

Measurement of Magnetic Fields Emitted From Welding Machines

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Abstract

The electric arc welding process makes use of the heat produced by the electric arc to fusion weld metallic pieces. The aim of this work is to determine the electromagnetic field strength emitted by different electrical welding machines at different ranges and identify the safe ranges in order to avoid its negative health effects on the welder body. The research has been performed in two parts, mathematical calculations and practical measurements using portable (EMF-827) field tester. Both measurements indicate that these exposure levels lie within permissible international standard limits , but in some very close to the torch the values of magnetic filed are above the standard permissible values, so there is no harm to human health if the exposure is for an intermittent and discontinuous periods.

Key words: Electromagnetic field, Health effect, welding machine.

Abbreviations:

- 1- DNA : Deoxyribonucleic Acid
- 2- EMF : Electromagnetic Field
- 3- ELF : extremely low frequency
- 4- EER : Energy Efficiency Ratio
- 5- ICNIRP : International Commission on Non-Ionizing Radiation Protection
- 6- WHO : World Health Organization

1-Introduction:

Electromagnetic fields are present everywhere in our environment but are invisible to the human eye, there are natural sources and man made sources of EMF such as the electricity that comes out of every power socket associated with low frequency electromagnetic fields. EMF in highly levels exist in work places usually near all electrical equipment including arc and resistance welding machines and leads, electric cranes, even photocopiers are sources of magnetic fields. In welding, strong magnetic fields can be produced close to the power source and the current-carrying cables, and these cables are often close to or touching the welder's body[1].

In addition to direct effects of EMF exposure and interaction of the fields with the human body, magnetic fields are created when electric current flows .the greater the current, the stronger the magnetic field. So ,the strength of the magnetic field will vary with power consumption. Exposure to strong electromagnetic fields can cause harmful health effects, so limits and guidelines for human exposure are set by WHO to prevent a negative health effects to human body due to exposure to the EMF fields [2,3] .This research will focus on the measuring the EMF levels in the vicinity of the welding torch and cables near the welder in the work place and determine the safe ranges from the torch.

1.1 Background

In arc welding machine one electrode is the welding rod or wire, while the other is the metal to be welded. The arc is started by momentarily touching the electrode on to the plate and then withdrawing it to about 3 to 4 mm from the plate. When the electrode touches the plate, a current flows, and as it is withdrawn from the plate the current continues to flow in the form of a spark across the very small gap first formed. So, arc welding uses high electric currents up to some hundreds of Amperes which flows through the torch-cable, into the work-place and back to the power source through the ground cable. So, current flows in the welding and cutting machines produce magnetic fields around all parts of the welding circuit; the most relevant exposure of the welder is to be expected where the torch-cable be close to his body. As the distance to the body of the welder is a minimum for the torch cable and also the lowest gradient is applicable for this type of field source, this part of the welding circuit represents the most relevant exposure situation. [4].

1.2 literature review

Investigation of electromagnetic fields emitted from welding and cutting machines have given rise to discuss in both public and scientific communities for many decades. Some researches in this field are :

- In a study of electrical workers, Bowman et al (1988) took spot measurement at extremely low frequency (ELF) below 100Hz, adjacent to eight TIG welders. The magnetic fields measured were relatively low compared to those reported by other researchers at 2.4-9.0 μT (mean) for AC TIG and 0.4-1.6 μT (mean) for DC TIG. No values for the welding currents were given.[5]
- The study carried out by Stuchly and Lecuyer (1989) shows that the measurements at 10 cm away from the operator's body, magnetic fields up to 200 μT , 300 μT and 400 μT were measured at the welders head, chest and waist respectively and up to 1000 μT at the welders hand, due to holding the welding torch or electrode holder. Measurements were also conducted at 10cm away from the welding cables. The maximum magnetic field measured at 10cm from the welding cable was in level of 1256 μT , which is about three times of the ICNIRP reference level at 50Hz [6].
- Allen (1994) also achieved some measurements which were carried out by the NRPB on a TIG welder. Magnetic fields of 100-200 μT were measured at the operators position, 100 μT close to the power supply and 1000 μT at the surface of the welding cable.[6]
- Skotte and Hjollund (1997) assessed exposure to ELF magnetic fields of welders and other metal workers and compared exposure from different welding processes. Measurements were carried out over the working day using personal exposure meters attached to a belt. Some measurements were also made for short durations 1cm away from the welding cables.[7]

2-Biological effects of EMF:

