

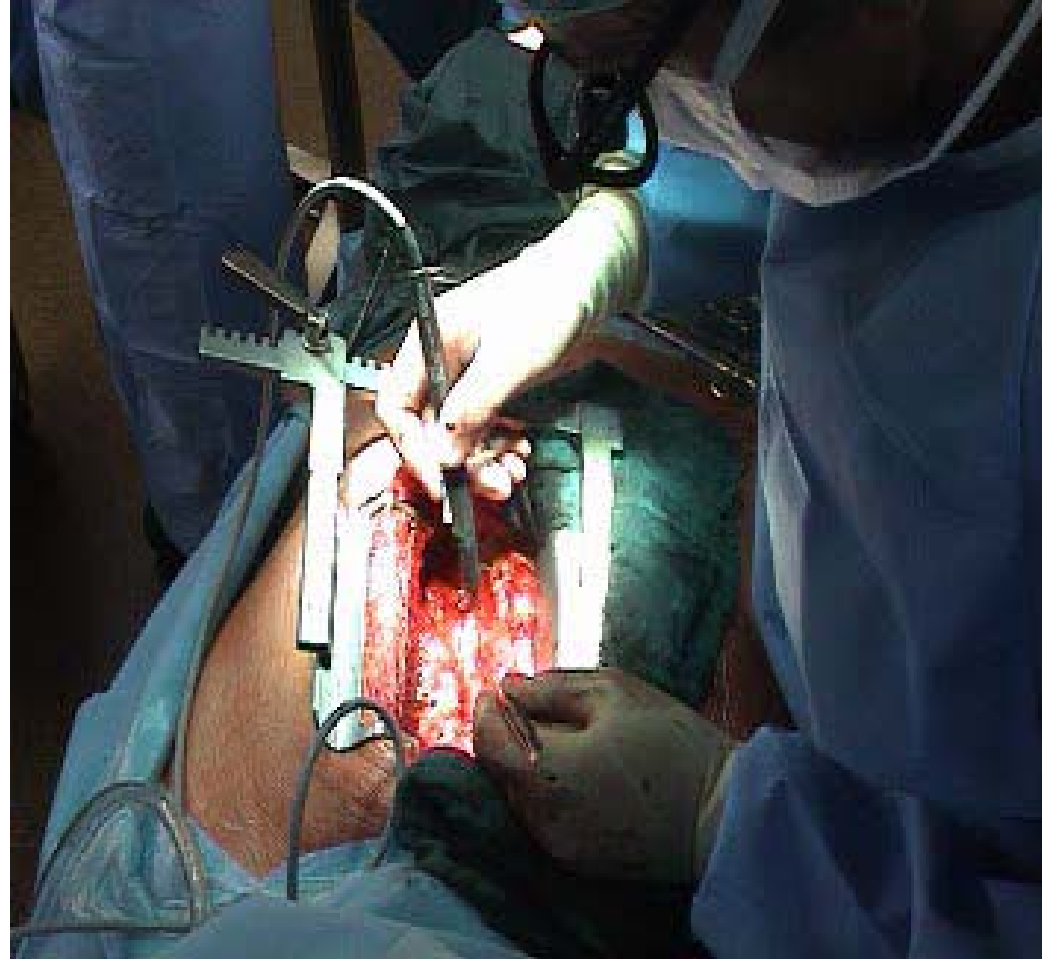


Surgical diathermia, potential overexposures

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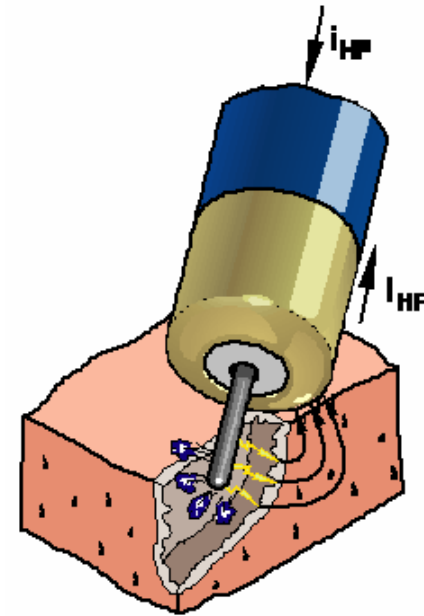
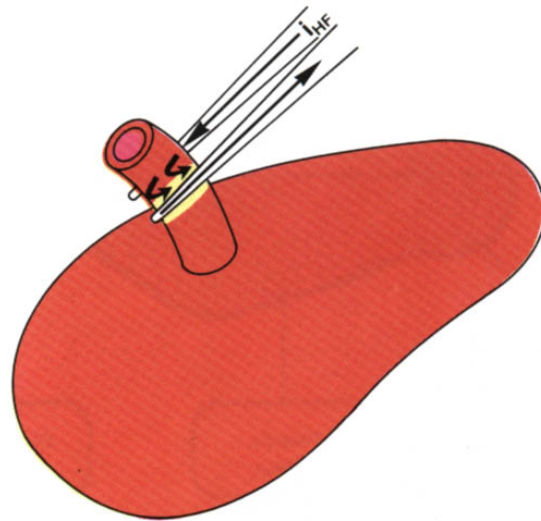




Electrosurgical units (ESU)

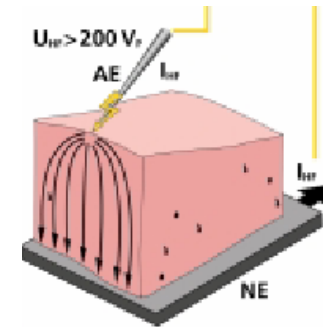
- Cutting and coagulating tissue
- ~50,000 hospital grade units in Europe today
- Radio frequency current of 0.3 – 5 MHz
- Limit values both in induced current density and SAR (100 kHz- 10 MHz)

