EME UPDATE PRESENTATION

CIHC – December 3, 2024

EME SAFETY, LLC

TYPICAL TRAINING AGENDA

HAZARD DISCUSSION

CONSEQUENCES OF EXPOSURE

BEHAVIOR TO AVOID/MITIGATE EXPOSURE

NIR STANDARDS AND CONTROLS

TRAINING SUBJECTS

EMPLOYEE PARTICIPATION

SOURCES OF INFORMATION

HAZARD DISCUSSION

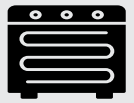
WHY SHOULD YOU LEARN THIS?

- To make an informed decision, persons need to understand the effects of exposures and to be able to control their exposures.
- Antennas (intentional) or leakage from unintentional sources may create fields that exceed exposure limits. These could present legal or health issues.
- Potential hazards may include more than just sources. Concomitant hazards may include:
  - Trip/Fall Hazards
  - Induced/Contact Currents
  - Electrocution
  - ELF/VLF Exposure

ELECTROMAGNETIC RADIATION

- May be described by three quantities:
  - **Photon energy** (**E** in joules)
  - **Wavelength** (**λ**) – distance between 2 points in the same phase of consecutive wave cycles; also, one complete cycle of a wave -- units of length: meters to nanometers (nm, 10^{-9}) or micrometer (µm, 10^{-6})
  - **Frequency** (**ƒ**) – number of complete wave cycles that occur in one second (units of frequency: 1 hertz (Hz) = 1 cycle per second; multipliers = GHz (10^9 Hz), MHz (10^6 Hz), kHz (10^3 Hz)

THE ELECTROMAGNETIC SPECTRUM

Static	ELF/VLF	RF and Microwave				Infrared	Visible Light	UV	X-Rays	Nuclear
										
MRI	Electricity	AM/FM Radio	TV	Cell Phone	Satellite	Heat Lamps	Sunlight	Tanning Devices	Medical	Ionizing A, B, Γ
Non-Ionizing						Optical			Ionizing	
Induced Currents		Tissue Heating			Surface Heat		Photochemical Effects		Broken Chemical Bonds	
0 Hz	50/60 Hz	0.5 to 100 MHz	30 to 700 MHz	0.7 to 6 GHz	1 to 100 GHz	1mm to 800 nm	800 nm to 380 nm	400 nm to 100 nm	100 eV to 100 keV	> 1 MeV

Photon Energy Increases with Frequency →

NON-IONIZING (RF) EXPOSURES

- Exposure effects differ over frequencies. Static fields and ELF/VLF regions are not normally an issue for humans without implanted medical devices.
- In the 3 kHz to 100 kHz region, tissues start to absorb some energy, limits based on PNS or peripheral nerve stimulation.
- Specific Absorption Rate (SAR) is the dosimetric quantity over the 100 kHz to 6 GHz region.
- Above 6 GHz, exposures are close to the surface of the body.
- Removing the body from the field ceases the exposure effect. Unlike Ionizing radiation, low-level exposures are not regarded as important.
- Ionizing exposures are cumulative while non-ionizing exposures are not.

3 kHz to 30 MHz

Body starts to absorb both E and H fields as frequency increases and reaches peak at resonant frequency.

Electric field induces currents that cause heating at joints. Fields can also cause deep heating that is not easily detected.

In extreme exposure situations:
Shock or burn from current flow to ground.
Heat related effects (stress, dehydration)

In the resonant region (50 to 300 MHz) the depth of penetration is highest and deep heating can occur.

Extreme exposure situations cause:
Shocks or burns from current flow to ground
Heat related effects (stress, dehydration)

30 to 300 MHz

Penetration depth decreases as frequency increases, heating is confined to the exposed area.

Significant exposures can almost always be felt as heat.

