

HAZARD ASSESSMENT FOR RESPIRATOR SELECTION

I. HAZARD ASSESSMENT IN GENERAL.

A. Respirators are selected based on the inhalation exposures to which workers are exposed. Making informed decisions on respirator selection requires performing a hazard assessment as the first step to determine inhalation exposures and other workplace hazards. Proper respirator selection requires considering the nature and extent of the hazard, work requirements, environmental conditions, and capabilities and limitations of respirators.

B. More specifically, hazard assessment includes obtaining relevant information on worker exposure, including all possible respiratory, eye, and skin hazards, along with environmental conditions, including temperature and humidity. Determine if there is an OSHA substance specific standard (e.g., lead, asbestos) for the contaminant(s), which may require specific respirators to perform the operation. Evaluate the nature of the hazard(s), including concentration and occupational exposure limits, nature of the operation, and location of the hazardous area.

C. Once workplace hazards are characterized use only respirators approved by NIOSH or NIOSH/Mine Safety and Health Administration (MSHA) that provide proper level of worker protection. Consider respirator characteristics, capabilities, and limitations, and assigned protection factors (APFs). Employee acceptance of the respirator is an important factor. Therefore, if more than one type of respirator provides the required protection, consider providing the worker with the most comfortable respirator.

D. Also, workplace hazard assessment should be accomplished initially and periodically thereafter, based on the complexity of the operation. Reevaluate work operations when work conditions change, including installation of industrial ventilation.

II. NATURE OF THE HAZARD.

A. Oxygen deficiency. The Navy (reference 1), Occupational Safety and health Administration (OSHA) (reference 2), and the National Institute for Occupational Safety and health (NIOSH) (reference 3) define oxygen deficient atmospheres as below 19.5% oxygen at sea level, which is equivalent to an atmospheric oxygen partial pressure (PO_2) <148 mmHg. In contrast, the 1992 edition of *American National Standard Institute (ANSI) Z88.2* (reference 4) defined oxygen-deficient IDLH¹ atmospheres as follows:

“Oxygen deficiency immediately dangerous to life or health is defined as an oxygen content below 12.5% at sea level (95 mmHg ppO₂) or an atmospheric pressure less than 450 mmHg (8.7 psi) equivalent to 14,000 ft (4270 m) altitude.”

1. The ANSI 12.5% (95 mmHg ppO₂) oxygen level does not allow any room for error because under these conditions, the hemoglobin of the alveolar blood is only 83% saturated with oxygen. When the oxygen content of the hemoglobin drops below 83% saturation, symptoms of debilitating physiological oxygen deficiency can occur suddenly, without warning, after only relatively small decreases in oxygen

¹ Per ANSI Z88.2, IDLH is any atmosphere that poses an immediate hazard to life or poses immediate irreversible debilitating effects on health.

levels. However, the current ANSI Z88.2 Subcommittee is amending Z88.2 reduced oxygen policy to be compatible with NIOSH and OSHA policies (See Table 1).

2. Both OSHA (paragraph (d)(2)(iii) of reference 2) and Navy policy (paragraph 1507 of reference 1) consider all oxygen-deficient atmospheres (<19.5% O₂ by volume) to be IDLH and require personnel entering these atmospheres to wear either full face, pressure demand, self-contained breathing apparatus (SCBA) or full face, pressure demand combination airline/SCBA.

3. However, OSHA allows an exception when the employer can demonstrate that, under all foreseeable conditions, the oxygen concentration can be maintained within the ranges at the altitudes specified in *Table II of the OSHA Respirator Standard* (reproduced below); then any atmosphere supplying respirator may be used. In other words, under these conditions, an airline respirator is allowed if the source of the oxygen reduction is understood and controlled.

OSHA's Table II From 29 CFR 1910.134	
Altitude (feet)	Oxygen-deficient Atmospheres (% O ₂) for which the employer may rely on any atmosphere-supplying respirator
Less than 3,001	16.0-19.5
3,001-4,000	16.4-19.5
4,001-5,000	17.1-19.5
5,001-6,000	17.8-19.5
6,001-7,000	18.5-19.5
7,001-8,000	19.3-19.5

a. At high altitudes, OSHA (reference 2) and ANSI Z88.2-1992 (reference 4), require oxygen-enriched breathing air for atmosphere-supplying respirators (see footnote 4 of Table 1).

b. However, OSHA allows acclimated workers to perform their work without atmosphere-supplying or oxygen-supplying respirators, at altitudes up to 14,000 feet, as long as the ambient oxygen content remains above 19.5%.