Bipolar technique

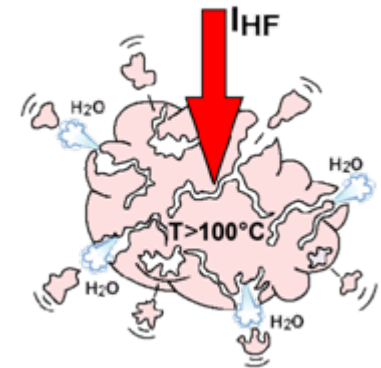


Cutting mode

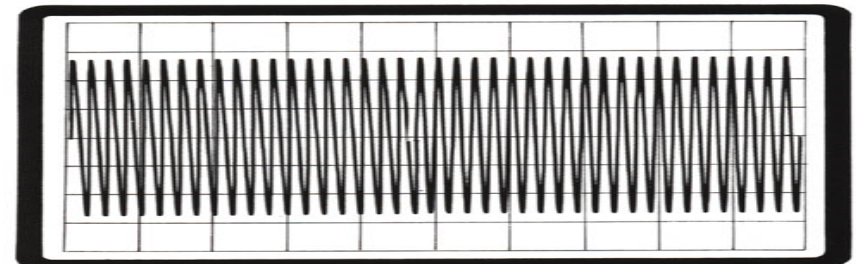
Cutting and coagulating tissue



Rapid temperature increase ($> 100^{\circ} C$)
Cell explosion

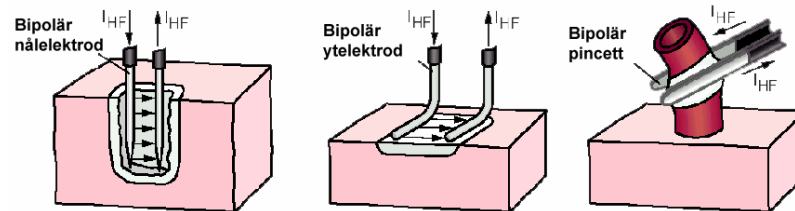


Current often sinusoidal
are applied.
Voltage $> 200V$



