

# Measuring Radiofrequency and Microwave Radiation from Varying Signal Strengths

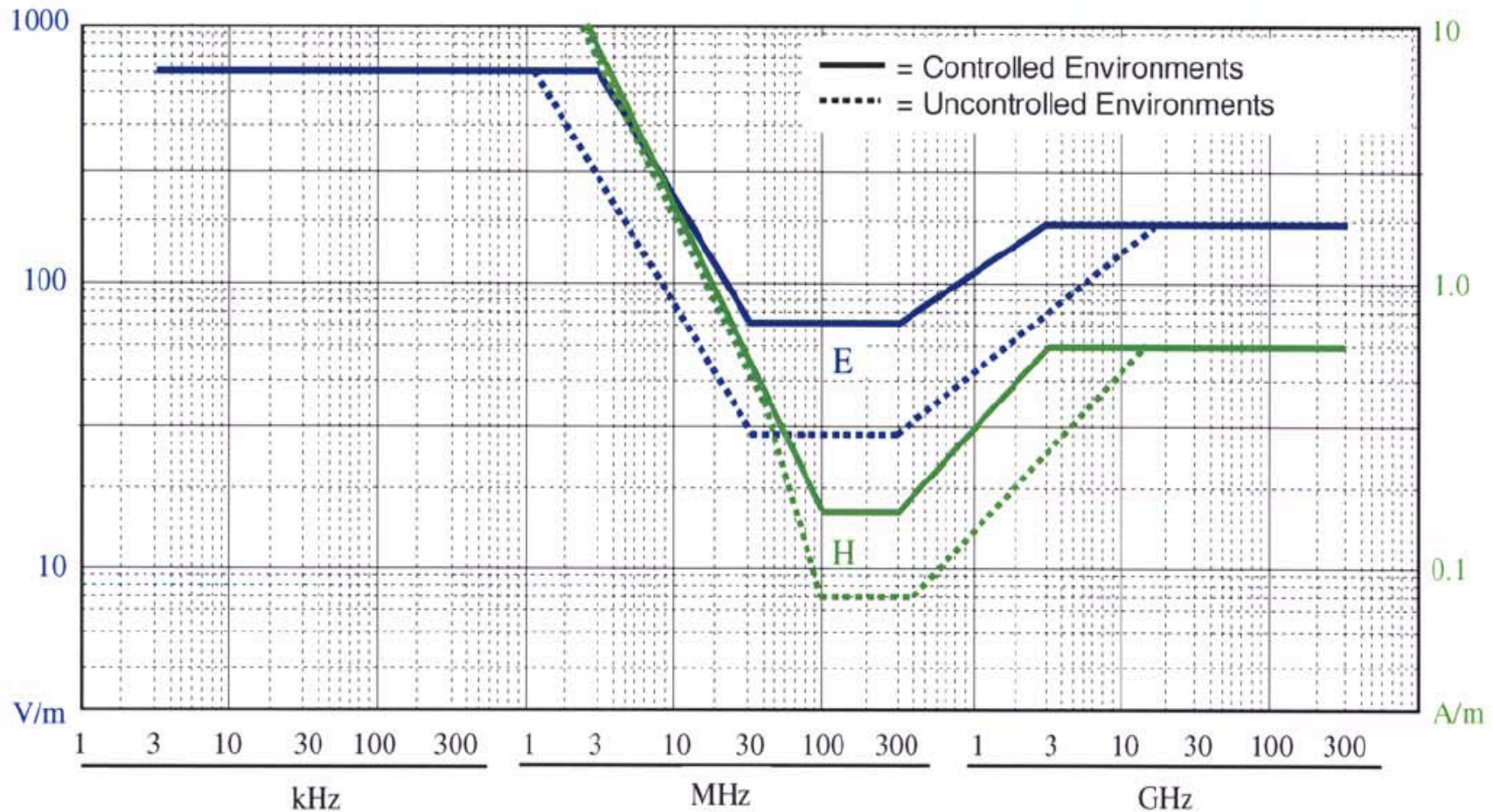
W.C. Gaul, Ph. D., CHP, CHMM  
Chesapeake Nuclear Services

B. Davis, MS, CIH, CSP, CAC,  
NASA Dryden Research Flight Center

# Limits and Guidelines

- OSHA
  - From 10 MHz to 100 GHz 10 mW/cm<sup>2</sup> - 0.1 hr
- FCC
  - Varies with frequency range
  - For occupational worker and general public
- IEEE
- ACGIH
  - Both also vary with frequency