4. The best way to determine oxygen concentration is by direct measurement. However, if the contaminant concentration is known, then the oxygen concentration can be estimated. The contaminant concentration in percentage is simply subtracted from normal 20.9 % oxygen concentration. The following equation calculates the % contaminant concentration from the contaminant concentration in parts per million (ppm):

$$\% \text{ Contaminant} = \text{ppm contaminant} / 10^6 \times 100$$

Example: What is the oxygen concentration in an atmosphere with a toluene concentration of 2,500 ppm?

Answer: % Contaminant = 2,500 ppm toluene / 10⁶ X 100 = 0.25 % toluene

Therefore: Oxygen concentration = 20.9% oxygen - 0.25 % toluene = 20.65% oxygen.

Although this atmosphere is not oxygen deficient, the IDLH concentration for toluene is 2,000 ppm.

5. Table 1, adapted from Draft ANSI Z88.2, summarizes the respiratory protection required for protection against reduced oxygen atmospheres.

Table 1 Respirator Selection for Combined Effect of Altitude and Reduced Percentage of Oxygen			
Altitude/Total pressure	% O₂ at Sea Level		
	20.9%	<19.5%	<16% and below (Note 1)
	PO₂ [mmHg]	PO₂ [mmHg]	PO₂ [mmHg]
Sea level 760 mmHg	159 to 148 (19.5% O₂) Air-purifying respirator if needed for non-oxygen deficient inhalation hazards. (Note 2)	<148	<122
1 000 ft. 733 mmHg	153	143	117
2 000 ft. 707 mmHg	147.8	138 O₂ Deficiency Non-IDLH	113
3 000 ft. 681 mmHg	142	133 Airline Respirator (Note 3)	109
4 000 ft. 656 mmHg	137	128	105
5 000 ft. 632 mmHg	132	123	101
6 000 ft. 609 mmHg	127	119	97
7 000 ft. 584 mmHg	122	114	93
8 000 ft. 565 mmHg	118*	110 O₂ Deficiency IDLH	90
9 000 ft. 543 mmHg	113*	106 Pressure Demand, Full Face SCBA or Combination Airline/SCBA	87
10 000 ft. (Note 4) 523 mmHg	109*	102	84
11 000 ft. 503 mmHg	105*	98	80
12 000 ft. 484 mmHg	101*	94	77
13 000 ft. 465 mmHg	97*	91	74
14 000 ft. 450 mmHg	94*	88	72

* Acclimatized individuals can continue to perform their work without atmosphere-supplying or oxygen-supplying respirators, at altitudes up to 14,000 feet, as long as the ambient oxygen content remains above 19.5% and has no medical condition requiring using supplemental oxygen.

Notes:

- 1) Oxygen partial pressures <122 mmHg dictate the need for an SCBA or a combination airline respirator with auxiliary air cylinder and assumes a normal healthy un-acclimatized worker.
- 2) For oxygen partial pressures between 159 and 148 mmHg air-purifying respirators may be worn if the source of the oxygen reduction is understood and controlled and the type of other inhalation hazards and their concentrations are such that the protection provided by air-purifying respirators is adequate. NIOSH approval for air-purifying respirators is valid only for atmospheres containing 19.5% oxygen or greater at sea level.
- 3) For oxygen partial pressure equal to or greater than 122 and less than 148 mmHg airline respirators may be worn if the source of the oxygen reduction is understood and controlled.
- 4) At 10,000 feet or higher or in any space where the total ambient pressure is less than 523 mmHg, specially designed and approved SCBA supplying enriched oxygen or a closed-circuit SCBA shall be used. At least 23% oxygen is required at 10,000 feet or at a total ambient pressure of less than 523 mmHg and 27% oxygen at 14,000 feet or at a total ambient pressure of less than 450 mmHg.

B. Contaminant characteristics. Determine all of the materials used in the operation. Through interviews with supervisory personnel, work process flow charts, standard operating procedures, and material safety data sheets identify the raw materials, impurities, intermediate products, end products, by-products, and waste-products. Identify the physical and chemical properties, physiological effects, warning properties, concentration, and occupational exposure limits.