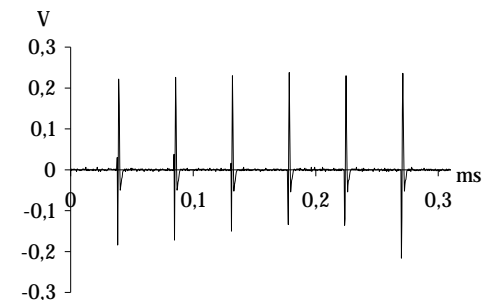
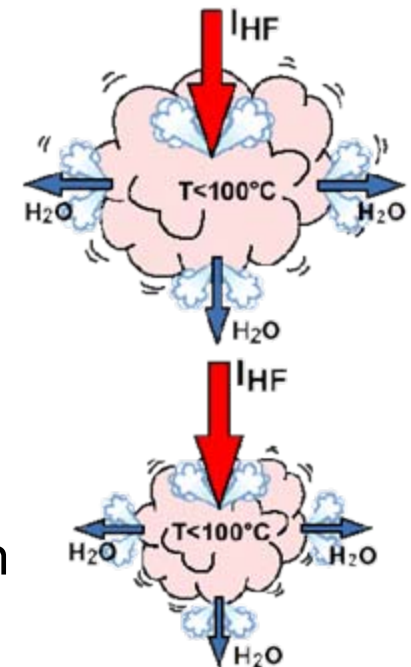
Coagulation mode

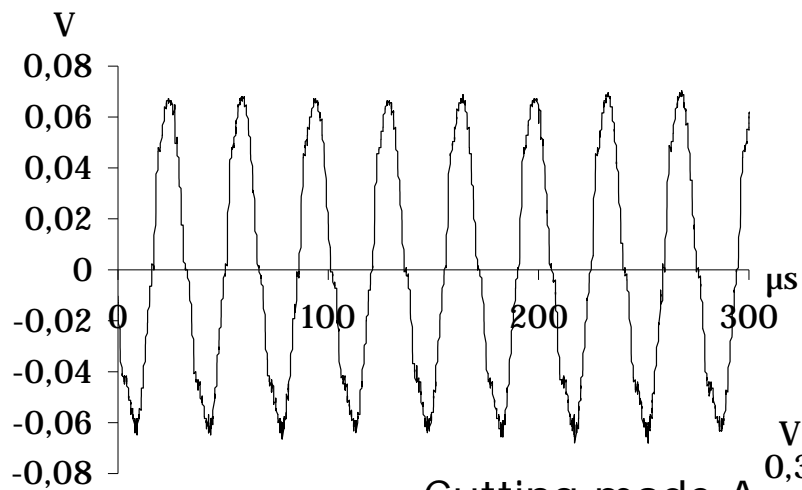
Coagulating tissue (also cutting)



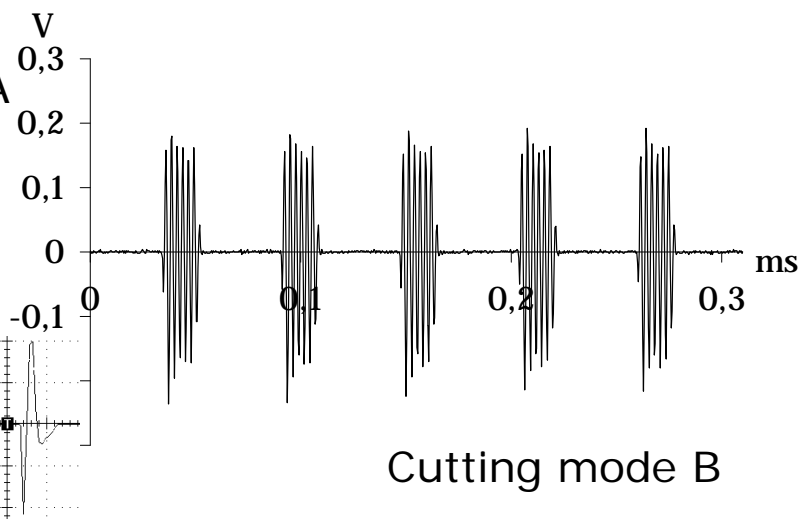
Slow heating process, vaporization of the intra cellular fluid, coagulation of cell plasma

