Encountered problems in ELF exposure assessment of highly exposed groups

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Sources of high occupational EMF exposure

Static fields

aluminium melting plants, electrolysis, NMR

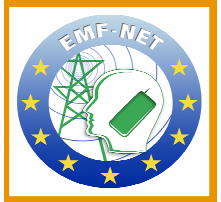
ELF fields

Electric welding devices, Electric trains, EAS, induction heaters

(RF fields

RF heaters and sealers

Mobile telephones, Radio and TV transmitters)



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Highly exposed groups

How to do the exposure assessments?

We need practically “easy to use” measurement protocol. Most cases covered but….

non sinusoidal exposure (pulsed fields, burst etc) needs additional work!

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Compliance measurements are not equal to exposure assessment for epi-studies!

We have to measure the worst case situation.

How to determine this?

Bring a chair and
sit down and watch
the work!

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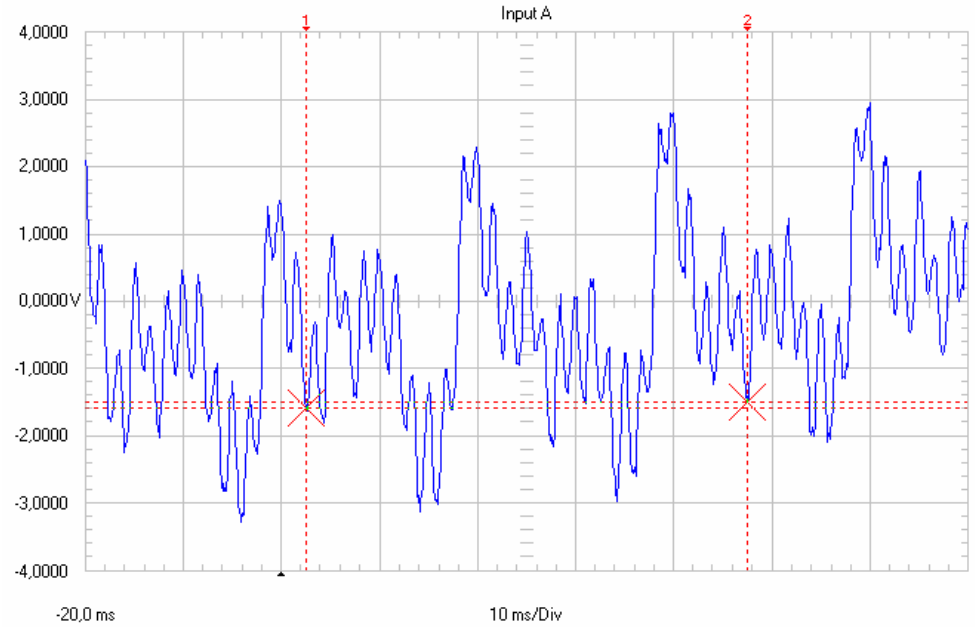
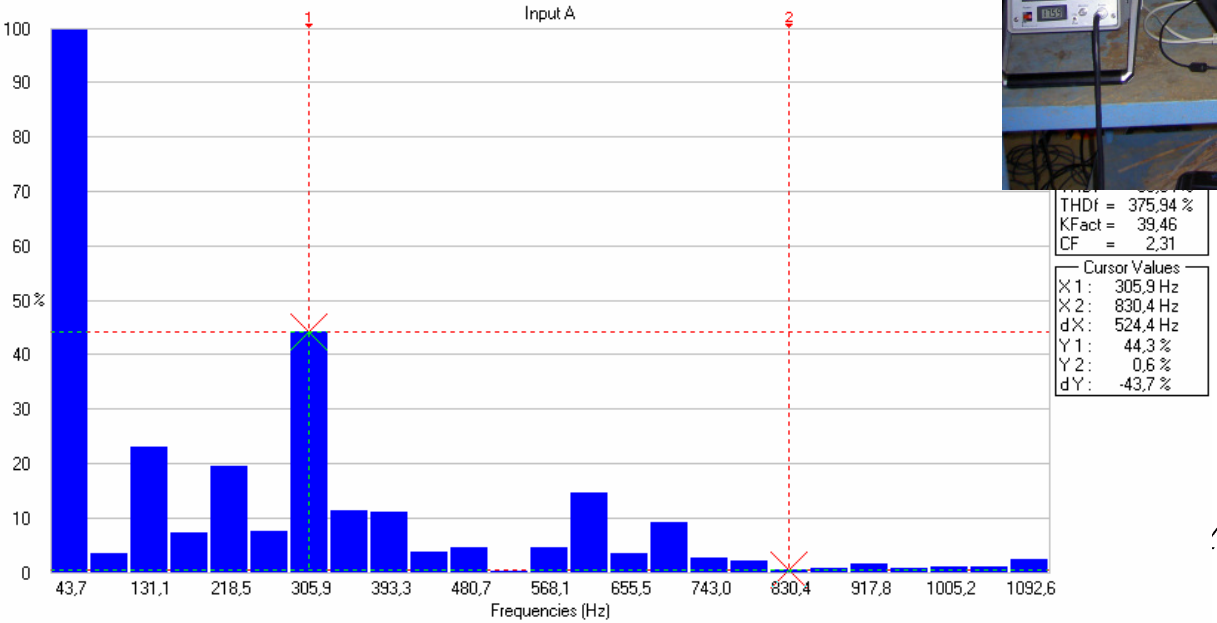
Aluminium plant

