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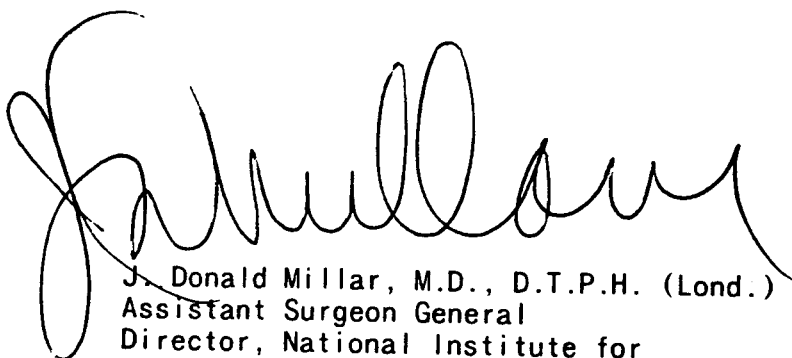
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FOREWORD

The initial Respirator Decision Logic was developed in 1975 as part of the National Institute for Occupational Safety and Health/Occupational Safety and Health Administration (NIOSH/OSHA) Standards Completion Program and was updated in 1978. Due to technical advances in respirator design and research, NIOSH has again revised the Respirator Decision Logic.

This revision retains many aspects of the original Respirator Decision Logic, but it differs in five areas: odor warning properties with respect to air-purifying cartridge/canister respirators, recognition of the problems in assigning protection factors, changes in protection factors for certain respirator classes, respirator recommendations for carcinogens, and medical recommendations.

The recognition of wide variation among workers in their sensitivities for detection of odors has led to the recommendation that employers not rely solely on currently published data on odor thresholds to ensure that workers who wear air-purifying cartridge or canister respirators are capable of smelling the contaminant at the applicable exposure limit. Recent research on in-plant respirator testing suggests that some previously assigned protection factors based on data from laboratory fit testing may not be valid. This revised Respirator Decision Logic has incorporated assigned protection factors based on data from recent in-plant research for some powered air-purifying respirators (PAPR) and some similar respirators, such as loose-fitting and tight-fitting continuous flow air-line respirators. Since NIOSH maintains that there is no safe exposure to carcinogens, only the most protective respirators should be used to protect workers from exposure to carcinogens in the workplace. Finally, specific medical recommendations are included to assist physicians in determining an individual's fitness to wear a respirator.



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I. INTRODUCTION

A. Background and Scope

The National Institute for Occupational Safety and Health (NIOSH) routinely makes recommendations regarding the use of respirators for workers exposed to workplace environments that contain hazardous concentrations of airborne contaminants and/or oxygen-deficient atmospheres. Such recommendations are made only when engineering controls are not technically feasible, while controls are being installed or repaired, or when emergency and other temporary situations arise. Respirators are the least preferred method of worker protection from respiratory hazards because they can be unreliable if an adequate respiratory protection program is not established by the employer and because they require worker cooperation. The intent of this decision logic is to provide industrial hygienists and other professionals knowledgeable in respirator selection with a procedure for selecting suitable classes of respirators for particular concentrations of specific contaminants. In this decision logic, concerns are raised about limitations of the data used to set protection factors for several classes of respirators.

To ensure uniformity and adherence to proper respirator usage, NIOSH recommendations have been based on the Respirator Decision Logic developed jointly in 1975 by NIOSH and the Occupational Safety and Health Administration (OSHA) as part of the Standards Completion Program and updated in June 1978. That decision logic incorporated requirements contained in 30 CFR 11 and fit factor data developed by the Los Alamos National Laboratory (LANL). NIOSH has now modified that decision logic to reflect new developments that include increased use of respirators to control exposure to carcinogens in the workplace, introduction of new respiratory equipment, and reporting of field research data on workplace protection factors (WPF's).

This modified decision logic identifies the criteria necessary to determine the classes of respirators that will provide a known degree of respiratory protection for a given work environment, assuming that the respirators are used correctly. The degree of protection is related in part to protection factors. Many of the assigned protection factors (APF's) that appear in this decision logic are based on laboratory studies and should be regarded as approximate.

The selection of a specific respirator must be made by individuals knowledgeable about the limitations associated with each class of respirators and familiar with the actual workplace environment, including the job task(s) to be performed. The correct use of a respirator is just as important as the selection process if adequate worker protection is to be achieved. Without a complete respiratory protection program, workers will not receive the degree of protection anticipated from a respirator, even if it is a correct choice for the situation. Training, motivation, medical

evaluation, fit testing, and a respirator maintenance program are critical elements for the successful use of a respirator. As a minimum, compliance with 29 CFR 1910.134 is mandatory whenever respirators are used by workers, whether on a required or voluntary basis.

B. Cautionary Statements

NIOSH concerns about the use of respirators are discussed further in various parts of the document and are summarized in the following six cautionary statements:

• Assigned Protection Factors

In general, the assigned protection factors (APF's) that appear in this decision logic are not based on measurements of actual field (workplace) performance. As noted in the footnotes accompanying Tables 1, 2, and 3, in only a few instances are the APF's based on any workplace performance testing; the majority of the APF's have no workplace performance basis at all. APF's based solely on laboratory fit testing should be viewed and applied with particular caution, even when the laboratory testing involves a simulated work regimen. To date, no relation has been demonstrated between laboratory fit factors and measured workplace performance. As more performance testing of respirators is undertaken in the workplace by NIOSH and others, NIOSH may find it necessary to revise the APF's upward or downward. For the present, APF's should not be considered reliable predictors of performance levels that will be achieved during actual use, since APF's are not based on a sufficient amount of workplace testing.

• Fit Testing

No qualitative or quantitative fit tests have been demonstrated to be capable of effectively identifying inadequately fitting respirators (i.e., respirator-wearer combinations that provide less protection than the APF). The presently used fit tests (e.g., ANSI-recommended, OSHA-approved) may fail to identify individual wearers with inadequate respiratory protection. Thus fit tests should be used with caution and with recognition of their possible deficiencies. As appropriate, periodic evaluations of the effectiveness of each respirator during use in the workplace should be conducted to ensure that each wearer is being provided with adequate respiratory protection.

• QNFT Fit Factor Screening Levels

Regarding quantitative fit testing (QNFT), no studies are available to indicate what fit factor value (i.e., screening level) will ensure a high probability of identifying inadequately fitting respirators. That is, there are no studies demonstrating what fit factor values are adequate

accept/reject criteria for QNFT fit screening. When QNFT is used for fit screening, the fit factor screening level should be chosen with caution and with recognition of the uncertainty of its effectiveness. As appropriate, periodic evaluation of the effectiveness of each respirator during use in the workplace should be conducted to ensure that each wearer is being provided with adequate respiratory protection.

- **Adequate Warning Properties**

No physiological effects in humans (e.g., odor, taste, eye irritation, respiratory irritation) have been demonstrated as being capable of consistently providing respirator wearers with timely, consistent, persistent, and reliable warning of hazardous airborne concentrations inside a respirator. Individual wearers may be unable to detect the warning effect when necessary and may fail to take action necessary to protect themselves (e.g., leaving the area where respirators are necessary or changing the sorbent cartridge or canister). When warning properties must be relied on as part of a respiratory protection program, the employer should accurately, validly, and reliably screen each prospective wearer for the ability to detect the warning properties of the hazardous substance(s) at exposure levels that are less than the exposure limits for the substance(s). Warning properties should be regarded with caution and with recognition of their unreliability.

- **Service Life Information**

For essentially all gases and vapors, no adequate service life information is available to respirator wearers or to those responsible for respiratory protection programs. When this information is not available, respirators with air-purifying sorbent elements should be used with caution and with recognition of the wide variability of service lives under differing use conditions. Employers should possess valid and reliable estimates of service lives for all sorbent elements used in the respiratory protection program. Service life test data should be representative of all conditions of intended use that can be reasonably anticipated. Factors known to affect the service lives of sorbent elements include, but are not limited to, the make and model of sorbent element, airborne concentrations of contaminant(s), and relative humidity through each sorbent element. When appropriate service life data is available, any reliance on the data should be undertaken with caution and with recognition of the limitations and uncertainties of the information.

- **Determination of Protection Factor Levels Required for Adequate Protection**

Workers are never exposed to a single unvarying concentration of a contaminant. In a given work area, individual exposures may vary widely between workers, during a workshift, and between days. The range of potential exposures should be appropriately determined for all workers and for all circumstances that can be reasonably anticipated. The

highest anticipated exposure for each respirator wearer should be used to compute the protection factor required for each wearer. Required protection factors should be used with caution and with recognition of their uncertainties.