High voltage, low power current
Pulsed current

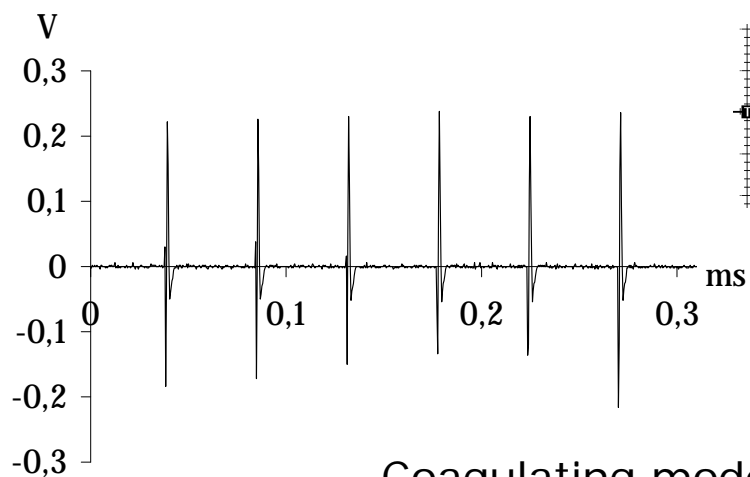




Cutting mode A



Cutting mode B

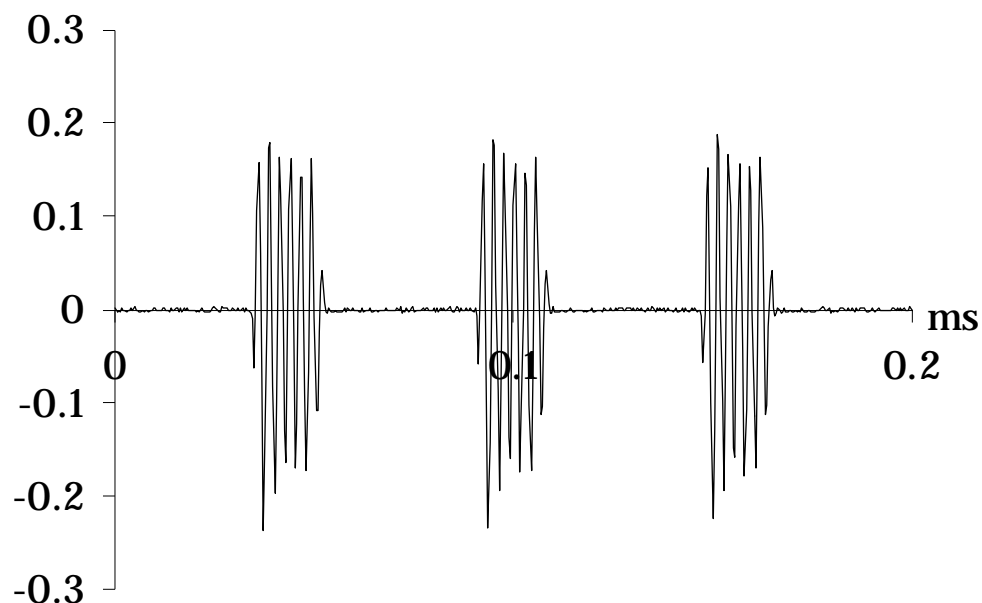


Coagulating mode

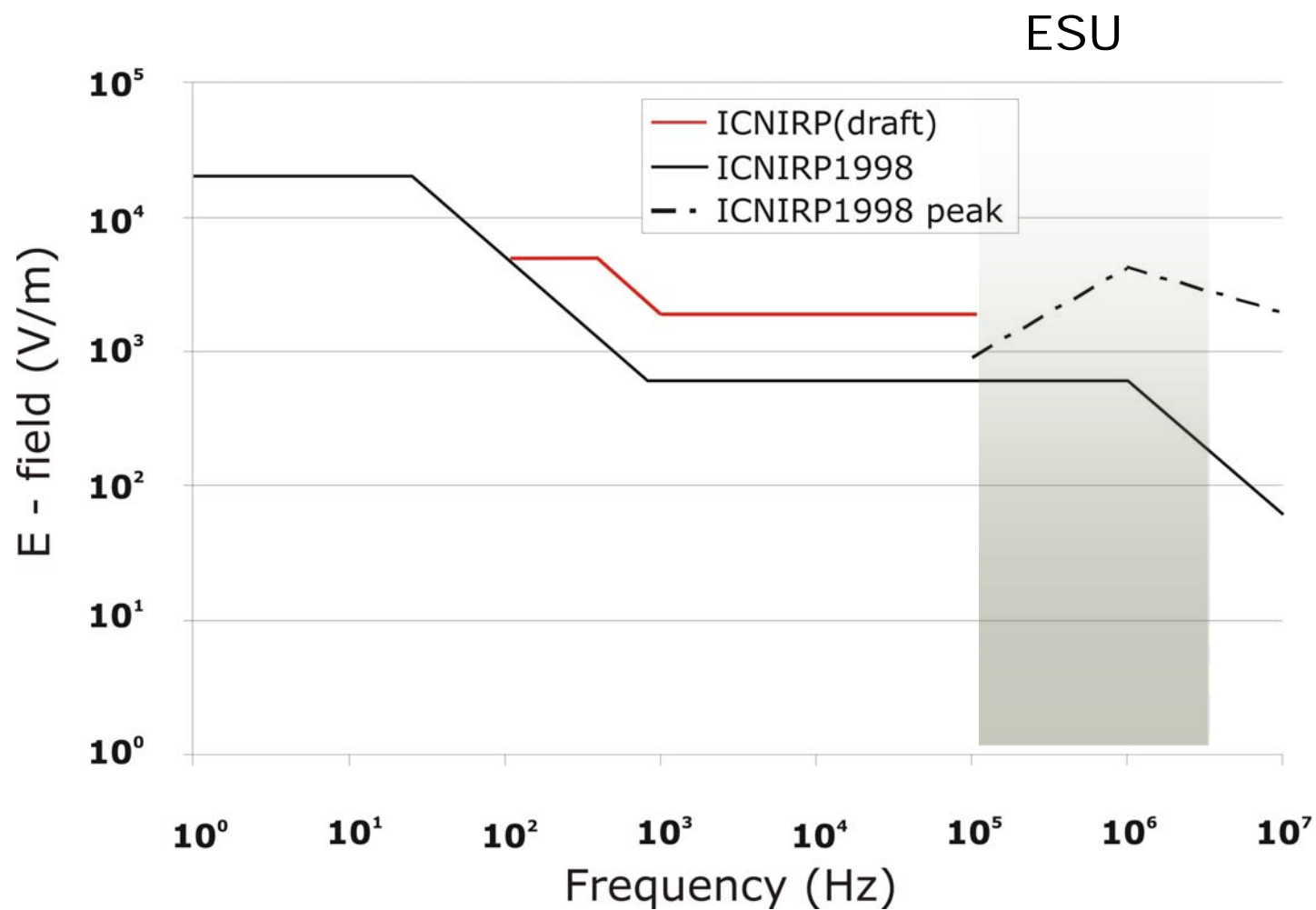


Both current density and SAR are limits for ESU

- **Peak values:** rms in the pulse



- **6-min average:** rms over a number of periods, averaged over 6-min



For frequencies between 100 kHz and 10 MHz, peak action values for the field strengths are calculated by multiplying the relevant rms values by 10^a , where $a = (0,665 \log (f/105) + 0,176)$, f in Hz.