110 kA current, very good rectification, low ELF component

DC B field about 1 – 20 mT

Measurements from a chlorate industry





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Induction heaters

- Induction heaters and furnaces, operating at 50 Hz - 3 MHz, are used to heat metals in industrial processes, such as melting, surface hardening, tempering, annealing, soldering, glass-to-metal sealing, and fatigue testing.
- Nominal powers range from 2 to 500 kW.
- EMF shielding of the devices can be introduced to reduce exposure level.
- New device often have pulsed fields!
- The guidelines can be exceeded manifold during work procedures close to furnaces.

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How to deal with compliance when measurement are taken with a broadband instrument?

Example: Low frequency magnetic field instrument, 30 Hz to 2 kHz, broadband reading 30 µT.

Compliance with occupational reference levels?

Ref value at 2 kHz is 30.7 µT, so in most cases this is in compliance. However, some theoretical possibility exists of non-compliance.

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Exposure vs emission

We need to do an exposure assessment. But if we have to assess both large industrial equipment plus handheld equipment there is a problem.

Use of handheld equipment are assessed under CENELEC EN 50392. Here the weighted results should be done as:

$$W = \sqrt{\sum_{1}^{n}\left(\frac{B_f}{B_{RLf}}\right)^2}$$

The normal procedure according to ICNIRP is a linear summation of the harmonics!

$$\sum_{j=1\,\mathrm{Hz}}^{150\,\mathrm{kHz}} \frac{H_j}{H_{L,j}} + \sum_{j>150\,\mathrm{kHz}}^{10\,\mathrm{MHz}} \frac{H_j}{b} \le 1$$

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The reason for the square summation is said to hold down the influence of the harmonics, since adding linearly without taking the phase into account leads to an overestimation.

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CE class 1 marked handheld equipment

What if you have several machines nearby?

What if the environment is a switchyard, machine shop, stray currents…?

Still ”deemed to comply” with prEN 50499!

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Local vs whole body exposure

”The reference levels are intended to be spatially averaged values over the entire body of the exposed individual, but with the important proviso that the basic restrictions on localized exposure are not exceeded.” ICNIRP (1998).

How can this be shown without extensive numerical calculation??

To be on the safe side we can not do any spatial averaging, or …..

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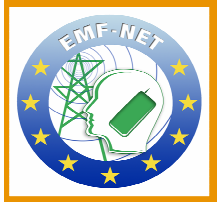
In electric welding high currents – hundreds of Ampere are used and the corresponding magnetic field will be high and possibly exceeding the ICNIRP reference levels.