Welding and cutting arcs produce electromagnetic radiation. The radiation potential effect on the body depends on the type and intensity of radiation, the distance from it and the duration of exposure.[8]. Time varying magnetic fields induce eddy currents in the structure of conductive material. The published average conductivity of living tissues is about 0.2 S/m, which is sufficiently high to create relevant currents in body tissues. These currents, flowing through the cross-sections of the body and characterized by the resulting current density J, usually expressed in mA/m². Cells may be stimulated by these currents if their amplitude is high enough, the time duration of the induced current exceeds the "response time" of the cell and the rise time of the excitation is faster than an established threshold value. so, the workers must be aware of potential risk and to take appropriate precautions [9].

studies up to dates have not answered questions about possible human health effects. These studies are, however, providing clues about how EMFs interact with basic biological processes. The cell membrane may be an important site of interaction with induced currents from EMFs. However some of these effects are:

1. Changes in functions of cells and tissues
2. Decrease in the hormone melatonin
3. Alterations of immune system
4. Accelerated tumor growth
5. Changes in biorhythms
6. Changes in human brain activity and heart rate [10].

3- Research methodology

In this research there have been two methods of determining the levels of EMF ,the mathematical calculations and the practical measurements.

3-1- Mathematical calculations:

The value of magnetic flux density (B) which depends on the distance from the source and the amount of current that flowing through the device can be calculated using Amperes law as follows[11]:

$$B = \frac{\mu_0 I}{2\pi r} \dots\dots\dots (1)$$

Where:

B : Magnetic field (density), measured in Tesla (T)

r : distance from the source of EMF , measured in meter (m)

I : Electrical current , measured in ampere (A)

μ_0 : Permeability of free space , measured in Tesle. meter/ampere (T . m / A)

$\mu_0 = 4 \pi \times 10^{-7} \text{ T . m / A}$

3.2. Results of mathematical calculations:

Calculation result of EMF are indicated in table (1) .and figure (1) shows the graphical representation of these results.

Table (1) mathematical calculations of magnetic field levels for Single phase AC /AC ARC Welding machines

welding machine	at (10cm)from the lead	at (50cm)from the lead	at (1 m)from the lead	Current(I) flow in welding machine
	B (μT)	B (μT)	B (μT)	I(ampere)
Single phase AC /AC ARC Welding	$\frac{500}{10} > 100$	100	50	250 Amps
	$\frac{260}{10} > 100$	52	26	130 Amps
	$\frac{184}{10} > 100$	36.8	18.4	92 Amps

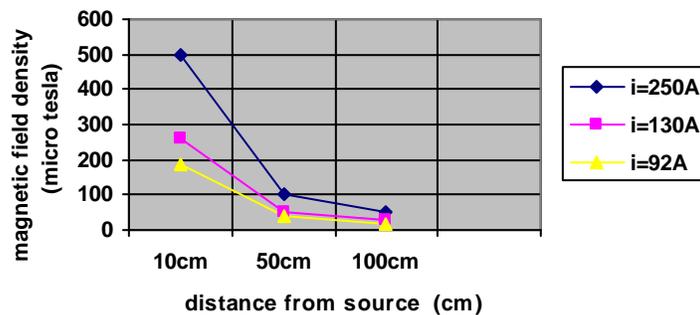


Fig. (1) Graphical representation of the mathematical calculations for Single phase AC /AC ARC Welding machines

3.2. Practical measurement

In this work the practical measurements of the electromagnetic field produced by the three types of arc welding (single phase, three phases with rectifier and engine driven generator) for high, medium and low current are carried out by using electromagnetic field tester EMF- 827 which is available in electrical engineering laboratory. This device provide the user with resalable and easy way for measuring the electromagnetic field at low frequencies up to (50HZ),

Measurements have been conducted at the following three ranges:

1. (10 cm) from the torch.
2. (50cm) from the torch.
3. (1 m) from the torch.