1. Physical properties. Physical properties of the hazard include particle size, molecular weight, boiling point, lower explosive limit, and vapor pressure. Is the physical state solid, vapor, or gas? Is the contaminant present in more than one physical state (e.g., does it exist as both a particulate and a vapor)? Please refer to reference 5 for a detailed discussion concerning how certain contaminants may exist as a vapor at one concentration; but at another concentration, they may exist as both vapor and particulate. Also, substances from the American Conference of Governmental Industrial Hygienists (ACGIH) TLV booklet with the inhalable fraction vapor (IFV) footnote should be considered to be present in both aerosol and vapor form unless determined otherwise.
2. Chemical properties. Chemical properties of the hazard include solubility in water and other liquids, reactivity with other chemicals, reactivity with sorbent materials in respirator cartridges/canisters, and hazardous decomposition products.
 - a. Is the substance corrosive? Some substances (e.g., NO₂ and SO₂) react with water vapor to form acids. This is particularly important when temperatures drop below the dew point because these acids condense into liquid aerosols.
 - b. Particulate filters approved under 42 CFR 84 (reference 3) are classified by their ability to filter oil because oil aerosols tend to degrade filter efficiency. Therefore, it is important to know whether the aerosol contains oil.
3. Physiological effects. Physiological effects on the body include skin absorption, eye and mucus membrane irritation, simple or chemical asphyxiation, anesthesia, sensitization, carcinogenic, and reproductive hazards.
4. Warning properties. Warning properties include odor, taste, or irritant effects. If the odor or irritation threshold of a substance occurs at concentrations greater than

the Navy occupational exposure limit (OEL) or the substance causes olfactory fatigue, it should be considered to have poor warning properties.

- a. Some substances (e.g., hydrogen sulfide) upon brief exposure desensitize individuals, making them unable to detect the substance through sense of smell. Olfactory fatigue is a more gradual loss of sense of smell caused by exposure to certain substances.
- b. Chemical cartridge air-purifying respirators are appropriate for protection against gases and vapors, including isocyanates and other substances without good warning properties up to their maximum use concentration if a cartridge change schedule is developed and implemented. Alternatively, atmosphere supplying respirators or air-purifying respirators equipped with approved end-of-service-life indicators (ESLI) can be used.

5. Concentration. The actual concentration of a toxic compound must be known to determine the degree of protection necessary. If the contaminant concentration cannot be determined then consider the atmosphere to be IDLH. According to paragraph 1507 of reference 1, only full face, pressure demand SCBA or combination full face, pressure demand airline/SCBA can be worn into oxygen-deficient or IDLH atmospheres.

- a. The online [NIOSH Pocket Guide to Chemical Hazards](#) contains IDLH atmosphere concentrations, along with exposure limits, chemical and physical properties, health hazards, analytical sampling methods, and much more. The Pocket Guide is linked to the [NIOSH Documentation for IDLH Concentrations](#).

- b. Use the Navy adopted OELs. Paragraph 1602 of reference 1 states that the Navy will follow the hierarchy of exposure standards listed below:

- i. 1989 OSHA permissible exposure limits (PELs).

- (i) The Navy uses 1989 PELs, which are lower than current, original PELs. The original PELs, published in 1971, came mostly from the 1968 ACGIH Threshold Limit Values (TLVs).

- (ii) In 1989, using primarily the 1987 ACGIH TLVs, OSHA updated the PELs, changing about 400 PELs. However, in July of 1992, the Eleventh Circuit Court of Appeals vacated the new PELs and restored the original 1971 PELs to the status of current PELs.

- (iii) As a result of this Court action, the current OSHA PELs are basically the 1968 ACGIH TLVs, which are over 40 years old. Over the past 40 years, much toxicological and exposure information has become known making it clear that many of the original PELs do not provide a sufficient level of protection. [\(Note: OSHA recognizes their PELs are out dated, so OSHA annotated the PELs with Cal/OSHA PELs, the NIOSH Recommended Exposure Limits \(RELs\) and ACGIH® TLVs®s. However, skin absorption/sensitization notations are not included.\)](#)

- ii. Substance specific regulations issued by OSHA under section 6.(b) of the Occupational Safety and Health Act of 1970 [such as Asbestos and Lead standards].

iii. Navy developed standards. When there is no OSHA PEL or Navy developed standard, the ACGIH TLV shall be used as the Navy OEL.

1. When the OEL is based on a limit derived from the OSHA Z-1, Z-2, or Z-3 Tables, reports of data shall include the ACGIH TLV as additional guidance.