The field-properties around welding equipment are defined by the properties of the welding current, which in turn depends on the welding process and capabilities of the equipment.

The current path – cable position – in relation to the welder is of outermost importance for the exposure.



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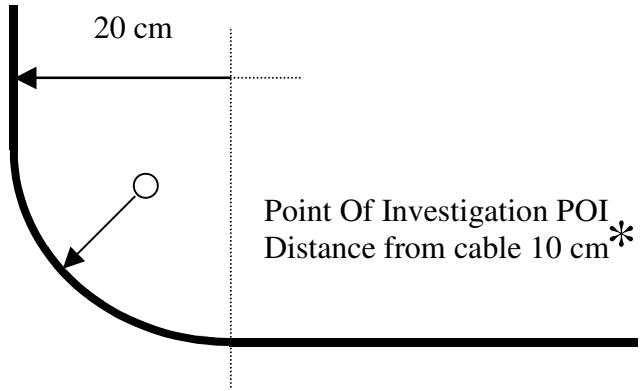
We have measured the magnetic field from several different welding equipments with the method introduced by the CENELEC working group 26A, TC 106, dealing with these measurement problems.



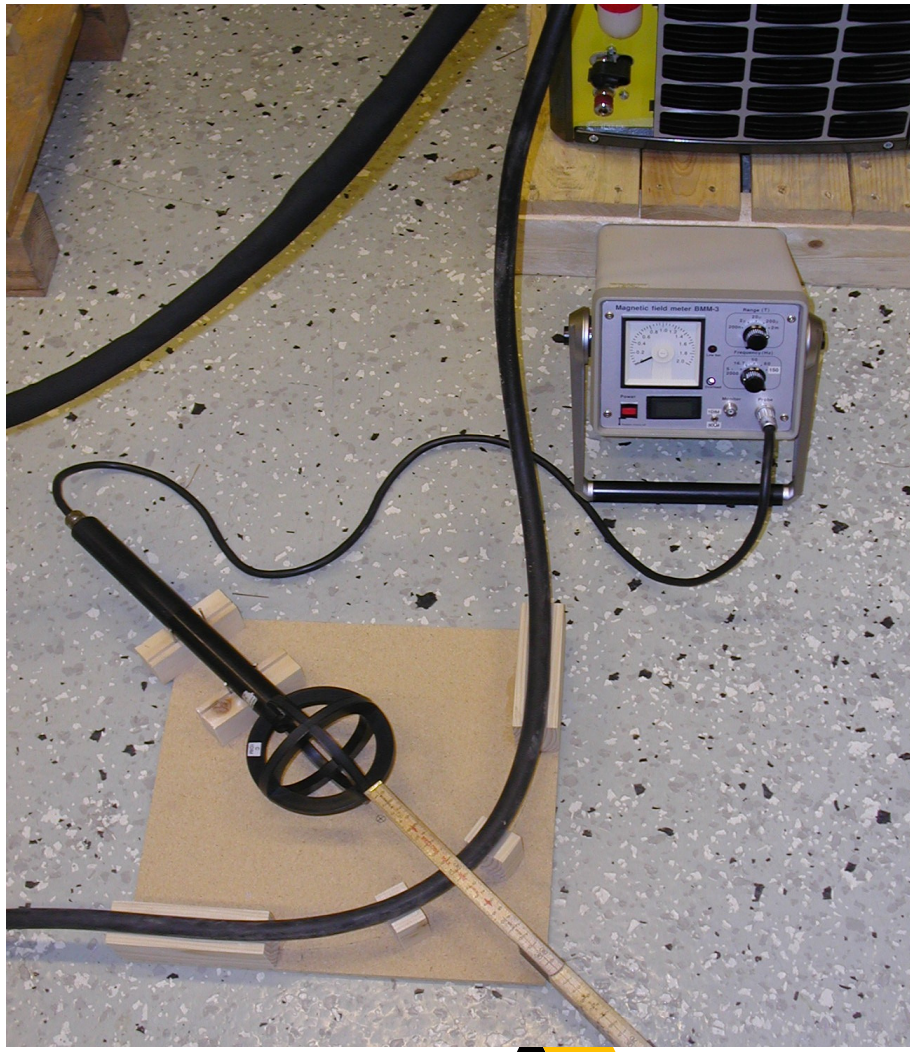


Fig 1. Set-up for measuring the magnetic field

*in first draft 10 cm distance, now set to 20 cm

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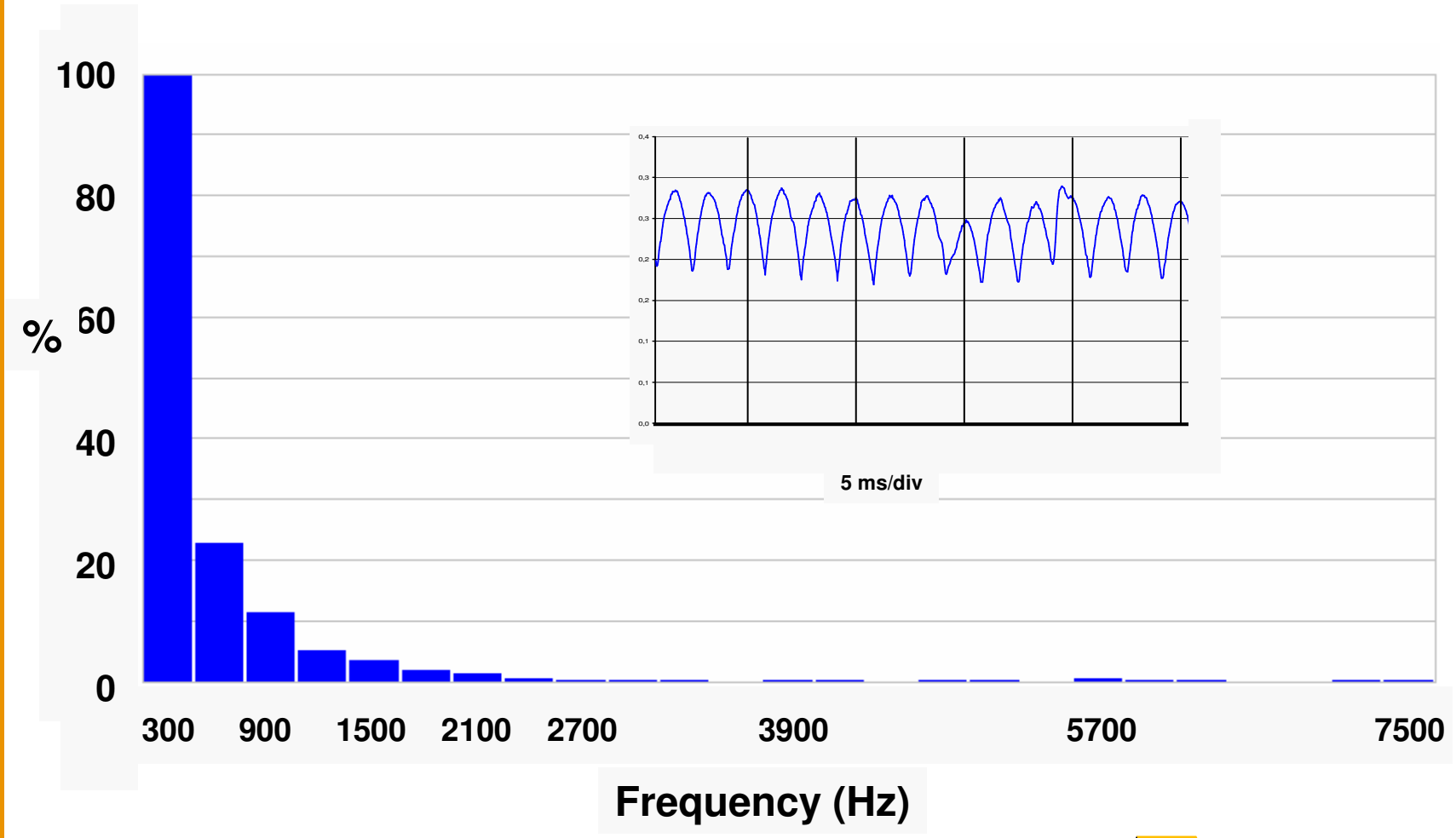
Spray arc welding