The results of practical measurements are indicated in tables (2,3,4) and the graphical representation of these results are indicated in figures (4,3,2) as follows :

Table (2) practical measurements of electromagnetic levels from DC generator ARC Welding machine

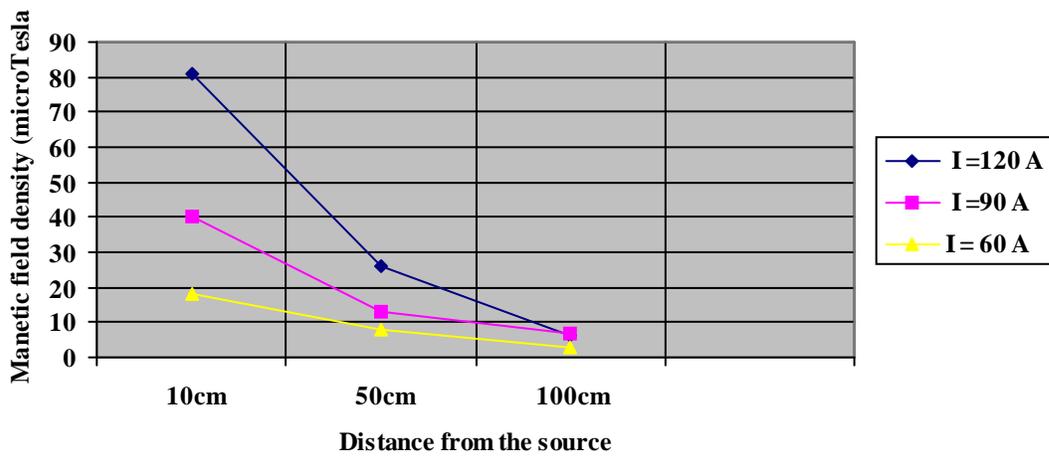


Fig.(2)
graphical representation of the practical measurements for DC generator ARC Welding machine

welding machine	at (10cm)from the lead	At (50cm)from the lead	at (100cm)from the lead	Current(I) flow in welding machine
	B (μT)	B (μT)	B (μT)	I(ampere)
DC Generator	81	26	6	120
Arc machine	40	13	7	90
	18	8	3	60

Table (3) practical measurements of electromagnetic field levels from single phase AC /DC ARC Welding machine

welding machine	at (10cm)from the lead	At (50cm)from the lead	at (50cm)from the lead	Current(I) flow in welding machine
	B (μT)	B (μT)	B (μT)	I(ampere)
Single phase AC /AC ARC Welding	<u>180>100</u>	<u>140>100</u>	18	250
	<u>140>100</u>	49	22	130
	58	34	18	92

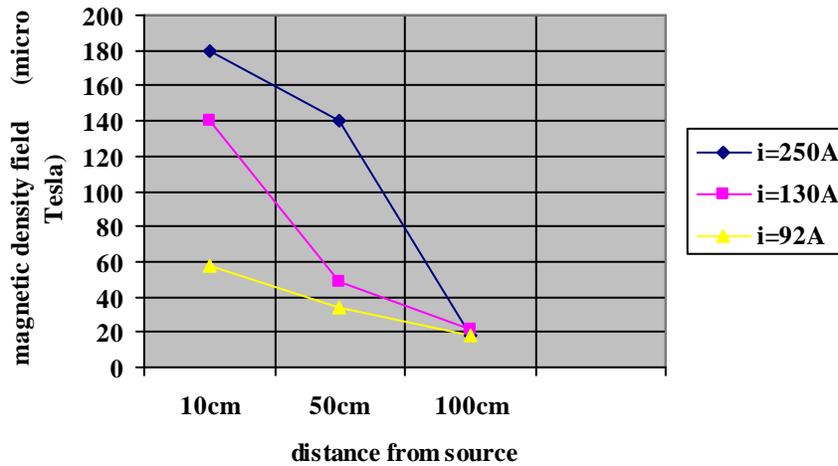


Fig. (3) graphical representation of the practical measurements for single phase AC /C ARC

Table (4) practical measurements of electromagnetic field levels from three phase AC /DC ARC Welding

welding machine	At (10cm)from the lead	At (50cm)from the lead	At (100 cm)from the lead	Current(I) flow in welding machine
	B (μT)	B (μT)	B (μT)	I(ampere)
THREE PHASE AC/DC ARC WELDING	<u>410</u> >100	46	18	250
	<u>220</u> >100	32	14	150
	92	28	9	100