II. RESPIRATOR DECISION LOGIC

This decision logic contains a series of questions regarding situations which may require the use of respirators. (See Respirator Decision Logic Sequence, page 8.) In answering these questions, the user of this decision logic is assisted in identifying specific classes of respirators, applicable restrictions, and the appropriate respirator selection table to use. When using one of the tables to identify a suitable class of respirators, the user must keep in mind the restrictions identified in the question section of this decision logic.

This decision logic identifies the criteria necessary to determine the classes of respirators that will provide the minimum acceptable degree of protection for a chemical at a given concentration. Classes of respirators offering greater protection can usually be used in place of the minimum acceptable class of respirators. Respirator classes are consistent with respirator certification groupings as specified in 30 CFR 11.

The recommendations in this decision logic are based primarily on the physical, chemical, and toxicologic properties of the contaminant and on the limitations of each class of respirators, including filtration efficiency, air supply capability, and face seal characteristics and leakage. Thus this decision logic is limited to identifying classes of acceptable respirators, rather than individual respirators.

After various classes of respirators are identified as being suitable for a given situation, an evaluation is made of other factors of the particular work environment so that the best respirator within the recommended classes can be chosen. In some situations, the selection of a respirator classified as providing a higher level of protection may be advisable.

To assist the user, this decision logic contains ten subparagraphs following the Respirator Decision Logic Sequence that describe respirator limitations, use of applicable exposure limits, warning properties, protection factors, oxygen limitations, and medical evaluation of suitability to wear respirators. Additional supporting information is contained in Appendices A through E. To properly use this decision logic, the user should carefully read the subparagraphs.

The assigned protection factors (APF's) used in this decision logic were based on quantitative fit factor data developed by Los Alamos National Laboratories (LANL) under contract to NIOSH and on field evaluation data gathered by NIOSH and others. Specific references and summaries of the data used to generate certain protection factors can be found in Subparagraph 8, page 28. Fit factors determined for the individual wearer of a respirator by quantitative fit testing or by any other method used to determine fit should not be substituted for the APF given for each class of respirators. However, the fit factor determined through quantitative fit testing must be greater than the APF; otherwise, the respirator cannot be used by the worker.

A. Criteria for Selecting Respirators

To use this decision logic, the user must first assemble the necessary toxicologic, safety, and other relevant information for each contaminant, including the following:

- General use conditions, including determination of contaminant(s);
- Physical, chemical, and toxicologic properties of the contaminant(s);
- Odor threshold data;
- NIOSH recommended exposure limit (REL) or when no REL exists, OSHA permissible exposure limit (PEL) or other applicable exposure limit;
- Immediately dangerous to life or health (IDLH) concentration;
- Eye irritation potential; and
- Any service life information available (for cartridges and canisters).

Obtaining complete information on all criteria needed to use this decision logic may be difficult. When conflicting or inadequate data are found, experts should be consulted before decisions are made that could affect the proper use of this decision logic. In addition, the adequacy of the respirator selected is dependent on the validity of the exposure limit used. While the decision logic can be used with any exposure limit, NIOSH recommends that an REL be used when one exists for a given contaminant. For a more detailed discussion on the use of exposure limits, especially when selecting respirators for protection against carcinogens, see Subparagraph 2, page 21.

The information obtained on general use conditions for respirators should include a description of the actual job task, including the duration and frequency, location, physical demands, and industrial processes, as well as the comfort of the respirators. Some general use conditions may preclude the use of specific types of respirators in certain circumstances because the individual must be medically and psychologically suitable to wear a given respirator for a given task, particularly if the respirator is a self-contained breathing apparatus (SCBA).

Information obtained on the service life of the cartridge/canister under conditions of intended use should be evaluated regardless of the odor warning properties of the chemicals. These evaluations should be based on all gas(es) and vapor(s) present at the temperature and relative humidity extremes (high and low) in the workplace. NIOSH recommends that when the employer or a representative of the employer conducts the tests, the challenge concentrations of the gases and vapors should be at least 10 times the maximum use concentration of the respirator. The service life value

obtained from these tests should be used to determine how long a cartridge/canister could provide protection under actual use conditions. This information can be used to set up cartridge replacement schedules and should be used in conjunction with sensory warning properties. Workers should be trained to exit the contaminated area whenever they detect the odor of the contaminant. (See Subparagraph 6, page 26, for a discussion on service life testing for chemicals with poor warning properties.)

B. Restrictions and Requirements for All Respirator Usage

The following requirements and restrictions must be considered to ensure that the respirator selected will provide adequate protection under the conditions of intended use:

1. A complete respiratory protection program should be instituted which includes regular worker training; maintenance, inspection, cleaning, and evaluation of the respirator; use of the respirator in accordance with the manufacturer's instructions; fit testing; and environmental monitoring. Whenever possible, quantitative evaluation of the protection factor in the workplace should be performed to confirm the actual degree of protection provided by the respirator to each worker. Minimum respiratory protection requirements for all contaminants can be found in the OSHA Safety and Health Standards, 29 CFR 1910.134, and in separate sections for specific contaminants (e.g., 1910.1001 for asbestos, 1910.1025 for lead, etc.).

2. Qualitative or quantitative fit tests should be provided as appropriate to ensure that the respirator fits the individual. Periodic evaluation of the effectiveness of each respirator during use in the workplace should be conducted to ensure that each wearer is being provided with adequate respiratory protection. When quantitative fit testing (QNFT) is used, the fit factor screening level should be chosen with caution and with the recognition of the uncertainty of its effectiveness since no studies have demonstrated what fit factor values provide adequate accept/reject criteria for quantitative fit screening.

3. Negative pressure respirators should not be used when facial scars or deformities interfere with the face seal.

4. No respirator (including positive pressure respirators) should be used when facial hair interferes with the face seal.

5. The respirators should be properly maintained, correctly used, and conscientiously worn.

6. The usage limitations of air-purifying elements, particularly gas and vapor cartridges, should not be exceeded.

7. The respirators must be approved by the Mine Safety and Health Administration and the National Institute for Occupational Safety and Health (MSHA/NIOSH).

8. Workers should be instructed to leave the contaminated area immediately upon suspicion of respirator failure and then to determine the problem.

9. Workers are not exposed to a single unvarying concentration of a hazardous substance, rather individual exposures may vary throughout a workshift and between days. The highest anticipated concentration should therefore be used to compute the required protection factor for each respirator wearer.

10. Respirator wearers should be aware of the variability in human responses to the warning properties of hazardous substances. When warning properties must be relied on as part of a respiratory protection program, the employer should screen each prospective wearer for the ability to detect the warning properties of the hazardous substance(s) at exposure concentrations that are less than the REL for each given substance. (See Subparagraph 6, page 26, and Appendix C, page 48, for additional information.)

11. The assigned protection factors (APF's) that appear in this decision logic are based for the most part on laboratory studies. However, a few APF's have been validated and revised as necessary after consideration of data obtained from studies of workplace protection factors (WPF's). As more WPF testing of respirators is undertaken by NIOSH and others, the APF values may be further revised. For the present, the APF's should be regarded as approximate if they are not based on WPF's.

C. Respirator Decision Logic Sequence

After all criteria have been identified and evaluated and after the requirements and restrictions of the respiratory protection program have been met, the following sequence of questions can be used to identify the class of respirators that should provide adequate respiratory protection:

1. Is the respirator intended for use during fire fighting?

a. If yes, only a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure demand or other positive pressure mode is recommended.

b. If no, proceed to Step 2.

2. Is the respirator intended for use in an oxygen-deficient atmosphere, i.e., less than 19.5% oxygen at sea level? (Refer to Subparagraph 1, page 21, for a discussion of oxygen deficiency.)

a. If yes, any type of SCBA or supplied-air respirator (SAR) with an auxiliary SCBA is recommended. Auxiliary SCBA must be of sufficient duration to permit escape to safety if the air supply is interrupted. If additional contaminants are present, proceed to Step 3.

b. If no, proceed to Step 3.

3. Is the respirator intended for use during emergency situations?

a. If yes, two types of respirators are recommended: a SCBA with a full facepiece operated in pressure demand or other positive pressure mode or an SAR with a full facepiece operated in pressure demand or other positive pressure mode in combination with an auxiliary SCBA operated in pressure demand or other positive pressure mode. Auxiliary SCBA must be of sufficient duration to permit escape to safety if the air supply is interrupted.

b. If no, proceed to Step 4.

