



Safety Management

RF - Radiofrequency Site Safety



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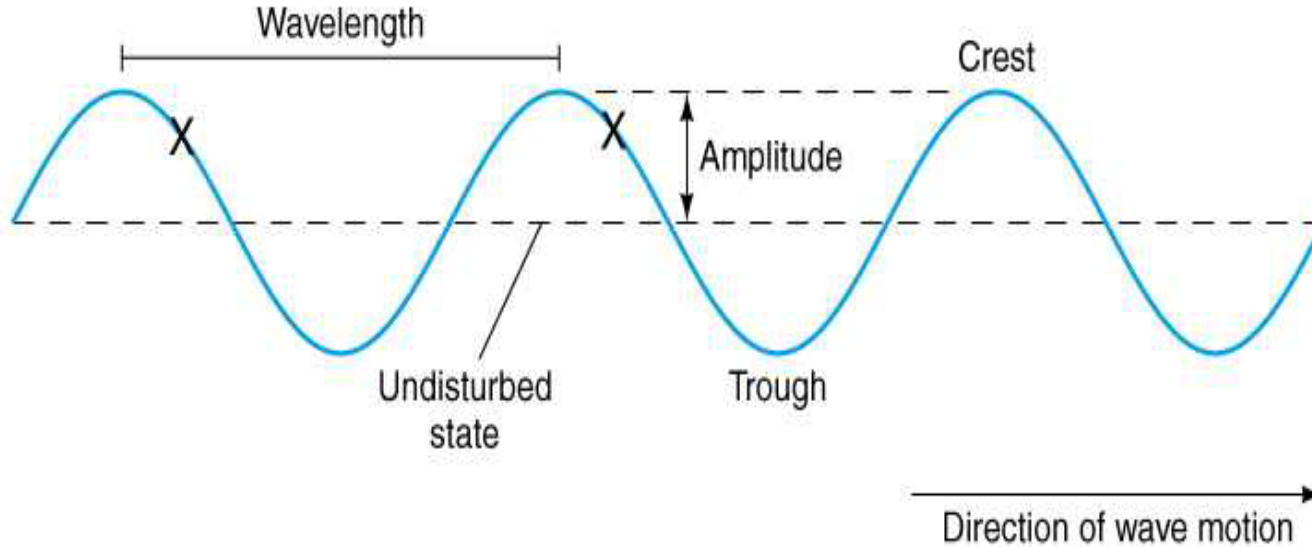
Purpose

Provide:

- Basic Technical Understanding
- Overview of FCC Regulations and Compliance Issues
- Hazard Recognition Skills
- Awareness of RF Exposure Control Measures
- Outline of an RF Site Workplan

What is RF Energy?

- Electromagnetic Energy
 - Electric Field
 - Magnetic Field
- Non-Ionizing Radiation
- Energy Waves Travel at Speed of Light
- Frequency Range of Concern:
~300kHz to 100GHz

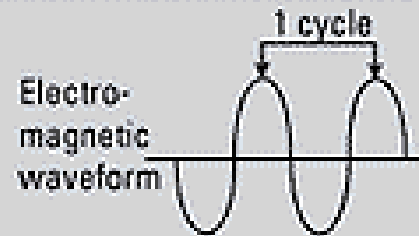


Frequency and Wavelength

Frequency is shown in Hertz (Hz). 1 Hz = 1 cycle per second.

