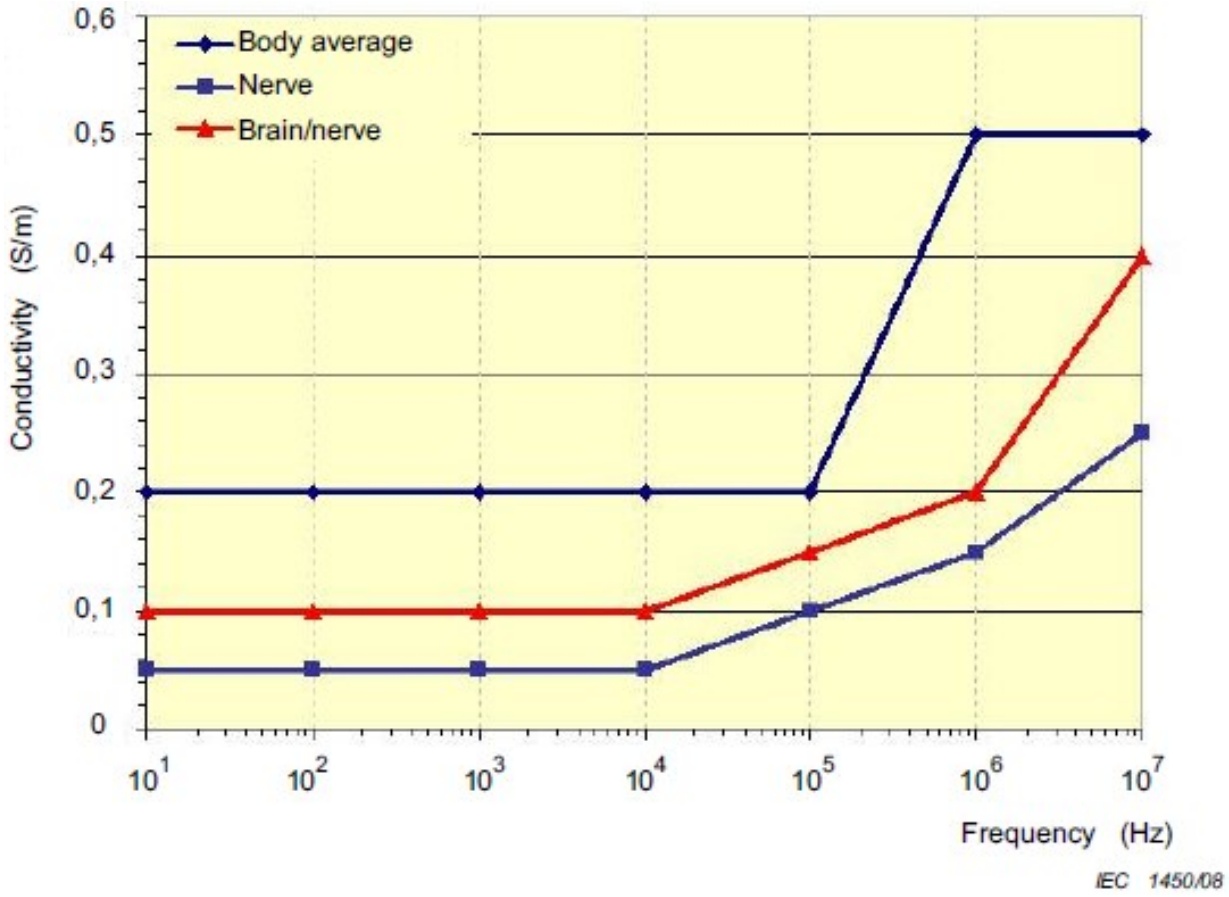
Relationship between Induced Current, SAR and H in the band 0.1-30 MHz

$J = \sigma \omega R B / 2$ and $SAR = J^2 / \rho \sigma$

- σ is electric tissue conductivity in S/m (Next Power Point Conductivity as function of the frequency)
- ρ is the density of tissue (= 1000 Kg/m³)
- J is the induced current density in (A/m²),
- $\omega = 2 \pi f$ in which f is the frequency (in Hz)
- $B = \mu H$, B is the magnetic flux density (in μT) and H is the magnetic fieldstrength in A/m
- Appropriate for adults is a conduction path R = 0.2 m.
- Antenna d<40 cm: R can be reduced proportional

Conductivity as f(frequency)