2. Navy adopted OELs are listed in [Appendix A Table Z-1-A](#) and [Table Z-2](#) of this manual.

III. NATURE OF THE OPERATION.

A. Initially perform a hazard assessment for each work process. Reassess operations when work conditions change and after installation or modification of ventilation systems. Consider operation or process characteristics; work area characteristics; materials used or produced during the process; workers' duties and actions; and abnormal situations (e.g., emergencies that may necessitate a different respirator selection).

B. Location of the hazardous area. Location of the hazardous area may limit the types of respirators that can be safely used. For example, if entry into the hazardous area requires using ladders or crossing railroad tracks, then airline respirators should not be selected because of the possibility of tangling or severing the supplied air hoses. Also, when using SCBA or combination airline/SCBA, the distance from the hazardous area to the nearest staging area containing a breathable atmosphere must be known to ensure that the SCBA selected will have an adequate supply of breathing air or that the service life of the auxiliary escape cylinder of the combination airline/SCBA is adequate for emergency escape.

C. Time respiratory protection is required. The length of time a respirator will have to be worn is a factor that must be considered. This is most evident when using an SCBA, where the air supply is finite. However, time is also a factor during routine use of air-purifying respirators. Cartridge change schedules must be established and implemented. Also consider worker acceptance and comfort, which are essential to ensure proper use of the respirator. Most respirators are not comfortable and workers' tolerance decreases with extended respirator wear time.

IV. RESPIRATOR CHARACTERISTICS, CAPABILITIES, AND LIMITATIONS.

A. The description of respirator characteristics, capabilities, and limitations for each class of respirator is addressed in the article on *Respirator Classification* in the "Respirator Toolbox" under the NMCPHC [Industrial Hygiene](#) homepage. In addition, references 4 and 6 provide excellent descriptions of the various classes of respiratory protection.

B. The very informative NIOSH Respirator Decision Logic, included in reference 6 has been updated in reference 7. Also, NIOSH includes protections, cautions, and use limitations for each respirator on the full respirator approval label.

V. PROTECTION FACTOR (PF) AND ASSOCIATED CALCULATIONS.

A. The protection factor is an expression of respirator performance based on the ratio of two measured variables, the challenge agent concentration outside the respirator ($C_{(out)}$) to the challenge agent inside the respirator facepiece ($C_{(in)}$), (i.e., $PF = C_{(out)} / C_{(in)}$).

1. Another way to express protection factor is based on leakage ($PF = 100 / \% \text{ respirator leakage}$). For example, a full face air-purifying respirator has an assigned protection factor of 50, which is based on inward leakage of 2%. In this case, $PF = 100 / 2\% = 50$.
2. Special types of protection factors include:
 - a. Fit Factor (FF). Fit factor is a ratio of the ($C_{(out)}$) to ($C_{(in)}$) on a particular individual measured during quantitative fit testing, ($FF = C_{(out)} / C_{(in)}$). In general, the higher the fit factor, the better the respirator seals to the individual's face. Passing a qualitative fit test is equivalent to passing a quantitative fit test with a fit factor equivalent to 100.
 - b. Assigned Protection Factor (APF) is the protection afforded by a certain class of respirators.
 - c. Workplace Protection Factor (WPF) is a measure of respiratory protection afforded in the workplace.
 - d. Simulated Workplace Protection Factor (SWPF) is similar to (WPF) but measured in a simulated laboratory environment.

B. Assigned Protection Factors (APFs). The protection afforded by respirators is dependent upon the seal of the facepiece to the face, leakage around valves, and leakage through or around cartridges or canisters. By considering and measuring the effect of these variables during WPF studies and SWPF studies the degree of protection may be estimated and combined with a safety factor to assign a protection factor. APFs only apply when respirators are used within the context of a comprehensive respirator program. Therefore, APFs are defined as the workplace levels of respiratory protection that would be provided by properly functioning and properly used respirators or class of respirators when all elements of an effective respiratory protection program are established and are being enforced.

