European Welding Association

Introduction to methods of prevention and extraction of welding fume”

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INTRODUCTION

EWA-European Welding Association

The European Welding Association (EWA) is an industrial body made up of national associations and manufacturers of arc welding and cutting equipment, welding consumables, flame welding and cutting equipment and health and safety equipment for welders from all over Europe.

EWA was founded in 1987. Its predecessor was the Association of European Manufacturers of Welding Consumables (CEFE), founded in 1958. EWA's current official headquarters are in Paris.

EWA Commitments and Objectives:

EWA monitors the mutual technical and economic interests of the European welding industry and its customers by:

- Contributing to the development and application of all the relevant specifications and standards with a bearing on the welding industry, working hand-in-hand with the trade organizations, EU authorities and every other body concerned.
- Gathering and analyzing industry-specific market data
- Promoting the welding industry and welding as a profession.
- Encouraging the safe use of welding and cutting processes

Since 2018 EWA has been registered with the EU Transparency Register (ID number 711840531940-21)

EWA Technical Committees:

The EWA technical committees work on every technical detail of the welding manufacturing process. At present, there are 4 technical committees:

- EWA TC Equipment (Arc welding/cutting equipment)
- EWATC Consumables (welding consumables);
- EWA TC Flame equipment (oxy-fuel)
- EWA TC HSE (Health and safety equipment for welders)

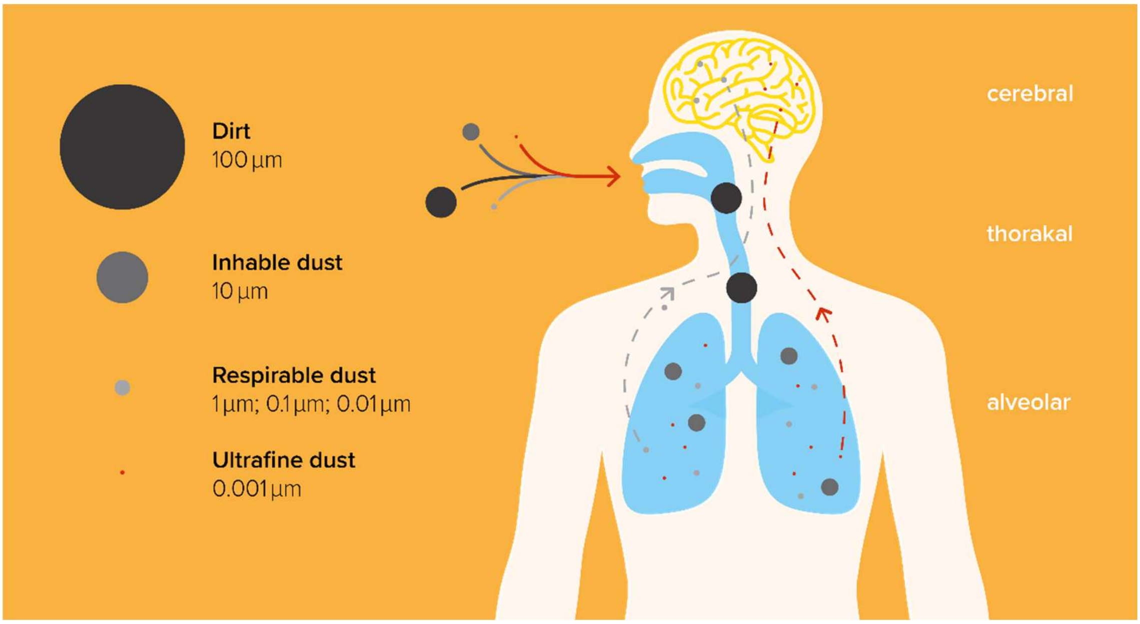
CONTENTS

1. Introduction

To mitigate the health risks represented by welding fumes, and by the related processes, it is essential to implement solutions to reduce exposure.

A clean and healthy working environment is essential for workplaces. The employer is responsible for the protection of his employees from hazardous substances and must take protective measures before activity begins. The aim is not only to meet legal exposure standards but to establish a healthy working environment which is increasingly a prior condition for keeping employees and attracting new ones.

