# EXPOSURE TO RADIOFREQUENCY (RF) IN INDUSTRY. EXAMPLES OF MEASUREMENT AND IMPROVEMENT.

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## Introduction

During the last 20 years in Italy there has been a progressive increase in industrial use of radiofrequency equipment for heating materials, thus creating serious problems in terms of health-risk assessment for the workers involved and in terms of setting up procedures and standards for prevention (2,7,8,9,12). It has recently been estimated (1985) that in Italy there are about 8000 apparatuses with approximately 12000 exposed workers mainly in the plastic, wood and metal-working industries (9). In the Occupational Health Institute of Milan a specific group has been dealing with RF apparatuses in industry since 1980 with a view towards occupational exposure, equipment improvement and medical surveillance. This paper reports the measurement results so far, some of the most meaningful equipment improvements, and considerations about the way and materials to be used when designing RF equipment improvement.

## Methods

Measurement of electric (E) and magnetic (H) field strengths was performed with an Aeritalia instrument model TE307 equipped with isotropic balanced sensors and a model TE308 optical fibre remote repeater(1). The survey on every piece of equipment was devided into three phases:

1) study of the technical features of the machine and of the characteristics of the working environment;
2) analysis of the tasks and exposure times;
3) measurement of radiation levels at the work station and comparison of results with international standards and the proposed Italian standards (1982) for maximum values of electromagnetic fields at the work place (4); when needed, the measurements were repeated after the improvement.

## Results

The survey results of the Occupational Health Institute of Milan are shown in Tab.1. Electromagnetic field average values, standard deviations and ranges are reported with reference to the work place for both metal-engeneering and plastic/wood industries. Table 2 illustrates the results of an improvement on a metal-working apparatus. Table 3 reports electric and magnetic field strengths for an unshielded machine and for a shielded one with the same main characteristics in the plastic industry.

## Discussion

From Table 1 it can be seen that workers' exposure varies greatly depending on type of application, device power, electrode shape, source-worker distance and, mostly, on whether or not some proper shieldings have been implemented; these results are compatible with those of other authors (5,6,11). Table 2 and 3 show that, even where electromagnetic fields are very high, a successful improvement can be carried out.

Result analysis of the improvement measures confirms, in agreement with other authors (3, 10) that the factors influencing the shielding efficacy are:

1) the metal shielding material used: at low frequencies, f $<$10 MHz, stainless steel or copper is recommended;
2) the shielding surface: the greater the surface, the greater the efficacy of the screening device; if the shield is made out of wire netting, it should be kept in mind that the larger the mesh the lower the efficacy of the screening device;
3) the thickness of the shield: efficacy increases with the thickness of the shield;
4) distance between the shield and the source: the shield must be installed as far as possible from the source;
5) grounding of the shields and metallic surfaces that can transmit the electromagnetic field at a distance must be separate and of suitable size according to the frequency of use.

Finally it has to be pointed out that:

a) generally, the material needed for the improvements is cheap and easy to use even on equipment that is already installed;
b) when suitably designed and implemented, the improvements permit the electromagnetic field to be kept within the most stringent limits required by international regulations.

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TAB. 1 - Technical characteristics and exposure values at the workplace. 137 RF apparatuses.

| TECHNICAL CHARACTERISTICS | | METAL-WORKING ENGINEERING | PLASTIC and WOOD INDUSTRIES |
|---|---|---|---|
| Number of apparatuses | | 80 | 57 |
| Frequency range (MHz) | | 0,3 - 2 | 13,6 - 29 |
| Power range (kW) | | 1,5 - 600 | 0,5 - 25 |
| Electric field (V/m) | average value | 38 | 103 |
| | standard deviation | 157 | 192 |
| | range | 2 - 2150 | 2 - 850 |
| Magnetic field (A/m) | average value | 1,96 | 0,18 |
| | standard deviation | 3,47 | 0,64 |
| | range | 0,02 - 33 | 0,02 - 1 |

TAB. 2 - Metal engineering industry: horizontal metal tempering. Electric and magnetic field values before and after improvement (f = 300 kHz, P = 18 kW)

| MEASUREMENT POSITION | INITIAL VALUES | | VALUES AFTER IMPROVEMENT | |
|---|---|---|---|---|
| | E (V/m) | H (A/m) | E (V/m) | H (A/m) |
| Eyes | 2150 | 33 | 36 | 1,5 |
| Trunk | 860 | 14,5 | 31 | 0,7 |
| Gonads | 430 | 5,9 | 46 | 0,5 |
| Transit area | 130 | 0,3 | 9 | 0,05 |
| Adjoining work stations | 25 | 0,05 | 1 | 0,05 |

TAB. 3 - Plastic industry: welding of plastic materials. Values of electromagnetic field for non-shielded and shielded machineries (f = 27 MHz; P = 12-18 kW)

| MEASUREMENT POSITION | NON-SHIELDED MACHINERY | | SHIELDED MACHINERY | |
|---|---|---|---|---|
| | E (V/m) | H (A/m) | E (V/m) | H (A/m) |
| Eyes | 800 | 0,30 | 42 | 0,18 |
| Trunk-gonads | 600-700 | 0,60 | 38 | 0,32 |
| 120 cm from electrodes | 220 | 0,30 | 20-22 | 0,02 |
| 200 cm from electrodes | 75 | 0,20 | 8 | < 0,02 |