time, included the following discussion on this issue:

a. "With respect to the question of perforated tympanic membranes, Shell Oil (Ex. 36-50) submitted a report by Dr. Thomas Milby which reviewed the issue of potential employee exposure to hydrogen sulfide via the route of damaged tympanic membranes. The report stated that there was no valid information in the scientific literature supporting that perforated eardrums would produce an increased risk of contamination for workers. Calculations were performed for the Shell report which showed, in a worst case analysis, ambient air concentrations of H_2S [hydrogen sulfide] *would have to reach some 158 ppm before the worst case loss of an ear drum would permit exposure at the PEL of 10 ppm. Shell also included a study by Richard Ronk and Mary Kay White of NIOSH (Ex. 38-11) which concluded that workers with perforated eardrums should not be excluded from working in hydrogen sulfide atmospheres. They stated that in no reasonable case can the presence of a tympanic membrane defect significantly affect respiratory protection. California OSHA (Ex. 36-44) cited the NIOSH study as showing that tympanic membrane perforation was not a problem. Other commenters also recommended that this provision be dropped*

since it is not specifically a respirator related problem (Ex. 36-3, 36-18, 36-35, 36-47, 36-52).

b. "In light of the scientific review of tympanic membrane perforation submitted by Shell Oil, and the report by NIOSH which also reports no significant exposure from perforated eardrums, the recommendation for checking for perforated tympanic membranes has not been included in this proposal."

2. ANSI Z88.6-2006, the national consensus standard on respirator medical evaluations (reference 8) states, "*workers with perforated tympanic membranes should not be routinely excluded* [from wearing respirators]." "Routinely excluded" is interpreted to mean that a perforation (or a pressure equalizer tube, which is essentially a controlled eardrum perforation) is not an automatic disqualifier for using a respirator.

3. Although inhalation exposure potential via perforated tympanic membranes is minimal, it is not entirely absent. Thus, a perforated tympanic membrane warrants increased scrutiny where exposure to especially harmful substances is anticipated, such as substances with toxicity at low doses or that are irritating to the middle ear or eustachian tube, or airborne biologicals with a low infectious dose. Patency[1] of the eustachian tube and the availability of airtight earplugs may be factors for consideration in such cases.

4. In all cases, when qualitative fit testing reveals that the worker can smell the odoriferous indicator, the worker should be disqualified from using a respirator (whether the leak is due to a perforated tympanic membrane or other reason).

5. Use of positive pressure respirators, such as PAPRs (which, on loss of battery power, tight-fitting PAPRs revert to negative pressure air-purifying respirator mode), may be considered, taking into account the severity of potential injury should the respirator malfunction.

6. In conclusion, this medical decision boils down to the judgment of the physician in the specific use situation. Positive pressure respirators, such as PAPRs, airline respirators, SCBAs, and pressurized suits seem compatible with perforated eardrums. For negative pressure respirators, a tiny eardrum perforation and N95 filtering facepiece respirator worn for nuisance dusts protection may be reasonable, and may allow fit testing to proceed; not so for N95 use to prevent tuberculosis exposure.

V. REFERENCES

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http://doni.daps.dla.mil/Directives/05000%20General%20Management%20Security%20and%20Safety%20Services/05-100%20Safety%20and%20Occupational%20Health%20Services/5100.23G%20w%20CH-1.pdf

2 Draft American National Standards Institute (ANSI): American National Standard for Respiratory Protection (ANSI Z88.2). New York: ANSI, 201X.

[1] Patency is defined as the quality or state of being open or unobstructed.

3 National Institute for Occupational Safety and Health (NIOSH): A Guide to Industrial Respiratory Protection. DHEW (NIOSH) Publication No. 76-189 : NIOSH. Cincinnati, OH.

4 Tanic, S., Matthews, P., Haase, S., and Dorn, J.:McGraw Hill MediaPhys 2.0, An Introduction to Human Physiology website (2002).
http://www.mhhe.com/biosci/ap/mediaphys2_inprogress/data/index.html

5 NMCPHC Technical Manual OM 6260 , Occupational Medical Surveillance Procedures Manual and Medical Matrix edition 11, of July 2011.
http://www.med.navy.mil/sites/nmcphc/occupational-and-environmental-medicine/oemd/Pages/medical-surveillance-certification.aspx