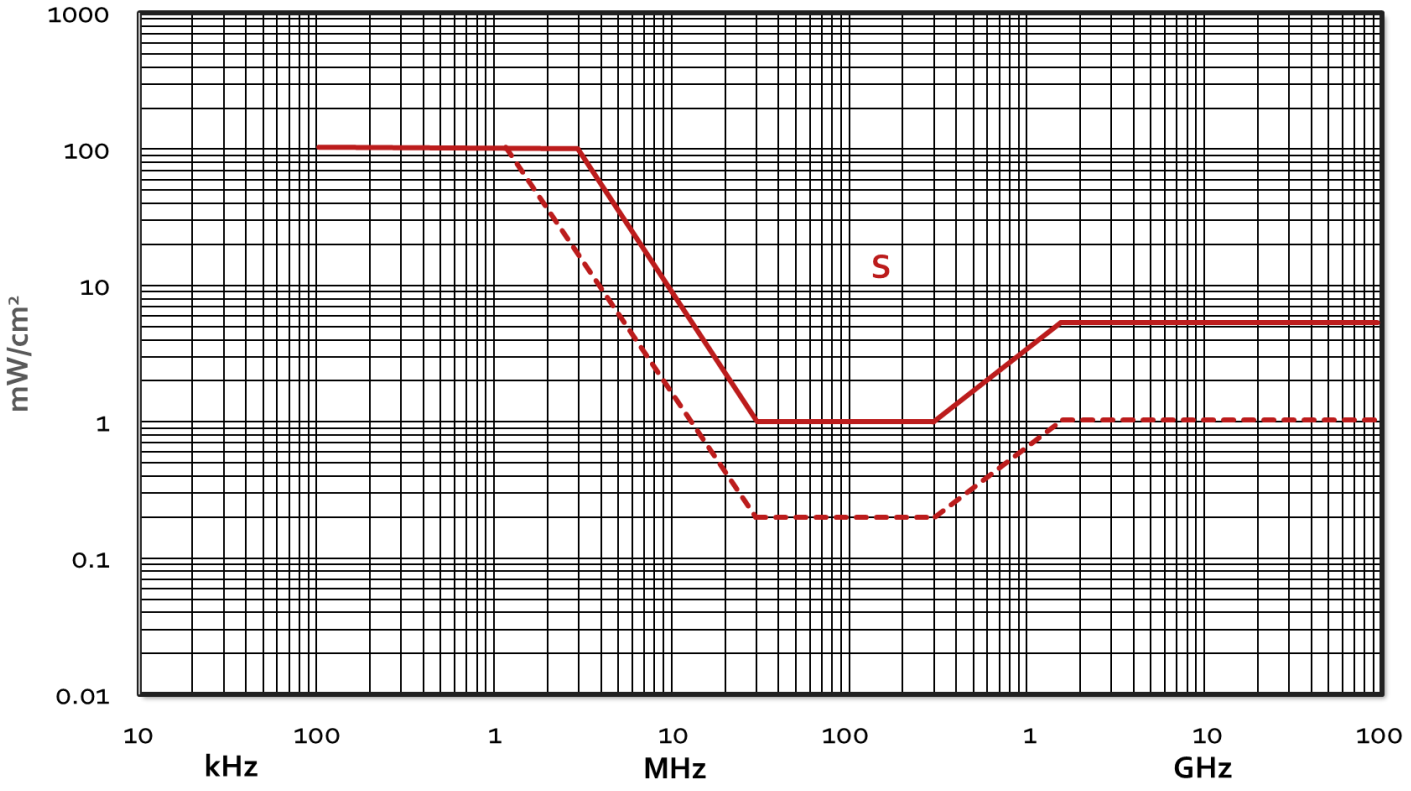
Above 300 MHz

Surface tissues can be heated quickly, potentially resulting in burns.

IDENTIFYING SIGNIFICANT SOURCES

- Power Level (“Significant” changes over frequency)
  - 5 Watts below 6 GHz, 1 Watt above 6 GHz
- Frequency (Wavelength)
  - Energy increases as frequency increases.
- Names and Labels
  - Antennas, transmitters, and sources may be identified
- Condition of Equipment
  - Are covers and controls in place?

SPECIFIC ABSORPTION RATE (SAR) VS. FIELDS



FCC field exposure limits vary by frequency and knowledge

SAR limits were developed years ago. Animal research indicated levels of 4 W/kg heated tissue enough to cause temporary behavioral effects.

- The 1982 ANSI C95.1 standard set human exposure limits to levels of 0.4 W/kg and those limits are still being used.
- The US NCRP recommended an additional safety factor of 5 for the general public who could be exposed to fields roughly 5 times as long as a typical worker.
- Research determined that while SAR is constant over frequency, human absorption of fields is not. Therefore, standards are “shaped” to account for absorption.