1. OSHA promulgated their APF final ruling (reference 8) on 24 August 2006. The APF final rule applies to OSHA regulated substances including OSHA substance-specific standards. This standard eliminates separate APF tables in most OSHA substance-specific standards and resolves inconsistencies between OSHA, NIOSH, and ANSI APF values. Standardizing the APFs reduced confusion and helped clarify the respirator selection process. OPNAVINST 5100.19E (reference 9) adopted the OSHA APFs (see Table 2) with the exception of filtering facepiece respirators, for which the Navy retains its current APF of five. Please note that there is a typographical error in the APF Table in OPNAVINST 5100.19E. The APF of five for filtering facepiece respirators should have been under the half mask column, not the quarter mask column because there are no quarter mask filtering facepiece respirators.
2. There are a few exceptions that do not follow the APF table such as the respirator selection provisions of the 1,3-Butadiene (BD) Standard, which retains its APF table because of the short service life of air-purifying cartridges above 50 ppm BD. Other respirator selection requirements retained to provide protection against

hazardous conditions that are unique to OSHA substance specific substances are discussed in section VIII of reference 8.

3. Footnote C of Table 2 concerns the APF of airline respirators and powered air purifying respirators (PAPRs) designed with hoods or helmets. This footnote emphasizes that employers are responsible for ensuring that these types of respirators provide a protection level of 1,000 or greater. The footnote states that respirator manufacturers shall provide employees with proof based on WPF or SWPF studies demonstrating that their respirators perform at an APF of 1,000; otherwise these hood/ helmet respirators will receive an APF of 25, which is the same APF granted to loose-fitting PAPRs and airline respirators. In their APF Final Rule (reference 8), OSHA did not identify specific test conditions, performance criteria, and testing protocols that are acceptable to OSHA and that shall be followed by the manufacturer to determine protection level testing. However, in their preamble, OSHA cited the *Organizational Resource Counselors Worldwide* (ORC) study, performed at *Lawrence Livermore National Laboratory* as an acceptable SWPF testing protocol, and stated that PAPRs and SARs passing this testing protocol will provide the required level of protection for employees who use these respirators. Cohen, et al. published the findings of this ORC study in a journal article (reference 10).

a. Per reference 11, OSHA accepts respirator manufacturers' empirical test data demonstrating that hooded respirators provide an APF of 1,000. In the absence of such testing, these respirators are to be treated as loose-fitting facepiece respirators, and receive an APF of 25.

b. OSHA also said that previous interpretations of studies where OSHA granted an APF of 1,000 for specific operations (e.g., pharmaceutical and lead construction) will be extended to all applications.

C. Maximum Use Concentration. According to reference 7, the maximum use concentration (MUC) is the maximum atmospheric concentration of a hazardous substance from which an employee can be expected to be protected by a class of respirators. MUC is determined by the lesser of either the calculated MUC ($MUC = APF \times OEL$) or a MUC established by respirator manufacturers. However, if the IDLH concentration is lower than the MUC, then the IDLH concentration takes precedence over the calculated MUC.

For multi-component mixtures, the MUC can be calculated by:

$$MUC_{(Mixture)} = [Concentration1/MUC1 + Concentration 2/MUC2 + \dots Concentration n/MUCn].$$

The total should be < 1 .

If 1 is exceeded for half mask $MUC_{(Mixture)}$, then calculate $MUC_{(Mixture)}$ for full face respirators. If 1 is exceeded for full face $MUC_{(Mixture)}$, select an appropriate respirator with an appropriately higher APF. Remember IDLH takes precedence over calculated MUC.