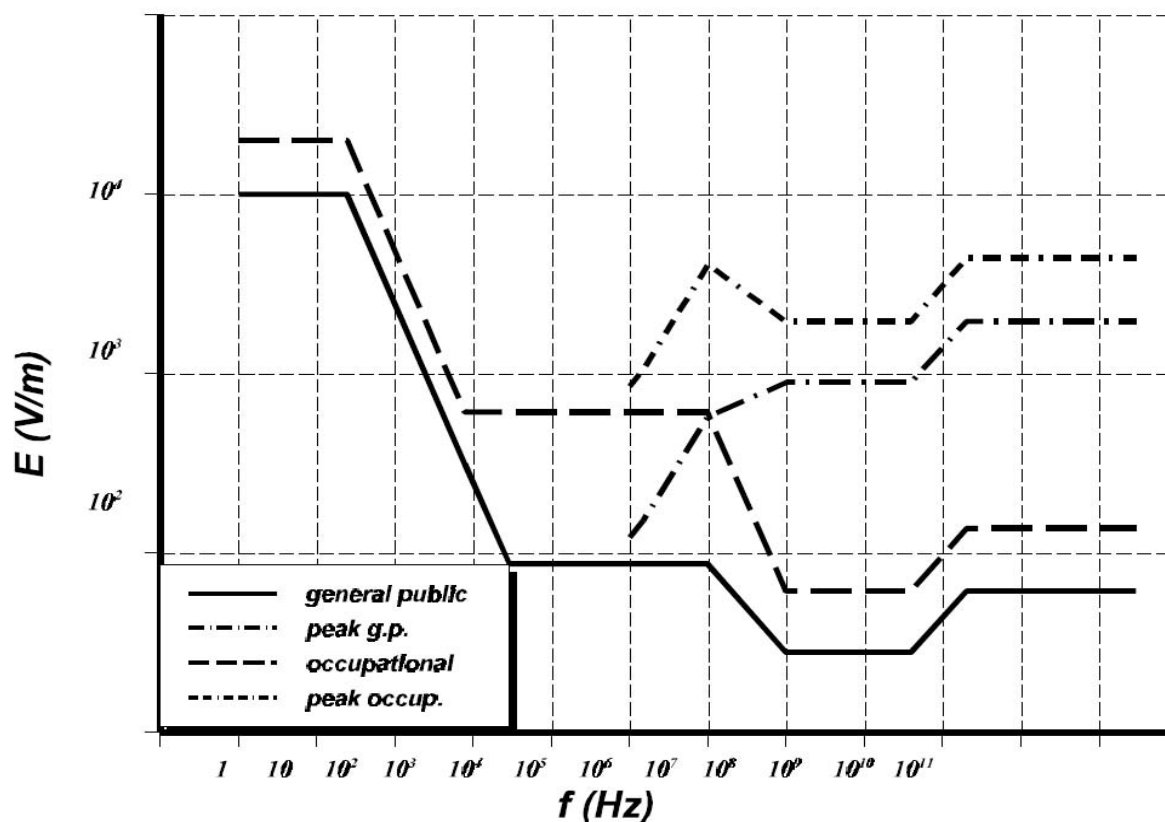