4. Is the contaminant regulated by the Department of Labor as a potential occupational carcinogen or identified by NIOSH as a potential human carcinogen in the workplace, and is the contaminant detectable in the atmosphere?

a. If yes, two types of respirators are recommended: a SCBA with a full facepiece operated in pressure demand or other positive pressure mode or an SAR with a full facepiece operated in pressure demand or other positive pressure mode in combination with an auxiliary SCBA operated in pressure demand or other positive pressure mode. Auxiliary SCBA must be of sufficient duration to permit escape to safety if the air supply is interrupted.

b. If no, proceed to Step 5.

5. Is the exposure concentration of the contaminant, as determined by acceptable industrial hygiene methods, less than the NIOSH REL or other applicable exposure limit? (Whenever a worker is given a respirator to use on a voluntary basis when ambient levels are below applicable limits, OSHA requires the implementation of a complete respiratory protection program, which includes medical evaluation, training, fit testing, periodic environmental monitoring, and all other requirements in 29 CFR 1910.134.)

a. If yes, a respirator would not be required except for an escape situation. Proceed to Step 7.

b. If no, proceed to Step 6.

6. Are conditions such that a worker who is required to wear a respirator can escape from the work area and not suffer loss of life or immediate or delayed irreversible health effects if the respirator fails, i.e., are the conditions not immediately dangerous to life or health (IDLH)? (Refer to Subparagraph 3, page 22, for additional information on IDLH's.)

a. If yes, conditions are not considered to be IDLH. Proceed to Step 7.

b. If no, conditions are considered to be IDLH. Two types of respirators are recommended: a SCBA with a full facepiece operated in pressure demand or other positive pressure mode or an SAR with a full facepiece operated in pressure demand or other positive pressure mode in combination with an auxiliary SCBA operated in pressure demand or other positive pressure mode. The auxiliary SCBA must be of sufficient duration to permit escape to safety if the air supply is interrupted.

7. Is the contaminant an eye irritant, or can the contaminant cause eye damage at the exposure concentration? (Refer to Subparagraph 4, page 23, for a discussion of eye irritation and damage.)

a. If yes, a respirator equipped with a full facepiece, helmet, or hood is recommended. Proceed to Step 8.

b. If no, an orinasal respirator may still be an option, depending on the exposure concentration. Proceed to Step 8.

8. Divide the 8-hour time-weighted average (TWA) exposure concentration for the contaminant (or maximum exposure concentration for a contaminant with a ceiling limit) determined in Step 5 by the NIOSH REL or other applicable exposure limit to determine the minimum protection factor required. For escape respirators, determine the potential for generation of a hazardous condition caused by an accident or equipment failure. If a potentially hazardous condition could occur or a minimum protection factor has been calculated, proceed to Step 9.

9. If the physical state of the contaminant is a particulate (solid or liquid) during periods of respirator use, proceed to Step 10; if it is a gas or vapor, proceed to Step 11; if it is a combination of gas or vapor and particulate, proceed to Step 12.

10. Particulate Respirators

10.1. Is the particulate respirator intended only for escape purposes?

a. If yes, refer to Subparagraph 5, page 24, for a discussion and selection of "escape only" respirators.

b. If no, the particulate respirator is intended for use during normal work activities. Proceed to Step 10.2.

10.2. A filter medium that will provide protection against exposure to the particulate in question is recommended. (Refer to Subparagraph 9, page 29, for a discussion on limitations of approvals for filter media.) Proceed to Step 10.3.

10.3. Respirators that have not been previously eliminated from Table 1 and that have APF's equal to or greater than the minimum protection factor determined in Step 8 are recommended. (Refer to Subparagraph 8, page 28, and Appendix D, page 50, for a discussion of protection factors, and to Subparagraph 9, page 29, for a discussion on limitations of filter approvals.) Maximum airborne concentrations for each level of respiratory protection can be calculated by multiplying the NIOSH REL or other applicable exposure limit by the APF for that class of respirators. Workers wearing respirators should meet the medical guidelines discussed in Subparagraph 10, page 30.

11. Gas/Vapor Respirators

11.1. Is the gas/vapor respirator intended for "escape only" purposes?

- a. If yes, refer to Subparagraph 5, page 24, for a discussion on selection of "escape only" respirators.
- b. If no, the gas/vapor respirator is intended for use during normal work activities. Proceed to Step 11.2.

11.2. Are the warning properties for the gas/vapor contaminant adequate at or below the NIOSH REL or other applicable exposure limit? (Refer to Subparagraph 6, page 26, and Appendix C, page 48, for additional information on requirements for adequate warning properties.)

- a. If yes, proceed to Step 11.3.
- b. If no, an air-purifying respirator equipped with an effective end-of-service-life indicator (ESLI), a supplied-air respirator, or a self-contained breathing apparatus is recommended. (Refer to Appendix A, page 43, for additional information on approval of air-purifying respirators with ESLI's.) Proceed to Step 11.4.

11.3. An air-purifying chemical cartridge/canister respirator is recommended that has a sorbent suitable for the chemical properties of the anticipated gas/vapor contaminant(s) and for the anticipated exposure levels. (Refer to Subparagraph 7, page 27, for the recommended maximum use concentrations of air-purifying chemical cartridge/canister respirators.) Proceed to Step 11.4.

11.4. Respirators that have not been previously eliminated from Table 2 and that have APF's equal to or greater than the minimum protection factor determined in Step 8 are recommended. (Refer to Subparagraph 8, page 28, and Appendix D, page 50, for a discussion of protection factors.) Maximum airborne concentrations for each class of respiratory protection can be calculated by multiplying the NIOSH REL or other applicable exposure limit by the APF for that class of respirators. The calculated maximum use concentration limits should not exceed the limitations noted in Subparagraph 7, page 27. Workers wearing respirators should meet the medical guidelines discussed in Subparagraph 10, page 30.

12. Combination Particulate and Gas/Vapor Respirators

12.1. Is the combination respirator intended for "escape only" purposes?

a. If yes, refer to Subparagraph 5, page 24, for a discussion and selection of "escape only" respirators.

b. If no, the combination respirator is intended for use during normal work activities. Proceed to Step 12.2.

12.2. Does the gas/vapor contaminant have adequate warning properties at or below the NIOSH REL or other applicable exposure limit? (Refer to Subparagraph 6, page 26, and Appendix C, page 48, for additional information on requirements for adequate warning properties.)

a. If yes, proceed to Step 12.3.

b. If no, either an air-purifying respirator equipped with an effective ESLI (Appendix A, page 43), a supplied-air respirator, or a self-contained respirator is recommended. Proceed to Step 12.4.

12.3. An air-purifying chemical cartridge/canister is recommended that has a particulate prefilter suitable for the specific type(s) of gas/vapor and particulate contaminant(s) and for the exposure concentrations. (Refer to Subparagraphs 7, page 27, and Subparagraph 9, page 29, for recommended maximum use concentrations and filter limitations.) Proceed to Step 12.4.

12.4. Respirators that have not been previously eliminated from Table 3 and that have APF's equal to or greater than the minimum protection factor determined in Step 8 are recommended. (Refer to Subparagraph 8, page 28, and Appendix D, page 50, for a discussion of protection factors and Subparagraph 9, page 29, for a discussion on limitations of filter approvals.) Maximum airborne concentrations for each level of respiratory protection can be calculated by multiplying the NIOSH REL or other applicable exposure limit by the APF for that class of respirators. The calculated maximum use concentration limits should not exceed the limitations noted in Subparagraph 7, page 27. Workers wearing respirators should meet the medical guidelines discussed in Subparagraph 10, page 30.

Table 1.--Assigned protection factor classifications of respirators for protection against particulate exposures¹

Assigned protection factor	Type of respirator
5	Single-use (see definition in Glossary) or quarter mask ² respirator
10	Any air-purifying half-mask respirator including disposable ³ (see definition in Glossary) equipped with any type of particulate filter except single use ^{2,4} Any air-purifying full facepiece respirator equipped with any type of particulate filter ⁵
25	Any supplied-air respirator equipped with a half-mask and operated in a demand (negative pressure) mode ² Any powered air-purifying respirator equipped with a hood or helmet and any type of particulate filter ⁴ Any supplied-air respirator equipped with a hood or helmet and operated in a continuous flow mode ⁴
50	Any air-purifying full facepiece respirator equipped with a high efficiency filter ² Any powered air-purifying respirator equipped with a tight-fitting facepiece and a high efficiency filter ⁴ Any supplied-air respirator equipped with a full facepiece and operated in a demand (negative pressure) mode ² Any supplied-air respirator equipped with a tight-fitting facepiece and operated in a continuous flow mode ⁴

- 1 Only high efficiency filters are permitted for protection against particulates having exposure limits less than 0.05 mg/m³.
- 2 The assigned protection factors (APF's) were determined by Los Alamos National Laboratories (LANL) by conducting quantitative fit testing on a panel of human volunteers [6].
- 3 An APF factor of 10 can be assigned to disposable particulate respirators if they have been properly fitted using a quantitative fit test.
- 4 APF's were based on workplace protection factor (WPF) data or laboratory data more recently reported than the LANL data [7-11, 14-17].
- 5 The APF was based on consideration of efficiency of dust, fume, and/or mist filters.