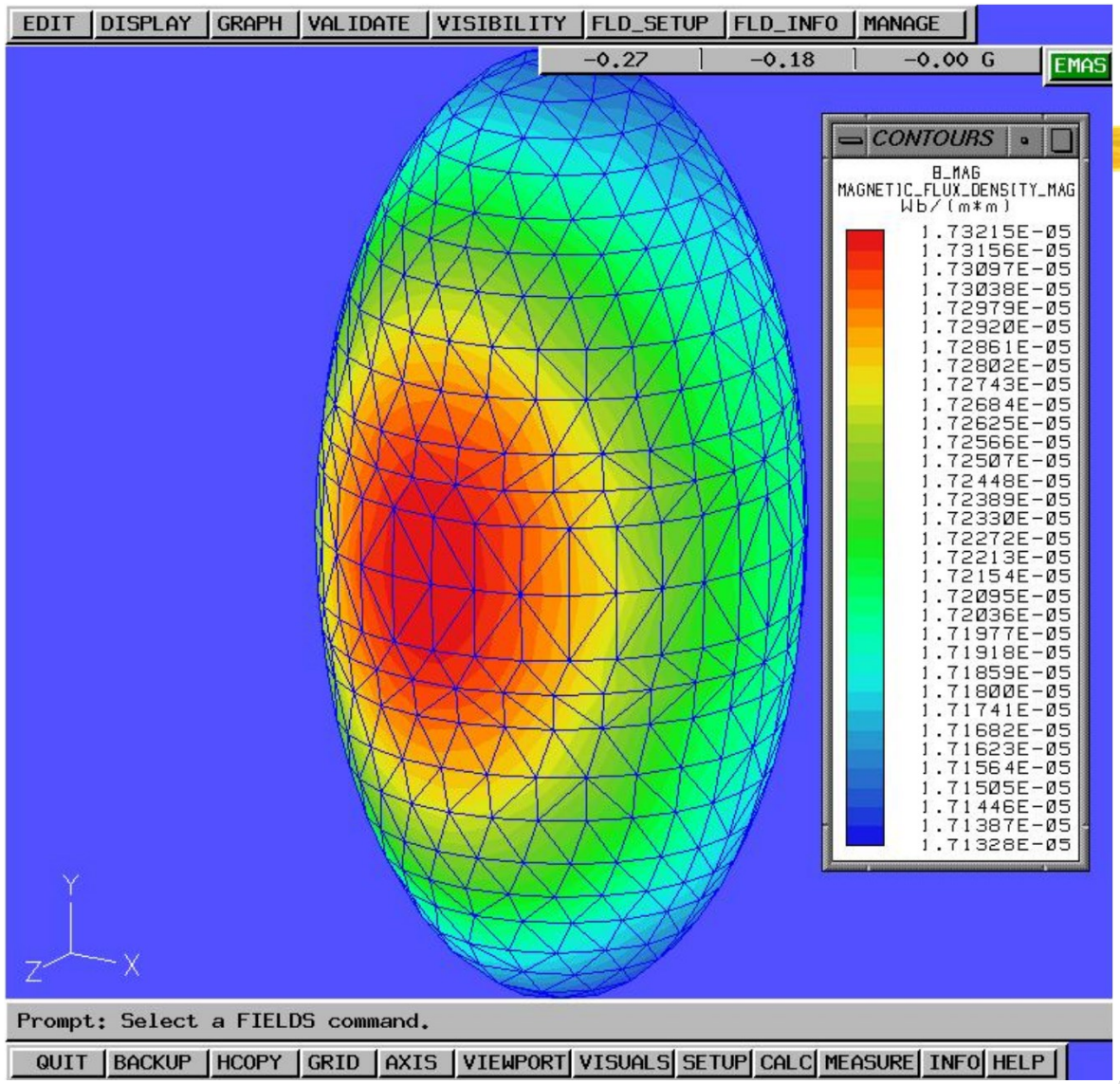
Stage 2: Localised SAR for frequencies 30 MHz - 10 GHz.

- Compliance with Basic Restrictions by means of numerical modelling
- ICNIRP Guidelines define localised SAR over 10 gr. of tissue
- All transmitted power goes into 0.01 kg
- Basic restriction is 2000 mW/kg
- Any unit that supplies less than 20 mW (=0.01 kg * 2000 mW/kg) from its antenna port will meet the Basic Restriction.
- May be averaged over 6 min.

Stage 3: Numerical modelling

- Computational dosimetry
- MRI data or photographs of anatomical sectional diagrams
- Include accurate tissue conductivities
- Reseach is continuing in this area
  New methods and information will come available.