6 Occupational Safety and Health Administration (OSHA): 29 CFR Parts 1910 and 1926 Respiratory Protection: Final Rule. Federal Register 63(5):1278–1279. Washington, D.C.: U.S. Government Printing Office, Office of the Federal Register, January 8, 1998, as amended 8June 2011.
http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_id=12716&p_table=standards

7 Occupational Safety and Health Administration (OSHA): 29 CFR Parts 1910 and 1926 Respiratory Protection; Proposed Rule. Federal Register 59 FR 58921: 1218-0099. Washington, D.C.: U.S. Government Printing Office, Office of the Federal Register, November 15, 1994.
https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=FEDERAL_REGISTER&p_id=13426

8 American National Standards Institute (ANSI): American National Standard for Respiratory Protection-Respirator Use-Physical Qualifications for Personnel (ANSI Z88.6). New York: ANSI, 2006.

APPENDIX D

RESPIRATOR CLASSES RANKED BY

DECREASING PHYSIOLOGICAL EFFECTS

I. CLASSES OF RESPIRATORS RANKED FROM HIGHEST TO LOWEST PHYSIOLOGICAL EFFECTS

All respirators add additional stress to the body. The purpose of this appendix is to rank classes of respirators from the most to the least physiologically challenging to wear. This ranking is as follows:

Military Gas Masks

Self Contained Breathing Apparatus (SCBA)

Full Face Non-Powered Air-Purifying Respirators

Half Mask Non-Powered Air-Purifying Respirators

Supplied-Air (Airline) Respirators

Powered Air Purifying Respirators (PAPRs)

Filtering Facepiece Respirators

Decreasing Physiological Effects ↓

A. **Military gas masks** are the most physiologically challenging respirators because of their increased inhalation and exhalation breathing resistance and because of the physically demanding workload and stress of combat. The Navy primarily uses the MCU-2/P gas mask shown in Figure D-1. The MCU-2/P is a negative pressure respirator and inhalation through the canister and exhalation through the exhalation valve depend only on the breathing action of the lungs.

1. The MCU-2/P is NOT NIOSH approved and is designed for maximum protection against chemical warfare agents and minimum leakage of contaminants into the facepiece. A by-product of the MCU-2/P protective design is an increase in inhalation and exhalation breathing resistance. Increased exhalation resistance reduces possible leakage of chemical warfare agents into the gas mask through the valve. The exhalation valve closes more quickly than on industrial gas masks due to valve design, giving hazardous chemicals and materials of the battlefield less chance to enter through the quickly closing valve. Increased inhalation resistance is a product of the filter canister design.

Figure D-1
MCU-2/P

2. In combat, military gas masks are worn as the respirator component of MOPP[1] gear and use may be under extreme environmental conditions and under extreme performance requirements, which further increases the physiological challenge of wearing these respirators. There is a great contrast between warfighters wearing military gas masks during combat operations and industrial workers' routine, rescue, or escape respirator use. Industrial workers can take breaks and go home at the end of the work shift. In harsh contrast, during wartime conditions, military personnel will be required to wear gas masks under battlefield conditions for indefinite periods of time as protection against some of the most toxic materials known, in concentrations in excess of allowable industrial occupational exposure limits.

3. The MCU-2/P contains no latex. The facepiece is made of silicone rubber and is equipped with a butyl rubber second skin during combat, which is less permeable to chemical warfare agents than silicone.

B. **Self contained breathing apparatus (SCBA)** are the heaviest respirators, weighing up to 35 lbs. and the source of air is carried by the respirator wearer. SCBA are often worn with impermeable hazmat suits or firefighter turnout gear during strenuous, life-threatening conditions such as hazardous waste cleanup operations, firefighting inside burning buildings, and CBRN[2] response. These environments are often IDLH.[3] The combination of intense exertion while wearing the heavy SCBA may significantly increase cardiovascular stress. Most SCBA in the Navy are equipped with elastomeric full facepieces made of rubber, silicone, or neoprene.