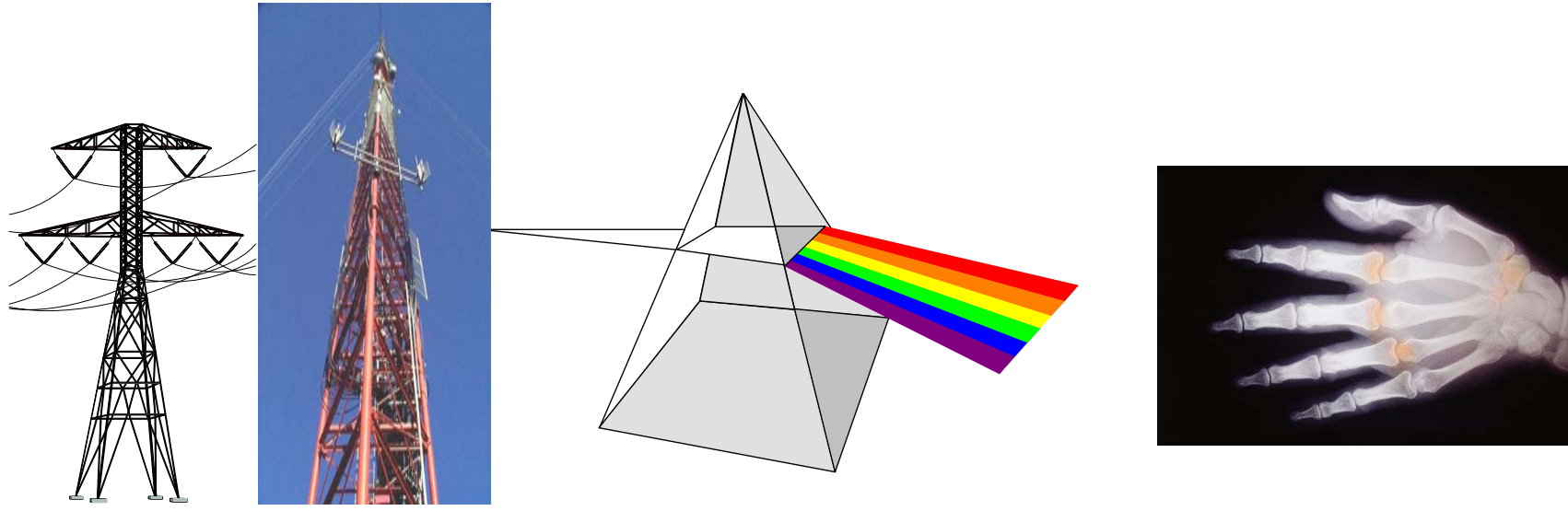
kHz = kilohertz = 1000 Hz

MHz = megahertz = 1,000,000 Hz



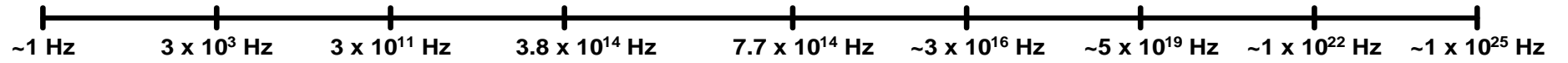
Examples:

Source	Frequency	Wavelength
Power line	60 Hz	3100 miles (5000 km)
Microwave oven (inside)	2450 MHz	4.8 inches (12.2 cm)



NON-IONIZING

IONIZING



Frequency Increasing →

← Wavelength Increasing

Terminology

- **ANTENNA** - conductive object that radiates RF energy at certain frequencies
- **DUTY FACTOR** - Ratio of average *on* time to total period of transmissions. i.e., continuous=1.0, 40% on 60% off during a specified period=0.4
- **EFFECTIVE RADIATED POWER** - ERP, Power supplied to the antenna and the effects of gain
- **GAIN** - Characteristic of an antenna, expressed in dB, that results in an increase of field strength at a given distance when compared to a reference antenna.
- **HERTZ** - Hz, Unit of frequency, 1 Hz = One cycle per second

- **FIELD STRENGTH** - The strength of the magnetic and electric fields at a given distance from source. The near field is $1/2$ wavelength or less from the antenna. The far field is greater than $1/2$ wavelength.
- **SPECIFIC ABSORPTION RATE** - SAR, The rate at which energy is absorbed in biological tissues. Safety guidelines are based on SAR threshold where tissue heating occurs.
- **MAXIMUM PERMISSIBLE EXPOSURE LIMITS (MPE)** - Established by the FCC based on ANSI/IEEE C95.1-1999, “Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields 3 kHz to 300 GHz. Two categories of limits are established. Controlled exposure limits apply to an employee who is fully **aware** of the potential for RF exposure and can exercise **control** over their exposure. Uncontrolled exposure limits apply for the general public or when there is no awareness for the potential for exposure. (see next slide)

Exposure Categories

General population/uncontrolled exposure. Applies to the general public or occupational exposure to RF fields when these individuals may not be fully aware of the potential for exposure or cannot exercise control over their exposure. Members of the general public always fall under this category. Exposure to employees who visit transmission/antenna sites fall under this category if they are not trained or have no awareness. These exposure limits are averaged over a 30 minute period.

Occupational/controlled exposure. Applies to occupational RF exposure for individuals who have been made fully aware of the potential for exposure and can exercise control over their exposure. These exposure limits also apply where exposure is of a transient nature as a result of incidental passage through a location where exposure levels may be above general population/uncontrolled limits (see definition above), as long as the exposed person has been made fully aware of the potential for exposure and can exercise control over his or her exposure by leaving the area or by some other appropriate means. These limits are averaged over a 6 minute period

Effects of RF Exposure

- Tissue Heating (effects vary with exposed body area)
- Skin Sensation - Extremely High Exposure
- RF Burns From Touching an Energized Source
- Electric Shock From Induced Currents
- Cataracts - UHF and Microwave Frequencies
- Some Anecdotal Reports of Physiological Effects
- No Confirmed Studies as a Carcinogen or Cancer Promoter (Energy levels are too low to cause ionization)