Table 1.--Assigned protection factor classifications of respirators for protection against particulate exposures¹--Continued

Assigned protection factor	Type of respirator
50 cont.	Any self-contained respirator equipped with a full facepiece and operated in a demand (negative pressure) mode ²
1,000	Any supplied-air respirator equipped with a half-mask and operated in a pressure demand or other positive pressure mode ²
2,000	Any supplied-air respirator equipped with a full facepiece and operated in a pressure demand or other positive pressure mode ²
10,000	Any self-contained respirator equipped with a full facepiece and operated in a pressure demand or other positive pressure mode ²
	Any supplied-air respirator equipped with a full facepiece operated in a pressure demand or other positive pressure mode in combination with an auxiliary self-contained breathing apparatus operated in a pressure demand or other positive pressure mode ²

- 1 Only high efficiency filters are permitted for protection against particulates having exposure limits less than 0.05 mg/m³.
- 2 The assigned protection factors (APF's) were determined by Los Alamos National Laboratories (LANL) by conducting quantitative fit testing on a panel of human volunteers [6].
- 3 An APF of 10 can be assigned to disposable particulate respirators if they have been properly fitted using a quantitative fit test.
- 4 The APF's were based on workplace protection factor (WPF) data or laboratory data more recently reported than the LANL data [7-11, 14-17].
- 5 The APF was based on consideration of efficiency of dust, fume, and/or mist filters.

Table 2.--Assigned protection factor classifications of respirators for protection against gas/vapor exposures

Assigned protection factor ¹	Type of respirator
10	<p>Any air-purifying half mask respirator (including disposable) equipped with appropriate gas/vapor cartridges²</p> <p>Any supplied-air respirator equipped with a half mask and operated in a demand (negative pressure) mode²</p>
25	<p>Any powered air-purifying respirator with a loose-fitting hood or helmet³</p> <p>Any supplied-air respirator equipped with a hood or helmet and operated in a continuous flow mode³</p>
50	<p>Any air-purifying full facepiece respirator equipped with appropriate gas/vapor cartridges or gas mask (canister respirator)²</p> <p>Any powered air-purifying respirator equipped with a tight-fitting facepiece and appropriate gas/vapor cartridges or canisters³</p> <p>Any supplied-air respirator equipped with a full facepiece and operated in a demand (negative pressure) mode²</p> <p>Any supplied-air respirator equipped with a tight-fitting facepiece operated in a continuous flow mode³</p> <p>Any self-contained respirator equipped with a full facepiece and operated in a demand (negative pressure) mode²</p>
1,000	<p>Any supplied-air respirator equipped with a half-mask and operated in a pressure demand or other positive pressure mode²</p>

- 1 The assigned protection factor (APF) for a given class of air-purifying respirators may be further reduced by considering the maximum use concentrations for each type of gas and vapor air-purifying element.
- 2 The APF's were determined by Los Alamos National Laboratories (LANL) by conducting quantitative fit testing on a panel of human volunteers [6].
- 3 The APF's were based on workplace protection factor (WPF) data or laboratory data more recently reported than the LANL data [7-11, 14-17].

Table 2.--Assigned protection factor classifications of respirators for protection against gas/vapor exposures--Continued

Assigned protection factor ¹	Type of respirator
2,000	Any supplied-air respirator equipped with a full facepiece and operated in a pressure demand or other positive pressure mode ²
10,000	Any self-contained respirator equipped with a full facepiece and operated in a pressure demand or other positive pressure mode ²
	Any supplied-air respirator equipped with a full facepiece operated in a pressure demand or other positive pressure mode in combination with an auxiliary self-contained breathing apparatus operated in a pressure demand or other positive pressure mode ²

- 1 The assigned protection factor (APF) for a given class of air-purifying respirators may be further reduced by considering the maximum use concentrations for each type of gas and vapor air-purifying element.
- 2 The APF's were determined by Los Alamos National Laboratories (LANL) by conducting quantitative fit testing on a panel of human volunteers [6].
- 3 The APF's were based on workplace protection factor (WPF) data or laboratory data more recently reported than the LANL data [7-11, 14-17].

Table 3.--Assigned protection factor classifications of respirators for protection against combination gas/vapor and particulate exposures¹

Assigned protection factor ²	Type of respirator
10	<p>Any air-purifying half-mask respirator equipped with appropriate gas/vapor cartridges in combination with any type of particulate filter³</p> <p>Any full facepiece respirator with appropriate gas/vapor cartridges in combination with a dust or mist or fume; dust and mist; or dust, mist, and fume filter⁴</p> <p>Any supplied-air respirator equipped with a half-mask and operated in a demand (negative pressure) mode³</p>
25	<p>Any powered air-purifying respirator equipped with a loose-fitting hood or helmet⁵</p> <p>Any supplied-air respirator equipped with a hood or helmet and operated in a continuous flow mode⁵</p>
50	<p>Any air-purifying full facepiece respirator equipped with appropriate gas/vapor cartridges in combination with a high efficiency filter or an appropriate canister incorporating a high efficiency filter³</p> <p>Any powered air-purifying respirator with a tight-fitting facepiece equipped with appropriate gas/vapor cartridges in combination with a high efficiency filter or an appropriate canister incorporating a high efficiency filter⁵</p> <p>Any supplied-air respirator equipped with a full facepiece and operated in a demand (negative pressure) mode³</p>

1 Only high efficiency filters are permitted for protection against particulates having exposure limits less than 0.05 mg/m³.

2 The assigned protection factor (APF) for a given class of air-purifying respirators may be further reduced by considering the maximum use concentrations for each type of gas and vapor air-purifying element.

3 The APF's were determined by Los Alamos National Laboratories (LANL) by conducting quantitative fit testing on a panel of human volunteers [6].

4 The APF was based on consideration of efficiency of dust, fume, and/or mist filters.

5 The APF's were based on workplace protection factor (WPF) data or laboratory data more recently reported than the LANL data [7-11, 14-17].

**Table 3.--Assigned protection factor classifications of respirators for protection against combination gas/vapor and particulate exposures¹--
Continued**

Assigned protection factor ²	Type of respirator
50 cont.	Any supplied-air respirator equipped with a tight-fitting facepiece and operated in a continuous flow mode ⁵ Any self-contained respirator equipped with a full facepiece and operated in a demand (negative pressure) mode ³
1,000	Any supplied-air respirator equipped with a half-mask and operated in a pressure demand or other positive pressure mode ³
2,000	Any supplied-air respirator equipped with a full facepiece and operated in a pressure demand or other positive pressure mode ³
10,000	Any self-contained respirator equipped with a full facepiece and operated in a pressure demand or other positive pressure mode ³ Any supplied-air respirator equipped with a full facepiece operated in a pressure demand or other positive pressure mode in combination with an auxiliary self-contained breathing apparatus operated in a pressure demand or other positive pressure mode ³

- 1 Only high efficiency filters are permitted for protection against particulates having exposure limits less than 0.05 mg/m³.
- 2 The assigned protection factor (APF) for a given class of air-purifying respirators may be further reduced by considering the maximum use concentrations for each type of gas and vapor air-purifying element.
- 3 The APF's were determined by Los Alamos National Laboratories (LANL) by conducting quantitative fit testing on a panel of human volunteers [6].
- 4 The APF was based on consideration of efficiency of dust, fume, and/or mist filters.
- 5 The APF's were based on workplace protection factor (WPF) data or laboratory data more recently reported than the LANL data [7-11, 14-17].

The Respirator Decision Logic Sequence is presented in Figure 1 in the form of a flow chart. This flow chart can be used to identify suitable classes of respirators for adequate protection against specific environmental conditions. Refer to the corresponding narrative section for additional information pertaining to a specific part of the flow chart.