Welding and the related metal working processes generate fumes consisting of airborne particulates that can be inhaled and that are respirable.



Depending on their composition, fumes can be harmful, toxic, or even carcinogenic. Components like Chromium (VI) or Nickel are considered as carcinogens and must comply with specific limit values.

In 2018 the International Agency for Research on Cancer (IARC) published Monograph 118, in which welding fumes were evaluated, and were reclassified as being in Group 1 (carcinogenic to humans) in general.

In November 2023, the Advisory Committee on Safety and Health at Work (ACSH) recommended that the EC adopt "Work involving exposure to fumes from welding processes containing substances that meet the criteria for CMR category 1A/1B set out in Annex I to the CLP regulation" as a new entry into Annex I under Directive 2004/37/EC. A final decision is expected in 2024.

With this document, EWA would like to provide as the most objective information possible about the generation of welding fumes and ways to reduce their release.

Further, measures for extraction, ventilation and the more extensive reduction of exposure risks are presented without being evaluated by comparison with each other.

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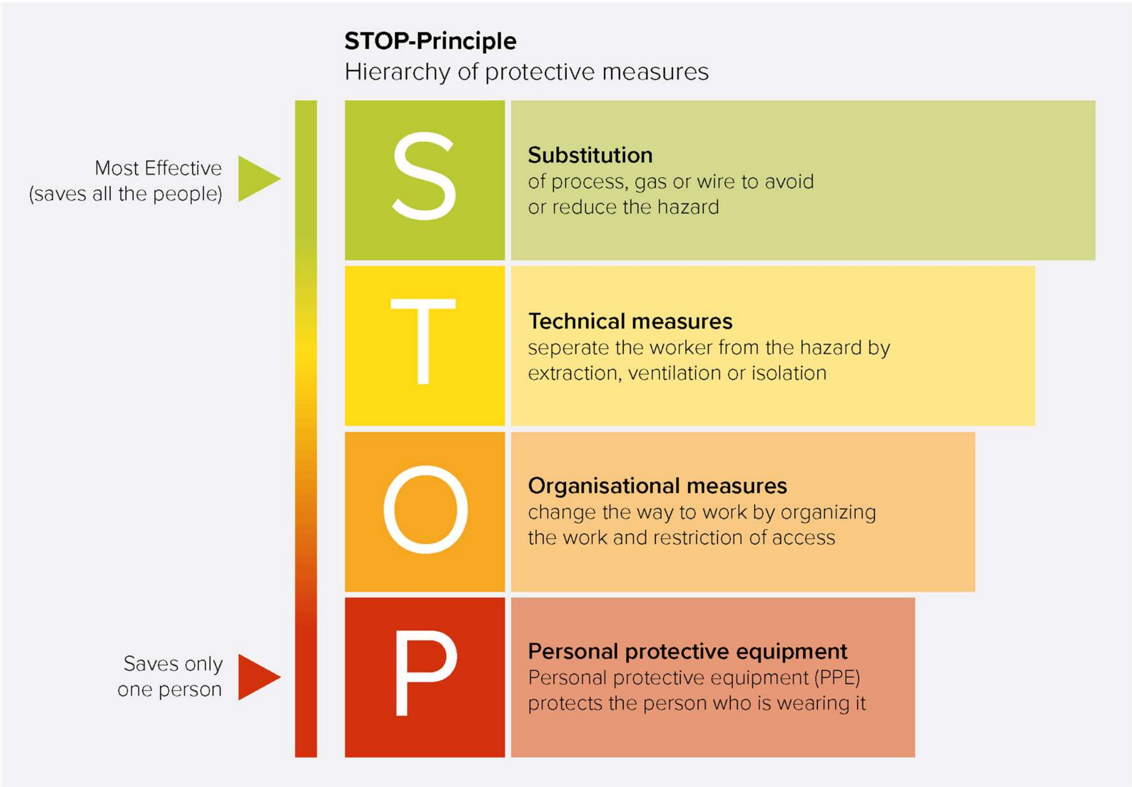
2. **STOP-Principle** (Prioritization of protective measures)

