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VENTILATION SYSTEMS AT FCAW

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Abstract: Flux cored arc welding (FCAW), by its specificity, requires usage of advanced forced ventilation systems, adapted to its particularities. Regulations in the field through the IIS/IIW Documents, are taken by enterprises with specific preoccupations, and are considered fundamental when designing equipments and also when adapting devices that use flux cored wire. Emission measurements results during FCAW are an important factor to be considered when choosing the proper ventilation system, together with specific measurements necessary to protect the human operator.

1. INTRODUCTION

Year after year, the industrial usage of flux cored wire has increased. The quality of these products, evolved constantly during the last years, both in terms of operation and reliability. An important issue is the constant of mechanical characteristics (deposited metal) and chemical composition of the welded joints.

Nowadays, metallurgical quality given by the coated electrodes can be achieved, combined with the high productivity compared with the regular welding wires.

The principal standards regarding the flux cored wire are: EN ISO 17632-A, EN ISO 17634-A, EN ISO 18276-A, AWS SFA – 5.18, AWS SFA – 5.20, AWS SFA – 5.29, AWS SFA – 5.22.

Among the characteristics of tubular wires, there are:

- Easy to manipulate
- High deposition rate, particularly for welding vertical ascendant,
- Good aspect of the deposited material,
- Ideal for the root layer, ceramic support KERALINE are recommended;
- Used with gases: CO_2 or Mix gas (Ar/CO_2 - 80/20).

During the FCAW welding process, fume is generated which may contain hazardous substances de-pending on the basis material and the consumables. These substances can be inhaled by the welder if not removed from his breathing zone.

Therefore welding fume extraction devices are used to protect the welder against said substances. In order to test the efficiency of the welding fume extraction devices test regulations have to be developed. The test result is of interest for the manufacturer, user and health and safety experts.

2. NOXES LIMITS AT FCAW

The influence of the welding process on the emission rate has been measured. Table 1 presents comparatively the results of emissions tests measurements during different welding processes.

Table 1 Results of emission measurements during different welding processes [2]

Welding process		Emission rate (mg/s)
Manual metal arc welding covered electrodes (MMA)		4-18
MAG	With solid wire	2-12
	With flux cored wire and shielding gas	6,7-54
	With self-shielded flux-cored wire	up to 97

The influence of electrode and electrode wire on the fume generation during welding has been studied, concluding that larger amounts of welding fume are generated when MIG/MAG welding with flux cored wire electrodes than when using solid wire electrodes [2].

The use of self-shielded flux-cored wire electrodes generates considerably higher welding fume emissions than the use of flux-cored wire electrodes under shielding gas. For example, MAG welding of unalloyed and low-alloy steel gave the emission rates presented in table 2.

Table 2 Welding fume emission rate depending on the electrode wire [2]

Filler metal	Welding fume emission rates (mg/s)
Solid wire	2-12
Flux-cored wire with shielding gas	6-54
Self shielded flux-cored wire	up to 97

In principle, the flux core of the wires contains components similar to those in the covering of a corresponding electrode. Depending on the type of filler metal, the constituents of the welding fume are presented in table 3.

Table 3 Correspondence between filler metal of the wire-welding fumes [2]

Filler metal	Welding fume emission rates (mg/s)
Unalloyed/low-alloy basic flux-cored wire (with shielding gas)	Manganese oxide
High alloyed flux-cored wire	Chromium (VI) compounds
Unalloyed/low-alloy self shielded flux-cored wire	Manganese oxide or barium compounds (depending on the filler wire)

The welding fumes concentration is subject to compliance with the key component and therefore depends on:

- The process and material;
- Chemical composition of the welding fume;
- Concentration of the key component in the welding fume and its limit values.

For all processes, where compliance with the valid air limit value for welding fume or the respirable fraction of the dust is not possible – in spite of ventilation measures – in certain areas, as confined spaces as well as other areas with low/insufficient air exchange, additional protection measures such as organisational measures and use of personal protective equipment are necessary [2].