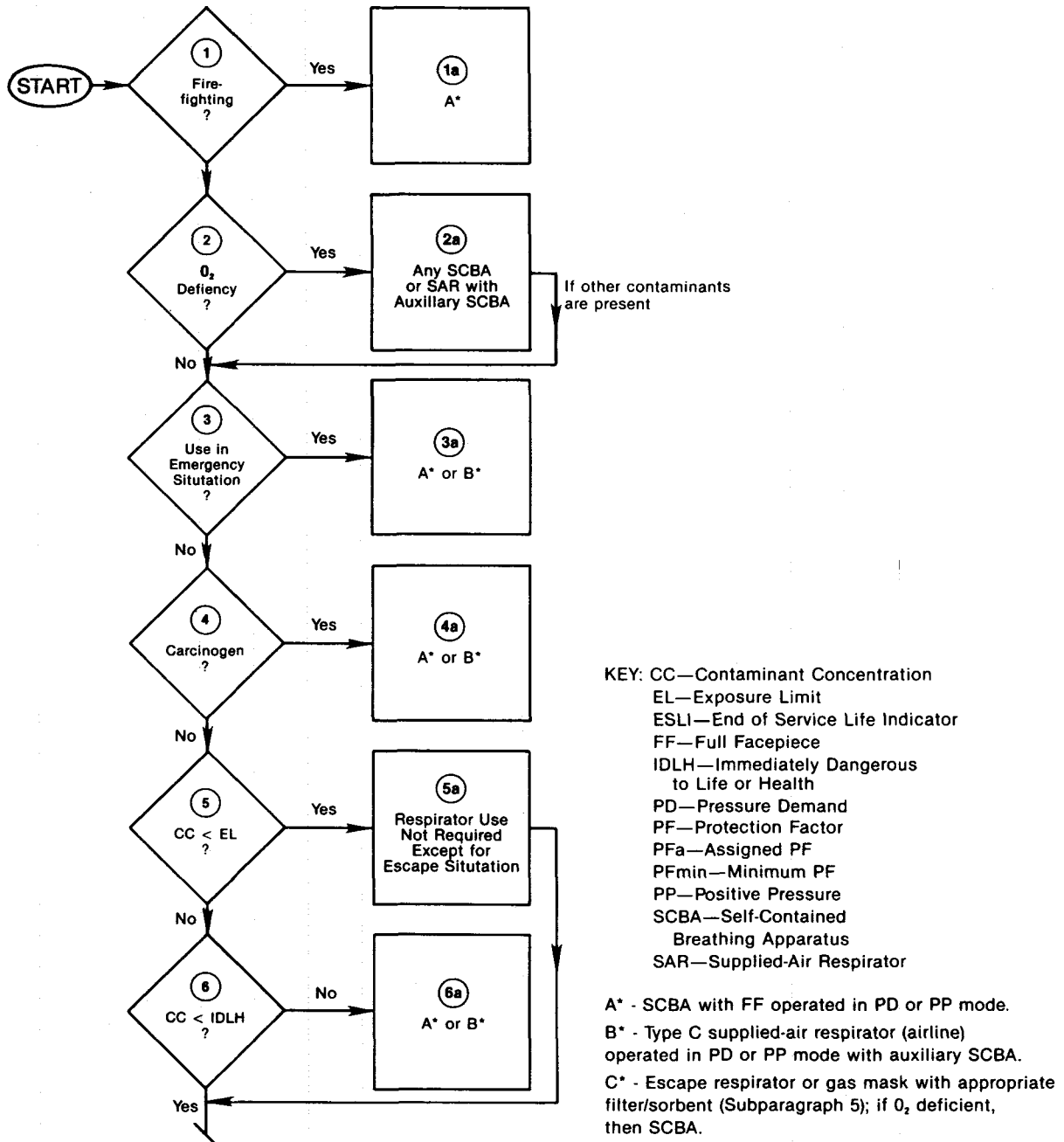


Figure 1. — Flow Chart of Respirator Decision Logic Sequence

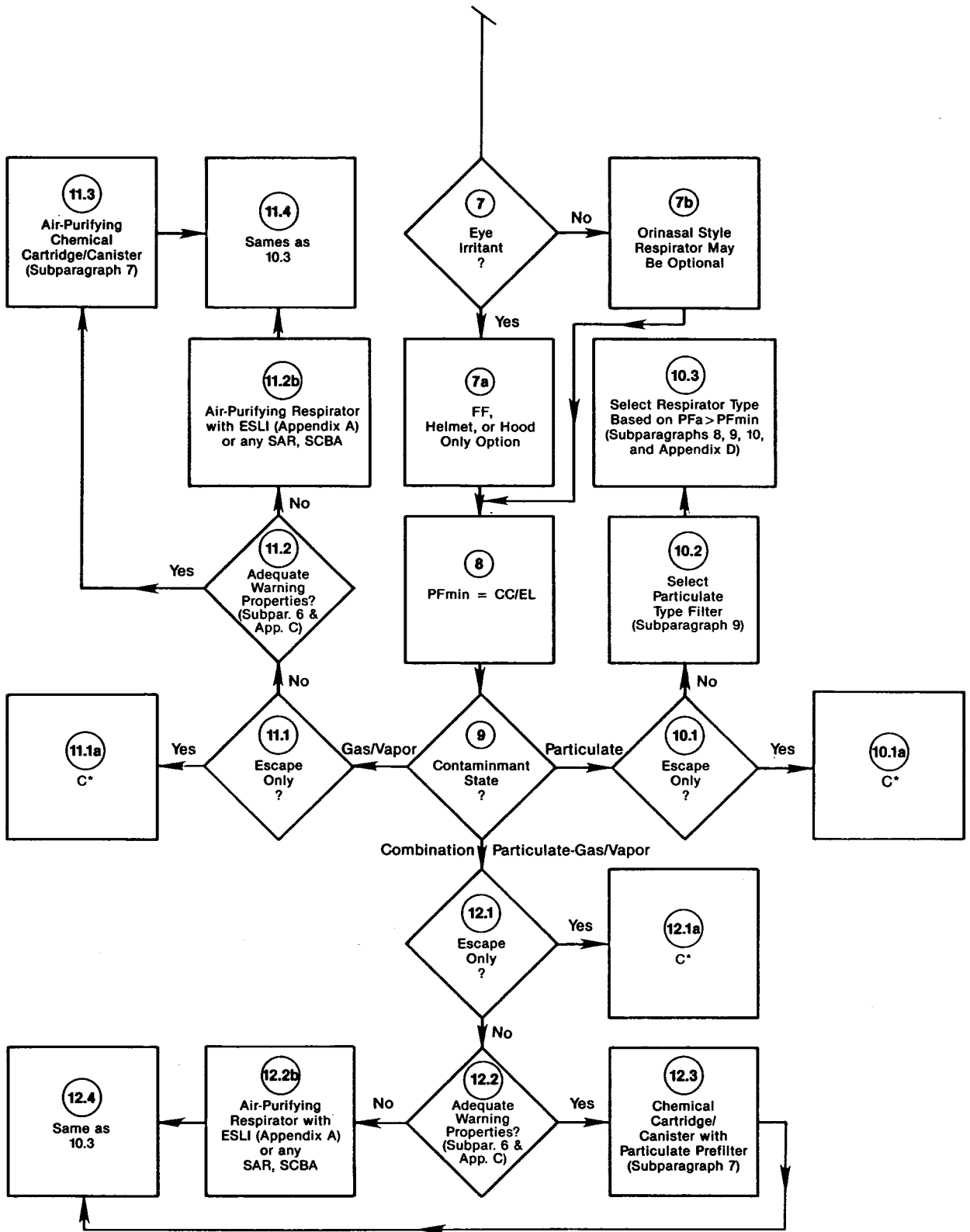


Figure 1. — Flow Chart of Respirator Decision Logic Sequence — Continued

D. Subparagraphs

The following subparagraphs provide additional information to assist the reader in using the Respirator Decision Logic Sequence:

Subparagraph 1: Oxygen-Deficient Atmosphere

The National Institute for Occupational Safety and Health (NIOSH) defines an oxygen-deficient atmosphere as any atmosphere containing oxygen at a concentration below 19.5% at sea level [1]. NIOSH certification of air-line or air-purifying respirators is limited to those respirators used in atmospheres containing at least 19.5% oxygen, except for those air-line respirators equipped with auxiliary self-contained breathing apparatus (SCBA).