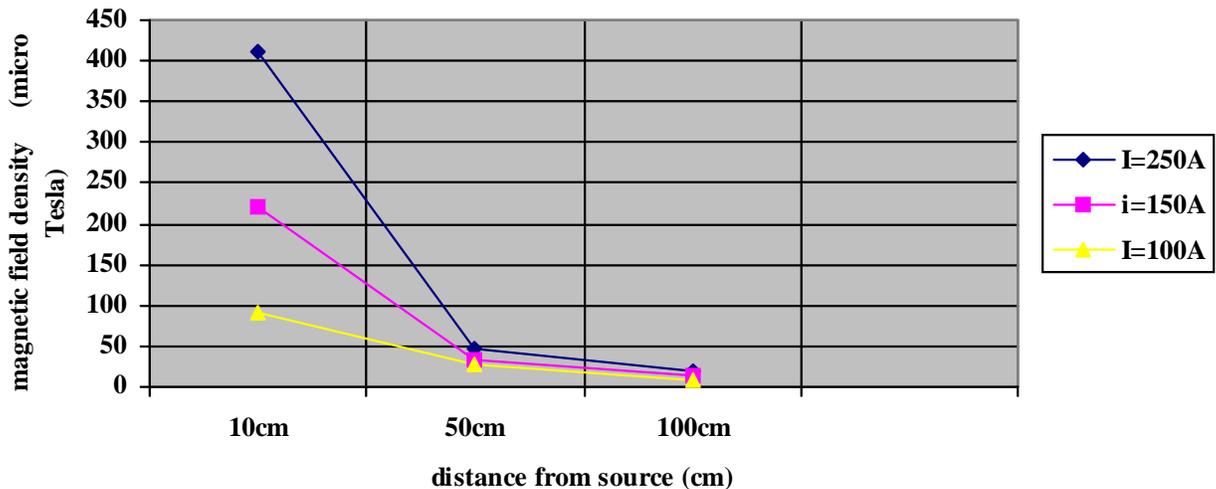


Fig. (4) Graphical representation from three phase AC /DC ARC Welding

4-Discussion:

In this work it has been examined the magnetic fields in the vicinity of a three types of arc welding equipment operated using typical welding conditions

. The results shows that in many cases the magnetic fields are higher than the effective ICNIRP reference levels and in the other cases the magnetic fields are within the effective ICNIRP reference levels:

1-very high fields have been indicated close to the three-phase welding electrodes. The highest field recorded was ($410 \mu\text{T} > 100 \mu\text{T}$) at 50Hz, 10 cm away from the electrode for a current of (250A).so, according to ICNIRP standard reference it consider not a safe range.

2- fields have been indicated close to the welding electrodes. The field recorded was ($220 \mu\text{T}$) at 50Hz, 10 cm away from the electrode for a welding current of (150A). so, according to ICNIRP standard reference it consider not a safe range.

3-for the three-phase welding machine, all the measured field results at $>50\text{cm}$ are within the ICNIRP standard reference ,so, they considered a safe ranges

-For the single phase welder ,the ICNIRP reference levels are exceeded at a typical operating position of 30 cm away from the electrodes and up to distances of the order of 1m. Measurements close to a kick less cable, as if used to supply a welding head from a remote transformer showed that the magnetic field was less than the reference level at a working distance of 20 cm away from the cable.

From the previous mathematical calculations and the practical results , we can conclude that both measuring results of determining the EMF levels are identical and they are within the international exposure limits set by the world health organization ($< 100 \mu\text{T}$) at ranges of (50cm,1m) and up to the limits ($100 \mu\text{T}$) at range of (10cm) .

7-Recommendation:

Based on the results obtained and above discussion, some precautions must be taken into account to reduce the EMF health effects as follows:

1. The welders should wear protection clothing to protect them from EMF radiation.
2. The welder must keep away the hand which holds the torch-cable as possible from his body to reduce the impact of radiation on his body.

3.The welder Should not be used the arc welding in case of high currents, except in emergency cases.
4.The welder should keep a way from the negative lead ,because it will pass through it the same current producing electromagnetic field around it .
5- Shielding and mitigation is a common terms for reducing exposure to electromagnetic fields. It covers shielding with ferromagnetic and/or conductive materials on the one hand and field reduction using passive or active cancellation wire loops on the other. Ferromagnetic material shielding creates an alternative path for the magnetic flux.

from all previous results and discussion we can conclude that there is no health hazard from working with these welding machines if the working time is for short and discontinued periods.

8- Conclusion:

In this research ,the electromagnetic field strength emitted by different electrical welding machines at different ranges are investigated and the safe ranges from torches electrode have been determined in order to avoid its negative health effects on the welder body. The research has been performed in two parts, mathematical calculations and practical measurements. Results indicate that the mathematical calculation generally identical to practical measurement and comparison the obtained results with the international standard limitation indicate that the levels exceed the standard level >100 at a range of ($R=10\text{cm}$),but for a range ($R >50\text{cm}$),the EMF levels are within the permissible limits set by the ICNIRP. so it pose no harm to human health if the exposure is for an intermittent and discontinuous periods.

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