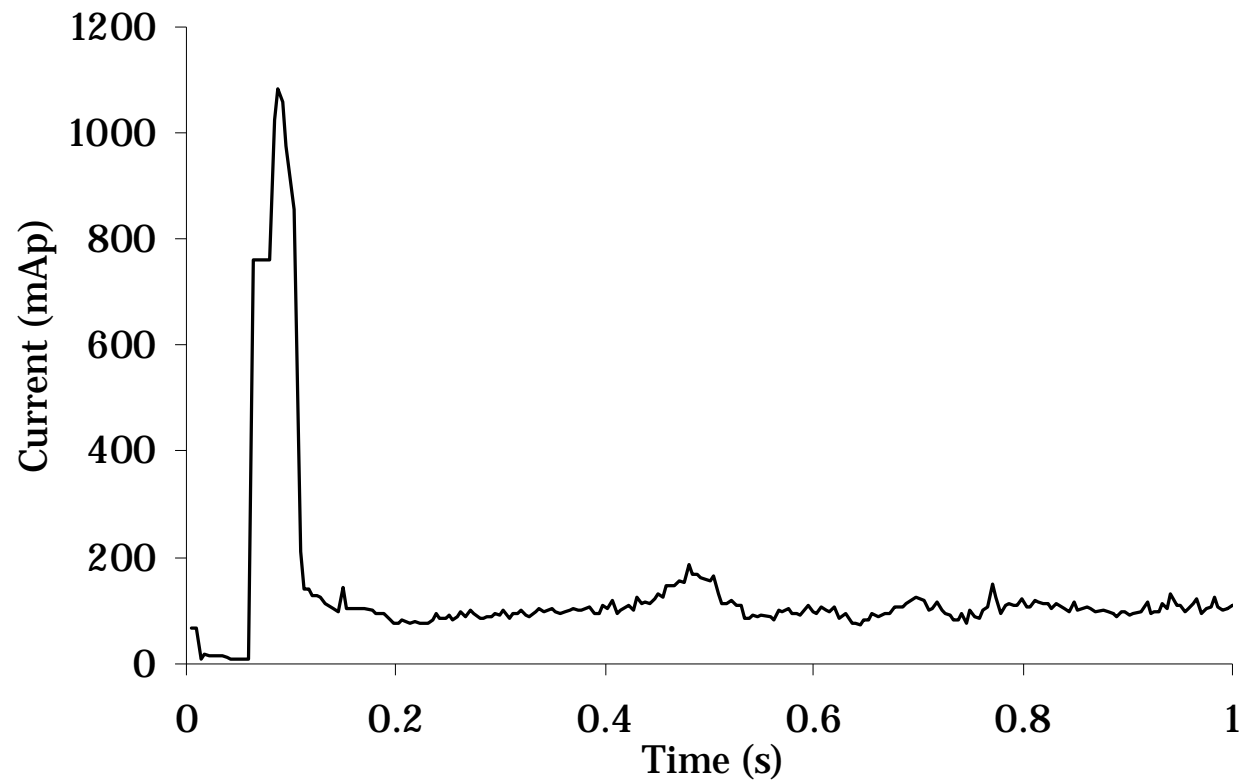