Biological Effects of RF Exposure

- Research has shown that exposure to RF fields on the order of $100\text{mW}/\text{cm}^2$ can clearly heat biological tissue. This level of RF fields is 100 times greater than the FCC Occupational/Controlled MPE limit for the 30-300MHz frequency range and 500 times higher than the FCC General Population/Uncontrolled MPE limit for the same frequency range (30-300MHz).
- Under certain conditions, human exposure to RF energy at power density levels of $1\text{-}10\text{mW}/\text{cm}^2$ and above can result in measurable heating of tissue (but not necessarily tissue damage).
- The extent of the tissue heating depends on several factors:
 - frequency and power of the radiation source;
 - size, shape and orientation of the exposed object;
 - duration of exposure;
 - environmental conditions; and
 - heat dissipation efficiency.
- Commonly reported effects of extended exposure to high levels of RF radiation include: headaches, dizziness, fatigue, and buzzing in the ears.
- At UHF and microwave frequencies heating of the lens of the eye from high intensity fields can result in the formation of cataracts.



RF Regulations

- **OSHA** 29 CFR 1910.97 Nonionizing Radiation
- **ANSI/IEEE** C95.1-1999, “Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields 3 kHz to 300 GHz”
- **FCC** Office of Engineering and Technology Bulletin 65, 97-01 (see ANSI/IEEE)
- **ACGIH** Threshold Limit Values, 2004 (see ANSI/IEEE)
 - Also based on the National Council on Radiation Protection and Measurements

RF Site Evaluation

The FCC requires that certain facilities and sites, owned and operated by **FCC licensees**, be evaluated to determine the levels of RF energy present. OSHA requires that employers provide their employees a safe and healthful workplace in which to work. The site evaluation determines whether the site has areas where exposure levels may exceed the FCC/OSHA requirements. An RF Site Evaluation (routine environmental evaluation) should be performed by the licensee for each communication site.



RF Site Evaluation

- *What is an RF Site Evaluation?*

An RF Site Evaluation is the process of analyzing a communication site to determine whether or not, due to its RF operation, it could have a significant environmental effect. The RF Site Evaluation will determine if RF fields in accessible areas at a site exceed the applicable FCC/OSHA human exposure limits.

- *When is an RF Site Evaluation required?*

FCC licensees/applicants must determine the environmental effects of their operation when filing for a new license, amending a license, or renewing a license. Per OSHA, a employer must provide a safe and healthful workplace for its employees. An RF Site Evaluation will determine if the workplace (communication site) is safe per the FCC/OSHA RF exposure standards (Conforms with OET Bulletin 65).

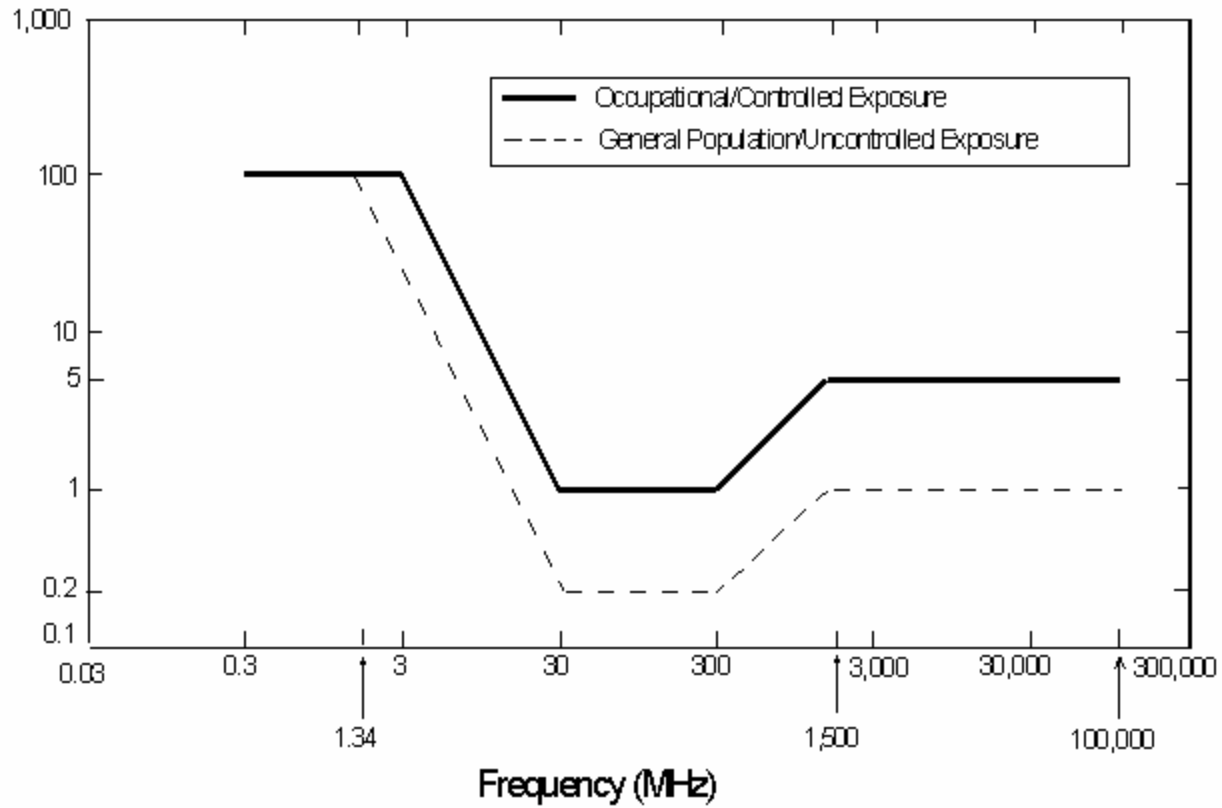
- Two FCC accepted methods for performing an RF Site Evaluation include **Field Measurements** and **Calculations/Tables**.