For carcinogenic substances, is specified the minimisation obligation according to the hazardous substances ordinance applied. Table 4 presents a few limit values for the fume concentration depending on the welding process.

Table 4 Limit values for the fume concentration depending on the welding process [2]

Process	First key components	Limit value of key component	Welding fume concentration when complying with the limit value of the key component
MMA with high alloy covered electrodes	Chromium (VI) components	0,1 mg/m^3	1,7 mg/m^3
MIG welding with nickel base filler metal	NiO	0,5 mg/m^3	1,0 mg/m^3
FCAW	Manganese oxide	0,5 mg/m^3	2,5 mg/m^3

3. DESIGN PRINCIPLES FOR THE VENTILATION SYSTEMS

The efficiency of a ventilation system is related to the welding fume extraction device and the extraction device which is positioned next to the emission source.

If the extraction device is positioned in the wrong way, the separation efficiency can be 100 % but the welder is treated with the welding fume which is not captured.

The relevant quantity to be measured is the minimum air flow rate. This value is specific for the geometry of the given extraction device. It is determined by measuring the air velocity in direction towards the extraction de-vice. This velocity has to be equal or higher than 0,4 m/s rectangular in the centre line of the extraction device and in a given distance. The distance is related to the cross sectional area of the extraction device. For the different shapes and cross sectional areas the distances are listed in table 5.

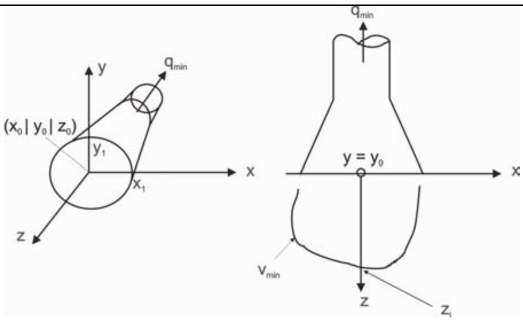
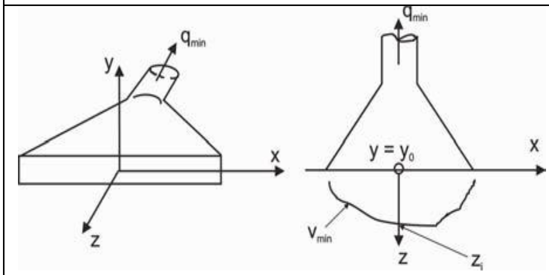
For extraction devices with a circular or elliptical cross section the standard differentiates three cross sectional areas. Related to these areas there are three different distances where the air velocity is measured. For rather slot shaped extraction devices the standard has only two cross sectional areas to separate.

In order to test the minimum flow rate of an extraction device several parameters have to be set. First of all the measurement point(s) have to be defined. In the beginning a set of five measurement points were discussed which were located at the ends and in the centre of a rectangular cross. The air flow rate through the extraction de-vice had to be so high that an air velocity of 0,3 m/s could be measured at all five points. The air flow rate of 0,3 m/s is required as minimum air velocity to draw the welding fume towards the extraction device.

In nearly all cases an air velocity of 0,3 m/s at the end point of the cross corresponded with an air velocity of 0,4 m/s at the measurement point in the origin of the cross. The effort of the test could be reduced by measuring only an air velocity of 0.4 m/s at the point in the centre line of the extraction device.

In order to achieve the minimum flow rate at an air velocity of exact 0,4 m/s a set of three measurements with air velocities of approximately 0,3, 0,4 and 0,5 m/s are carried out. The minimum flow rate can be determined from the air velocity/flow rate diagram at the air velocity of exact 0,4 m/s. The test was established because of the possible instability of the air velocity. By choosing this procedure an exact value can be determined.