The minimum requirement of 19.5% oxygen at sea level provides an adequate amount of oxygen for most work assignments and includes a safety factor. The safety factor is needed because oxygen-deficient atmospheres offer little warning of the danger, and the continuous measurement of an oxygen-deficient atmosphere is difficult.

At oxygen concentrations below 16% at sea level, decreased mental effectiveness, visual acuity, and muscular coordination occur. At oxygen concentrations below 10%, loss of consciousness may occur, and below 6% oxygen, death will result. Often only mild subjective changes are noted by individuals exposed to low concentrations of oxygen, and collapse can occur without warning [2,3,4].

Since oxygen-deficient atmospheres are life-threatening, only the most reliable respirators are recommended; the most reliable respirators are the self-contained breathing apparatus or the supplied-air respirators with auxiliary self-contained units. Because a high protection factor is not necessary to ensure an adequate supply of oxygen even in an atmosphere containing no oxygen, any certified self-contained unit is adequate. All aspects of a respiratory protection program must be instituted for these recommendations to be valid.

Subparagraph 2: Exposure Limits

The majority of the OSHA PEL's were adopted from the American Conference of Governmental Industrial Hygienists (ACGIH) TLVs® published in 1968. The difficulty in changing PEL's through promulgation of standards when new toxicologic information is identified has caused many standards to become outdated. The effectiveness of this decision logic is limited to the adequacy of the selected exposure limits in protecting the health of workers. Exposure limits based on a thorough evaluation of more recent or extensive data should be given priority.

For all chemicals that cause irritation or systemic effects but do not cause carcinogenic effects, it is currently believed that a threshold exposure

concentration exists such that virtually all persons in the working population (with the possible exception of hypersensitive individuals) would experience no adverse health effects.

For many carcinogenic substances, most available data provide no evidence for the existence of a threshold exposure concentration below which the substance would be safe. As with noncarcinogenic substances, there appears to be a dose-response relationship for carcinogenic substances. If no threshold exists for a carcinogen, then there is no safe exposure concentration; however, lower exposures would be associated with lower risks.

For some carcinogens, NIOSH attempts to identify the lowest REL on the basis of the quantitative detection limit for the method used to monitor exposures. For other carcinogens, NIOSH does not identify a precise exposure limit but recommends instead that the employer control worker exposures to the lowest feasible limit.

Regardless of the selected exposure limit for a carcinogen, the best engineering controls and work practices should be instituted. Respirators should not be used as a substitute for proper control measures. When respiratory protection is required to achieve the lowest exposure concentration, then only the most effective respirators should be used. Two types of respirators are recommended: a full facepiece SCBA operated in a pressure-demand or other positive pressure mode or a full facepiece supplied-air respirator (SAR) operated in a pressure-demand or other positive pressure mode in combination with a SCBA operated in a pressure demand or other positive pressure mode. The practicality of each situation must be assessed to determine the most technically feasible protection for the worker.

Other variables such as the specific situation, worker, or job may influence the selection of the appropriate exposure limit for a given contaminant. For example, the effects of some hazardous substances may be increased due to exposure to other contaminants present in the workplace or the general environment or to medications or personal habits of the worker. Such factors, which would affect the toxicity of a contaminant, would not have been considered in the determination of the specific exposure limit. Also, some substances are absorbed by direct contact with the skin and mucous membranes, thus potentially increasing the total exposure.

Subparagraph 3: Immediately Dangerous to Life or Health (IDLH)

An IDLH exposure condition is defined in this decision logic as one that poses a threat of exposure to airborne contaminants when that exposure is likely to cause death or immediate or delayed permanent adverse health effects or prevent escape from such an environment. The purpose of establishing an IDLH exposure level is to ensure that the worker can escape from a given contaminated environment in the event of failure of the respiratory protection equipment. The IDLH is considered a maximum level

above which only a highly reliable breathing apparatus providing maximum worker protection is permitted. Any appropriate approved respirator may be used to its maximum use concentration up to the IDLH concentration.

In establishing the IDLH concentration, the following conditions must be assured:

- a. The ability to escape without loss of life or immediate or delayed irreversible health effects. (Thirty minutes is considered the maximum time for escape so as to provide some margin of safety in calculating the IDLH.)
- b. The prevention of severe eye or respiratory irritation or other reactions that would hinder escape.

Sources of information for determining whether the exposure limit for a contaminant represents an IDLH condition are as follows:

- a. Specific IDLH guidelines provided in the literature such as the American Industrial Hygiene Association (AIHA) Hygienic Guides and the NIOSH Pocket Guide for Hazardous Chemical Substances (previous editions were published jointly by NIOSH and OSHA), and/or
- b. Human exposure and effects data, and/or
- c. Animal exposure and effects data, and/or
- d. Where such data specific to the contaminant are lacking, toxicologic data from analogous substances and chronic animal exposure data may be considered.

Subparagraph 4: Eye Irritation

Eye protection in the form of respirators with full facepieces, helmets, or hoods is required for routine exposures to airborne contaminants that cause any irritation to the mucous membranes of the conjunctivae or the cornea or cause any reflex tearing. Eye protection is required for contaminants that cause minor subjective effects as well as for those that cause any damage, including disintegration and sloughing of conjunctival or corneal epithelium, edema, or ulceration. NIOSH is not aware of any standards for gas-tight goggles that would permit NIOSH to recommend such goggles as providing adequate eye protection.

For escape, some eye irritation is permissible if the severity of irritation does not inhibit the escape and if no irreversible scarring or ulceration of the eyes or conjunctivae is likely.

When data on threshold levels for eye irritation are insufficient, quarter- or half-mask respirators can be used, provided that the worker experiences

no eye discomfort and no pathologic eye effects develop. Workers should be told that if any eye discomfort is experienced, they will be provided with respirators that have full facepieces, helmets, or hoods and that provide protection equivalent to the quarter- or half-mask respirators.

Subparagraph 5: Escape Apparatus

Escape devices have a single function: to allow a person working in a normally safe environment sufficient time to escape from suddenly occurring respiratory hazards.

Escape devices can be separated into two categories: air-purifying respirators and self-contained breathing apparatus. Air-purifying respirators remove contaminants from the air by sorbent and/or filter media, but because they do not provide air, these respirators cannot be used in an oxygen-deficient atmosphere. Air-purifying escape respirators include the escape gas mask (canister) respirator, the gas mask (canister) respirator, and the filter self-rescuer. The escape gas mask consists of a half-mask or a mouthpiece respirator. The mouthpiece respirator can be used for short periods of time to escape from low concentrations of organic vapor or acid gas. The escape gas mask, which utilizes a half-mask, filters contaminants from the air. These respirators may also be used to escape from low concentrations of organic vapor or acid gas. Escape gas mask respirators equipped with full facepieces can also be used for escape from IDLH conditions but not from oxygen-deficient atmospheres. No air-purifying device is suitable for escape from a potentially oxygen-deficient atmosphere. The filter self-rescue unit is the mouthpiece device, which is designed to protect specifically against less than 1% carbon monoxide.

A self-contained breathing apparatus (SCBA) provides air to the user for escape from oxygen-deficient environments. Escape SCBA devices are commonly used with full facepieces or hoods and, depending on the supply of air, are usually rated as 3- to 60-minute units. Self-contained self-rescuer (SCSR) devices have been approved by MSHA/NIOSH for escape from mines, but these devices may also have application in other similar environments. SCSR's are mouthpiece respirators that provide a source of oxygen-enriched air for up to 60 minutes. All SCBA devices can be used in oxygen-deficient atmospheres.

When selecting escape apparatus, careful consideration must be given to potential eye irritation. This consideration is important for determining whether a gas mask or SCBA equipped with a full facepiece should be selected rather than a device equipped with a half-mask or mouthpiece.

The majority of gas masks or escape gas masks can be used in situations involving gas(es), vapor(s), or particulates. For escape from particulate-contaminated environments, an air-purifying element must be selected that will provide protection against the given type of particulate. The information in Table 4 should be used to select the appropriate escape apparatus.

Table 4.--Selection options for escape respirators

Escape conditions	Type of respirator
Short distance to exit, no obstacles (no oxygen deficiency)	Any escape gas mask ¹ (canister respirator) or gas mask ² (canister respirator)
	Any escape self-contained breathing apparatus having a suitable service life ³
	Any acceptable device for entry into emergency situations
Long distance to exit or obstacles along the way (no oxygen deficiency)	Any gas mask ²
	Any escape self-contained breathing apparatus having a suitable service life ³
	Any self-contained self-rescuer having a suitable service life
Potential oxygen deficiency	Any escape self-contained breathing apparatus having a suitable service life ³
	Any self-contained self-rescuer having a suitable service life

¹ An escape gas mask is a respirator designed for use during escape only from immediately dangerous to life or health (IDLH) or non-IDLH atmospheres. It may consist of a half mask facepiece or mouthpiece, appropriate air-purifying element for the contaminant, and associated connections. Maximum use concentrations for these types of respirators are designated by the manufacturer.