Figure D-2
Open-Circuit SCBA

1. In **open-circuit SCBA** (Figure D-2), exhaled air is expelled to the outside atmosphere and any contaminant(s) in the facepiece will be purged. Open-circuit SCBA are generally heavier than closed-circuit SCBA because of the large tank of Grade D quality air that is carried on the back. Because of carrying this weight, the amount of physical work a worker is capable of doing may be considerably reduced while wearing these respirators. The NIOSH weight restrictions limit the maximum service life. SCBA service times vary and are available in durations over an hour (currently up to 1 ¼ hours). The open-circuit SCBA used by the Navy are pressure-demand respirators in which the air pressure inside the respirator is normally positive with respect to the ambient air pressure during inhalation and exhalation. Maximum NIOSH exhalation and inhalation

[1] MOPP is the acronym for *Mission Oriented Protective Posture*, the protective ensemble worn by warfighters in combat for protection against chemical warfare agents and other toxic chemicals and materials.
[2] CBRN (chemical, biological, radiological, and nuclear) fully encapsulated ensembles are designed to protect first responders against chemical, biological, and radioactive warfare agents and high concentrations of toxic industrial chemicals and materials.
[3] Per ANSI Z88.2, an IDLH (immediately dangerous to life or health) atmosphere is any atmosphere that poses an immediate hazard to life or poses immediate irreversible debilitating effects on health.

resistances are 51 and 32 mm H_20 water column,[4] respectively. Any break in the face seal of positive pressure respirators normally produces an outward flow of air, forcing contaminants away from the face. Under extreme workloads, it is possible to over breathe positive pressure respirators, causing outside air to enter the respirator.

2. **Closed-circuit SCBA** (Figure D-3) are referred to as re-breather devices because they recirculate the user's exhaled breath within the respirator after CO_2 is removed and O_2 is replaced. Closed-circuit SCBA are smaller and lighter than open-circuit SCBA and can be designed to function for longer service times (up to four hours) but still stay within the required NIOSH weight limitation (i.e., 35 lbs.). Closed-circuit SCBA are lighter than open-circuit SCBA because they are not equipped with heavy air cylinders. Closed-circuit SCBA may be either positive or negative pressure with respect to the ambient workplace atmosphere. Maximum NIOSH exhalation and inhalation resistances are 51 and 49 mm H_20 water column, respectively.

Figure D-3
Closed Circuit SCBA

a. General operation. Re-oxygenation is accomplished either by a small cylinder of compressed oxygen or by chemical reaction. Oxygen concentrations may be quite high. The Navy oxygen breathing apparatus reached almost 100 % oxygen by the end of its service life. The carbon dioxide is chemically removed from the exhaled breath, and then the exhaled breath mixes with oxygen in the breathing bag before returning to the facepiece where it is re-breathed.

b. High temperature breathing air. All closed-circuit SCBAs remove carbon dioxide from the exhaled air by a chemical reaction referred to as "scrubbing," which is an exothermic reaction resulting in warm inspired air. Some closed-circuit SCBA also chemically generate oxygen by a heat producing, exothermic chemical reaction. The breathing air temperature of the Navy closed-circuit escape-only SCBA (Ocenco M20.2) can reach a maximum temperature of 130° F (54° C) due to exothermic removal of carbon dioxide (NIOSH allows up to 135° F [57° C]). Breathing such warm air may cause discomfort and increased cardiac stress, and this physiological stress increases with high ambient work area temperatures, intense workloads, and wearing other protective clothing.

[4] These pressures are measured in mm water column instead of psi. The reason NIOSH uses this unit of measurement for inhalation and exhalation pressures instead of psi is analogous to why we don't measure our height in miles. The pressures exerted by exhalation and inhalation pressure is of course much lower than the pressures required to inflate tires.

C. **Air-purifying (non-powered) elastomeric respirators** include half mask respirators and full face respirators, including gas masks. The air pressure inside of these respirators, with respect to the ambient air pressure, is positive during exhalation, but negative during inhalation, which draws air through the air-purifying filters/cartridges. Any break in the respirator facial seal of negative pressure respirators causes the surrounding atmosphere (including any contaminants) to flow into the respirator facepiece where it is inhaled by the wearer. The filters/cartridges (Figure D-4) remove aerosols, vapors, gases, or a combination of these contaminants. The elastomeric facepieces are usually made of rubber, silicone, or neoprene. Cartridges have 50 - 200 grams of sorbent material. Breathing through these respirators takes extra effort because the wearer's inhaled breath must overcome the resistance of drawing air through both the filter/cartridge medium and the inhalation valve and the exhaled breath must overcome the exhalation valve resistance to expel exhaled breath from the respirator. Maximum inhalation and exhalation resistances are 35 and 25 mm H_20 water column, respectively.

