Protection Factors for Respirator Selection

Eric Dzuba (with Marc Ettema)
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Protection Factors for Respirator Selection

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General Information

Definition of a Protection Factor

Protection Factor

The protection level expected by a certain class of respirators. Or, the level of protection that a specific wearer may achieve.

In other words:
The difference between wearing a specific respirator type and wearing no respirator at all.

\[
\text{Protection Factor} = \frac{\text{Concentration of test substance outside}}{\text{Concentration of test substance inside}}
\]

\[
\text{Protection Factor} = \frac{1}{\text{Total Inward Leakage}}
\]
Why is knowing the Protection Factor Important?

Protection factors are a key tool to assist in choosing the appropriate level of respiratory protection.
The decision on choosing appropriate respiratory protection should be based on overall analysis of the specific conditions and not on protection factors alone.

- **Training level** of users
- **Workplace conditions** (tight spaces, potential for other hazards, etc.)
- **Work intensity**; affects breathing rate
- **Amount of body movement**
- **Maintenance** of the equipment
- **Danger** of the substance
- **Warning properties** of substance
- **Concentration levels**, or **peaks**
The APR Family – Air-Purifying Respirators

All general aspects of APR are valid for PAPR as well – Powered Air Purifying Respirator
General Information
Meaning of APR 2/2

**APR = Air-Purifying Respirators**

**General requirement to use APR**

- **O₂ min. 17 Vol.%**
  - (Germany)

- **Type and concentration**
  - of contaminant must be known

- **Not allowed** in poor ventilated areas or confined spaces
  - (e.g. Tanks, small rooms, tunnels or vessels)

- **Contaminant must have clear warning properties** (smell or taste)

- **Concentration below IDLH**
  - (immediately dangerous to life or health)
## General Information

### Comparison with other Respirators

<table>
<thead>
<tr>
<th>Type of Respirator</th>
<th>Class</th>
<th>NPF(^1)</th>
<th>APF(^2) D</th>
<th>APF(^2) UK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Filtering half mask (EN 149)</td>
<td>FFP3</td>
<td>50</td>
<td>30</td>
<td>20</td>
</tr>
<tr>
<td>Half mask (EN 140)</td>
<td>P3</td>
<td>48</td>
<td>30</td>
<td>20</td>
</tr>
<tr>
<td>Full face mask (EN 136)</td>
<td>P3</td>
<td>1,000</td>
<td>400</td>
<td>40</td>
</tr>
<tr>
<td>PAPR/Airline with hood or helmet (EN 14594-1)</td>
<td>TH3</td>
<td>500</td>
<td>100</td>
<td>40</td>
</tr>
<tr>
<td>PAPR/Airline with tight fitting mask (EN 12942)</td>
<td>TM3</td>
<td>2,000</td>
<td>500</td>
<td>40</td>
</tr>
<tr>
<td>Compressed air w/full mask (EN 14593-1)</td>
<td>Demand</td>
<td>2,000</td>
<td>1,000</td>
<td>40</td>
</tr>
<tr>
<td>SCBA positive pressure (EN 137)</td>
<td>Demand</td>
<td>2,000</td>
<td>&gt;1,000</td>
<td>2,000</td>
</tr>
<tr>
<td>CCBA (EN 145)</td>
<td></td>
<td>2,000</td>
<td>&gt;1,000</td>
<td></td>
</tr>
</tbody>
</table>

\(^1\) Nominal Protection Factor; \(^2\) Assigned Protection Factor

PAPR with tight fitting headpiece and class TM3 offer the highest protection level among air purifying respirators.
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Total leakage into the respirator caused by:

- Filter does not remove 100% of particles (filters remove 80% to 99.97% of particles depending on class)
- Mask does not correctly fit user due to size
- Leakage along sealing lines due to face shape, facial hair or long hair in sealing line
- Inconsistent quality of RPD maintenance (RPD=Respiratory Protective Device)
- Inconsistent donning and use
- Various breathing patterns
- Mask leakage of parts (lens, valves, gaskets, seals)
The maximum percentage of TIL permitted in relevant EN standards for a given class of respirators

- NPF was developed in laboratory tests using a small sample of trained individuals
- Therefore, this may not represent the true protection factor achieved by an individual in the workplace
- These values are used more as a reference
**Assigned Protection Factor**

