

RF Safety Awareness for World Trade Center Workers

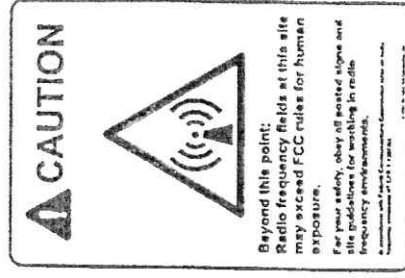
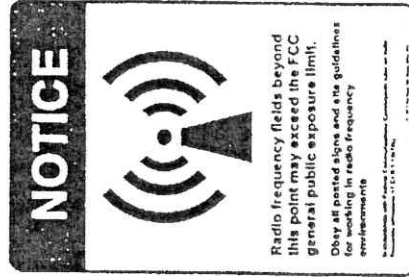
A Presentation at the World Trade Center

New York, New York

February, 1999

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2/3/99

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RF Safety Awareness for World Trade Center Workers

A Presentation at the World Trade Center

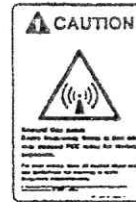
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Just a Friendly Reminder



Keeping these items as quiet as reasonably possible during our meeting will be appreciated by all.

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Some Definitions

- RF for radiofrequency
- RFR for radiofrequency radiation
- EME for electromagnetic energy
- MPE for Maximum Permissible Exposure

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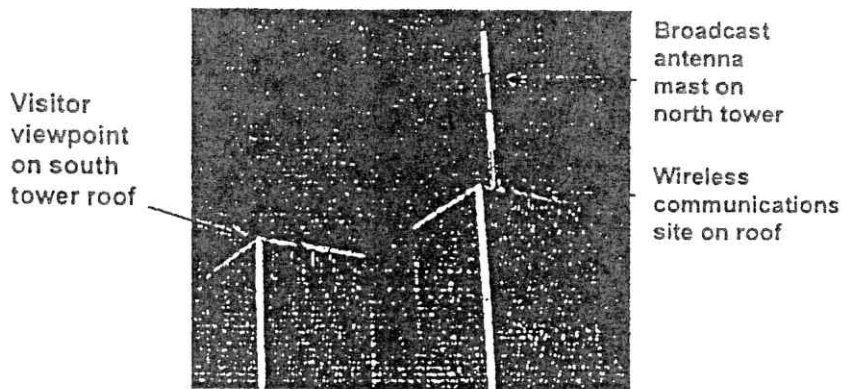
RF Safety Seminar Goals

- To learn what radiofrequency energy is;
- To learn about the biological effects of exposure to RF fields;
- To understand the RF exposure regulations that must be obeyed;
- To visualize the RF fields produced by antennas;
- To learn practical methods for preventing excessive RF exposure;
- To work with RF safety in mind.
- To learn about what the WTC has done for RF safety.

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The World Trade Center Towers



The WTC broadcast facility provides service to the New York metropolitan area.

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The WTC RF Environment

- The north tower of the WTC supports a major radio and television broadcast facility;
- The north tower rooftop is also the location of many, lower powered communications antennas;
- RF safety precautions and procedures have been put into effect to ensure that work on the roof is safe;
- New Federal regulations make it important to understand the basic elements of RF safety.

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Workers and RF Fields

- The installation and maintenance of broadcast and communications transmitting antennas requires that personnel may often work in close proximity to strong RF fields.
- Since strong RF fields can deliver significant energy to the body's tissues, care must be used to avoid excessive exposure that could be hazardous.
- New regulations from the Federal Communications Commission (FCC) require that all individuals working in certain RF environments become aware of RF safety related matters.

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Why we are here.

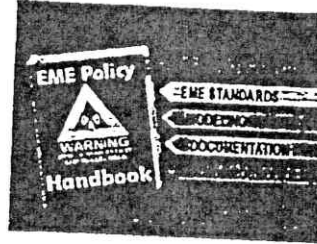
This RF safety orientation seminar is designed to ensure that all relevant WTC workers receive appropriate information on this subject as required by new FCC rules.

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What the WTC has done about RF safety

- The WTC, in concert with the broadcasters and telecommunications management firm, has developed a comprehensive RF safety program to meet these new FCC requirements for worker training.



- This seminar addresses those issues deemed most important in the WTC RF safety program.