WHAT LIMITS APPLY? (ITU)

- For someone to be considered to be an RF worker or RF informed worker, an RF Safety program is required that includes at least 5 steps
  - Performing risk and exposure assessments
  - Training RF workers
  - Providing information on safety practices to RF informed workers
  - Providing RF workers with the right tools
  - Applying preventative measures.
- May not include pregnant women or workers bearing implanted medical devices

EXPOSURE STANDARDS

- Many standards exist in the world, but most of them are based on recommendations from ICNIRP or IEEE.
- RF and light standards are essentially harmonized from ICNIRP and IEEE and further agreement is pending.
- Canada's SC6 (a little more conservative) and the NATO STANAG 2345 (less conservative) will join the rest of us.
- ACGIH RF TLV's have not yet been updated, but probably will be shortly.

STANDARDS FOR NIR SAFETY PROGRAMS

IEEE generates standards and recommendations for more than just exposures.

There are standards for safety programs as well as survey or calculation procedures.

All are available on the IEEE GET program page, at no charge.

ICNIRP generates guidance's for different frequency ranges, from Static fields to ultraviolet frequencies.

WHAT IS YOUR RISK OF EXPOSURE?

To make an informed decision about the risk of non-ionizing radiation exposure, one must be able to identify the hazard, know what their potential exposure is from that hazard, and how to control their exposure, if required.

Time, distance, and shielding are common methods of control.