Figure 2 Reference levels for exposure to time varying electric fields (compare tables 6 and 7)



The RF current in the cable





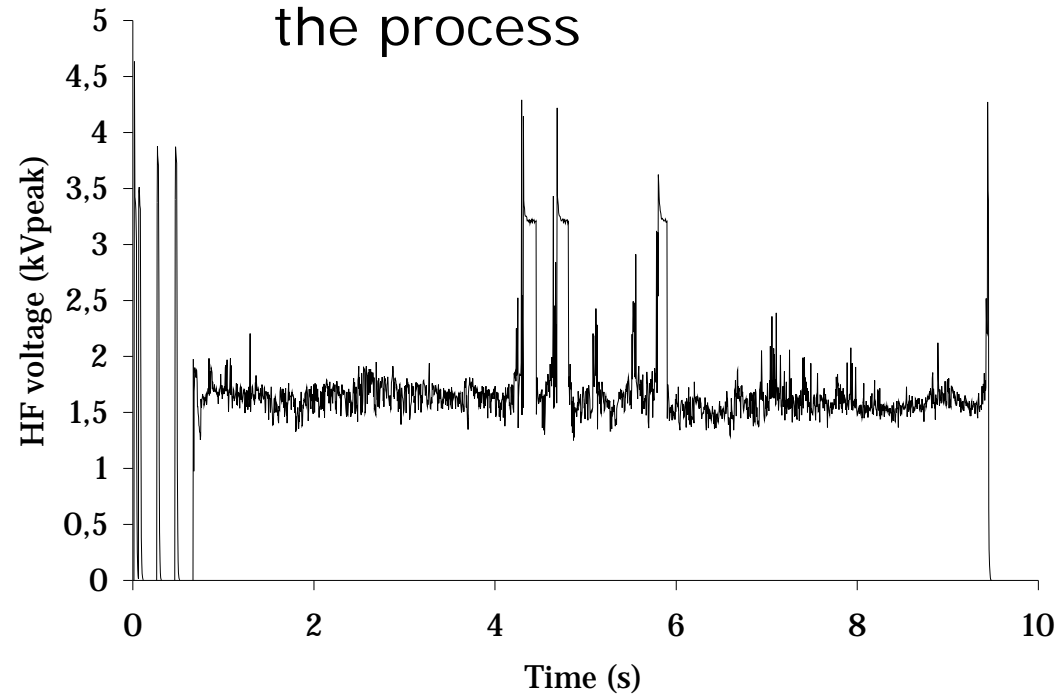
Magnetic field around ESU

- Below the reference values (ICNIRP 1998), rms in the pulse as well as 6-min average.
- rms in the pulse 0.7 – 10 μT
ICNIRP 1998 ~ 20 μT (350 kHz)



Applied voltage

Initially high voltage is applied to achieve spark discharge and start the process





Electric field around ESU

- 6-min average values: OK!
- rms in the pulse:
 - OK! when voltage up to ~ 1 kV is applied
 - Can reach tens of kV/m
 - ICNIRP 1998: 2kV/m (peak)



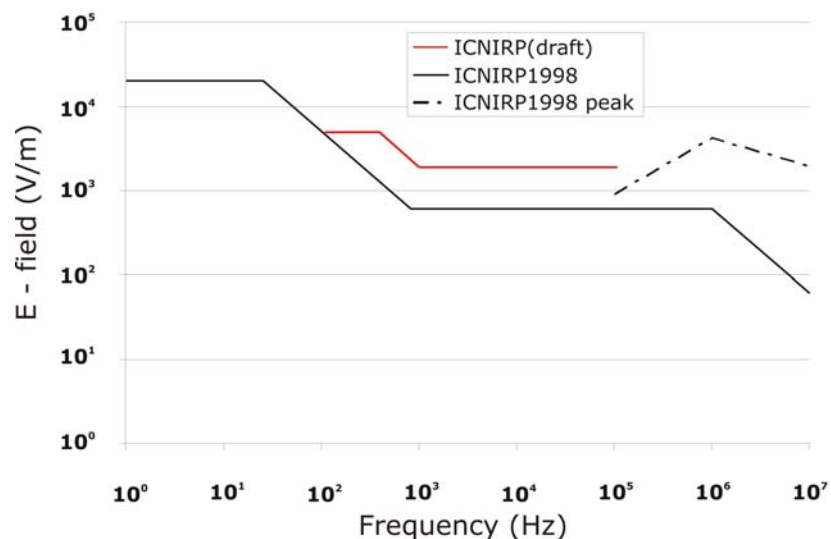
Limit values (basic restrictions)

- SAR – not a problem
- Current density is still the basic restriction for 100 kHz – 10 MHz (besides SAR)
- In worst case, cable hanging over the surgeons shoulder, it is not unlikely that the current density is exceeding the basic restriction



ICNIRP draft (2009)

- Induced E-field up to 100 kHz
- SAR and current density from 100 kHz – 10 MHz
- SAR from 10 MHz – 10 GHz
- Discontinuity at 100 kHz





Solutions?

- Shielding the cable will reduce the E-field significantly – difficult?
- Education of professionals (surgeons nurses, technicians) – how?