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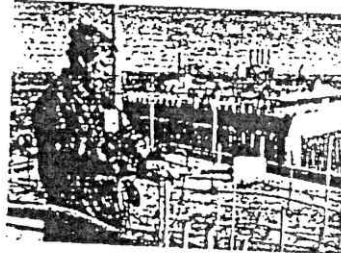
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A Preview of what you will shortly see:

RF Survey Map of Roof



How the survey was done

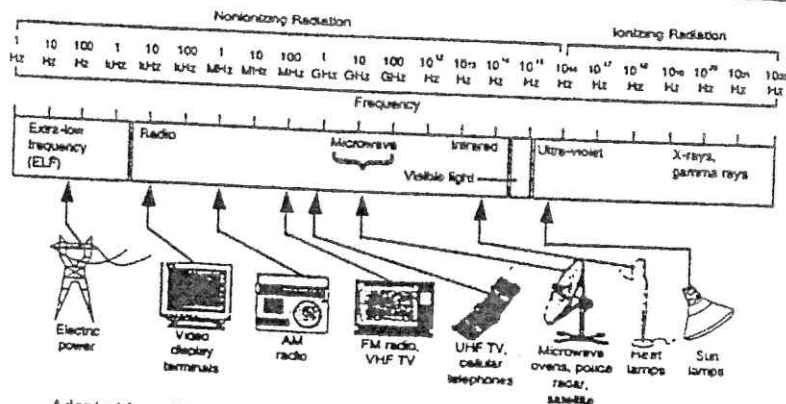


Practical information based on real-world experience on how to stay safe when working on the roof of the WTC.

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But, first, a word about the electromagnetic spectrum



Adapted from *Wireless Technical Services Phase II Project A Health and Safety Issues of Radio Frequency Fields from Wireless Communications Devices*. Electric Power Research Institute, 1996.

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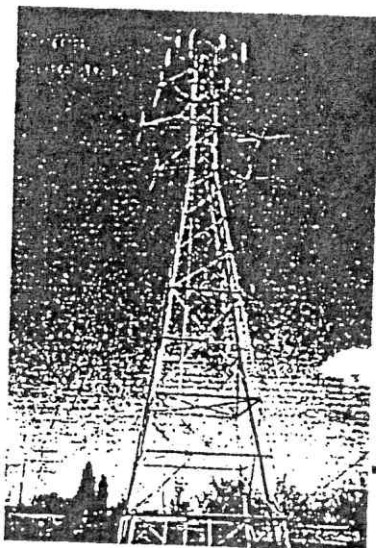
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Antennas are used to transmit many different types of signals including:

- AM and FM radio broadcast signals;
- Television signals;
- Shortwave radio signals;
- Two-way radio communications signals;
- Cellular telephone signals;
- Personal Communications Service (PCS) signals;
- Paging signals;
- Mobile radio service signals;
- Satellite communications signals;
- Air traffic control radar signals;
- Microwave data communications signals.

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Wireless
communications
antennas can be
found anywhere.

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Important Parameters that Relate to RF Exposure

- Power density of RF field
milliwatts per square centimeter
(mW/cm²)
- Frequency of RF field (MHz);
- Antenna input power (watts);
- Antenna size;
- Body position relative to antenna

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The Body is Like a Fat, Absorptive Antenna



Thin, lossless
dipole antenna



Fat, lossy body
antenna

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SAR

- SAR, or specific absorption rate, is the rate at which RF energy is absorbed by the body.
- It is measured in watts per kilogram of body tissue.

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FCC RF Exposure Limits are Based on Specific Absorption Rate (SAR)*

For occupational/controlled exposures:



- Whole body average SAR = 0.4 W/kg
- Spatial peak SAR limit = 8 W/kg, except for
- Spatial peak SAR in extremities = 20 W/kg

*SAR is the rate at which RF energy is absorbed in the tissues of the body for a given incident power density.

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SAR is related to the energy
absorbed by our body and



Power density is the intensity of
the RF field to which we are
exposed.

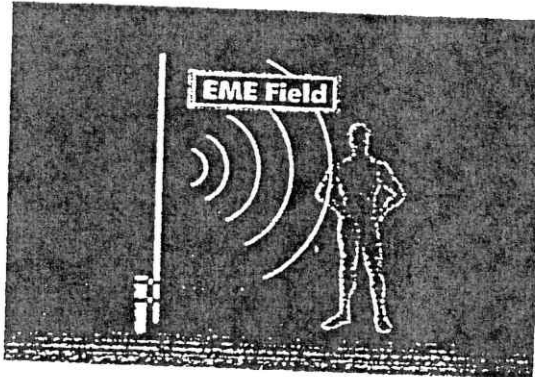


SAR helps us understand the
relationship between the
external RF field intensity and
energy that gets absorbed.