One of the biggest health risks facing a welder is the inhalation of welding fume. Measures that protect everybody in the workshop are preferable to those that protect the welder exclusively. That is why it is advisable to follow a certain sequence of measures using what is known as the "STOP" principle, applying as part of the legislation in some countries:

- **S**ubstitution of welding process, shielding gas, wire material or welding process parameters can reduce the generation of welding fume.
- **T**echnical measures like extraction or ventilation are the next possibility to prevent welding fumes from spreading in a room.
- **O**rganizational measures like spatial or time restricted access to welding areas or better preparation of work reduce the number of people at risk or even the generation of fumes.
- **P**ersonal protective measures like fresh air helmets protect exclusively the people who wear them.



3. Substitution

It is up to the employer to ensure that "Substitution" is used whenever is practically applicable and to facilitate the use of the healthiest welding process for the job.

The applicable process/material combinations with the lowest fume emissions must always be chosen when possible. Options for reduction of welding fumes by changing the process, its parameters, the composition of the shielding gas or filler material, are the keys to providing welder and environment protection and must be chosen at an early stage of the process.

To meet welding quality requirements, the first issue is that of choosing the right welding process. Various methods are available and can sometimes be automated. They range from MIG/MAG or TIG welding to oxy-fuel welding or resistance welding, and various arc processes such as stick welding,

The "healthiest" process for welders, related workers and the environment should be chosen whenever its practical use is possible as a means of limiting exposure to health hazards. Such processes should be considered, for example, when it is possible:

- To use optimized process parameters to create less fumes:
  - Regulated process variants (waveform control) such as pulsed arc welding or modified processes (e.g., controlled short arc) may generate less welding fumes compared to conventional processes
  - Avoiding transition area between a short arc and a spray arc
  - Metal transfer mode and temperature distribution
  - Optimal arc length
  - Avoiding spatter
  - Welding processes with digital controlled parameters
  - Look at the manual of the welding power source, ask the manufacturer

- To use a filler material with lower content in hazardous substances, e.g., manganese.
  Ask the manufacturer and/or welding engineer about possibilities and limits.

- To use a shielding gas with less active components (CO_2). Replacing shielding gas 82%Ar/18%CO_2 by 92%Ar/8%CO_2 can reduce fumes emission by 25%.
  Ask the manufacturer and/or welding engineer about possibilities and limitations.

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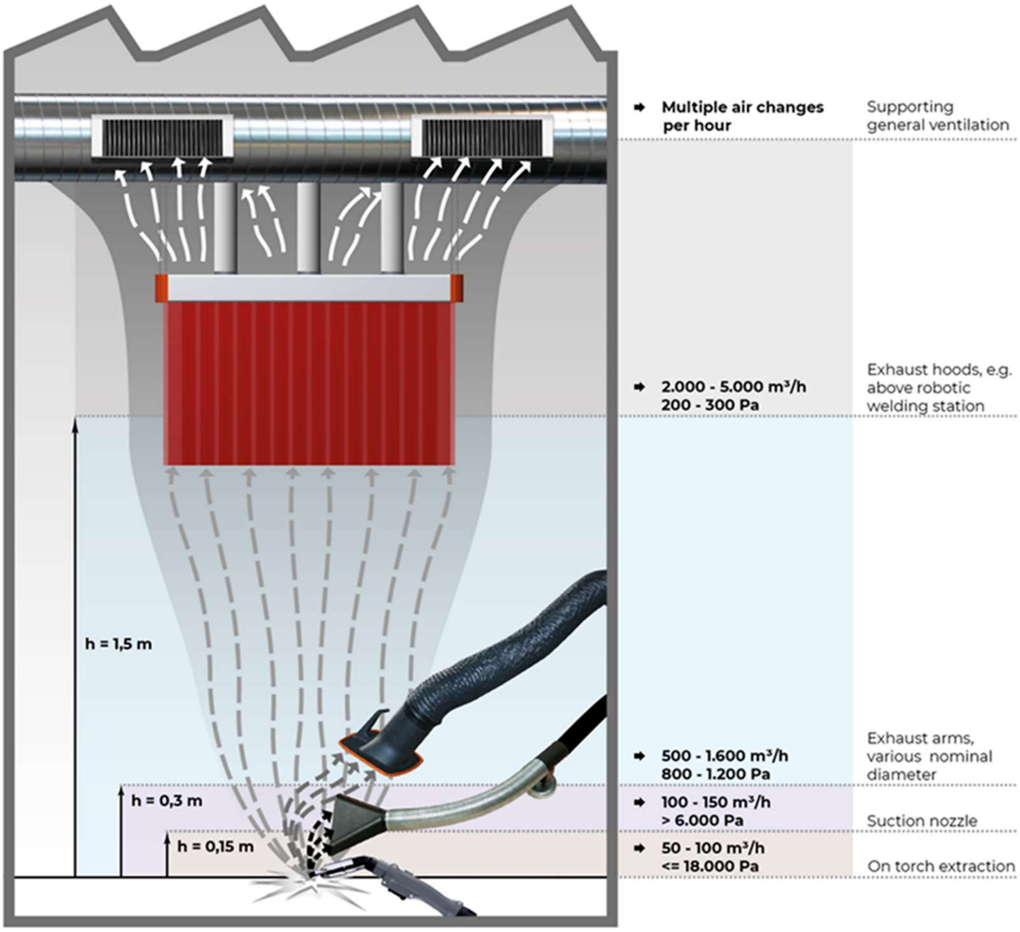
4. Technical measures