- The realistic level of respiratory protection that can be achieved by 95% of properly trained workers
- Established by appointed groups at national levels, and can vary greatly amongst countries
- APF values are more realistic than NPF values since they were obtained through simulated workplace testing
- If available these values should be used (or are required to be used) when selecting respirators

**Assigned Protection Factor**

- The workplace level of respiratory protection that a respirator or class of respirators is expected to provide to properly fitted and trained workers
- These are the only values to use when making a respirator selection for those who follow OSHA. Calculated values by OSHA through workplace simulated exercises
Example for Nominal Protection Factor (NPF)

Based on EN 12941:
- TH1: inward leakage max. 10% → NPF = 10
- TH2: inward leakage max. 2% → NPF = 50
- TH3: inward leakage max. 0.2% → NPF = 500

Example for Assigned Protection Factor (APF)

Based on lose fitting headpiece with TH3:
- NPF = 500
- APF Finland = 200
- APF Germany = 100
- APF UK = 40
Terms, Definitions & Acronyms

WPF – Workplace Protection Factor

Ratio between breathing zone concentration and its concentration inside the facepiece

- This study should be conducted on the employees at their workplace
- This is the most accurate value that really shows what protection factor is obtained by each employee while working
- Should only be derived for PAPR or SAR devices
Ratio between breathing zone concentration and allowable concentration inside the facepiece

- The MRPF is used to select respirator types
- The concentration outside the facepiece will be based on actual measurements
- The concentration allowed inside will be based on Exposure Limits for the particular substance
Terms, Definitions & Acronyms

IDLH – Immediately Dangerous to Life or Health

Concentration level that poses an immediate effect on life or health of a person

- An air purifying respirator should not be used above this level
- For OSHA, these limits are specifically defined
- For EN, they are not specifically defined
Terms, Definitions & Acronyms

MUC – Maximum Use Concentration

Used to determine if a respirator type will provide adequate protection

- Determine adequate protection against a known concentration of a substance
- Take the protection factor of the respirator multiplied by the exposure limit (OEL\textsuperscript{1}, PEL\textsuperscript{2}, TLV\textsuperscript{3}, etc.) regulation
- This gives the maximum concentration the respirator can be used
- Note that other respirator use limitations must be considered

\textsuperscript{1} Occupational Exposure Limit; \textsuperscript{2} Permissible Exposure Limit; \textsuperscript{3} Threshold Limit Value
**ActPF – Actual Protection Factor**

- The actual measure of protection a worker receives in real situations
- Rarely used as this has to be tested individually at a workplace

**FF – Fit Factor**

- A numeric assessment determined by a Fit Test
- How well does a tight-fitting respirator fits a wearer during a quantitative fit test

**Fit Test**

- The use of a challenge agent or quantitative measurement
- Determine an individual’s ability to obtain an adequate seal with a specific respirator
### Terms, Definitions & Acronyms

**Which one do I use?**

First choose whichever Protection Factor is specified in the regulations of your country

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>APF</td>
<td>Assigned Protection Factor</td>
</tr>
<tr>
<td>NPF</td>
<td>Nominal Protection Factor</td>
</tr>
<tr>
<td>WPF</td>
<td>Workplace Protection Factor</td>
</tr>
<tr>
<td>FF</td>
<td>Fit Factor</td>
</tr>
<tr>
<td>MRPF</td>
<td>Minimum Required Protection Factor</td>
</tr>
<tr>
<td>ActPF</td>
<td>Actual Protection Factor</td>
</tr>
</tbody>
</table>
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# Protection Factor Values