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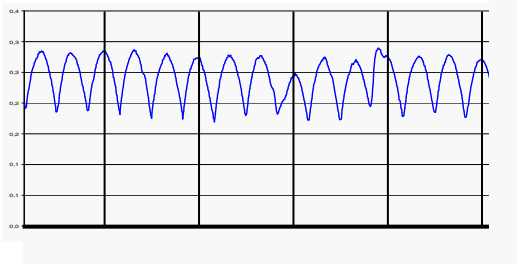
Spray arc welding



5 ms/div

Broadband value **90 µT**

Freq.	Measured	Ref.	Measured
Hz	µT	µT	/Ref.
300	87,0	83,3	1,04
600	20,0	41,7	0,48
900	9,6	30,7	0,31
1200	4,4	30,7	0,14
1500	2,6	30,7	0,09
1800	1,7	30,7	0,06
2100	0,9	30,7	0,03
2400	0,9	30,7	0,03
		Sum	**2,18**

$$\sum_{j=1Hz}^{65kHz} \frac{B_j}{B_{L,j}} \leq 1$$

Reference value is exceeded

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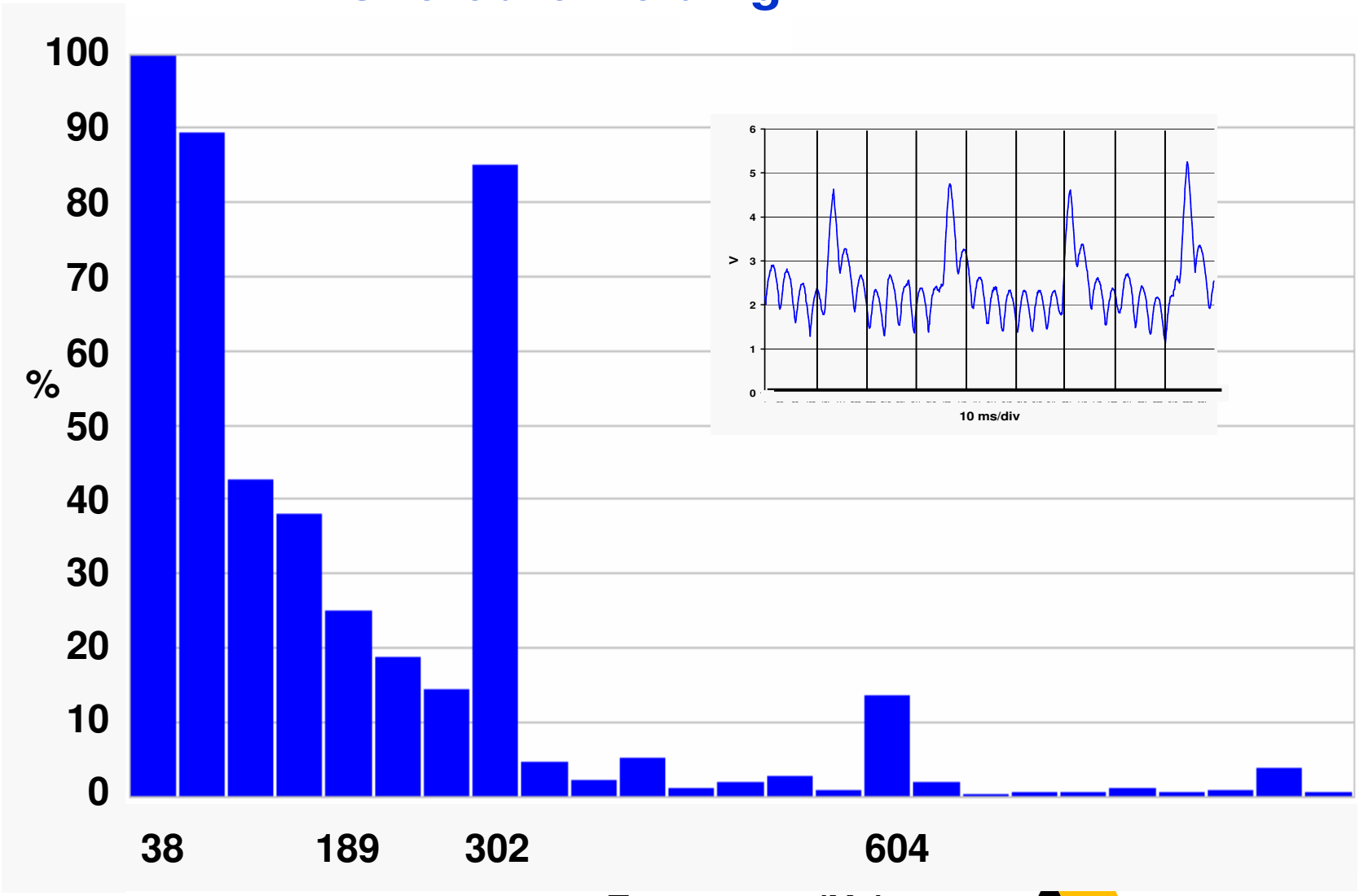
Short arc welding