4.1. Extraction near the source, on torch, nozzles, arms

Technical measures using a capture device to extract the welding fumes directly near the emission point. The size of the capture area according to the measure and is always dependent on the minimum extraction volume, which must always be complied with.



4.1.1. On-torch extraction devices

There are 2 types of welding fume extraction torches. On the one hand, there are extraction torches with directly integrated extraction and on the other, there are also extraction sets that can be mounted on a standard torch.

The on-torch device can be connected to a single-point or a central filtering system.

Characteristics:

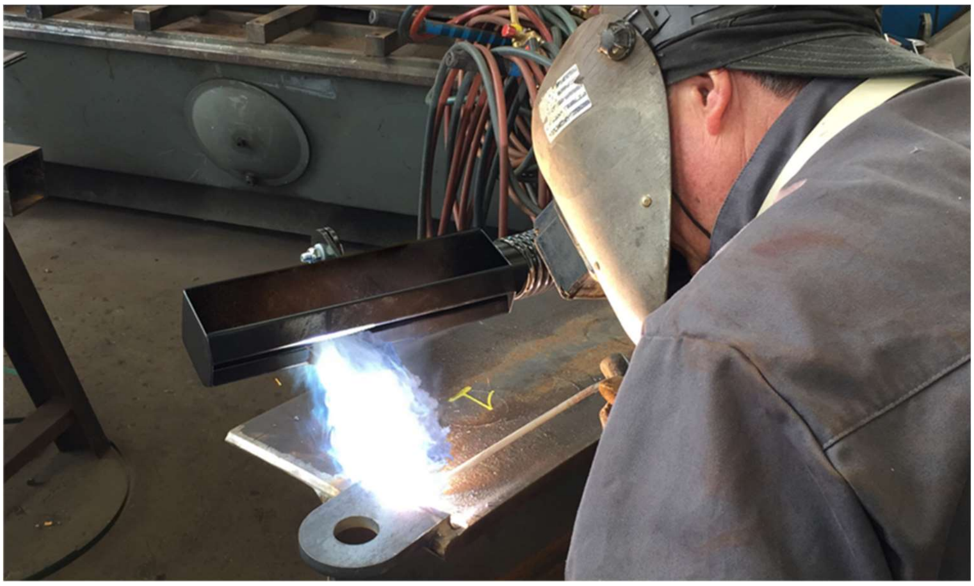
- By integrating the extraction nozzle with the torch, the extraction is always accessible and correctly positioned for optimal extraction efficiency. Hence, there is no need to separately reposition the extraction device.
- On-torch is the most efficient type of extraction as it is as close to the source as possible.
- Fume extraction torches are also used in robotic welding
- The extraction efficiency depends on the welding position.
- The achievable capture rate with an on-torch extraction system is influenced by extraction flow rate, torch geometry, welding position, torch inclination angle, welding direction (push or pull) shielding gas volume flow and contour of the workpiece.
- For a correct fume extraction result, the careful selection of the combination between the extraction torch and the suitable filtering device/system is essential.
- Following ISO 21904-1 "Health and safety in welding and allied processes – equipment for capture and filtering of welding fume" information about needed airflow rate and negative pressure should be given by the manufacturer on the nameplate of the torch.