## Protection Factors of masks 1/2

<table>
<thead>
<tr>
<th>Type of Respirator</th>
<th>Class</th>
<th>NPF</th>
<th>APF Fin</th>
<th>APF D</th>
<th>APF It</th>
<th>APF Sw</th>
<th>APF UK</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Filtering Half Mask EN 149</strong></td>
<td>FFP1</td>
<td>4</td>
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<td>FFP2</td>
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<tr>
<td></td>
<td>FFP3</td>
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<td>20</td>
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<td>20</td>
<td>20</td>
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<tr>
<td><strong>Half Mask EN 140</strong></td>
<td>P1</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
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<tr>
<td></td>
<td>P2</td>
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<td>10</td>
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<tr>
<td></td>
<td>P3</td>
<td>48</td>
<td>30</td>
<td>30</td>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>GasX</td>
<td>50</td>
<td>20</td>
<td>30</td>
<td>30</td>
<td>20</td>
<td>10</td>
</tr>
<tr>
<td><strong>Full Face Mask EN 136</strong></td>
<td>P1</td>
<td>5</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>P2</td>
<td>16</td>
<td>15</td>
<td>15</td>
<td>15</td>
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<tr>
<td></td>
<td>P3</td>
<td>1000</td>
<td>500</td>
<td>400</td>
<td>400</td>
<td>500</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>GasX</td>
<td>2000</td>
<td>500</td>
<td>400</td>
<td>400</td>
<td>500</td>
<td>20</td>
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</table>

*Note: Refer to EN 529 for Details*
### Protection Factor Values

**Protection Factors of masks 2/2**

<table>
<thead>
<tr>
<th>Type of Respirator</th>
<th>Class</th>
<th>NPF</th>
<th>APF Fin</th>
<th>APF D</th>
<th>APF It</th>
<th>APF Sw</th>
<th>APF UK</th>
</tr>
</thead>
<tbody>
<tr>
<td>PAPR with hood or helmet EN 12941</td>
<td>TH1</td>
<td>10</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>TH2</td>
<td>50</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>TH3</td>
<td>500</td>
<td>200</td>
<td>100</td>
<td>200</td>
<td>200</td>
<td>200</td>
</tr>
<tr>
<td>PAPR with tight fitting mask EN 12942</td>
<td>TM1</td>
<td>20</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>TM2</td>
<td>200</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>TM3</td>
<td>2000</td>
<td>1000</td>
<td>500</td>
<td>400</td>
<td>1000</td>
<td>40</td>
</tr>
<tr>
<td>Compressed air w/ full mask EN 14593-1</td>
<td>Demand</td>
<td>2000</td>
<td>1000</td>
<td>1000</td>
<td>400</td>
<td>1000</td>
<td>40</td>
</tr>
<tr>
<td>SCBA positive pressure EN 137</td>
<td>Demand</td>
<td>2000</td>
<td>&gt;1000</td>
<td>1000</td>
<td>400</td>
<td>1000</td>
<td>2000</td>
</tr>
<tr>
<td>CCBA EN 145</td>
<td></td>
<td>2000</td>
<td>500</td>
<td>&gt;1000</td>
<td>400</td>
<td>500</td>
<td></td>
</tr>
</tbody>
</table>

*Note: Refer to EN 529 for Details*

**According to EN**
### Protection Factor Values

**Assigned Protection Factor (APF) of masks**

<table>
<thead>
<tr>
<th>Type of Respirator</th>
<th>Half Mask</th>
<th>Full Face Mask</th>
<th>Helmet/Hood</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Purifying Respirator</td>
<td>$10^3$</td>
<td>$50^5$</td>
<td></td>
</tr>
<tr>
<td>Powered Air Purifying Respirator (PAPR)</td>
<td>50</td>
<td>1,000</td>
<td>25/1,000$^4$</td>
</tr>
<tr>
<td>Supplied Air Respirator (SAR)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>– Demand Mode</td>
<td>10</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>– Continuous Flow Mode</td>
<td>50</td>
<td>1,000</td>
<td>25/1,000$^4$</td>
</tr>
<tr>
<td>– Pressure Demand</td>
<td>50</td>
<td>1,000</td>
<td></td>
</tr>
<tr>
<td>Self Contained Breathing Apparatus (SCBA)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>– Demand Mode</td>
<td>10</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>– Pressure Demand</td>
<td></td>
<td>10,000</td>
<td>10,000</td>
</tr>
</tbody>
</table>

1. Employers may select respirators with higher protection; 2. An effective respiratory program must be implemented; 3. Includes filtering facepiece respirators; 4. Manufacturer must provide test data to demonstrate an APF of 1,000 is achieved; 5. Per (Canada) CSA Z94.4-02, the APF for a full face mask is 100.
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Example 1

**Customer A** plans to use a respirator for protection against **styrene**. Through measurement devices, the maximum concentration is **125 ppm**. Which respirator type should they choose?