² A gas mask consists of a full facepiece and either chin-style or front- or back-mounted canisters with associated connections. Maximum use concentrations for canister air-purifying elements are listed in Table 5.

³ Escape self-contained breathing apparatus can have rated service lives of 3 to 60 minutes. All acceptable devices for entry into emergency situations can also be used.

Subparagraph 6: Potential Warning Properties for Use With Cartridge/Canister Air-Purifying Respirators

For the purpose of this decision logic, warning properties are defined according to odor, taste, eye irritation, or respiratory irritation. Adequate warning properties imply that the gas or vapor of interest has a persistent odor or irritant effect at concentrations at or below the OSHA PEL or NIOSH REL. Recognition of an odor depends on a person's sensory ability to detect it. Since the range of odor recognition thresholds within a population is very large, odor recognition should not be relied on as the only means for determining that a cartridge or canister is no longer effectively removing a contaminant from the air. A more detailed discussion of variability of odor detection within a population is provided in Appendix C.

NIOSH recommends that the employer ensure that each worker who is required to wear an air-purifying cartridge or canister respirator is capable of recognizing the odor of the substance of concern at a concentration at or below the applicable exposure limit. Such a determination will necessitate that an odor screening test be conducted on each individual for each substance of concern in the particular workplace.

It is recognized that existing screening tests are subjective in nature and not sufficiently sensitive and that conducting screening tests for a group of workers exposed to several substances may be impractical. Therefore, NIOSH knows of no compelling reason not to develop quantitative service life test data to supplement or replace odor screening test results if it can be demonstrated that such a procedure will afford the wearer a level of protection at least equivalent to that indicated by odor screening. Even when service life test data are used, the employer and the respirator wearer should not ignore the usefulness of sensory detection properties (for those who can detect the contaminant's presence) to serve as a warning that the cartridge/canister has failed or that the integrity of the respirator face seal has been compromised.

It is important to realize that 30 CFR 11 [specifically, 30 CFR 11.90(b) (note 4) for gas masks (canister respirators) and 30 CFR 11.150 (note 7) for chemical cartridge respirators], which provides for approval of air-purifying (organic vapor) devices, prohibits their approval for use against organic vapors with poor warning properties unless there is an OSHA standard which permits their use. A more detailed discussion appears in Appendix C.

A recent policy decision by NIOSH allows the use of respirators with effective end-of-service-life indicators for protection against contaminants with poor warning properties, provided that certain conditions are met. These conditions are described in that policy statement, which is reproduced in Appendix A.

Subparagraph 7: Limitations of Respirators for Gases and Vapors

Air-purifying respirators cannot be used in IDLH atmospheres or in atmospheres containing less than 19.5% oxygen by volume. Gas masks (canister respirators) may be used for escape if the atmosphere is not oxygen-deficient.

If, after the APF is multiplied by the REL or other applicable exposure limit (APF X REL), the product exceeds the IDLH value, then the IDLH value shall be the maximum use concentration. (See Tables 1, 2, and 3.) In addition, there are maximum use concentrations associated with all gas and vapor air-purifying elements. (See Table 5.)

Air-purifying devices should not be allowed for either entry into or escape from hazardous environments when supporting evidence exists to demonstrate that unreasonably short service life would occur at the maximum use concentration.

Where there is reason to suspect that a sorbent has a high heat of reaction with a substance, use of that sorbent is not recommended. For such a substance, only non-oxidizable sorbents should be allowed.

Air-purifying respirators cannot be used for protection against gases and vapors with poor warning properties unless the respirator is approved with an effective ESLI. (See Appendix A.)

Although limited in number, there are specific air-purifying respirators that are approved by MSHA/NIOSH for protection against gases and vapors when respirators approved for a given class of contaminants (e.g., organic vapors) cannot be used due to sorbent deficiencies.

Subparagraph 8: Assigned Protection Factors (APF's)

APF's (sometimes referred to in the literature as respirator protection factors), which appear in the 1975 and 1978 versions of the OSHA/NIOSH Respirator Decision Logic, in the 1980 American National Standards Institute (ANSI) standards for respiratory protection, and in all OSHA health standards, are based on quantitative fit testing (QNFT) of respirators [6]. (See definition of fit factors in Appendix D.) No data have been reported in the literature to demonstrate that the results of QNFT are sufficiently indicative of the protection that a given respirator provides in the workplace. Recent studies by NIOSH [7-9] and others [10-12] have suggested that fit factors do not correlate with the workplace protection factors provided by powered air-purifying respirators (PAPR's) and negative pressure half-mask respirators. (See definition of workplace protection factors in Appendix D.)

Table 5.--NIOSH recommended maximum use concentrations (expressed in ppm) for gas and vapor air-purifying elements

Classification of gas and vapor air-purifying elements

Type of gas or vapor	Cartridge(s)	Chin-style canister	Front- or back-mounted canister
Organic vapors	1,000*	5,000†	20,000†
Acid gases			
Sulfur dioxide (SO ₂)	50	100	100
Chlorine (Cl ₂)	10	25	25
Hydrochloric (HCl)	50	100	100
Ammonia (NH ₃)	300	500	500
Methyl amine (CH ₃ NH ₂)	100	--	--
Carbon monoxide (CO)	NA	NA	1,500

* Maximum use concentration will be 1,000 ppm or the immediately dangerous to life or health (IDLH) value for the specific organic vapor, whichever is lower.

† Maximum use concentration for "entry into" will be limited to the value listed or to the IDLH value for the specific organic vapor, whichever is lower.

APF's that are still based on the fit factors determined by Los Alamos National Laboratories (LANL) can be used for those classes of respirators for which no WPF data or simulated workplace protection factor (SWPF) data are available. However, as WPF data are developed, these APF's will be revised, as have the current APF's for powered air-purifying respirators (PAPR's) [7-9,11,14-16]. It should be noted that a number of studies [17-20] on the workplace performance of respirators have appeared in the literature. However, the results of these studies are of little value for establishing APF's because their protocols did not require proper fit or correct use and conscientious wearing of the respirator while in-facepiece sampling was done. A notable exception is the study by Revoir (1974) [21].

When WPF data existed, NIOSH utilized the point estimate equation proposed by Myers et al. [13] to help establish the APF's recommended in this decision logic. The point estimate equation is as follows:

$$\text{protection factor (PF)} = \mu g / Sg^{Zp}$$

where μg = the geometric mean of the measured WPF

Sg = the geometric standard deviation of the measured WPF

Zp = the value corresponding to the selected proportion (p) on the log-normal probability distribution

When WPF data existed, NIOSH selected a confidence limit of $p=0.95$. Thus for a given set of data and given class of respirators, NIOSH would expect that 95% of the WPF's would exceed the calculated point estimate value.

Despite the fact that some of the PF's have a statistical basis, they are still only estimates of an approximate level of protection. It must not be assumed that the numerical values of the APF's presented in this decision logic represent the absolute minimum level of protection that would be achieved for all workers in all jobs against all respiratory hazards. The industrial hygienist or other professional responsible for providing respiratory protection or evaluating respiratory protection programs is therefore encouraged to evaluate as accurately as possible the actual protection being provided by the respirator.

Subparagraph 9: Particulate Filter Respirators

MSHA/NIOSH particulate respirators are certified according to seven basic categories. These categories consist of the following types of exposures:

- Dusts: Airborne exposure limit not less than 0.05 mg/m³ or 2 mppcf (see Appendix B);
- Fumes: Airborne exposure limit not less than 0.05 mg/m³ or 2 mppcf;
- Mists: Airborne exposure limit not less than 0.05 mg/m³ or 2 mppcf (see Appendix B);
- Dusts, Fumes, and Mists: Airborne exposure limit less than 0.05 mg/m³ or 2 mppcf and radionuclides;
- Radon Daughters;
- Asbestos-Containing Dusts and Mists (see Appendix B); and
- Single-Use Dust and Mist Respirators (see Appendix B).