Exposure Considerations

- Transmitter Power
- Frequency
- Duty Cycle
- Exposure Duration (Controlled MPE based on 6 minutes)
- Antenna Gain and Directionality
- Distance of Individual from the Antenna
- Other Transmitting Antennas at the Site

Figure 1. FCC Limits for Maximum Permissible Exposure (MPE)

Plane-wave Equivalent Power Density



How is RF Exposure Evaluated?

- **RF Measurements**
 - Field Strength Meter
 - Measures Power Density (used for site assessments)
 - Dosimeter
 - Measures personal exposure level (dose over time)
- **Calculations to Approximate Power Density**
 - Power Input to Antenna
 - Gain of Antenna
 - Distance of Individual From Antenna
- **Tables in OET Bulletin 65 – Need the following information:**
 - Frequency
 - ERP
 - Distance to Radiating Antenna

Hand-held RF Survey Meters

- Training needed
- Frequency specific
- Orientation with antennas is critical
- Interpretation requires technical understanding
- Used for site evaluations



Personal Dosimeter
Worn by worker, measures exposure over time.
Audible and visual warning

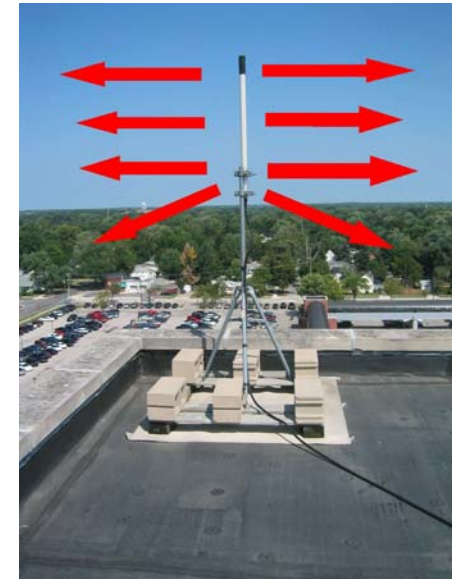
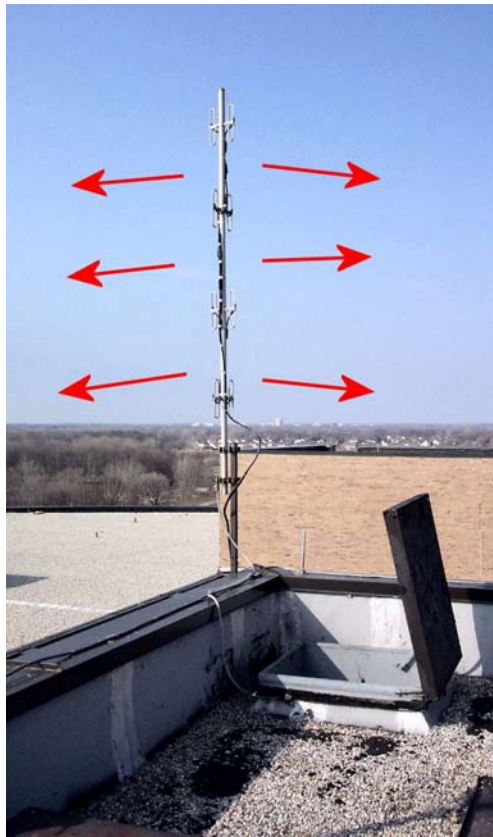
What is at a Typical RF Site?