**EN (UK)**

- **OEL:** 20 ppm
- **PEL:** 100 ppm TWA
- **Use:** MRPF
- **IDLH:** 700 ppm
- **Use:** MRPF

**OSHA**
Example 1

Customer A plans to use a respirator for protection against styrene. Through measurement devices, the maximum concentration is 125 ppm. Which respirator type should they choose?

Styrene requires „A“ filters, so look at the EN table for a mask with GasX cartridges with min. 6.25 PF.

Styrene requires OV filters. Look at the APF table for a mask with min. 1.25 PF.

A half mask offers an APF of 10
Example 2

Customer B has many half masks for their employees. A new application requires the use of Toluene in the plant. What is the maximum concentration their workers can be exposed to while wearing a half mask?

- **OEL**: 50 ppm
- **Use**: MUC

- **PEL**: 200 ppm TWA
- **IDLH**: 500 ppm
- **Use**: MUC
Example 2

**Customer B** has many half masks for their employees. A new application requires the use of **Toluene** in the plant. What is the maximum concentration their workers can be exposed to while wearing a half mask?

**EN (UK)**

<table>
<thead>
<tr>
<th>OEL: 50 ppm</th>
<th>PEL: 200 ppm TWA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use: MUC = APF × OEL</td>
<td>Use: MUC = APF × PEL</td>
</tr>
<tr>
<td>= 10 × 50</td>
<td>= 10 × 50</td>
</tr>
<tr>
<td>= 500 ppm</td>
<td>= 2,000 ppm</td>
</tr>
</tbody>
</table>

Toluene requires „A“ filters, so look at the EN table for APF of a half mask with GasX cartridges.

Caution: since IDLH is 500 ppm, an APR cannot be used above this level.

A half mask can be used up to 500 ppm
Example 3

**Customer C** welds on magnesium, which creates *magnesium oxide fumes*. Usually, they weld under a fume hood which pulls away most of the fumes thus keeping levels **around 25 mg/m³**, therefore they wear a **P2 (N95) FFP** under their welding helmets. However, the hood broke and **levels now reach 500 mg/m³**. Can they still wear a **P2 (N95) FFP**?

<table>
<thead>
<tr>
<th>EN (UK)</th>
<th>OEL: 3 mg/m³</th>
<th>Use: MRPF</th>
</tr>
</thead>
<tbody>
<tr>
<td>OSHA</td>
<td>PEL: 15 mg/m³</td>
<td>IDLH: 750 mg/m³</td>
</tr>
</tbody>
</table>
**Example 3**

**Customer C** welds on magnesium, which creates magnesium oxide fumes. Usually, they weld under a fume hood which pulls away most of the fumes thus keeping levels around 25 mg/m³, therefore they wear a P2 (N95) FFP under their welding helmets. However, the hood broke and levels now reach 500 mg/m³. Can they still wear a P2 (N95) FFP?

**OEL:** 3 mg/m³  
**Use:**  
\[ \text{MRPF} = \frac{\text{Conc.}}{\text{OEL}} = \frac{500}{3} = 166.7 \text{ PF} \]

**PEL:** 15 mg/m³  
**IDLH:** 750 mg/m³  
**Use:**  
\[ \text{MRPF} = \frac{\text{Conc.}}{\text{PEL}} = \frac{500}{15} = 33.3 \text{ PF} \]

In UK, max. PF of an APR is 40, they cannot wear a half mask any longer.

Since max. PF of a half mask is 10, they cannot wear a half mask any longer.

An SCBA must be used over 120 mg/m³

A full face mask with P100 must be worn.
Customer D wants you to help them provide proper protection against Chlorine Dioxide. They are trying to decide between Dräger and a competitor, so your knowledge and support can gain their trust. There are two areas of the plant where they measured ClO₂, one at 10 ppm and the other at 2 ppm. What would you suggest?

**EN (UK)**

<table>
<thead>
<tr>
<th>OEL: 0.1 ppm</th>
<th>Use: MRPF</th>
</tr>
</thead>
</table>

**OSHA**

<table>
<thead>
<tr>
<th>PEL: 0.1 ppm</th>
<th>IDLH: 5 ppm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use: MRPF</td>
<td></td>
</tr>
</tbody>
</table>
Example 4

Customer D wants you to help them provide proper protection against Chlorine Dioxide. They are trying to decide between Dräger and a competitor, so your knowledge and support can gain their trust. There are two areas of the plant where they measured ClO₂, one at 10ppm and the other at 2ppm. What would you suggest?