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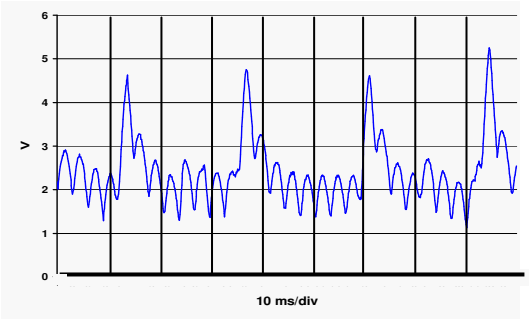
Short arc welding

Broadband value		90 µT	
Frequency	Measured	Ref.	Measured
Hz	µT	µT	/Ref.
38	77,0	657,9	0,12
76	69,3	328,9	0,21
110	33,1	227,3	0,15
150	29,3	166,7	0,18
190	19,3	131,6	0,15
230	14,6	108,7	0,13
260	10,8	96,2	0,11
300	65,5	83,3	0,79
340	3,9	73,5	0,05
380	1,5	65,8	0,02
420	3,9	59,5	0,06
450	0,8	55,6	0,01
490	1,5	51,0	0,03
530	2,3	47,2	0,05
570	0,8	43,9	0,02
600	10,8	41,7	0,26
640	1,5	39,1	0,04
680	0,0	36,8	0,00
720	0,8	34,7	0,02
760	0,0	32,9	0,00
790	0,8	31,6	0,02
830	0,8	30,7	0,03
870	0,8	30,7	0,03
900	3,1	30,7	0,10
		Sum	2,57



$$\sum_{j=1Hz}^{65kHz} \frac{B_j}{B_{L,j}} \leq 1$$

Reference value is exceeded

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The exposure to the head can be quite high depending on how the cable is positioned.

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Some people do not care what part of the body that get exposed!