4.1.2. Fume extraction nozzles

Fume extraction nozzles are typically fitted with a magnetic foot or clamp and placed close to the welding area. The extraction nozzle can be connected to a central system or a movable free-standing unit for welding fume separation (equipment with an integrated fan).

According to ISO 21904-1, nozzles need to be marked with the size of the extraction area and the minimum airflow. It is critical that the user is warned if the minimum airflow is not maintained by the system.

Typical flow rates are 100 m³/h to 150 m³/h at 5 kPa to 10 kPa and the nozzle is usually positioned at a distance of approximately 15 cm from the welding area.



Characteristics:

- Fume extraction nozzles are an efficient type of extraction as they are placed close to the source. Due to the relatively low extracted airflow, it takes less energy to heat or cool the facility if the air is not being recirculated.
- The distance from the welding torch to the nozzle is sufficient to ensure that there is no impact on the welding process. Neither is the nozzle in the way during work.
- The capture zone is limited, so that when welding larger seams, the nozzles need to be repositioned frequently in order to be effective and have a good capture rate.

4.1.3. Fume extraction arms

Flexible extraction arms consist of a tube with joints or a hose with a movable suspension system and an extraction hood for capturing the fume. A typical tube/hose diameter is 100 to 200 mm.

The extraction arms are either fixed, e.g., to a wall or a pillar as part of a local exhaust ventilation system or can be part of a movable free-standing unit for welding fume separation (equipment with an integrated fan).

According to ISO 21904-1, the hoods of exhaust arms need to be marked with the size of the extraction area and the necessary minimum airflow. It is critical that the user be warned if the minimum airflow is not maintained by the system.

Typical flow rates are 700 m^3/h to 1500 m^3/h at 800 Pa to 2 000 Pa and the hood is usually positioned 30 to 40 cm away from the welding area.

Characteristics:

- By virtue of the larger diameter, the suction field capture zone is significantly larger compared to a fume extraction nozzle. The capture rate is usually particularly good within this zone.
- Although the hood is positioned close to the source, extraction arms require higher airflow volumes than on-torch systems or nozzles. At the same time, the capture zone is larger.
- When working on larger objects fume extraction arms need to be repositioned frequently, following the welding process. This makes it necessary that the extraction hood can be moved easily and stays in its position.
- Its use may be difficult when working in confined spaces and alike.

Solutions without fume capture devices near the source are not legally permitted as the sole measure in some countries because they do not prevent welders from inhaling the fume. However, such general ventilation measures can be a worthwhile supplement to other solutions.

4.2. Extraction tables, enclosures, receiving hoods

If extraction near the source is not feasible, welding on an extraction table is a good option. With the welder in the flow of the incoming air from the room, weld fume is extracted from his breathing zone. The temperature causes the welding fume to rise, and it is advisable to place the extraction above the weld seam.

If the welding process is automatic e.g., done by a robot, it may be possible to use an enclosure for the robot. In this case the extraction system for the enclosure should be designed to ensure that no fume escapes.

In addition to the enclosure, receiving hoods are often seen above welding robots. This gives the robot full mobility while the welding fume rises and reaches the suction field of the hood.
To reduce cross-drafts or competing airflows from impacting the effectiveness of the hood, translucent colored weld curtains are often attached to the receiving hood.

4.3. General ventilation

Solutions without fume capture devices near the source are not legally permitted as the sole measure in some countries because they do not prevent welders from inhaling the welding fume. However, such general ventilation measures can be a worthwhile addition to other solutions.

Ventilation in the facilities can be natural or mechanical. Natural ventilation is through gravity forces or by wind.