Subparagraph 10: Suggested Medical Evaluation and Criteria for Respirator Use

The following NIOSH recommendations allow latitude for the physician in determining a medical evaluation for a specific situation. More specific guidelines may become available as knowledge increases regarding human stresses from the complex interactions of worker health status, respirator usage, and job tasks. While some of the following recommendations should be part of any medical evaluation of workers who wear respirators, others are identified as being applicable for specific situations.

a. A Physician Should Make the Determination of Fitness to Wear a Respirator by Considering the Worker's Health, the Type of Respirator, and the Conditions of Respirator Use.

The recommendation above satisfies OSHA regulations and leaves the final decision of an individual's fitness to wear a respirator to the person who is best qualified to evaluate the multiple clinical and other variables. Much of the clinical and other data could be gathered by other personnel. It should be emphasized that the clinical examination alone is only one part of the fitness determination and that collaboration with foremen, industrial hygienists, and others may often be needed to better assess the work conditions and other factors that affect an individual's fitness to wear a respirator.

b. A Medical History and At Least a Limited Physical Examination are Recommended.

The medical history and physical examination should emphasize the evaluation of the cardiopulmonary system and should elicit any history of respirator use. The history is an important tool in medical diagnosis and can be used to detect most problems that might require further

evaluation. Objectives of the physical examination should be to confirm the clinical impression based on the history and to detect important medical conditions (such as hypertension) that may be essentially asymptomatic.

c. While Chest X-Ray and/or Spirometry May Be Medically Indicated in Some Fitness Determinations, These Should Not Be Routinely Performed.

In most cases, the hazardous situations requiring the wearing of respirators will also mandate periodic chest X-ray and/or spirometry for exposed workers. When such information is available, it should be used in the determination of fitness to wear respirators. (See Recommendation h, page 33.)

Routine chest X-rays and spirometry are not recommended solely as data for determining if a respirator should be worn. In most cases, with an essentially normal clinical examination (history and physical) these data are unlikely to influence the respirator fitness determination; additionally, the X-ray would be an unnecessary source of radiation exposure to the worker. Chest X-rays in general do not accurately reflect a person's cardiopulmonary physiologic status, and limited studies suggest that mild to moderate impairment detected by spirometry would not preclude the wearing of respirators in most cases. Thus it is recommended that chest X-ray and/or spirometry be done only when clinically indicated. (See Appendix E, page 52, for further discussion on the pulmonary effects of wearing respirators.)

d. The Recommended Periodicity of Medical Fitness Determinations Varies According to Several Factors but Could Be as Infrequent as Every 5 Years.

Federal or other applicable regulations shall be followed regarding the frequency of respirator fitness determinations. The guidelines for most work conditions for which respirators are required are shown in Table 6. These guidelines are similar to those recommended by ANSI, which recommends annual determinations after age 45 [22]. The more frequent examinations with advancing age relate to the increased prevalence of most diseases in older people. More frequent examinations are recommended for individuals performing strenuous work involving the use of SCBA. These guidelines are based on clinical judgment and, like the other recommendations in this section, should be adjusted as clinically indicated.

e. The Respirator Wearer Should Be Observed During a Trial Period to Evaluate Potential Physiological Problems

In addition to considering the physical effects of wearing respirators, the physician should determine if wearing a given respirator would cause extreme anxiety or claustrophobic reaction in the individual. This could be done during training, while the worker is wearing the respirator and

is engaged in some exercise that approximates the actual work situation.

Present regulations state that a worker should be provided the opportunity to wear the respirator "in normal air for a long familiarity period..." [23]. This trial period should also be used to evaluate the ability and tolerance of the worker to wear the respirator [24]. This trial period need not be associated with respirator fit testing and should not compromise the effectiveness of the vital fit testing procedure.

Table 6.--Suggested frequency of medical fitness determinations*

	<u>Worker age (years)</u>		
	<35	35 - 45	>45
Most work conditions requiring respirators	Every 5 yrs	Every 2 yrs	1-2 yrs
Strenuous work conditions with SCBA†	Every 3 yrs	Every 18 mos	Annually

* Interim testing would be needed if changes in health status occur.

† SCBA = self-contained breathing apparatus

f. Examining Physicians Should Realize that the Main Stress of Heavy Exercise While Using a Respirator Is Usually on the Cardiovascular System and that Heavy Respirators (e.g., Self-Contained Atmosphere Supplying) Can Substantially Increase this Stress. Accordingly, Physicians May Want To Consider Exercise Stress Tests with Electrocardiographic Monitoring When Heavy Respirators Are Used, When Cardiovascular Risk Factors Are Present, or When Extremely Stressful Conditions Are Expected.

Some respirators may weigh up to 35 pounds and may increase workloads by 20 percent. Although a lower activity level could compensate for this added stress [25], a lower activity level might not always be possible. Physicians should also be aware of other added stresses, such as heavy protective clothing and intense ambient heat, which would increase the worker's cardiac demand. As an extreme example, firefighters who use SCBA inside burning buildings may work at maximal exercise levels under life-threatening conditions. In such cases, the detection of occult cardiac disease, which might manifest itself during heavy stress, may be important. Some authors have either recommended stress testing [26] or

at least its consideration in the fitness determination [22]. Kilbom [26] has recommended stress testing at 5-year intervals for firefighters below age 40 who use SCBA and at 2-year intervals for those aged 40-50. He further suggested that firemen over age 50 not be allowed to wear SCBA.

Exercise stress testing has not been recommended for medical screening for coronary artery disease in the general population [27,28]. It has an estimated sensitivity and specificity of 78% and 69%, respectively, when the disease is defined by coronary angiography [27,29]. In a recent 6-year prospective study, stress testing to determine the potential for heart attack indicated a positive predictive value of 27% when the prevalence of disease was 3 1/2% [30,31]. While stress testing has limited effectiveness in medical screening, it could serve to detect those individuals who may not be able to complete the heavy exercise required in some jobs.

A definitive recommendation regarding exercise stress testing cannot be made at this time. Further research may determine whether this is a useful tool in selected circumstances.

g. An Important Concept Is that "General Work Limitations and Restrictions Identified for Other Work Activities Also Shall Apply for Respirator Use" [22].

In many cases, if a worker is able to do an assigned job without an increased risk to health while not wearing a respirator, the worker will in most situations not be at increased risk when performing the same job while wearing a respirator.

h. Because of the Variability in the Types of Respirators, Work Conditions, and Workers' Health Status, Many Employers May Wish to Designate Categories of Fitness To Wear Respirators, Thereby Excluding Some Workers from Strenuous Work Situations Involving the Wearing of Respirators.

Depending on the various circumstances, there could be several permissible categories of respirator usage. One possible scheme would consist of three overall categories: full respirator use, no respirator use, and limited respirator use including "escape only" respirators. The latter category excludes heavy respirators and strenuous work conditions. Before identifying the conditions that would be used to classify workers into various categories, it is critical that the physician be aware that these conditions have not been validated and are presented only for consideration. The physician should modify the use of these conditions based on actual experience, further research, and individual worker sensitivities. The physician may wish to consider the following conditions in selecting or permitting the use of respirators:

- History of spontaneous pneumothorax;
- Claustrophobia/anxiety reaction;
- Use of contact lens (for some respirators);
- Moderate or severe pulmonary disease;
- Angina pectoris, significant arrhythmias, recent myocardial infarction;
- Symptomatic or uncontrolled hypertension; and
- Age.

It seems unlikely that wearing a respirator would play any significant role in causing lung damage such as pneumothorax. However, without good evidence that wearing a respirator would not cause such lung damage, it may be prudent to prohibit the individual with a history of spontaneous pneumothorax from wearing a respirator.

Moderate lung disease is defined by the Intermountain Thoracic Society [32] as being a forced expiratory volume in one second (FEV_1) divided by the forced vital capacity (FVC) (i.e., FEV_1/FVC) of 0.45 to 0.60 or an FVC of 51 to 65% of the predicted FVC value. Similar arbitrary limits could be set for age and hypertension. It would seem more reasonable, however, to combine several risk factors into an overall estimate of fitness to wear respirators under certain conditions. Here the judgment and clinical experience of the physician are needed. Even many impaired workers would be able to work safely while wearing respirators if they could control their own work pace, including having sufficient time to rest.

Conclusion

Individual judgment is needed in determining the factors affecting an individual's fitness to wear a respirator. While many of the preceding guidelines are based on limited evidence, they should provide a useful starting point for a respirator fitness screening program. Further research is needed to validate these recommendations and others currently in use. Of particular interest would be laboratory studies involving physiologically impaired individuals and field studies conducted under actual day-to-day work conditions.