Figure D-4
Variety of Air-purifying Filters and Cartridges

1. **Full Face respirators** (Figure D-5), which enclose the face from hairline to underneath the chin, have the greatest facial/respirator sealing surface, and are the hardest types of facepieces to dislodge; therefore, they provide the most reliable fit and protection. Full face respirators provide eye protection. Full facepieces also contain the most dead air space. Full facepieces add 815 cc dead air space to the 150 cc volume of the anatomical dead air space. This increased dead air space increases breathing effort.

Figure D-5
Full Face Non-Powered Air-Purifying Respirator

Figure D-6
Full Facepiece Nose Cup

a. Nose cups. Nose cups (Figure D-6) can be installed inside full face respirators, which decrease the dead air space to about 260 cc. Nose cups direct the exhaled breath directly through the exhalation valve, which greatly reduces fogging of the facepiece lens.

b. Spectacle kits. According to paragraph (g)(1)(ii) of 29 CFR 1910.134, corrective glasses (and other gear) must not interfere with the seal of the respirator facepiece to face seal. Corrective glasses must not be worn with full face respirators because the temple pieces break the respirator facepiece seal, allowing contaminated workplace air to leak into the facepiece. NIOSH requires every manufacturer of approved full facepiece respirators to provide spectacle kits (Figure D-7), which mount inside the mask for vision correction. Spectacle kits have to be approved by NIOSH with the whole respirator assemblage and are NOT approved for use with any other manufacturer's full facepiece. Using generic spectacle kits negates the NIOSH approval.

Figure D-7
Full Face Respirator Spectacle Kit

c. Contact lenses. The respirator community once thought that wearing contact lenses with airline respirators would blow dust behind the lenses or that tightening head straps too tight could pop them out. OPNAVINST 5100.23*series* and OPNAVINST 5100.19*series* have allowed the use of contact lenses for over two decades. This was based on a *Lawrence Livermore National Laboratory* (LLNL) study reporting that firefighters who wore contact lenses with SCBA during firefighting did not have problems. Therefore, the Navy allowed using contact lenses with all types of respirators, even when at the time OSHA considered wearing contact lenses with respirators a violation.

i. ANSI Z88.2-1992 allows contact lens use with respirators if the individual had previously demonstrated that they could successfully wear contact lenses with respirators and that they first practice, in a safe environment, wearing the respirator while wearing contact lenses.

ii. When the OSHA Respirator Standard (29 CFR 1910.134) was revised in 1998, it conspicuously did not address contact lenses in the standard. However, the preamble explained that contact lens use is allowed with respirators (based on the LLNL contact lens/firefighter study).

2. **Industrial gas masks** (Figure D-8) are full facepiece air-purifying respirators that instead of being equipped with cartridges, are approved with a canister worn on the facepiece, chest, or back. Gas mask canisters are much larger and heavier than respirator cartridges and result in gas masks being more physiologically challenging to wear than full face respirators with their lighter weight cartridges. Gas mask "chin" style canisters have 250 - 500 grams of sorbent and are threaded directly into the inhalation port located on the chin or on one side of the gas mask. Gas mask

front or back mounted canisters have between 1000 - 1200 grams of sorbent material and are worn either in front or on back of the wearer in a harness assembly and are connected to the facepiece by a flexible hose (Figure D-8).

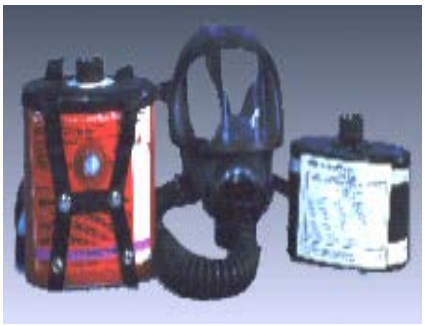

Figure D-8
Industrial Gas Masks

Figure D-9
CBRN Gas Mask

3. **CBRN (chemical, biological, radiological, and nuclear) gas masks** (Figure D-9) are gas masks designed to protect first responders against those agents and high concentrations of toxic industrial chemicals and materials. The heavy CBRN canisters can weigh up to 500 grams. These gas masks are usually worn with impermeable Level C (Class 3) chemical protective ensembles. CBRN gas mask facepieces are usually made of hycar rubber, which is effectively impermeable against nerve and mustard agents.

4. **Half mask elastomeric respirators** (Figure D-10) fit from the bridge of nose to under the chin and are the most common respirator found in the workplace today. Like full facepieces, half masks operate by the worker's respiratory effort drawing workplace air through filters and cartridges to purify the air. In general, half masks add about 260 cc of dead air space to the respiratory system.