In large space shop floors, the ventilation is through following mechanical methods:

- Push-Pull system
- Displacement system
- Diluter system

These systems are aimed at controlling and removing airborne containment to ensure optimal air quality and worker protection.

4.3.1. Push-Pull system

A push-pull system is a method of general filtration designed to prevent accumulation of welding or cutting fume in the workshop air and to reduce fine dust on the workshop floor.

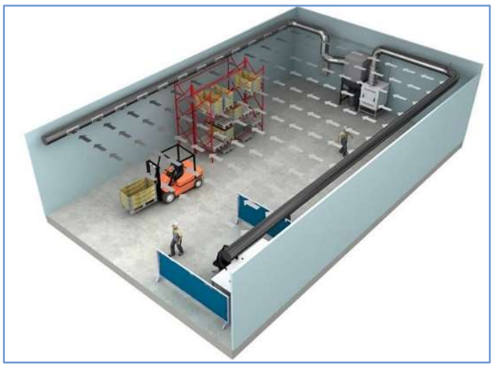
Welding fume consists of evaporated and condensed metal oxides and other particulate matter formed by the reaction with air. 90% originates from melting the welding consumable during the welding process.

The particulate matter has a high temperature, which starts rising then cools down. In this process it meets air at the same temperature, typically at a height of between 4-6 meters and forms a blanket of concentrated welding fume. After a while, the particulate matter will cool down and fall back to the floor or land on the machines.

The push-pull system typically consists of ductwork with grids, one or two fans and one or two filter systems. The ductwork is installed at a height facing the blanket of concentrated welding fume.
It consists of a push side, under positive pressure, and a pull side, under negative pressure, facing each other, in this way the welding zone is enclosed by the ducting.

Filtered air is blown out by means of the fan pushing the concentrated welding fume towards the pull side where it is extracted. The air with welding fume is filtered and recirculated back through the system thus creating an airflow. A push-pull system can be installed in a U shape or as a functional parallel system matching the size of the welding area.

Parallel system

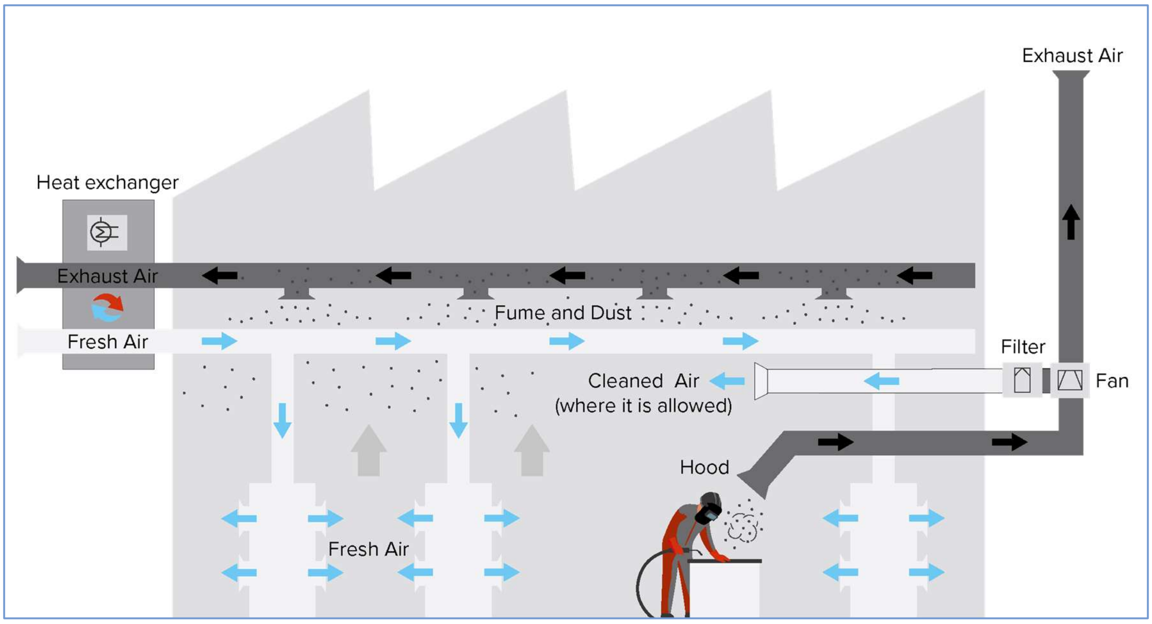


U-shape system

4.3.2. Displacement system

The displacement system operated based on the principle of temperature difference. Clean air typically with slightly lower room temperature are pushed from floor level and mixed with heated contaminated air. Under the influence of gravity force the mixed air will rise and be exhausted from the top.