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Very High Levels of Absorbed Energy Can Lead to Tissue Heating



But this will occur only when RF exposure substantially exceeds the FCC safe exposure limits

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Basis for the Exposure Limits Adopted by the FCC

- Observation of performance degradation in laboratory animals trained to perform a learned task when subjected to RF fields at high intensities sufficient to deliver an absorbed power of 4 watts per kilogram of body weight;
- Assumption that same effects might be possible in humans;
- Assumption that prolonged exposure could lead to a serious and adverse effect;
- Application of a safety factor of 10 to derive actual exposure limits.

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Let's get a practical 'feel' for SAR

If a typical coffee mug (350 ml) full of water heats 43°F (23.9 °C) in 1 min (real data from my kitchen), then the SAR in the water is about 1,668 W/kg! (A really thermalizing effect!)



REMEMBER, this is inside a microwave oven, not at an antenna site!!

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Now, let's get a 'feel' for 4 W/kg, the hazard basis of the FCC rules

For the coffee mug, an energy absorption rate of 4 W/kg would correspond to a temperature increase of about 0.057°C (or 0.10°F) in 1 minute.

If our body absorbed at the rate of 4 W/kg for an hour, and there was no loss of heat from the body, then we would expect an average body temperature increase of about 3.4°C or 6.2°F.

In reality, at least in neutral environments, blood flow will help reduce body temperature and the temperature increase will not be this much.

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Maximum Permissible Exposure (MPE)

- Maximum Permissible Exposure is the upper limit of RF field intensity, or power density, that is safe. It is at least 10 times lower than the actual hazard threshold.
- These limits depend on the frequency of the transmitted signals.
- The FCC has defined MPEs for all broadcasting and telecommunications stations.
- These limits have become a part of the FCC's regulations.

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Remember:

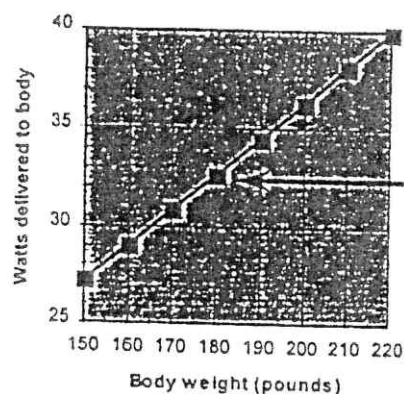
$$\text{MPE} = \frac{\text{Hazard level of exposure}}{10}$$

For persons provided with RF safety awareness training.

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How much power might we absorb at the MPE limit of 0.4 W/kg?



in a 180 pound person

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Some Important Observations from Biological and Medical Research of RF Fields

- RF fields are NOT the same as ionizing radiation. They cannot ionize tissue!
- RF fields are NOT believed to result in cancer.
- Biological effects are NOT accumulative like with ionizing radiation.
- Heating effects of RF exposure are related to a threshold below which no effects occur!

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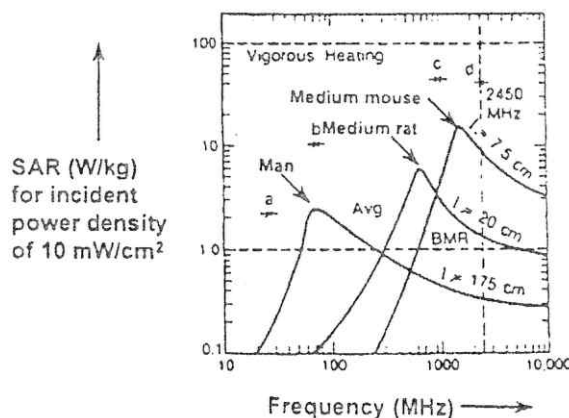
So-called Non-thermal Effects

- Some research has indicated the possibility of so-called 'non-thermal' effects.
- These reported effects are subject to considerable debate in the scientific community as to whether they are real.
- General consensus is that if such effects actually exist, they are also protected against by present exposure limits.

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The Body Antenna Exhibits a Resonance Frequency Like a Real Antenna Related to Its Dimensions



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Who Develops the Limits?

- IEEE/ANSI - Institute of Electrical and Electronics Engineers and the American National Standards Institute
- NCRP - National Council on Radiation Protection and Measurements
- ACGIH - American Conference of Governmental Industrial Hygienists
- Numerous foreign governments and organizations

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We don't measure SAR in the field!

- It just isn't socially acceptable!
- But, we can measure the intensity of the field, usually expressed as power density using special meters.
- The exposure limits depend on frequency since our bodies absorb RF energy similar to an antenna.