Prolate Spheroid Modelling Results



Magnetic Flux Density

nedap®

Antennas and field strength's at 10 and 0.20 m at 120 KHz

Field strength in dBµA/m at 10 m acc. to EN300 330	Antenna size in cm	Field strength at 20 cm in A/m
55	20 by 20	18.0
65	100 by 55	12.3
65	100 by 200	3.5

Limits at 120 kHz

- Basic restriction exposure values at 120 kHz

	Occupational	General Public
Induced current	1.2 A/m²	0.24 A/m²
Localised SAR	10 W/kg	2 W/kg
Whole body SAR	0.4 W/kg	0.08 W/kg

- Reference exposure values at 120 kHz

  Occupational: 13.3 A/m General Public: 5 A/m

1.	Antenna	20 by 20 cm	Both reference levels are exceeded
2.	Antenna	100 by 50 cm	Occupation reference level within the limit General Public Reference level exceeded
3.	Antenna	100 by 200 cm	Both reference levels are within the limit

Comparing measurements with the ICNIRP limits at 120 kHz

- Antenna 20 by 20 cm. Calculating the Induced current
  $J = \sigma * \pi * f * R * B$
  $\sigma = 0.21$ S/m; $f = 0.120$ MHz; $R = 0.1$ m and B (in μT) = 1.25 * H (in A/m)
  Induced Current: $J = 0.18$ A/m²>>Localised SAR = $J^2/\rho\sigma = 0.15$ mW/kg

  In compliance both with Occupational and General Public levels

- Antenna 100 by 55 cm, H=12.3 A/m at 20 cm.
  $J = \sigma * \pi * f * R * B$
  $\sigma = 0.21$ S/m; $f = 0.120$ MHz; $R = 0.2$ m and B (in μT) = 1.25 * H (in A/m)
  $J = 0.24$ A/m²>>Localised SAR = $J^2/\rho\sigma = 0.27$ mW/kg

  In compliance both with Occupational and General Public levels

Antena sizes and fieldstrength at 20 cm on 13.56 MHz

Field strength at 10 m in dBµA/m	Antenna size in cm	Field strength at 20 cm in A/m
60	100 by 55	2.62
60	100 by 200	0.51

SAR limits at 13.56 MHz

Exposure Characteristics	Reference level in A/m	Basic Restrictions Whole Body SAR in W/kg	Basic Restrictions localised SAR in W/kg
General Public Exposure	0.073	0.08	2
Occupational exposure	0.16	0.4	10

The reference levels are exceeded so we have to calculate the SAR

Comparing measurements with the ICNIRP limits at 13.56 MHz

- Antenna 100 by 55 cm H= 2.62 A/m at 20 cm. Localised SAR:

$$J = \sigma * \pi * f * R * B$$

σ = 0.5 S/m; f = 13.56 MHz; R = 0.2 m and B (in μT) = 1.25 * H (in A/m)

J = 13.95 A/m²>>Localised SAR = $J^2/\rho\sigma$ = 0.39 W/kg

- Antenna 1 by 2 m H=0.51 A/m at 20 cm. No compliance with the reference levels.

  The formula for Whole body SAR (≤ 0.08 W/kg) is 23/f = 1.7 A/m. So in compliance.

Max. power from RFID at 915 MHz

- USA and Canada: 902-928 MHz and 2400-2483.5 MHz, Peirp[1] = 4 W

[1]Peirp: Equivalent isotropic radiated power

(1) SAR measurement and calculations at 900 MHz

- For 900 MHz same modelling and - basic restrictions can be applied, because the SAR is independent of the frequency.
- The allowed Peirp is 4 W. With an antenna gain of approx. 8 dB, this comes down to a power at the antenna port of 600 mW, which is far above the mentioned 20 mW.
- So we have to perform modelling.
- Because the antennas are rather small the approach is localised SAR = 2 W/kg, to be averaged over any 10 gr. of tissue. This results in 20 mW in 10 gr. of tissue.
- Tissue density is 1000 kg/m^3. Assuming 10 gr is a cubic with sides: 2.16 cm.

(2) SAR measurement and calculations at 900 MHz

- The surface results in 2.16 * 2.16 = 4.66 cm²
- Absorbed power in 10 gr of tissue is: 4.66 * 10^-4 * Pd.
  In which Pd in W/m ² is Power density at a distance d = 20 cm.
- Allowed absorbed power is 20 mW, so 4.66 * 10 ^-4 * Pd = 20 * 10^-3
  Pd = 42.9 W/m²
- Peirp= Pd * 4 * π * d² = 21.6 W which may be averaged over a 6 min period.
- 4 W is below the limit.

Conclusion

This presentation shows that RFID Systems and its frequencies equipped with the mentioned antennas are in compliance with the reference levels and/or the basic restrictions from ICNIRP. The systems also comply with the Council Recommendation 1999/519/EC and the R&TTE Directive 1999/5/EC.

Of course always measurements have to be performed on actual systems according to the EN 62369-1.

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THANK YOU FOR YOUR ATTENTION