Figure D-10
Half Mask, Non-Powered, Air-Purifying Respirator

a. Protective eyewear worn with half masks, such as safety glasses and goggles must not interfere with respirator fit.

b. Protective equipment including eyewear, which is worn with respirators, must be fit tested with the respirator to ensure that protective equipment does not cause the respirator to leak.

D. **Supplied-air (airline) respirators.** These respirators deliver breathing air to the wearer from a compressed air source (e.g., air compressor) though an air hose (thus the name "airline respirator"). Most airline respirators used by the Navy are positive pressure (continuous flow or pressure demand). NIOSH approves supplied-air respirators with hoses in lengths up to 300 feet. Air hoses may become a hazard in themselves in that they may become a trip hazard. Air hoses may become tangled on workplace equipment, or severed, leaving the wearer without a source of breathing air.

That is why airline respirators are not allowed to be worn by themselves in IDLH atmospheres without an auxiliary SCBA air cylinder for escape.

1. **Demand airline respirators** are no longer manufactured and should not be used by the Navy. They operate under negative pressure, which draws contaminated workplace air into the facepiece through any leak in the facepiece seal.

2. **Continuous flow airline respirators** are normally under positive pressure and equipped with a hood or helmet, loose fitting facepiece, tight-fitting full face (Figure D-11), half mask (Figure D-12), or tight-fitting hood sealing around the neck.

Figure D-11
Full Face Continuous Flow Airline Respirator

Figure D-12
Half Mask Continuous Flow Airline Respirator

Figure D-13
Hooded Airline

Figure D-14
Loose-Fitting Airline

a. **Hooded airline respirators** (Figure D-13) and **loose-fitting facepiece** airline respirators (Figure D-14) operate under continuous flow and have no facial or neck sealing surfaces. Loose-fitting facepiece airlines are designed to form a loose, partial seal with the face and do not cover the neck and shoulders.

b. Hooded and loose-fitting facepiece airline respirators may be worn by individuals who cannot wear tight-fitting respirators because facial hair or facial features such as deep scars interfere with the respirator seal around the face (as long as these airline respirators provide the required level of protection).

3. **Pressure demand airline respirators** are normally under positive pressure and are equipped with a full or half mask facepiece. Pressure demand airlines have regulators with a spring mechanism that adjusts respirator air flow to maintain positive pressure inside of the facepiece. This pressure demand, spring mechanism is distinguishable by the distinctive gold-colored, dome-shaped regulators shown in the combination pressure demand airlines pictured in figures D-16 and D-17.

a. **Abrasive blasting airlines** (Figure D-15) are specially equipped hooded or full face respirators. Abrasive blasting airlines are equipped with hard protective exteriors and protective facepiece lens screens to protect the wearer against rebounding abrasive material. A protective shroud is an integral part of abrasive blasting respirators. The shroud greatly reduces skin surface area for evaporative cooling.

Figure D-15
Helmeted Abrasive Blasting Airline Respirator

b. **Combination airline respirators** are approved in combination with an SCBA (Figure D-16) or an air-purifying element (Figure D-17) for entry and egress of hazardous atmospheres. Combination airline/SCBA can be worn into IDLH atmospheres. There are currently no CBRN airline respirators.

Figure D-16
Combination Airline/SCBA

Figure D-17
Combination Airline/Air-Purifying Respirator

E. **Powered-air purifying respirators (PAPRs)** (Figures D-18 through D-24) operate by a motor driven blower drawing ambient air through an air-purifying element, which removes aerosols, vapors, gases, or a combination of these contaminants to provide a continuous flow of clean air to the wearer. PAPRs are normally under positive pressure and are equipped with a hood or helmet, loose-fitting facepiece, tight-fitting full facepiece, tight-fitting half mask, or tight-fitting hood sealing around the neck, such as the CBRN PAPR in Figure D-23. The motor and cartridges/canisters are usually worn on the belt resulting in more weight being carried by the respirator wearer. Even though PAPRs are heavier and bulkier than negative pressure air-purifying respirators, workers for the most part consider them more comfortable because of the PAPRs' cooling effect and PAPRs require less breathing effort due to the continuous flow of clean air to the PAPR wearer. Although the continuous flow of clean air to the user provides a cooling effect in warm temperatures, according to the OSHA Technical Manual on Heat Stress, forced air has a cooling effect by convection until the air temperature exceeds 95°F (35°C), then the air flow can increase the heat load on the body.