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New FCC RF Exposure Standard Effective October 15, 1997

- Based on recommendations of National Council on Radiation Protection and Measurements
- Similar to IEEE/ANSI standard in most of telecommunications bands

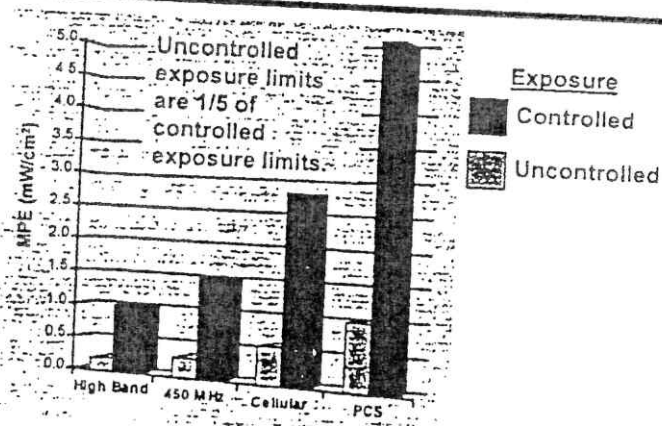
Frequency (MHz)	Power density limit (mW/cm ²)
Occupational/Controlled environment	
30-300	1.0
300-1,500	f/300
>1,500	5.0

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FCC Specified Limits for RF Exposure

Based on recommendations of the NCRP



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The New FCC Rules:

- Were based on the NCRP recommendations and IEEE standard;
- Were adopted in 1996;
- Went into effect October 15, 1997;
- Supported by the Food and Drug Administration, the Environmental Protection Agency and the Occupational Safety and Health Administration

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OSHA

- OSHA expects all employers to be in compliance with the RF rules adopted by the FCC!
- All employers are expected to provide a safe working environment for their employees.
- OSHA has publicly expressed the policy of applying the FCC adopted rules.

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Important Observation about RF Exposure Standards

Almost all RF exposure standards are based on the same underlying scientific finding of a threshold for adverse biological effects at an SAR of about 4 watts per kilogram in the body.

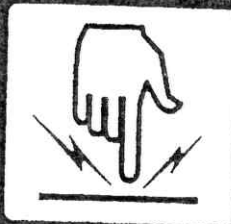
The exposure limits we follow are set well below this threshold for adverse effects, at least 10 times lower.

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RF Burns Can Occur When Touching Bare Antenna Elements

CAUTION:

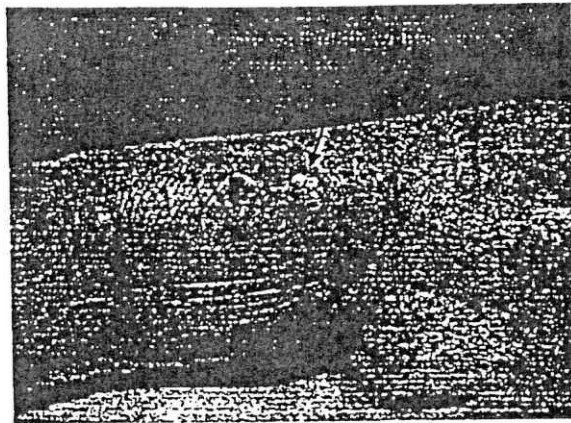


RF BURNS POSSIBLE

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RF Burns May Occur When Touching Active Antennas



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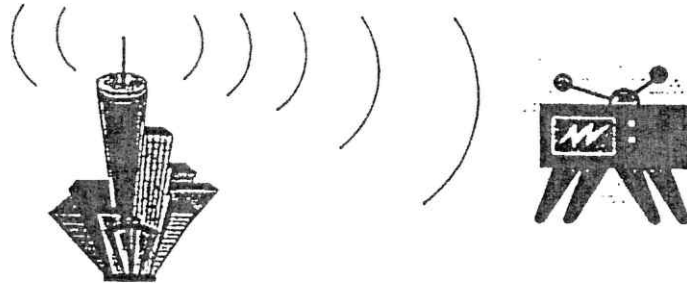
Electromagnetic Compatibility A Precautionary Note!

- Certain implanted medical devices, such as cardiac pacemakers and defibrillators, may be interfered with by strong RF fields.
- Interference is generally unlikely with pacemakers but some newer, non-pacemaker devices may be susceptible.
- Employees with implanted medical devices should consult with their physician about any special preventive measures they can take to avoid adverse interference.
- Employees are encouraged to identify themselves to the company RF safety officer to discuss safety measures for specific antenna sites.