- Fences
- Signs
- Equipment hut
- Equipment room
- Equipment cabinets
- Towers
- Antenna support frames
- Antennas
- Coax
- Wave Guides

Types of Antennas

- Omni-directional (Low or No Gain)
- Omni-directional (Moderate or High Gain)
- Directional
 - Yagi
 - Corner Reflector
 - Panel
 - Parabolic Dish
- Special Designs

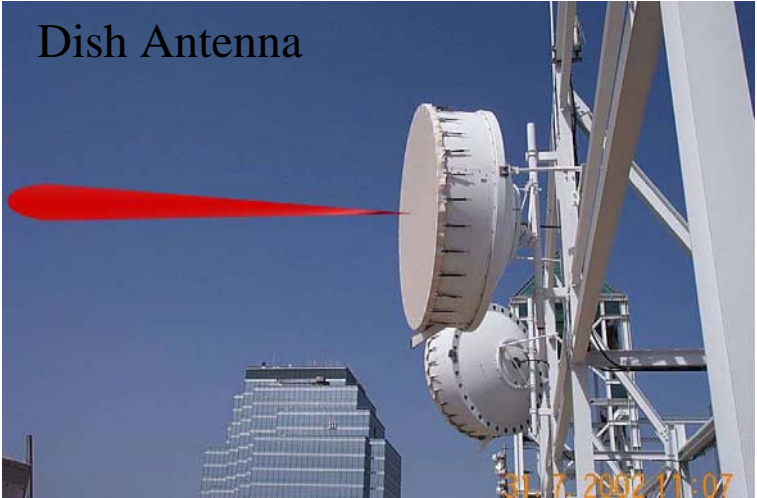
Omni Directional or “Stick” Antennas



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Directional Antennas



Panel Antennas

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Pole-Mounted Cellular Antennas



VZ Wireless, California

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Pole-Mounted Cellular Antennas

- **Proximity of worker to radiating antennas important (i.e., head, eyes and reproductive organs)**
- **Directional and omnidirectional antennas may be present**
- **Higher power directional gain antennas have greater potential for exposure**
- **MPEs for uncontrolled /general population apply unless techs have awareness training and can take action to reduce exposures**
- **Safe distances can vary considerably due to configuration, frequency and power levels (i.e., several inches to several feet)**
- **Attachments and equipment can be obstacles to climbing and access**



Tower Site

- RF exposure exceeding MPE at ground level unlikely when transmission equipment is properly shielded
- Precautions necessary when climbing
 - Antenna proximity - RF exposure
 - i.e., Lockout/Tagout
 - Fall Protection
- Signs identify levels of risk based on site assessment by licensees
- Multiple antenna arrays may be present

**Antenna Array for WWVH
Time Signal Transmission
Hawaii**



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Telecommunications Towers



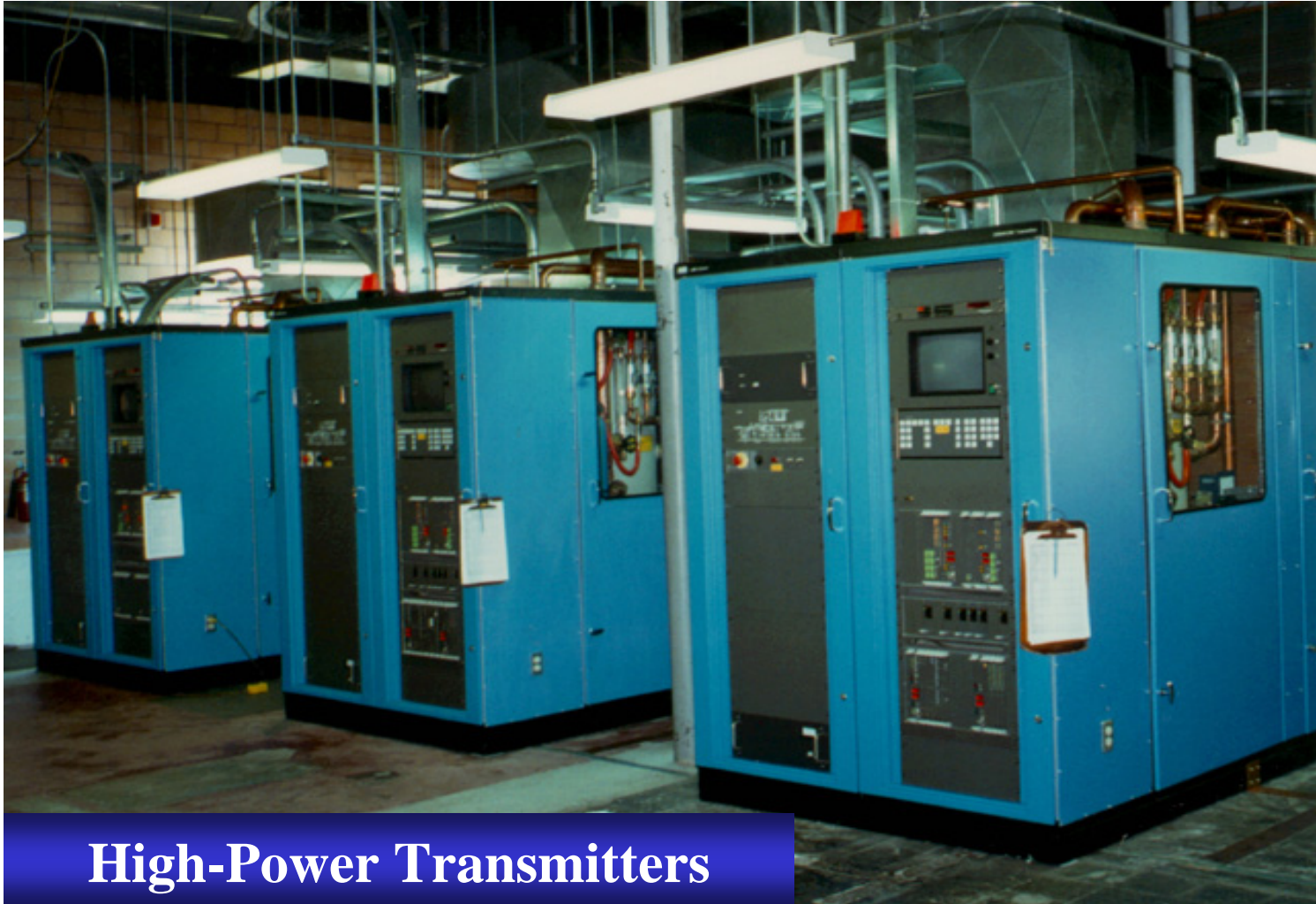
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Equipment Hut or Room