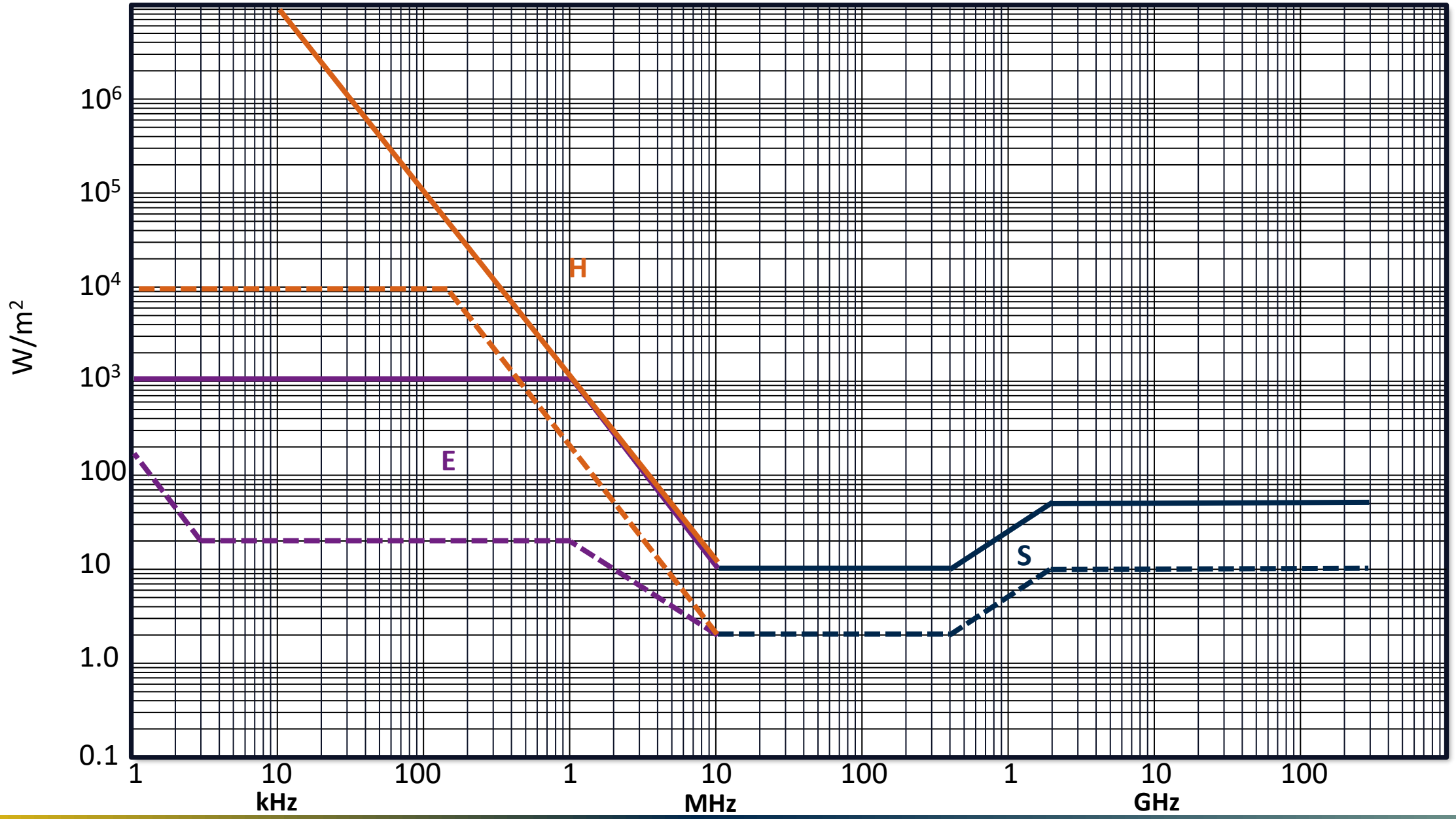
-Minimize time around antennas

-Keep your distance from high-power antennas

-Shield the source or receiver

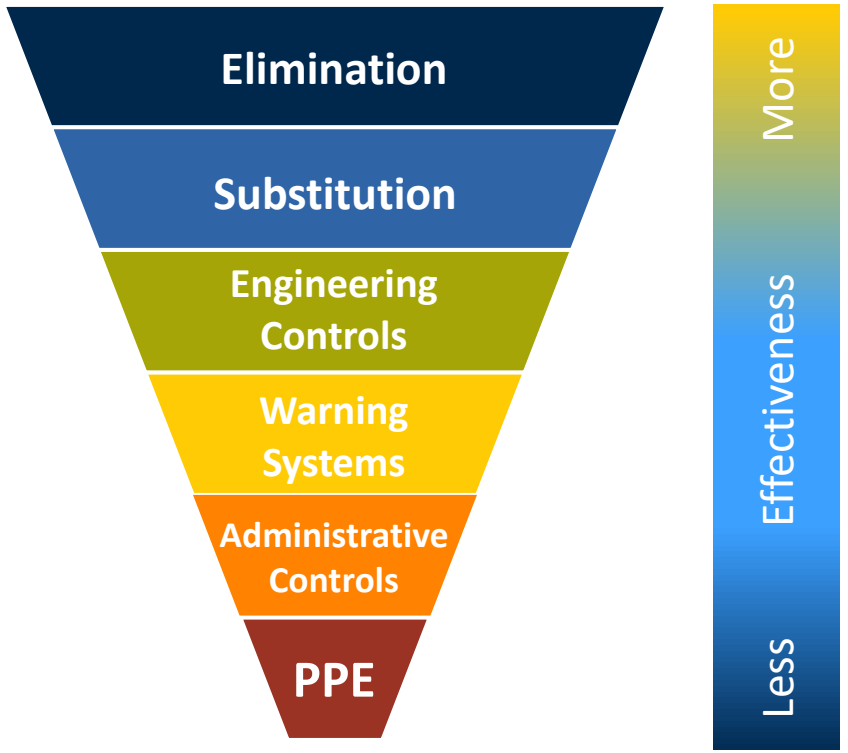
Most people would agree that standards are conservative and the risk of exposure effects is negligible if exposures comply with limits.

ICNIRP 2020


W/m²
10⁶
10⁵
10⁴
10³
100
10
1.0
0.1
H
E
S
1
10
100
1
10
100
1
10
100
kHz
MHz
GHz

MINIMIZING RF EXPOSURE CONSEQUENCES

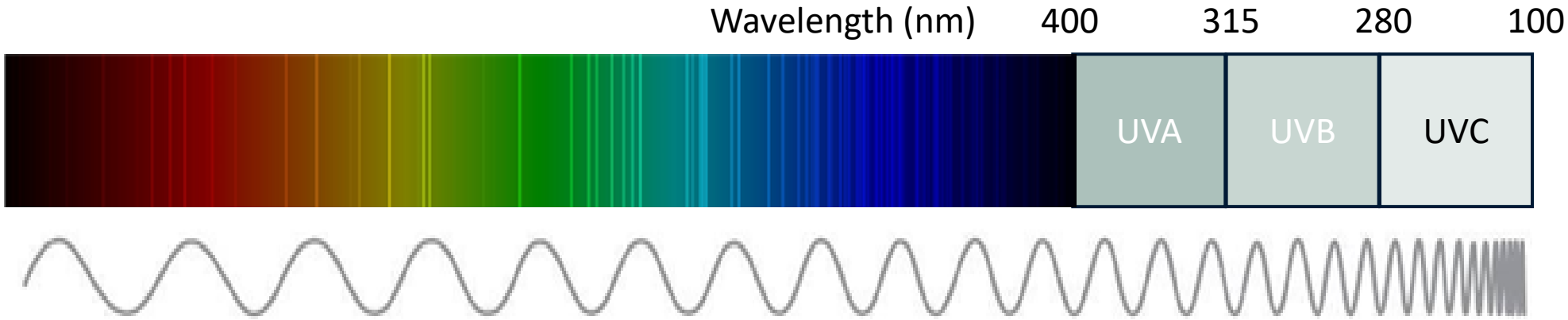
- Obey site signs and know their meanings
- Time, Distance, and Shielding
- Respect Barriers
- Employ Warning Systems when appropriate
- Know antennas and antenna patterns
- Use your eyes and experience
- Watch for concomitant hazards