Table 2 Assigned Protection Factors^D					
Type of respirator ^{A, B}	Quarter mask	Half mask	Full facepiece	Helmet/hood	Loose-fitting facepiece
Air-Purifying Respirator	5	10	10/50 ^G	—	—
Filtering Facepiece Respirators	—	5	—	—	—
Powered Air-Purifying Respirator (PAPR)	—	50	1,000	25/1,000 ^C	25
Supplied-Air Respirator (SAR) [Airline Respirator]^E					
Demand mode	—	10	10/50 ^G	—	—
Continuous flow mode	—	50	1,000	25/1,000 ^C	25
Pressure-demand or other positive-pressure mode (i.e., Continuous flow SAR meeting NIOSH pressure demand requirements are approved as pressure demand SAR.)	—	50	1,000 ^F	—	—
Self-Contained Breathing Apparatus (Open & Closed Circuit SCBA)					
Demand	—	10	10/50 ^G	50	—
Pressure-demand	—	—	10,000	10,000	—
<p>^A Employers may select respirators with greater protection factors than what is required by the hazard.</p> <p>^B APFs are only applicable if all elements of an effective respirator program are established and enforced according to the Respirator Chapter of OPNAVINST 5100.23 Series.</p> <p>^C The employer must have evidence that testing of these respirators demonstrates performance at a level of protection of 1,000 or greater to receive an APF of 1,000. Per reference 11, OSHA accepts respirator manufacturers' empirical test data demonstrating that hooded respirators provide an APF of 1,000. In the absence of such testing, these respirators are to be treated as loose-fitting facepiece respirators, and receive an APF of 25.</p> <p>^D These APFs do not apply to respirators used solely for escape. For escape respirators used in association with contaminants that are regulated by OSHA substance specific standards (e.g., acrylonitrile, formaldehyde, benzene), refer to the appropriate substance-specific standards. Paragraph (d)(2)(ii) of 29 CFR 1910.134 states that "<i>Respirators provided only for escape from IDLH atmospheres shall be NIOSH certified for escape from the atmosphere in which they will be used.</i>"</p> <p>^E When using a combination respirator ensure that the APF is appropriate to the mode of operation in which the respirator is being used. For example, a combination full facepiece pressure-demand SAR with an air-purifying canister would have an APF of 1,000 in the pressure-demand mode; but would have an APF of 50 in the negative pressure air-purifying mode.</p> <p>^F The protection provided by combination, full facepiece pressure-demand SARs with auxiliary SCBA is equivalent to the protection provided by full facepiece pressure-demand SCBA; therefore, the APF of 10,000 for pressure-demand SCBA applies.</p> <p>^G APF is 10 when qualitatively fit tested and 50 when quantitatively fit tested.</p>					

D. Hazard Ratio. Another useful calculation in respirator selection is the hazard ratio, which indicates the minimum APF required. Hazard ratios are calculated by dividing the exposure concentration of the contaminants, as determined by acceptable industrial hygiene methods, by the applicable OEL. Examples for calculating hazard ratios with applicable OELs include:

Divide the time-weighted average (TWA) exposure concentration by the 8 hour TWA OEL. If the exposure limit is based on a TWA other than 8 hours, use the TWA concentration for that time frame. For example, if the exposure limit is based on 10 hours, use a 10 hour TWA.

If the contaminant has a ceiling limit, divide the maximum exposure concentration for the contaminant by that ceiling limit.

If the contaminant has a short term exposure limit (STEL), divide the maximum 15 min exposure concentration for the contaminant by the STEL.

1. Determine the hazard ratio for each air contaminant. Then compare each hazard ratio with the APFs in Table 2. Select a respirator with an APF greater than the largest calculated hazard ratio.
2. Appendix E of reference 12 addresses calculating threshold limit values for mixtures of components that additively affect the same target organ. If the calculated result for the mixture is greater than one, this indicates a respirator is required and this result is the hazard ratio. Select a type of respirator with an assigned protection factor greater than this value using the MUC, to assure an appropriate level of protection. The [*Institut de recherche Robert-Sauvé en santé et en sécurité du*](#) is an interactive website that will help determine if the components of a mixture have similar effects on the same organs and describes the interactions (synergy, potentiation, antagonism...).

VI. **EMPLOYEE'S HEALTH AND RESPIRATOR ACCEPTANCE.**

A. Effective use of a respirator is dependent on an individual's ability to wear a respirator. Most respirators increase physical stress on the body, especially the heart and lungs. Individuals shall not wear a respirator on the job or be fit tested unless they have been medically qualified.

B. A special case worth noting is personnel with anosmia (inability to perceive smells). People with this condition are allowed to wear air-purifying respirators as long as a cartridge change out schedule is developed and implemented and as long as they are otherwise medically qualified per paragraph 1508 of reference (1). This medical qualification 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.

C. Employee Acceptance. Many factors affect the employee's acceptance of respirators, including comfort, ability to breathe without objectionable effort, adequate visibility under all conditions, provisions for wearing prescription glasses (if necessary), ability to communicate, ability to perform all tasks without undue interference, and

confidence in the facepiece fit. Failure to consider these factors is likely to reduce cooperation of the users in promoting a satisfactory program.

D. Effective Protection Factor. Protection factors are voided when employees remove their respiratory protection while in the contaminated atmosphere or when respirators are worn improperly such as with facial hair between the face and facepiece seal. If the respirator is not worn 100 percent of the time while the individual is exposed, then an effective protection factor (EPF) based on a realistic estimate of the time that the respirator was worn, can be calculated. The EPF must be greater than the calculated hazard ratio. The EPF equation is shown below:

$$EPF = APF / [1 + T_{not} (APF - 1)]$$

Where:

T_{not} = Percentage of time respirator was not worn.