- Enclosed transmission equipment shields personnel from RF.
- Cabinets usually are grounded to assure system efficiency and proper operation of transmitters.
- Exposure exceeding MPE unlikely if cabinets are closed and coax/waveguides are undamaged
- Similar environment as a telecommunications central office (batteries, cables and electronics)
- Some high voltage equipment may be present



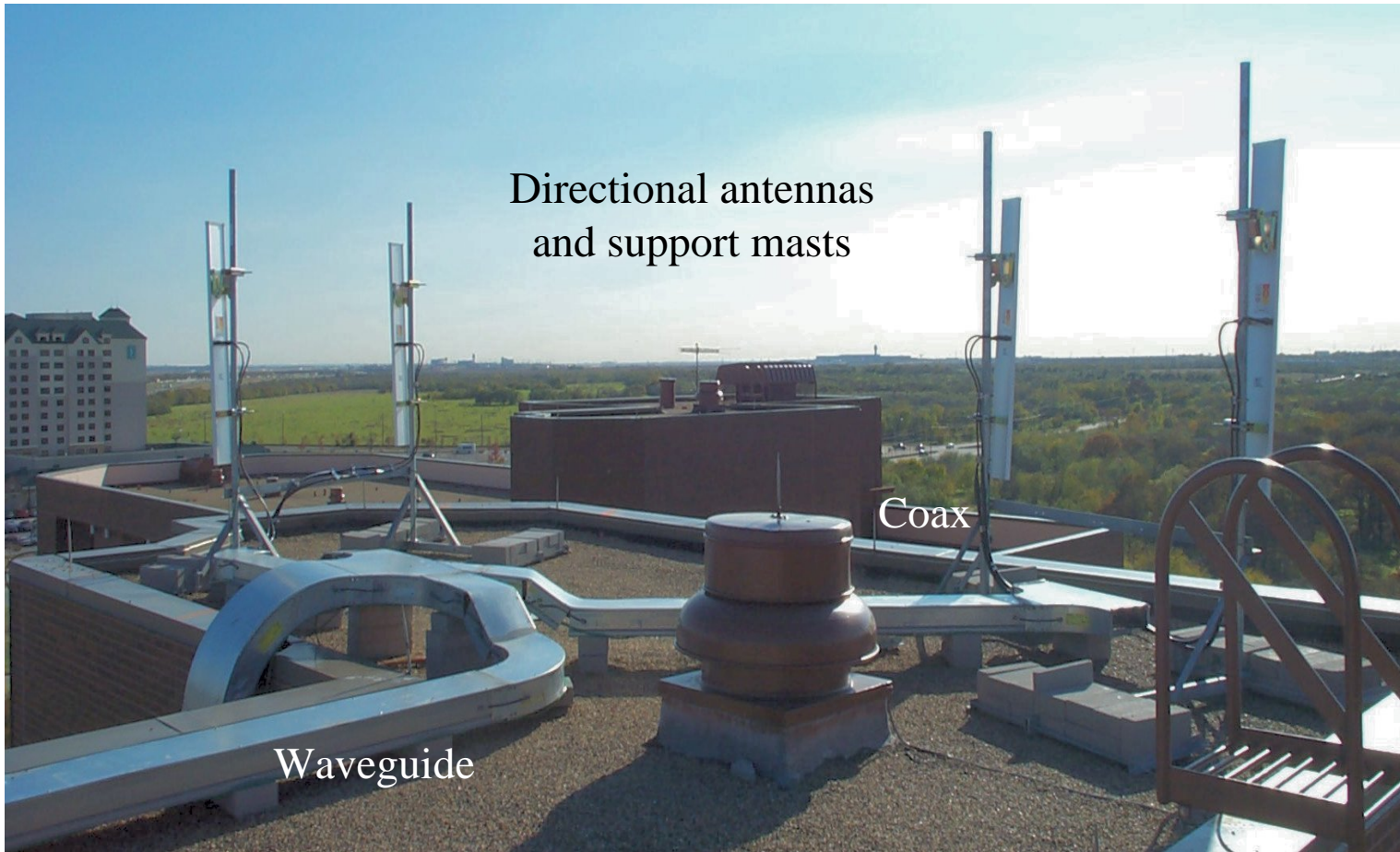
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Roof Area