Typically, the air supply (outlet) is located near the welding environment at floor level. Displacement systems are effective when the released contaminated air is warmer and lighter than the surrounding air.



4.3.3. Diluter system

Diluter ventilation is used to help prevent the concentration of containment. The system uses an exhaust fan to drive the air through inclined jets nozzles in the upper zone. The jet nozzles push the air supply at far higher velocities than in the occupied zone to prevent the buildup of undesirable odors in the air breathed in by the operators.

4.3.4. Controlling

In all the methods mentioned above, pressure losses in the filter will fluctuate with time and can influence the system efficiency. Mechanical ventilation systems are sometimes equipped with an air monitoring system to manage and optimize the energy consumption of the mechanical ventilation system. Air monitoring systems give you the benefit of:

1. Sensors to constantly control airflow through the ducting
2. Emission sensors to control air quality and especially to turn on the ventilation system where and when it is needed
3. Noise sensors to ensure that the noise created by a ventilation system is within the limit

5. Organizational measures

Organizational measures avoid or reduce health hazards for welders and other people nearby.

These measures include in particular:

- Training and information on possible hazard(s) and appropriate protective measures before starting work and on an annual basis (e.g., welding fume, radiation, electrical hazards, etc.).
- Organization of welding work (e.g., cleaning the surface of the workpiece, removing coatings, carrying out highly emissive activities at the end of the shift).
- Daily visual inspection and periodic control that the equipment is in good condition according to inspection plan (annual or time-interval depending on local regulations - in particular, intake, transport and filtering of hazardous substances) and that the desired protective effects are achieved.
- Only people necessary for the welding process should be in the welding fume hazard area. Personal, space or time restrictions are necessary to protect persons who are not employed in welding and related work. Anybody with employment restrictions is not permitted to enter the restricted area.
- Avoid unnecessary contact by stirring up settled welding fumes/dust particles. (e.g., vacuuming instead of sweeping, no eating at the workplace, putting on work clothes in an set-aside area).

6. Personal respiratory protection measures

Welding helmet with PAPR (powered air purifying respirator)

This particular version of the welding helmet combines a welding mask with an intelligent blowing system that sucks clean air from the back of the welder, filters it to eliminate welding pollutants and gases/vapors and drives it into the mask to be breathed by the welder.

PAPR should be used when:

- It is not possible to have an effective fume extraction system,
- It is not possible to comply with the limits prescribed by law.

When working in confined environments, a fresh air injection system from outside, must be used to guarantee the correct oxygen level.

PAPRs must comply with harmonized standards EN 1294.

Typical composition of this personal protection equipment (PPE) is:

- a helmet or hood with UV filter,
- a turbo unit designed to be carried / worn by the welder and to provide him with filtered fresh air,
- one or more filters,
- exhalation valves or other outlets, depending on the structure, through which the exhaled air and the air exceeding the user's requirements is discharged.

These devices are classified as TH1, TH2 and TH3.
For welding applications, they are usually classified as TH3 category.

Main characteristics of welding helmets with PAPR:

- Usually PAPR for welding is auto-darkening and it has a flip-up function or a bright anti-glare cassette in the open state.
- It is designed to provide protection against harmful UV and IR radiation for all welding processes.
- Typical PAPR air-flow range is from 160 l/min to 200 l/min.
- All PAPRs include an indication of the battery level and two alarms in case the flowrate drops too low: a sound and a vibration.
- PAPRs are powered by battery, usually lithium.
  Typical duration of use is in the range of 6 - 8 hours

In general, the following applies:

"For all kinds of protection and preventive measures, always also refer to the National Regulations"

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