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Emission of Fume, Nitrogen Oxides and Noise in Plasma Cutting of Stainless and Mild Steel

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Abstract: The amount of fumes and gases in plasma cutting operations depends on dry or wet cutting, cutting speed, plate thickness, alloy contents, design of cutting table, choice of gas and ventilation conditions. A "comparable" method has been used to measure in an exhaust channel the total emission of airborne fumes and nitrogen oxides in different cutting tests. Noise levels were also determined.

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Emission of fume, nitrogen oxides and noise in plasma cutting of stainless and mild steel

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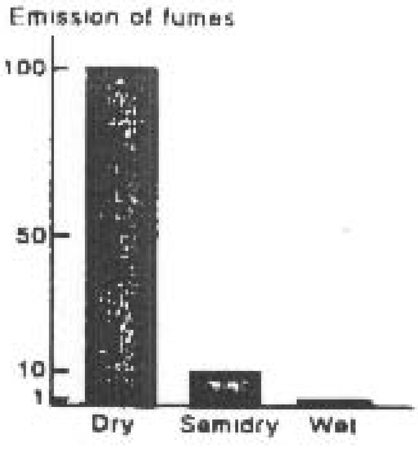
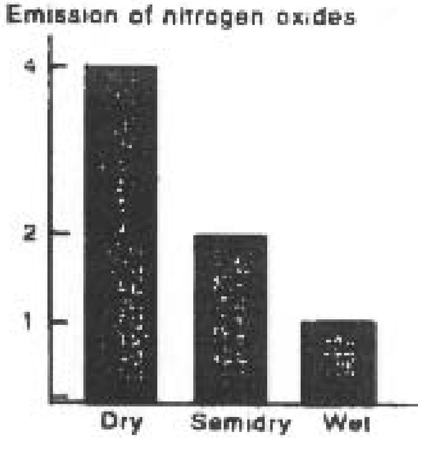
The amount of fumes and gases in plasma cutting operations depends on dry or wet cutting, cutting speed, plate thickness, alloy contents, design of cutting table, choice of gas and ventilation conditions. A "comparable" method has been used to measure in an exhaust channel the total emission of airborne fumes and nitrogen oxides in different cutting tests.

Cutting tests were performed in 8 mm thick mild steel with air and oxygen as plasma gases and in 8 and 35 mm thick stainless steel with air and nitrogen as plasma gases. All cutting tests used a current of 200 Ampere and air as shielding gas. The cutting speed varied between 2,7 m/min and 4,5 m/min for 8 mm plate thickness and from 0,3 to 0,45 m/min for 35 mm thickness. All cutting tests were repeated 2 or 3 times with measurements of fumes and nitrogen oxides.

Three different cutting techniques were used:

- Dry cutting
- Semidry cutting (water about 50 mm under the plate)
- Wet cutting (the burner 70 mm below the water surface)





The investigation showed that the three different cutting techniques gave a constant ratio between the amount of emitted fumes of 100:10:1 (dry = 100, semidry = 10, wet = 1). Similarly there was a constant ratio between the amount of emitted nitrogen oxides of 4:2:1 for dry, semidry and wet cutting. These relationships are valid both for mild and stainless steel.

Emission of fumes in plasma cutting of mild and stainless steel			
Material, thickness	**Dry** (g/min)	**Semidry** (g/min)	**Wet** (g/min)
Mild steel, 8 mm	20 - 26	2,0 - 4,0	0,1 - 0,4
Stainless steel, 8 mm	30 - 40	3,6 - 4,6	0,2 - 0,5
Stainless steel, 35 mm	1,8 - 3,4	0,1 - 0,3	0,02

The emission of fumes in 8 mm thick mild steel and 8 mm stainless steel were about the same. In 35 mm stainless steel the emission of fumes were about 10 times lower, at the same time as the cutting speed was about 10 times lower. The components in fumes from mild steel were metal oxides with 67 - 73 % iron, 2 - 10 % manganese and copper from not detectable to 1,4 %. Chromium, nickel and molybdenum were in most samples not detectable. The metal contents in stainless steel cutting varied for iron between 38 - 44 %, chromium 12 - 20 %, nickel 4 - 8 %, (uncertain figures manganese 4 - 10 %, copper 2 - 6 % and up to 1 % molybdenum). The composition was about the same independent of plasma gas, plate thickness and cutting speed.

Dry cutting in mild steel with oxygen as plasma gas gave an emission of fumes 25 % lower compared to air as plasma gas.

Emission of fumes expressed as % of the total amount of material removed by cutting			
Material, thickness, cutting speed	**Dry** (%)	**Semidry** (%)	**Wet** (%)
Mild steel, 8 mm, 3,5 m/min	5,0	0,5	0,05
Stainless steel, 8 mm, 3,5 m/min	7,0	0,7	0,07
Stainless steel, 35 mm, 0,375 m/min	1,0	0,1	0,01

The cutting kerf width in 8 mm plate thickness was 2 - 3 mm and 3 - 4 mm in plate thickness of 35 mm. The amount of emitted fumes expressed as % of the total amount of material removed by cutting can bee seen in the table above. For dry cutting in 8 mm plate thickness about 95 % of the material removed by cutting will remain in the cutting table. The corresponding amount for wet cutting in 35 mm thick stainless steel will be 99,99 %.