- Keep safe distance from antennas
 - 6 feet is usually adequate
- Avoid standing in front of microwave dishes and directional antennas
- Transmitters might operate intermittently – Difficult to identify an “active” antenna
- Avoid unprotected building perimeters, skylights and roof openings
- Tripping hazards may be present
- Multiple antennas can add to the exposure level



Directional antennas
and support masts

Waveguide

Coax





RF Survey Meter

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Warning Sign: "Beyond this point: Radio Frequency Exposure May Exceed Controlled Exposure Limits"



RF Exposure Controls

- Type of work or access
 - Occupational/Controlled Exposure
 - Restricted Access – RF exposure potential
 - General Public/Uncontrolled Exposure
 - RF exposure above MPE unlikely
- Distance (less risk with increased distance)
- Point Beam Path Away From Occupied Areas. (avoid being in beam direction of dishes and directional antennas)
- Signs appropriate to the site characteristics
- Awareness training to suit the conditions of exposure
- Avoid areas of suspected elevated RF levels

- Use of RF dosimeters or measuring equipment is discretionary based on the specific type of work at a site. The proximity to the radiating antennas and type of site equipment is assessed on a case by case basis.
- Whenever possible, a minimum worker distance of 6 feet should be maintained from all energized antennas. Avoid standing in one spot if near antennas or working in front of directional or dish antennas.
- For sites with tower mounted antennas and properly enclosed transmission equipment, exposures at ground level would not be expected to exceed the MPE for controlled or uncontrolled exposures.

Radiofrequency Awareness Training

Training includes:

- Basic understanding of the RF hazards and how to avoid exposures.
- How to interpret signs and general radio transmission site requirements.
- Recognition of RF sources (antennas and equipment) at a typical site.
- Complies with FCC OET Bulletin 65 / OSHA requirements. Maximum Permissible Exposure guidelines.

Note: Information in this module meets the FCC awareness criteria

- **When is a Work Plan needed?**
 - **Sites where an RF exposure risk exists:**
 - **High Risk Site**
 - *Special precautions and expertise required*
 - » Sites with exposure potential above MPE for Occupational / Controlled exposures
 - **Moderate Risk Site**
 - Potential for RF exposure above the MPE for General Public / Uncontrolled exposures

Information needed to prepare a Work Plan


- The type of RF transmission equipment,
- Number, type and location of antennas,
- Proximity of the work to the radiating sources,
- The duration of the work operation,
- Wording and location of Notice, Caution, and Warning signs,
- Contact information for the individual or organization responsible for the site,
- Site assessment information that was provided by the site contact, and
- Specific information regarding measures needed for employees to follow to reduce or eliminate exposures to RF energy

NOTICE

GUIDELINES FOR WORKING IN RADIOFREQUENCY ENVIRONMENTS

- ⚠ All personnel should have electromagnetic energy (EME) awareness training.
- ⚠ All personnel entering this site must be authorized.
- ⚠ Obey all posted signs.
- ⚠ Assume all antennas are active.
- ⚠ Before working on antennas, notify owners and disable appropriate transmitters.
- ⚠ Maintain minimum 3-foot clearance from all antennas.
- ⚠ Do not step in front of antennas.
- ⚠ Use personal RF monitors while working near antennas.
- ⚠ Never operate transmitters without shields during normal operation.
- ⚠ Do not operate base station antennas in equipment room.