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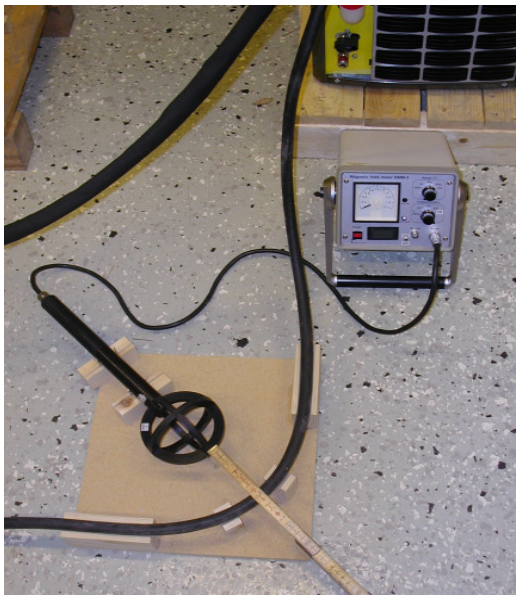
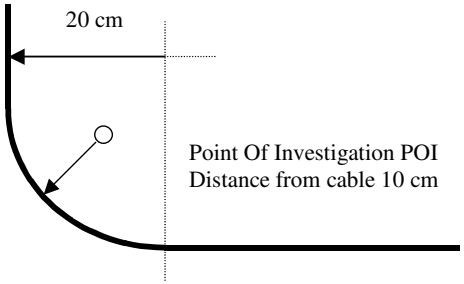
Emission vs. Human Exposure?





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Spot welding, resistance welding

Currents are of the order of tens of kA and the B field is in the mT-range!

No instruments commercially available.

We have used a pick-up coil and an oscilloscope.

Only one-dimensional, need to search for max.

Need to filter the signal for freqeuncy content or do summation of harmonics (linear or squared?)

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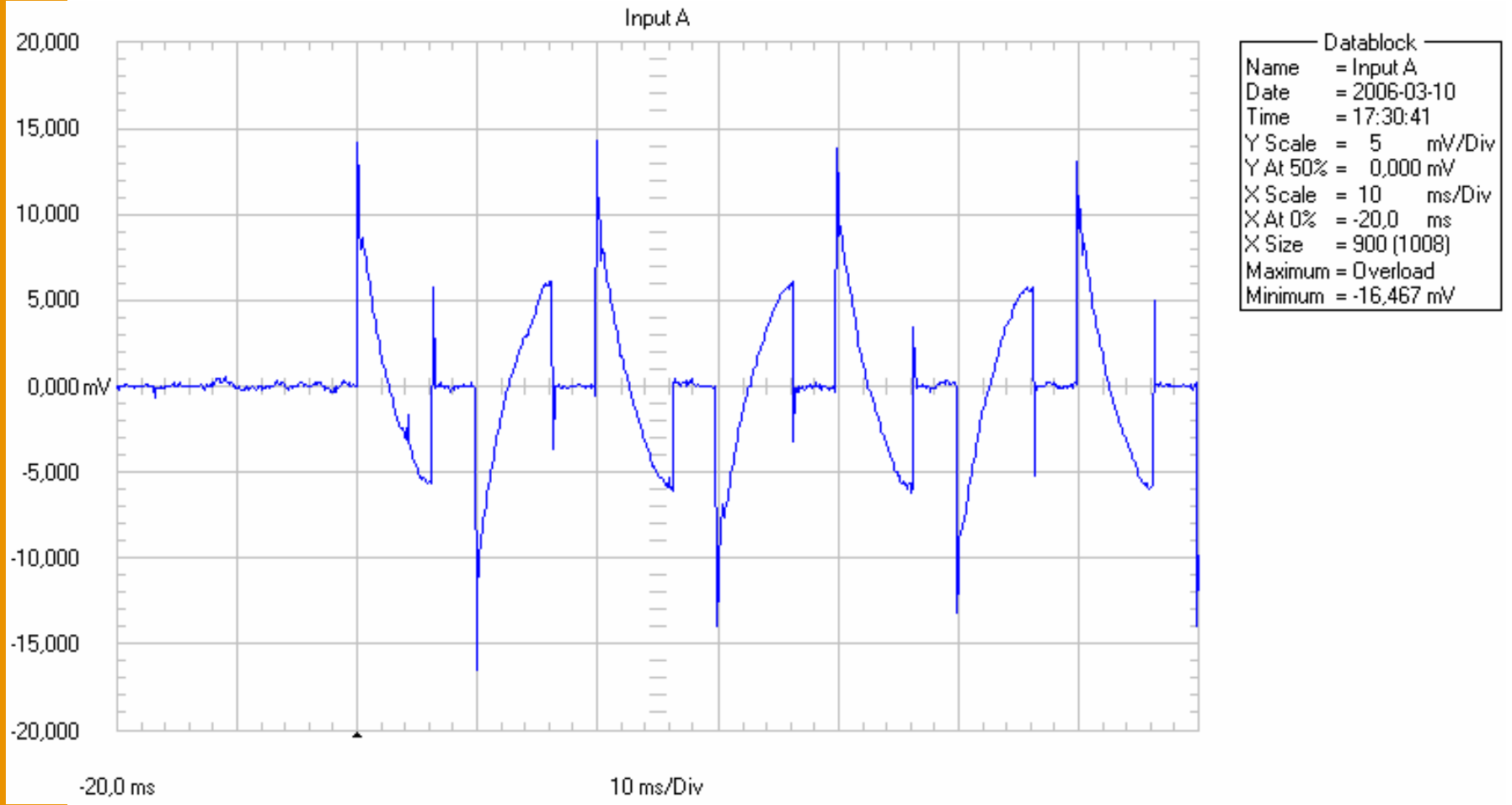
dB/dt from spot welding machine