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RF Fields and Signals



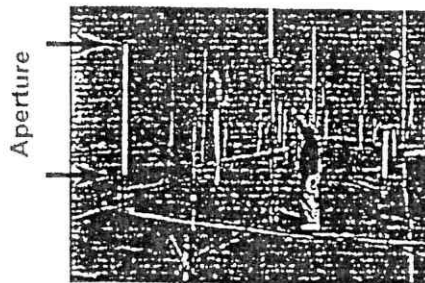
The RF field near an antenna is the signal transmitted (radiated, emitted) by the antenna for purposes of communications or broadcasting.

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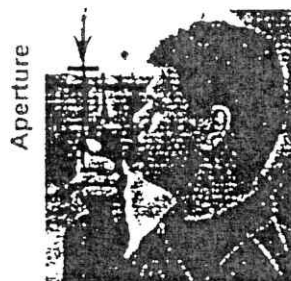
Antennas Come in All Sizes

Tall apertures



WTC roof-top base station antennas

Short aperture



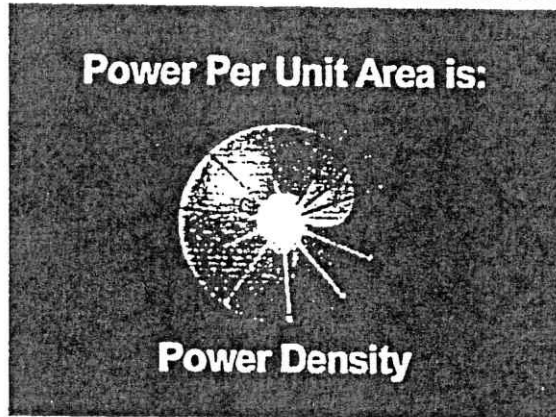
Hand-held portable radios

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Antennas Transmit Radio Frequency Energy

Power Per Unit Area is:

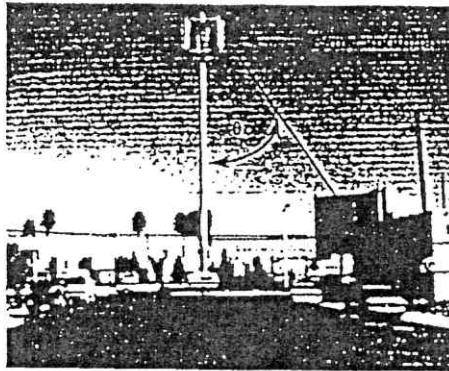


Most antennas, however, emit RF energy in a directional pattern.

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In the Far-field of a Cell Site
We can use the far-field radiation pattern
of the antenna for calculations



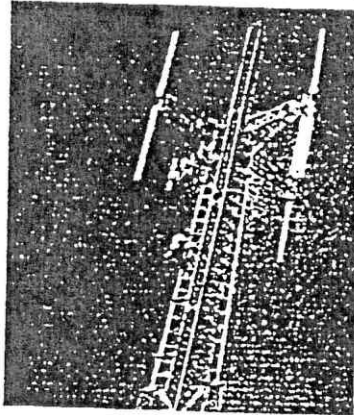
And the resulting RF fields are miniscule.

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Work on a Cell Site Tower is Typically Done in the Near Field

A rural cell site in
Puerto Rico



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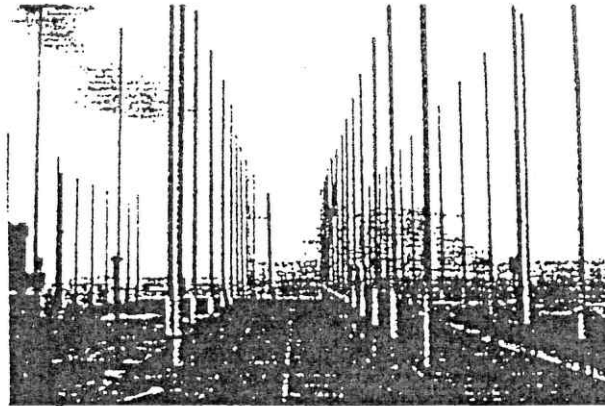


An Example of High Power Pagers and Roof Access

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A High Density Communications Site



Sometimes it can be difficult to get far enough away from every antenna!