**OEL:** 0.1 ppm
Use: \[ \text{MRPF} = \frac{\text{Conc.}}{\text{OEL}} \]
\[ = \frac{10}{0.1} \mid \frac{2}{0.1} \]
\[ = 100 \mid 20 \]

In UK, max. PF of an APR is 40. They must use an SCBA at 10ppm.

**PEL:** 0.1 ppm
IDLH: 5 ppm
Use: \[ \text{MRPF} = \frac{\text{Conc.}}{\text{PEL}} \]
\[ = \frac{10}{0.1} \mid \frac{2}{0.1} \]
\[ = 100 \mid 20 \]

Since IDLH is 5ppm, anything over this value must be supplied air.

At 2ppm, and an MRPF of 20, they could use a full mask with cartridges

At 2ppm, a half mask provides a PF of 10, and full mask 50. A full mask can be used
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Protection Factor (PF) is the level of protection expected by either a certain class of respirators or by the wearer.

Use the PF to select a respirator type only. Not for selecting or changing cartridges.

Use the PF value as specified in the local country

Do not only use PF to choose a respirator, consider workplace surroundings and use application

MUC = PF \times EL

Protection factors cannot vary amongst manufacturers as they are established by local authorities in laboratories for a certain class of respirators.

Manufacturers or Employers can establish higher protection factor values through workplace simulation tests, but only for PAPR, airline, or escape devices.

Per OSHA, no derived PF can be higher than 1,000, even if study demonstrates higher results.

MRPF = \frac{\text{Concentration}}{\text{EL}}
Important Points to remember

Selecting respirators

Never use a respirator above its **MUC calculation**.

Never use an air purifying respirator above the substances **IDLH** level.

Never use an APR in **low oxygen levels** (level limits vary amongst countries, but range from 17% to 19.5%).

**If concentration is unknown**, you must recommend supplied air.

“**Excessive**” protection can be less desirable from an economic and ergonomic perspective.

Ensure you **use the correct APF** in calculations based on the local regulations and respirator type.

Do not exceed the concentration **limitations of the filters** even if the MUC calculation indicates higher values. **Use the lower of the two values.**
Thank you!
### Protection Factors for Respirator Selection

#### Glossary 1/2

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RPD</td>
<td>Respiratory Protective Device</td>
</tr>
<tr>
<td>APR</td>
<td>Air Purifying Respirator (any device utilizing filters)</td>
</tr>
<tr>
<td>FFP</td>
<td>Filtering Face Piece Respirator</td>
</tr>
<tr>
<td>HM</td>
<td>Half Mask</td>
</tr>
<tr>
<td>FM</td>
<td>Full Mask</td>
</tr>
<tr>
<td>PAPR</td>
<td>Powered Air Purifying Respirator</td>
</tr>
<tr>
<td>SAR</td>
<td>Supplied Air Respirator</td>
</tr>
<tr>
<td>SCBA</td>
<td>Self Contained Breathing Apparatus</td>
</tr>
<tr>
<td>Filter</td>
<td>Removes particles (dusts, mists, fumes) from ambient air</td>
</tr>
<tr>
<td>Cartridge</td>
<td>Removes gases and vapors from ambient air</td>
</tr>
</tbody>
</table>
## Protection Factors for Respirator Selection

### Glossary 2/2

<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
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<tbody>
<tr>
<td>OEL</td>
<td>Occupational Exposure Limit</td>
</tr>
<tr>
<td>PEL</td>
<td>Permissible Exposure Limit</td>
</tr>
<tr>
<td>REL</td>
<td>Recommended Exposure Limit</td>
</tr>
<tr>
<td>AGW</td>
<td>Arbeitsplatzgrenzwerte (Germany)</td>
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<tr>
<td>WEL</td>
<td>Workplace Exposure Level</td>
</tr>
<tr>
<td>TWA</td>
<td>Time Weighted Average</td>
</tr>
<tr>
<td>STEL</td>
<td>Short Term Exposure Level</td>
</tr>
<tr>
<td>TIL</td>
<td>Total Inward Leakage</td>
</tr>
<tr>
<td>Combination Cartridge</td>
<td>Removes particles, gases and vapors from ambient air</td>
</tr>
</tbody>
</table>