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Contact current measurements

ICNIRP: point contact;

IEEE: grasp contact

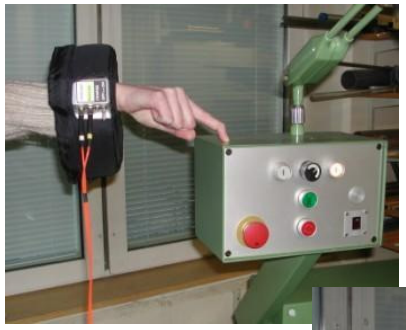
Instrumentation:
The Narda is no longer made.

This instrument
measures grasp contact,
for point contact add a
capacitance

How to measure contact current?

No instrument commercially available

Should we just use ourselves as guinea pigs? Any volunteers?



But should we do it like this now?

Should it be measured at the welding electrode? In worst case siutation the current can be tens of mA!

Electricity production and distribution (50/60 Hz)

ICNIRP recommendation - 500 µT / 10 kV/m

Workers exposure is usually below ICNIRP limits, but……

"For the specific case of occupational exposures at frequencies up to 100 kHz, the derived electric fields can be increased by a factor of 2 under conditions in which adverse indirect effects from contact with electrically charged conductors can be excluded.(page 510)"

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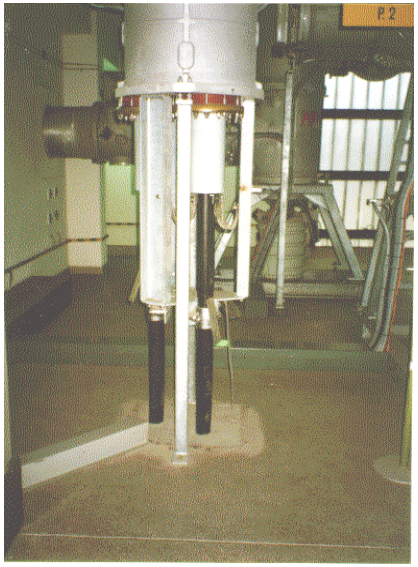

- At power stations, busbars carry high currents emitting relatively strong magnetic fields.
- Maximum magnetic fields of 400 µT have been measured at substations.

How to determine the worst case situation?

Local vs whole body exposure?

Exposure vs emission standard

measurements?

CE marked equipment – squared summation;

exposure – linear summation

More than one CE marked equipment plus

environment: deal only with the

environment?

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