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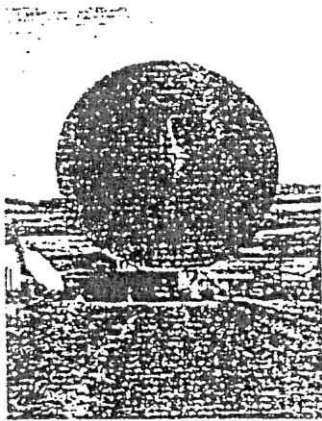
Power density is related to:

- Power delivered to the antenna;
- Antenna directivity;
- Antenna size;

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Some Interesting Observations



Smaller antennas produce stronger fields near them than larger antennas with the same input power.

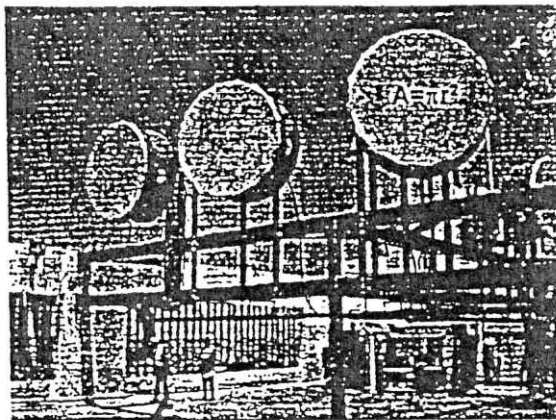


The smaller the physical size of an antenna, the more concentrated the power density is near it since there is less aperture area over which the power is distributed.

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Roof Mounted Microwave Dish Antennas

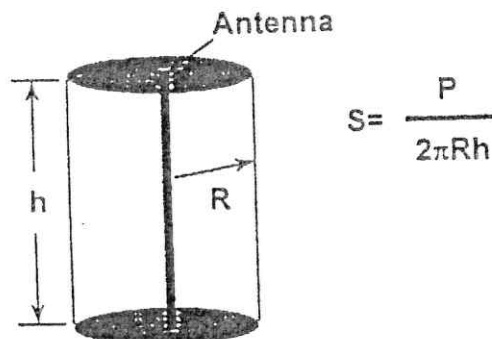


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Very Simple Models can be Used to Predict RF Fields in the Near-field

This is an example for vertical, collinear (whip type) antennas.

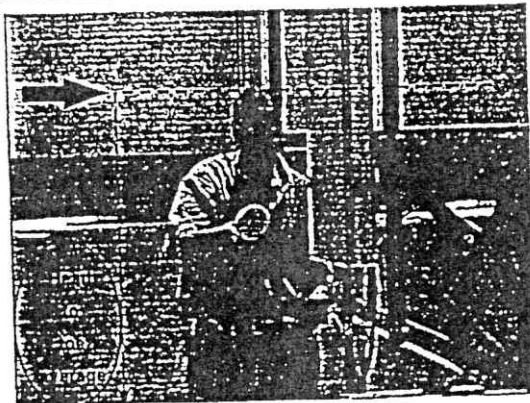


Distribute radiated power over surface area of an imaginary cylinder.

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MPEs are Based on Spatially Averaged Values of RF Fields

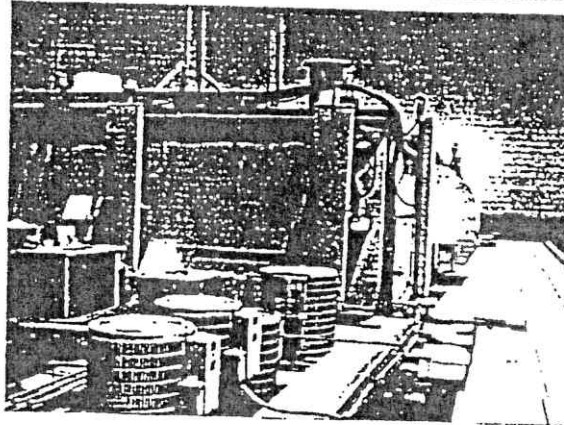


While local fields can be intense, compliance is generally determined by the spatially averaged RF field level.