Table 5 Test conditions – minimum air flow rate [4]

Type of hood or nozzle - schematic layout	Aspect ratio x_1/y_1 (with $x_1 > y_1$)	Cross sectional area of the entry plane (cm²)	Distance from the entry plane to the measure-ment point (mm)
	$1 \le (x_1/y_1) \le 4$	a) < 70 b) 70-200 c) >200-1000	a) 110 b) 200 c) 250
	$(x_1/y_1) > 4$	a) < 70 b) ≥ 70	a) 100 b) 150

There are several advantages of tested extraction devices. First of all the manufacturer can design his welding fume extraction system more specifically. Each extraction device has its own minimum flow rate so that the welding fume extractor can be built according to this value. The second aspect is the user/client who buys different extraction devices for different welding situations. He knows from the data on the extraction device that he can connect the extraction device to his welding fume extraction system and will get a system that is working in the specified way. As third group profiting from a tested and marked extraction device are health and safety experts because they can easily control the function of the welding fume extraction system including the extraction device.

4. REGULATIONS OF THE INTERNATIONAL INSTITUTE OF WELDING IIS/IIW

There are studies and researches that have as research object the development of tubular wires, for specific applications of different beneficiaries. There are constant preoccupations of the International Institute of Welding (IIS/IIW) in the field. When using welding guns with immediate noxes absorption, IIS/IIW through the Documents of the Commission VIII offers a general classification of such components, figure 1. General criteria to be taken into account include:

- suction field (speed);
- range of flow range collection;
- noxes evacuation devices.

The necessity to eliminate noxes at FCAW leads to finding solutions to protect the operator using noxes evacuation systems.

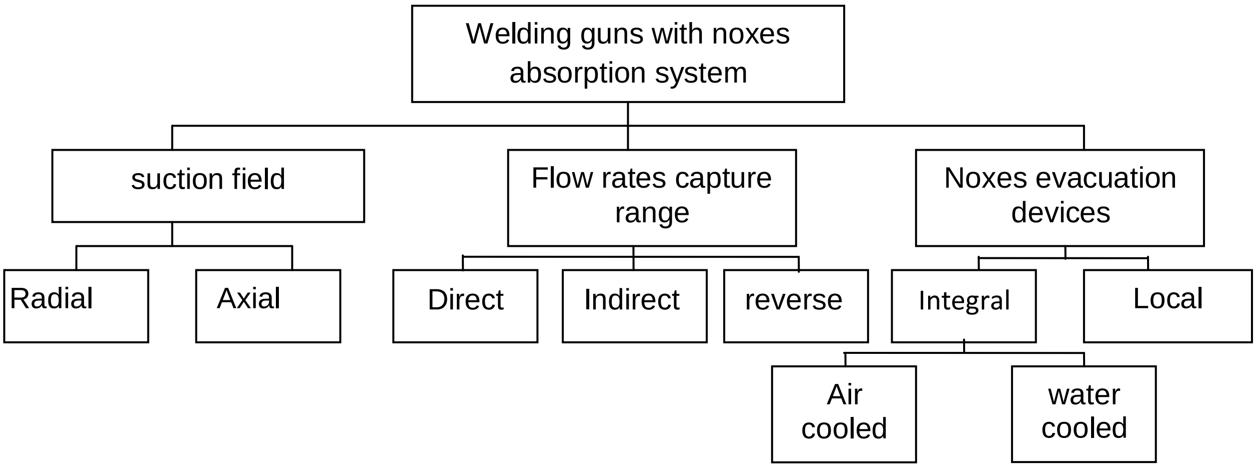


Figure 1. Welding guns with immediate noxes absorption systems (IIS/IIW DOC)

Figure 2 presents a few constructive variants for welding guns with noxes absorption, offered by producers with experience in the field.

K289- 500 Ampers at 60% DA, wire diameter 3.0-5.6 mm

K206- 350 Ampers at 60% DA, wire diameter 1.6-2.4 mm

K126- 350 Ampers at 60% DA, wire diameter 1.6-2.4 mm

Figure 3. Constructive variants for welding guns with noxes absorption

5. CONCLUSIONS

5.1. The problems regarding environmental protection at flux cored arc welding are presented in the paper, at the level of regulations emitted by the European Community.

5.2. The problems regarding the noxes according to occupational hazard international orhganisms are presented also.

5.3. All the presented data require special attention regarding the usage of FCAW process, considering the quality and productivity issues.

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