# Typical Variable Standard (IEEE) Frequency Dependent



# FCC Standard 47 CFR 1.1310

## Limits for Maximum Permissible Exposure (MPE) Occupational Exposure

Frequency range (MHz)	Electric field strength (V/m)	Magnetic field (A/m)	Power density (mW/cm <sup>2</sup> )	Averaging time (minutes)
0.3-3.0	614	1.63	*(100)	6
3.0-30	1842/f	4.89/f	*(900/f <sup>2</sup> )	6
30-300	61.4	0.163	1.0	6
300-1500			f/300	6
1500-100,000			5	6

f = frequency in MHz

\* = Plane-wave equivalent power density

# Compliance Follows Unity Rule

$$E_T = \sum_{i=1}^n \frac{p_i}{r_i} < 1$$

Where  $E_T$

$E_T$  total exposure

$p_i$  power measured source  $i$

$r_i$  regulatory requirement at power  $i$

# Multiple Sources Contribute



# Types of RF Signals

- Continuous output
  - Signal emitted at all times
- Pulsed output
  - Can be at regular intervals
    - Weather radar
- Irregular output
  - Police, ambulance, etc.

# Interfering Radiations

- Wireless LAN
- Wi-Fi Hotspots
- Cell phones, towers
- Radio towers
- Security radios
- Ambulance, Fire, Police
- HDTV – high power
- Hospitals
- HVAC systems
- Elevator controls
- Cleaning equipment
- Light ballasts
- Paper shredders



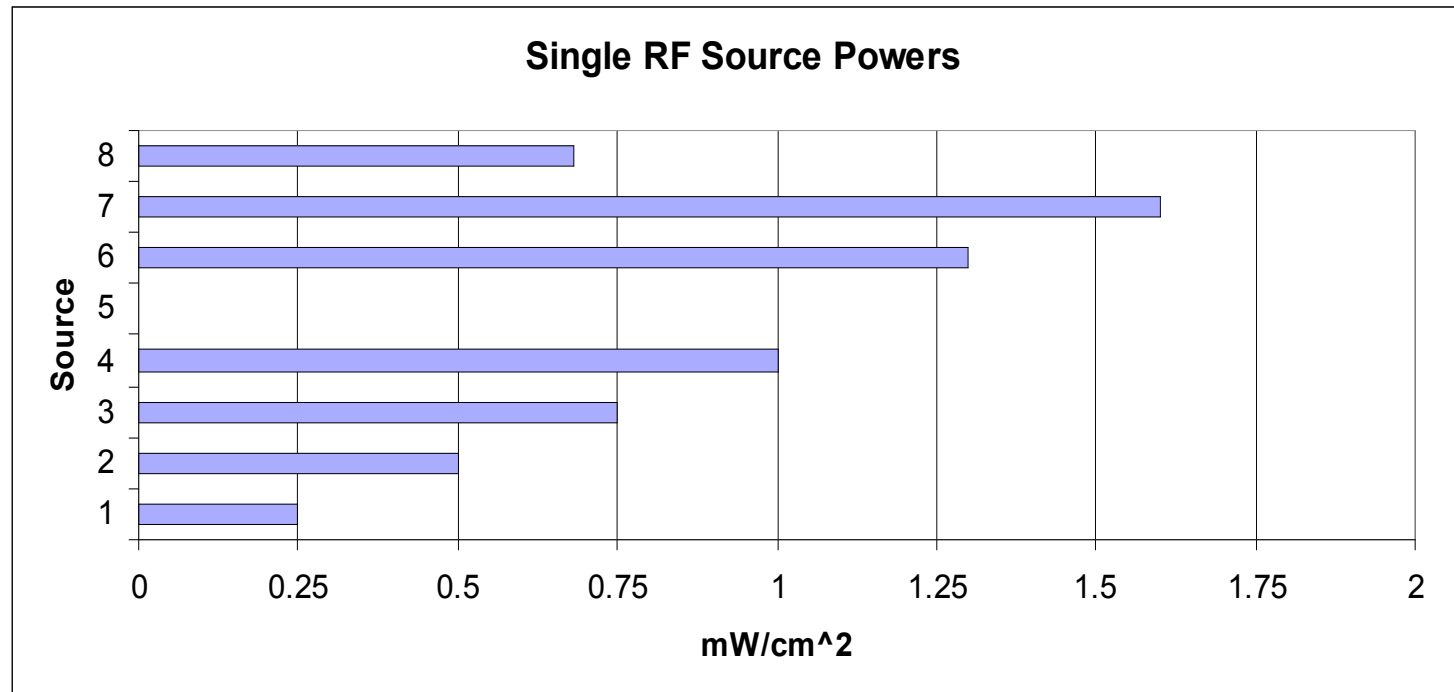
# Different Frequencies Different Powers