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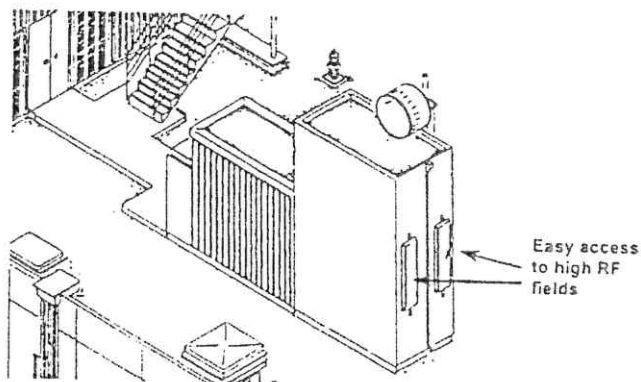
Antennas in Close Proximity to Air Conditioning Equipment Could Lead to Unnecessary Exposure



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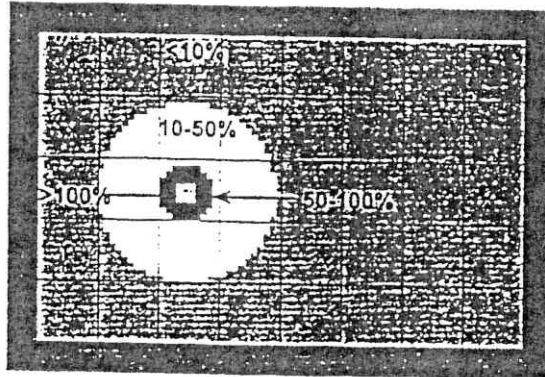
Convenient Antenna Mounting is Generally Incompatible with Controlling EME Exposure



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RF Fields Caused by Multiple Antennas are Additive

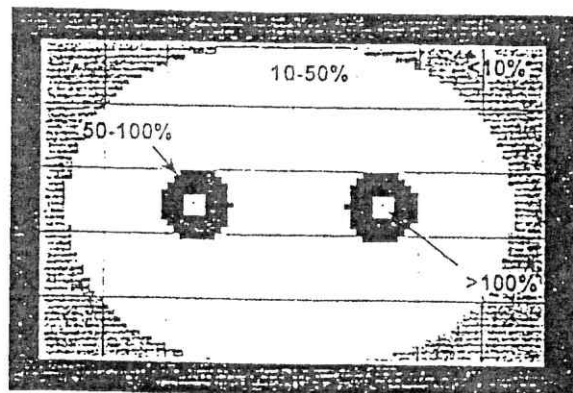


Produced with RoofView™ Software

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RF Fields in the Vicinity of Two Active Antennas

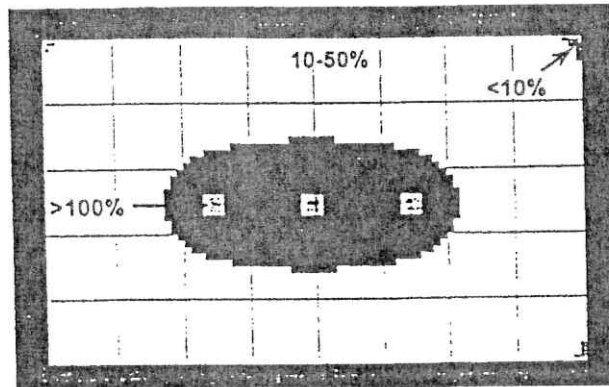


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RF Fields in the Vicinity of Three Active Antennas

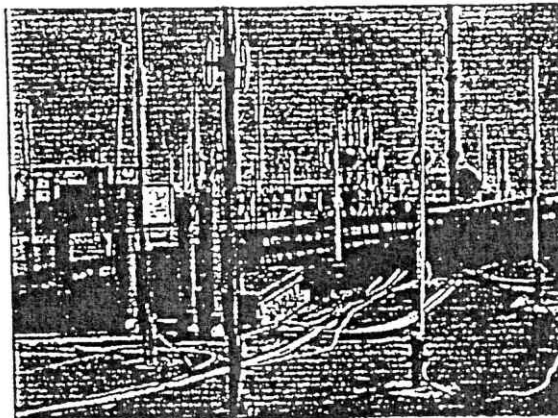


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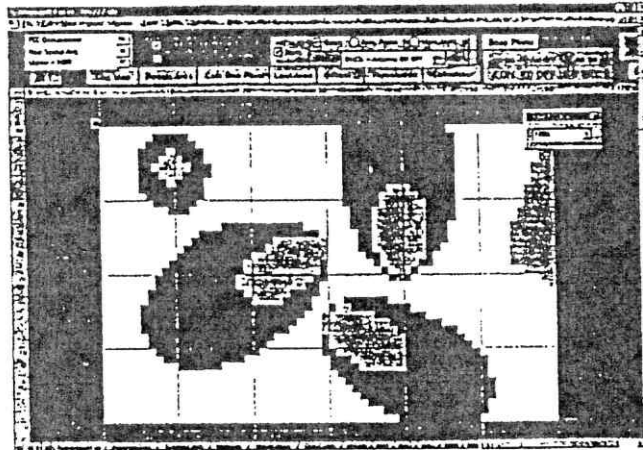
Antenna mounting density at the WTC
can make it difficult to get away from
strong fields



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Sophisticated Software Analysis Programs can Also be Used to Assess RF Fields



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Preventing Excessive RF Exposure

The Practical Aspects of Staying Safe
When Working Around Antennas

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The FCC Rules

- Are related to EXPOSURE of people
NOT
EMISSIONS!
- This is significant since it means that high RF fields at a site that are above the limits do not necessarily mean that the site is out of compliance.
- What counts is the RF field level to which individuals can actually be exposed.