Exposure measurements of fume, gases and noise

Exposure measurements of fumes, gases and noise in plasma cutting in stainless steel were performed at a company with two plasma cutting tables in the size of 18 * 4 m. The cutting was carried out semidry with the water level 25 mm below the plate´s lower surface. Measurements were performed in three cutting periods during a total time of 3,5 hours.

Respirable and total concentration of fumes were below the exposure limit values for fume in the exposure measurements. During 1,5 hours of intensive cutting at one of the cutting machines the concentrations of chromium and nickel on the operator exceeded the exposure limit values. At the same time cutting at the other machine gave the operator a 50 % lower exposure level of chromium and nickel although cutting conditions were equivalent. The differences probably depend on the operators position related to the plasma torch and on draught in the local environment, which affects the direction of the plume of fume, rather than minor differences in material and plasma gases.

Exposure measurements of nitrogen dioxides showed relative low exposure levels. The highest level 0,4 ppm was measured on the operator who also was exposed to the highest levels of chromium and nickel. With a direct reading instrument 2 ppm nitrogen dioxide was measured for short periods in the operators breathing zone. Ozon and carbon monoxide were in all tests close to zero.

The sound pressure level at the place of the operator was for semidry cutting in 90 mm thick stainless steel 108 dB(A) with a broadband spectrum without any elements of pure tones. The upper band of frequencies dominated the dB(A) value.

The sound pressurq level at the place of the operator for semidry cutting in 10 mm thick stainless steel was 103 dB(A). Personal exposure measurements for a period of 2½ hour showed a mean value of 98 dB(A) for the operator. The background noise varied between 68 and 85 dB(A).

Although the measurements were not performed during a whole working shift and therefore not can be compared to the exposure limit values, the results indicate that some actions should be taken in order to decrease the exposure levels.

After this measurement the company has installed an exhausting device close to the torch and slots exhausting devices under the portal girder on the machine where the highest exposure levels were measured. On the other plasma machine the walls at the cutting table have been raised in order to perform wet cutting.

Emission of nitrogen oxides			
Material, thickness	Dry (l/min)	Semidry (l/min)	Wet (l/min)
Mild steel, 8 mm	4,4 - 5,5	2,4 - 3,1	0,5 - 1,6
Stainless steel, 8 mm	4,1 - 5,4	2,2 - 2,7	0,9 - 1,4
Stainless steel, 35 mm	7,0 - 7,8	3,2 - 4,6	1,7 - 2,2

The amount of emitted nitrogen oxides increased with increasing thickness of plate. Cutting in 35 mm stainless steel increased the emission almost twice compared to cutting in steel of 8 mm thickness. The emission of nitrogen dioxide (NO_2) was about 7 - 8 % of the total emission of nitrogen oxides (NO and NO_2). Dry plasma cutting in stainless steel with nitrogen as plasma gas gave 20 % lower emission of nitrogen oxides compared to when air was used.

A few samples of the fume have been analysed for size distribution in a scanning electron microscope. Even if each particle was small, $<< 1\ \mu m$, most of the particles aggregated to bigger units. In semidry cutting those aggregates seemed to create regularly spheres with a diameter of about 11 μm. In dry cutting the aggregates were bigger, while wet cutting gave aggregates of more irregular form and a diameter less than 10 μm.

Emission of noise		
Cutting technique	Water level above the plate (mm)	Sound pressure (dBA)
Dry	- 250	98
Semidry	- 48	103
Semidry	- 25	103
Semidry	0	100
Wet	+ 25	92
Wet	+ 50	78
Wet	+ 75	71

Wet cutting considerably decreased the emission of noise compared to dry cutting. A reduction of the sound pressure (noise level) with 30 - 40 dB(A) was possible for the region of high frequencies, where the sound pressure seemed to be very irritating. The water level should be at least 75 mm above the plate in order to give this reduction.

PLASMA CUTTING (Compressed Air) FOR STAINLESS PLATE DATA

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TECHNICAL DEPT.

Type Plate (Stainless)	Current	Travel Speed (l.p.m.)	Plate: Start Wt.	Plate: Final Wt.	Plate: Dross Wt.	Plate: Actual Wt. Loss (grams)	Fume: Filter Start Wt.	Fume: Filter Final Wt.	Fume: Filter Wt Gain (grams)	Fume: Test Time (min.)	Fume: F.G.R g/min
304L (1/2" X 6" X 10")	63A										
310 (1/2" X 6" X 10")	63A	6.3	4465.5	4412.0	28.7	24.4	13.16	13.32	.16	.65	.25

310 Stainless

PLATE CHEMISTRY

%C	%Mn	%Si	%S	%P	%Cr	%Ni
.029	1.14	.62	<.003	.021	25.4	19.6

FUME CHEMISTRY

%Fe	%Mn	%Ni	%Cr(sol) VI	%Cr(insol) VI	%Cr(non) VI	%Cr(total) VI
25.4	4.4	10.3	.42	.77	19.0	20.2

304L Stainless

PLATE CHEMISTRY

%C	%Mn	%Si	%S	%P	%Cr	%Ni
.019	1.77	.45	.016	.030	18.2	8.2

FUME CHEMISTRY

%Fe	%Mn	%Ni	%Cr(sol) VI	%Cr(insol) VI	%Cr(non) VI	%Cr(total) VI

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