1. **PAPRs with tight-fitting facepieces,** pictured in Figure D-18 and D-19, are the most protective PAPRs because if they lose battery power, filtered air will still be drawn into the facepiece by the negative pressure created inside the facepiece by inhalation.

Figure D-18
Full Face PAPR

Figure D-19
Half Mask
PAPR

2. **PAPRs with hoods** (Figure D-20) do not have facial sealing surfaces. PAPRs with "**loose fitting facepieces**" (Figure D-21) have a partial flap-like bib that loosely rests on the facial surfaces at the temple, cheek, or chin that helps maintain positive pressure inside the facepiece but does not form a tight sealing surface. Loose fitting facepiece PAPRs, provide 40 times less protection than tight-fitting PAPRs because there is a much greater possibility of contaminants leaking into hoods and being inhaled by the wearer. Hooded and loose-fitting PAPRs may be worn by individuals when facial hair or facial features, such as deep scars, interfere with the respirator seal around the face (as long as these PAPRs provide the required level of protection).

Figure D-20
Hooded PAPR

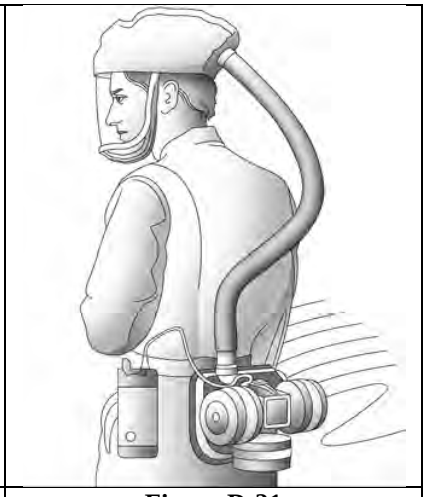

Figure D-21
Loose-Fitting Facepiece PAPR

3. **Tight-fitting CBRN PAPRs** are equipped with either full facepiece gas masks (Figure D-22) or tight sealing neck dam hoods (Figure D-23). Tight fitting CBRN PAPRs are designed to protect first responders against chemical, biological, and radiological warfare agents and high concentrations of toxic industrial chemicals and materials. These PAPRs are equipped with heavier CBRN canisters and usually worn with Level C (Class 3) chemical protective ensembles. CBRN gas mask facepieces are usually made of hycar rubber, which is impermeable to nerve and mustard agents. The arrows in the picture of the tight sealing neck dam hood in Figure D-23 are pointing to locations where NIOSH applies liquid mustard agent during CBRN respirator certification testing.

Figure D-22
CBRN Gas Mask PAPR

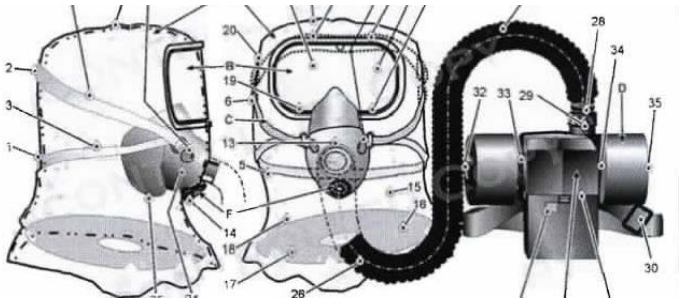

Figure D-23
CBRN PAPR with Tight-Fitting Neck Dam Hood

4. **Loose-fitting CBRN PAPRs** are (Figure D-24) hooded and designed to be worn by hospital first receivers. These PAPRs are equipped with CBRN cartridges – NOT CBRN canisters and are usually worn with Level C (Class 3) chemical protective ensembles. Loose-fitting CBRN PAPRs do not provide as much protection as the tight-fitting CBRN PAPRs and are tested at half the challenge agent concentrations during NIOSH certification testing. They are also not tested against liquid chemical warfare agents, and if they lose power no filtered air is provided to the wearer. In contrast, if a tight-fitting PAPR loses power, the wearer is still able to breathe filtered air by the negative pressure created during inhalation, which draws surrounding air through the CBRN filter canisters.