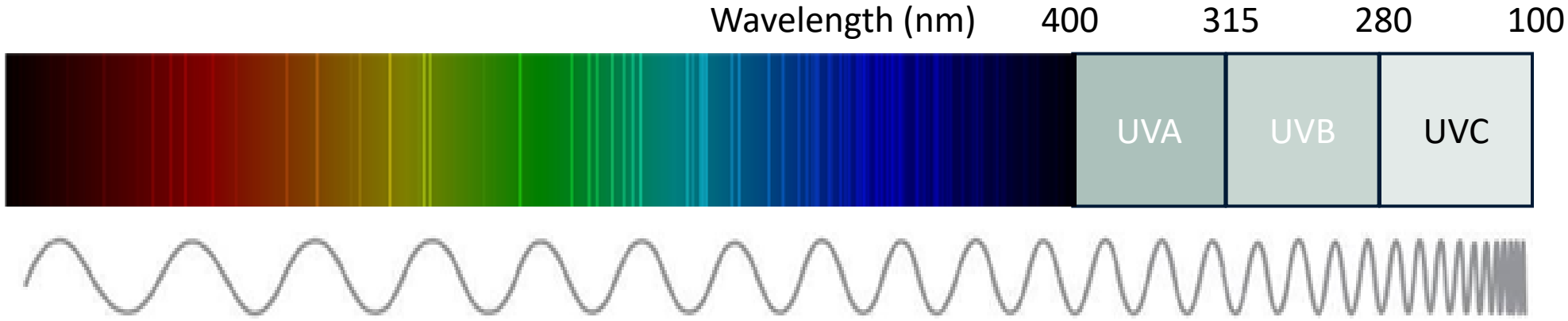
Controlling Hazards

IR, VISIBLE AND UV CONTROLS

- Elimination / minimization of reflective surfaces from work area
- Enclosure of work operation behind opaque or absorptive materials
- Eyeglasses, goggles, faceshields with UV-absorbing lenses
- Protective clothing (tightly-woven materials)
- Sunscreens (not protective against shorter wavelengths)



UVA	**400 to 315 nm**	**Tanning Rays**	**Blacklight, Tanning Beds**
UVB	**315 to 280 nm**	**Burning Rays**	**Sunburns**
UVC	**280 to 100 nm**	**Dangerous Rays**	**Lithography, Germicidal, Disinfecting**



- UVC is easily contained in most applications. Pyrex glass is an effective shield in most cases.
- Extreme UV (EUV or EUVL) at 13.5 nm presents soft X-Ray hazards.
- Lamps are usually rated at 1m distance. Inverse square law applies.
- Surveys are performed with sensor facing source for eye hazards and perpendicular for skin hazards.

RF AWARENESS TRAINING SUBJECTS (C95.7-2022)