APF = Assigned protection factor

Example: A half mask respirator (APF = 10) was not worn during 20 percent of the employee's exposure. The effective protection factor is calculated below:

$$EPF = 10 / [1 + 0.2 (10 - 1)] = 3.6$$

As shown above, not wearing the respirator during exposure greatly lowers the protection afforded by the respirator. In this case, not wearing the respirator during 20 percent of the exposure lowered the half mask EPF from 10 to 3.6.

VII. NEED FOR EYE PROTECTION.

A. For some operations, full face respirators may be required for eye and face protection even when contaminant concentrations are below 10 times the OELs. Per paragraph 84.76 of 42 CFR 84, full facepiece lenses shall meet impact and penetration requirements of GGG-M-125d of 11 Oct 1965, as amended on 1 July 1969, which is the federal specification for airline and air-filtering respirators. This outdated federal standard was based on the 1960's versions of ANSI Z87.1, which tested safety glasses and industrial eye protection made from glass (most modern lenses are made from polycarbonate).

1. "ANSI Z87.1-2010, *Occupational and Educational Personal Eye and Face Protective Devices* (reference 13) provides requirements for design, construction, testing, and use of eye and face protection. The 2003 version was the first version of ANSI Z87.1 to include respirator lens testing.
2. OSHA will adopt ANSI Z87.1-2010 through the [*Final Rule - Updating OSHA Standards Based on National Consensus Standards; Personal Protective Equipment*](#), which incorporates the latest three versions of national consensus personal protective equipment (PPE) standards into law when OSHA determines that new consensus standards provide equal or greater protection. OSHA must still undergo rule making process to incorporate new consensus standards into OSHA PPE standards. Using a new consensus standard prior to this rule making is a de minimis violation, which OSHA will not enforce. Although ANSI Z87.1-2010 is not currently incorporated

into 29 CFR 1910.133, *Eye and Face Protection* at the time of this writing, ANSI Z87.1-2010 meets and exceeds previous versions of the ANSI Z87.1 Standard.

3. Although ANSI Z87.1-2010 markings apply to respirator lenses, NIOSH has not incorporated this requirement into all their pertinent respirator certification standards. Per ANSI Z87.1-2010, eye protection is rated as either “impact” or “non-impact” and marked Z87+ and Z87, respectively. If work processes require full face respirators and impact protection, check with the respirator manufacturer to ensure respirator lenses comply with ANSI Z87.1 impact testing requirements.

VIII. REFERENCES.

1 OPNAVINST 5100.23 Series.

<http://doni.daps.dla.mil/allinstructions.aspx?RootFolder=/Directives/05000%20General%20Management%20Security%20and%20Safety%20Services/05-100%20Safety%20and%20Occupational%20Health%20Services&View={1FF912B1-1BC6-444A-8943-B769C77880F2}>

2 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.

http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=12716

3 National Institute for Occupational Safety and Health (NIOSH): 42 CFR Part 84: Respiratory Protective Devices; Final Rules and Notice. Federal Register 60(110):30336–30398. Washington, D.C.: U.S. Government Printing Office, Office of the Federal Register, June 8, 1995.

<http://www.gpo.gov/fdsys/pkg/CFR-2004-title42-vol1/pdf/CFR-2004-title42-vol1-part84.pdf>

4 American National Standards Institute (ANSI): American National Standard for Respiratory Protection (ANSI Z88.2). New York: ANSI, 1992.

5 Perez, C. and Soderholm S. C.: Some Chemicals Requiring Special Consideration when Deciding Whether to Sample the Particle, Vapor, or Both Phases of an Atmosphere. Appl. Occup. Environ. Hyg. 6(10):859-864 (1991).

6 National Institute for Occupational Safety and Health (NIOSH): NIOSH Guide to Industrial Respiratory Protection. DHHS (NIOSH) Publication No. 87-116. Cincinnati, Ohio: NIOSH, 1987.

<http://www.cdc.gov/niosh/docs/87-116/>

7 National Institute for Occupational Safety and Health (NIOSH): Respirator Selection Logic. DHHS (NIOSH) Publication No. 2005-100. Cincinnati, OH: NIOSH, 2004.

<http://www.cdc.gov/niosh/docs/2005-100/>

8 Federal Register Vol 71 # 164, PP 50122 - 50192. 29 CFR Parts 1910, 1915, and 1926 Assigned Protection Factors; Final Rule of 24 Aug 2006.

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