Figure D-24
Loose-Fitting CBRN PAPR

F. **Filtering facepiece respirators**, shown in Figure D-25 are the lightest (¼ - 1 oz.) and most comfortable respirators. Breathing is easier because air is drawn through the entire surface area of the facepiece (i.e., the filter is the respirator facepiece). Inhalation resistances are less than 35 mm H_20 and exhalation resistances are less than 25 mm H_20. Although these respirators produce the least sensory and communication stresses, wearing them is still more stressful than not wearing a respirator.

1. The combination of inspiratory resistance, expiratory resistance, increased dead air space, heat stress, respirator-associated anxiety, and irritation lead to an increase in respiratory rate, heart rate, and both systolic and diastolic blood pressure when compared to non-respirator wear (reference 1). The most marked changes associated with the use of these single-use disposable respirators are at high workloads.

Figure D-25
Filtering Facepiece Respirator

2. DuBois, et. al. 1990 (reference 2) compared the comfort of elastomeric half masks to filtering facepiece respirators and reported that both types of respirators were comfortable when skin temperature was below 93^{o}F (34^{o}C). Respirator wearers reported that at skin temperature above 93^{o}F the face feels increasingly warm, uncomfortable, and sweaty. This is related to thermal sensation, sweating and skin hydration, condensation of expired alveolar water vapor, cutaneous blood flow, and vascular congestion. The discomfort is related to the temperature of the face under the mask and not caused by the weight of the mask.

3. Filtering facepiece respirators equipped with exhalation valves (Figure D-26) permit egress of greater amounts of heat by lowering air resistance during exhalation; however, this only results in lower facial skin temperature at higher work rates and not during sedentary breathing (references 3 and 4).

Figure D-26
Filtering facepiece respirator
With exhalation valve

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2 DuBois, A. B. , Harb, Z. F. and Fox, S. H.: Thermal Discomfort of Respiratory Protective Devices, American Industrial Hygiene Association Journal, 51: 10, 550-554 (1990).

3 Monaghan, W. D., Roberge, M. R., Rengasamy. M., and Roberge, R. J.: ISRP Vol 26 Summer Thermal Imaging Comparison of Maximum Surface Temperatures Achieved on N95 Filtering Facepiece Respirators with and without Exhalation Valves at Sedentary Breathing Volumes.

4 Roberge, R. J.: Are Exhalation Valves on N95 Filtering Facepiece Respirators Beneficial at Low-Moderate Work Rates: An Overview. J. Occup. Environ. Hyg. 9(11): 617-623 (2012).

RESPIRATOR CLASSES RANKED BY DECREASING PHYSIOLOGICAL EFFECTS

	**Military Gas Mask** Greatest inhalation & exhalation pressure. Worn with MOPP[1] gear, which increases heat stress. Combat may require use for extended periods.
	**Self Contained Breathing Apparatus (SCBA)** Heaviest respirator (35 lbs.). Wearer carries the air source (e.g., air cylinder). Often worn with impermeable hazmat ensembles in atmospheres immediately dangerous to life and health (IDLH). Chemical reactions in "closed-circuit" (air recirculating) models produce warm air (up to 135° F).
	**Full Face** **Non-Powered Air-Purifying Respirators** Adds ~815 cc of dead air space to the respiratory system. Personnel needing vision correction must have prescription spectacle kits.
	**Half Mask** **Non-Powered Air-Purifying Respirators** Adds ~ 260 cc of dead air space to the respiratory system.
	**Supplied-Air (Airline) Respirators** Delivers breathing air to the wearer from a compressed air source (e.g., air compressor) though an air hose up to 300 feet in length. Air hoses may become tangled on workplace equipment, or severed, leaving the wearer without a source of breathing air. That is why they must not be worn in IDLH atmospheres without an auxiliary SCBA air cylinder for escape.
	**Powered Air Purifying Respirators (PAPRs)** Even though PAPRs are heavier and bulkier than negative pressure air-purifying respirators, workers for the most part consider them more comfortable because of the PAPRs' cooling effect and PAPRs require less breathing effort due to the continuous flow of clean air to the PAPR wearer.
	**Filtering Facepiece Respirator** Lightest (¼ - 1 oz.) and most comfortable respirators. Breathing is easier because air is drawn through the entire surface area of the facepiece (i.e., the filter is the respirator facepiece). Only adds 260 cc of dead air space to the respiratory system.

Decreasing Physiological Effects

[1] MOPP is the acronym for *Mission Oriented Protective Posture*, the protective ensemble worn by warfighters in combat for protection against chemical warfare agents and other toxic chemicals and materials.