- Wireless LAN 1 – 5 W
- Wi-Fi Hotspots 2 – 10 W
- Cell phones, towers 10 W
- Radio towers 100 kW
- Security radios 5 W
- Ambulance, Fire, Police 100 – 1000 W
- HDTV 1 million watt transmitters

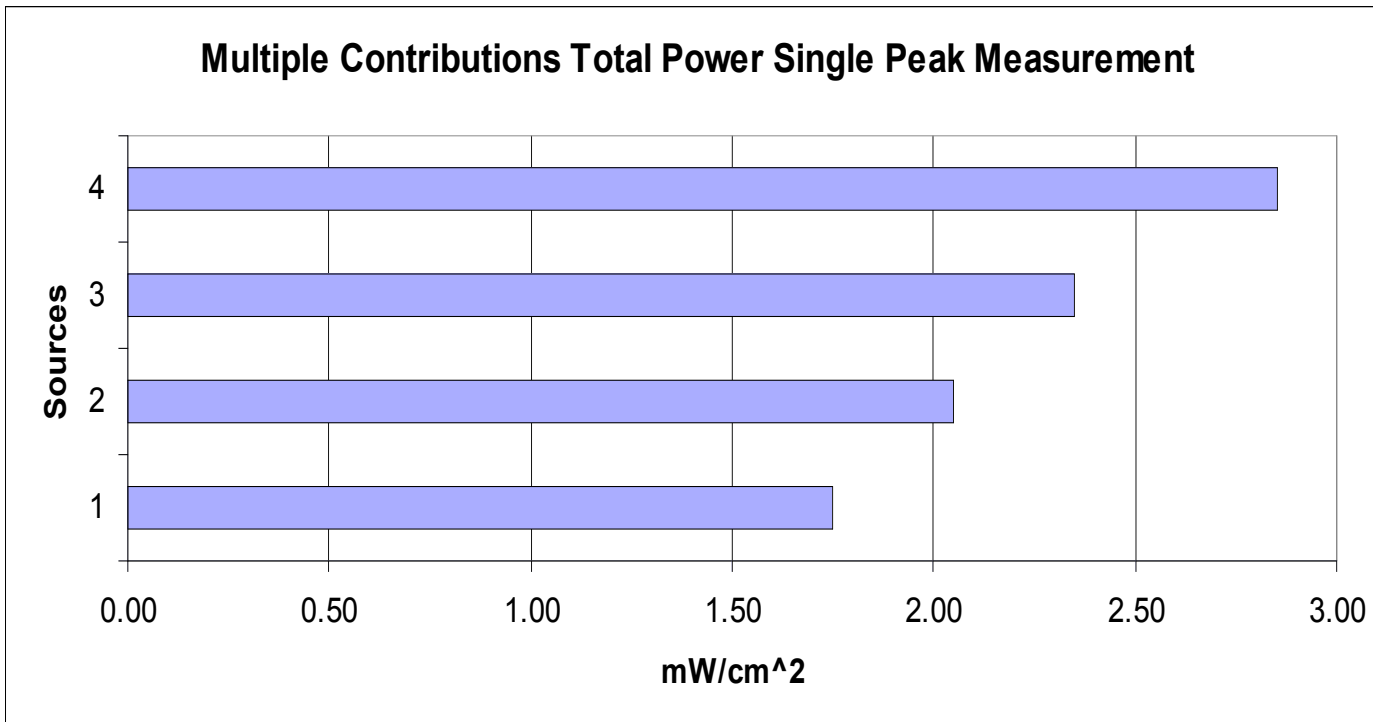
# Power Summing - Peak Power

- Typical instruments are set for peak power
  - Irregardless of frequency
  - Sums over a broad range
  - Different correction factors for each frequency
  - Orientation affects reading
  - Irregardless of time averaging
  - Irregardless of spatial averaging
- Good if you never go over 1 mW/cm<sup>2</sup>

# Contribution from Various Single Sources



# Total Power from Multiple Sources



# Are You Out of Compliance?

• Measured Power in mW/cm <sup>2</sup>	• Standard	--	% limit
25 mW/cm <sup>2</sup> @ 2.5 MHz	100 mW/cm <sup>2</sup>	--	25%
0.75 mW/cm <sup>2</sup> @ 125 MHz	1 mW/cm <sup>2</sup>	--	75%
0.5 mW/cm <sup>2</sup> @ 900 MHz	3 mW/cm <sup>2</sup>	--	17%

Out of compliance IF:

Sources all radiating at once

For six minutes continuously

- in a broad field

- over whole body

# In Compliance

- Know the generating frequency
- Know the pulse frequency
- Know the human exposure potential

# Conclusion

- Monitor all sources
- Consider multiple sources
- Know frequency distribution
- Work with your radiofrequency and microwave equipment owners
- Trust their knowledge