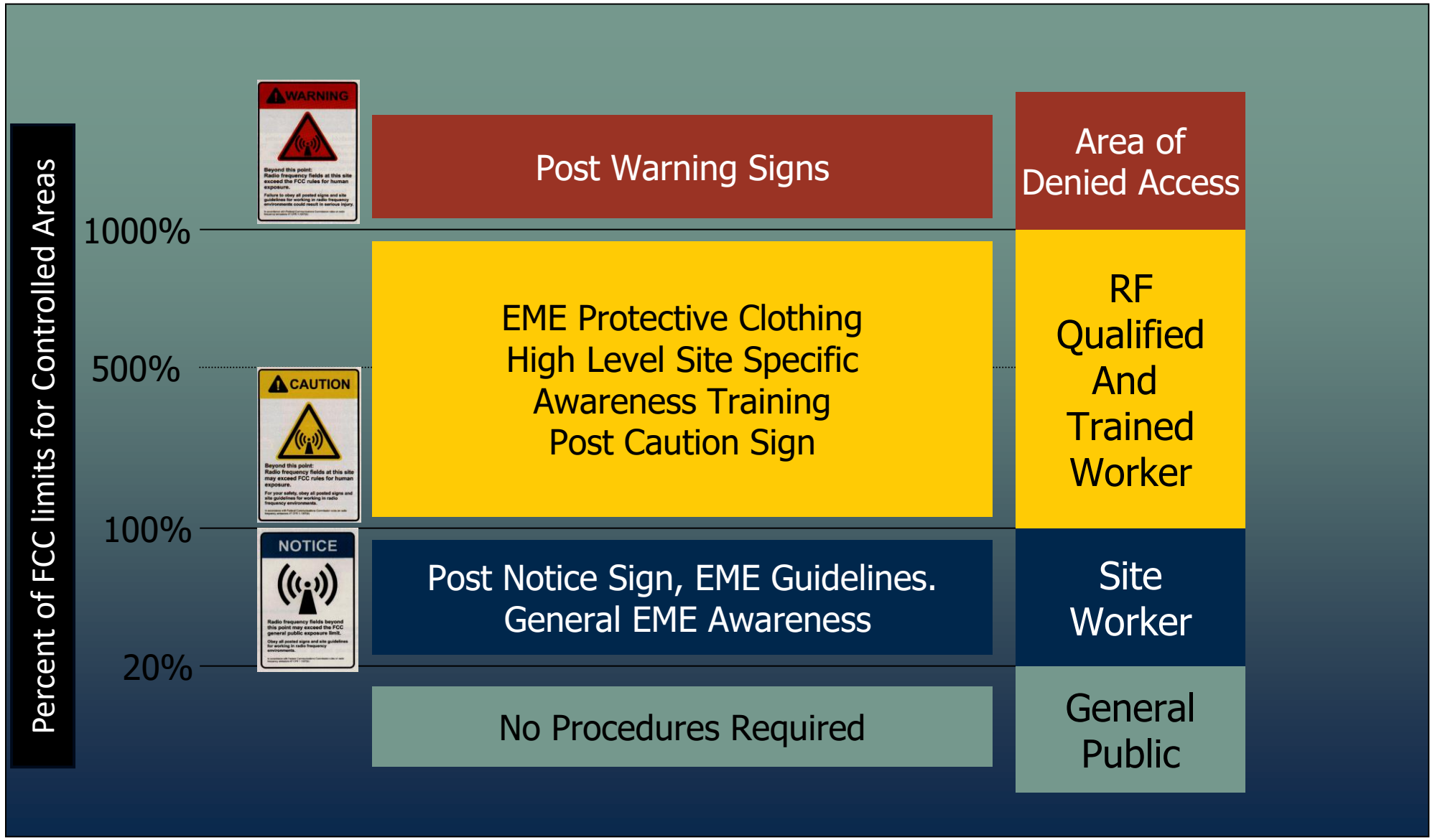
Hazard Discussion

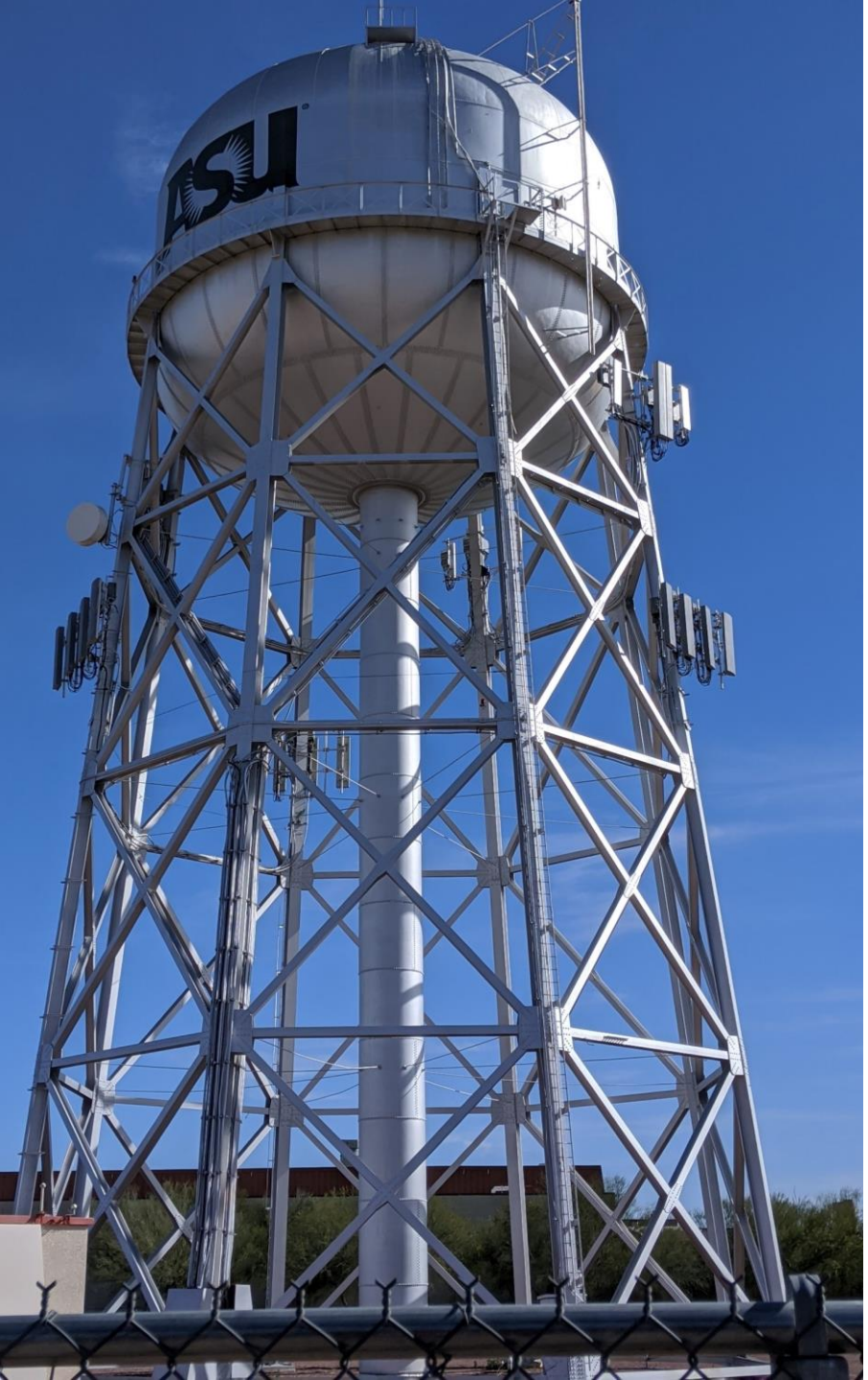
- Why should I learn this information?
- What are the kinds of EME I may encounter?
- Hazard identified by risk of exceeding exposure limits?
- How does this differ from ionizing radiation?
- EME Levels and limits

Consequences of Exposure

- Potential end effects (such as thermal loading, shocks/burns)

IEEE WARNING SIGNS AND LEVELS





EMPLOYEE PARTICIPATION

- Employees are encouraged to notify their supervisor if:
  - They feel unusual heating
  - They are dependent on personal medical devices
  - They are pregnant

RELIABLE SOURCES OF INFORMATION

1. Reliable products are from companies with accredited calibration systems, generally Narda or Wavecontrol.
2. Stay away from cheap products from Amazon.
3. Obviously, the internet is full of sites that promote unreliable information from persons or papers that are not peer-reviewed. Use at your own risk.

Additional Recommended Information:

- International Telecommunications Union ITU-T K.145 (12/2020) (Good general-purpose RF safety document for RF Workers, no matter what country)
- FCC Documents OET Bulletin 65 Note: OET Bulletin Number 65 is currently under review to provide updated guidance regarding the rule changes of FCC 19-126 that became effective May 3, 2021. FCC 19-126 (Important rule changes from the FCC) 47 CFR 1.1307, 47 CFR 1.1310
- IEEE C95 GET Program page. IEEE Standards are available for free through the "GET" program. Set up an IEEE account to download them. C95.1, C95.2, C95.3, and C95.7 are the most relevant to this training.

Thank You for your attention!

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Questions?