CAUTION




Beyond this point:
Radio frequency fields at this site may exceed FCC rules for human exposure.

For your safety, obey all posted signs and site guidelines for working in radio frequency environments.

In accordance with Federal Communications Commission Rules on radio frequency emissions 47 CFR 1.1307(a)

NOTICE




Radio frequency fields beyond this point may exceed the FCC general public exposure limit.

Obey all posted signs and site guidelines for working in radio frequency environments.

In accordance with Federal Communications Commission Rules on radio frequency emissions 47 CFR 1.1307(a)

WARNING













Beyond this point:
Radio frequency fields at this site exceed the FCC rules for human exposure.

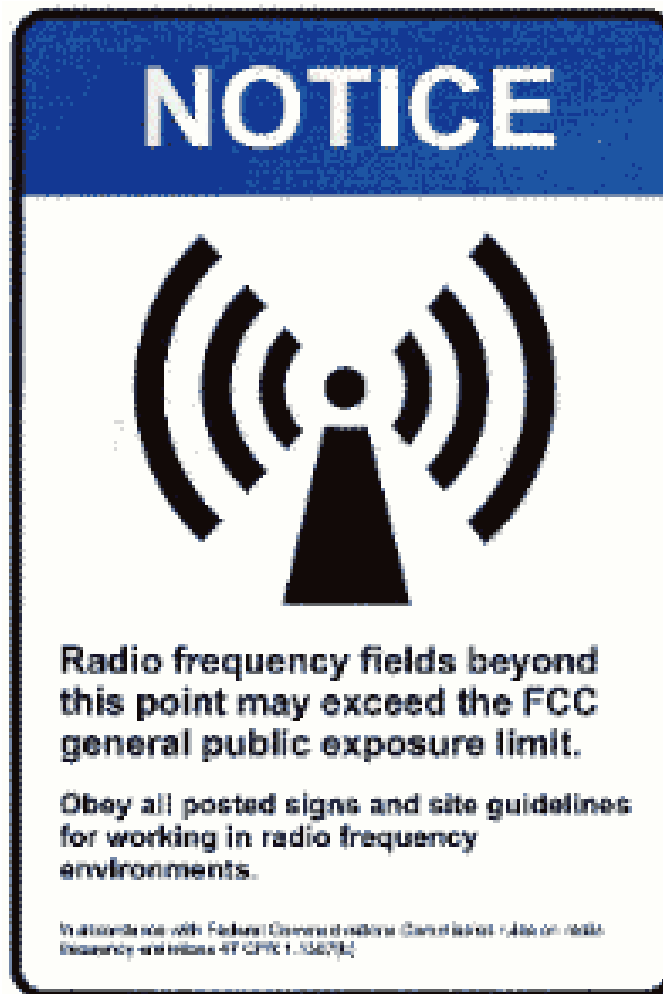
Failure to obey all posted signs and site guidelines for working in radio frequency environments could result in serious injury.

In accordance with Federal Communications Commission Rules on radio frequency emissions 47 CFR 1.1307(a)

 **NOTICE** 
**GUIDELINES FOR WORKING IN
RADIOFREQUENCY ENVIRONMENTS**

-  All personnel should have electromagnetic energy (EME) awareness training.
-  All personnel entering this site must be authorized.
-  Obey all posted signs.
-  Assume all antennas are active.
-  Before working on antennas, notify owners and disable appropriate transmitters.
-  Maintain minimum 3 feet clearance from all antennas.
-  Do not stop in front of antennas.
-  Use personal RF monitors while working near antennas.
-  Never operate transmitters without shields during normal operation.
-  Do not operate base station antennas in equipment room.

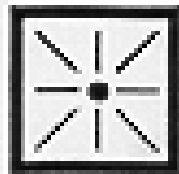
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Basic RF Controls

Enclosure/shielding



Distance



Time:



Questions?



Online RF References

- www.osha-slc.gov/SLTC/radiofrequencyradiation/index.html
- www.fcc.gov/oet/info/documents/bulletins/
- www.arrl.org/news/rfsafety/eval/
- <http://n5xu.ae.utexas.edu/rfsafety/>
- <http://ntp.niehs.nih.gov/index.cfm?objectid=03DB98A9-E505-AA26-833749D41A8F0B67>
- California Public Utilities Commission, Proposed Rule 94, General Order 95
http://www.cpuc.ca.gov/PUBLISHED/FINAL_DECISION/44173.htm

Verizon Intranet only:

- <http://baimsa.bell-atl.com/nss/hr/she/infopnt/safety/7525/html/frame.htm>
- “Guidelines For Working Near Radio Frequency Transmission Equipment And Antennas At Verizon And Customer Premises” (Verizon, 2005)

Contact Information:

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