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Being Aware of RF Safety

- FCC uses awareness to determine appropriate MPE limits to apply;
- EME awareness training;
- This training session is one way of becoming more aware of RF safety.

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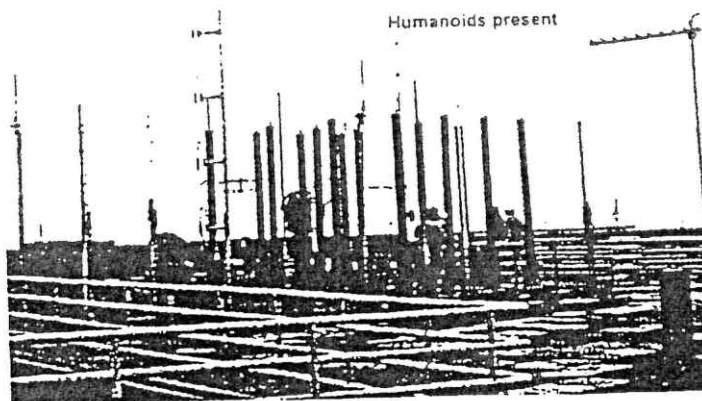
Engineering Controls

- EME design is best way to avoid potentially excessive exposure;
- Raising antennas, for example, is an effective way to reduce fields on a roof-top site;
- Locate directive antennas away from accessible areas, roof tops and towers

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Entering a Paging Forest



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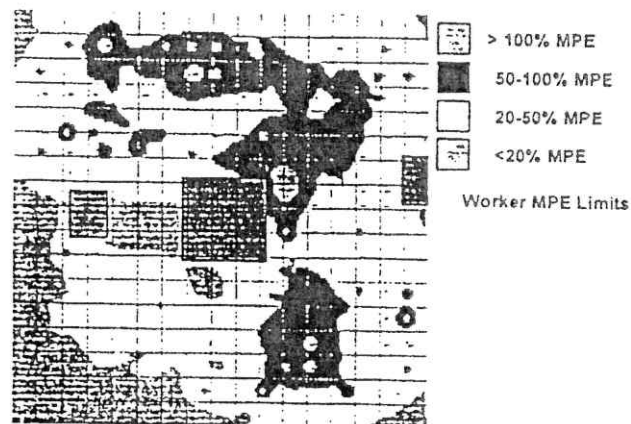
Identifying Areas of High Fields

- Simple calculations;
- Sophisticated computer analysis;
- RF field surveys;
- All of these have been accomplished for the WTC north tower roof.

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RF Survey Map of WTC North Tower Rooftop



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Alternative RF Alerting Signs

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 for safe exposure of fields > 100 kHz

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 for safe exposure of fields > 100 kHz

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 for safe exposure of fields > 100 kHz

Sign designs available through
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A Practical Rule of Thumb Applicable at Many Wireless Antenna Sites

MAINTAIN 3 FEET OF CLEARANCE FROM ANTENNAS

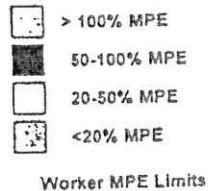
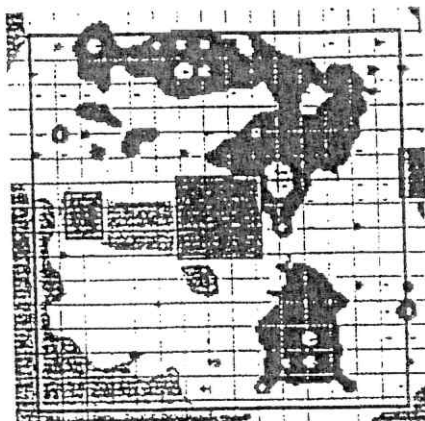
Note: Some antennas may produce fields that exceed the FCC MPE at greater than 3 feet!

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An Obvious Practical Insight from the Roof RF Survey Results

RF field levels around the edge are the weakest.

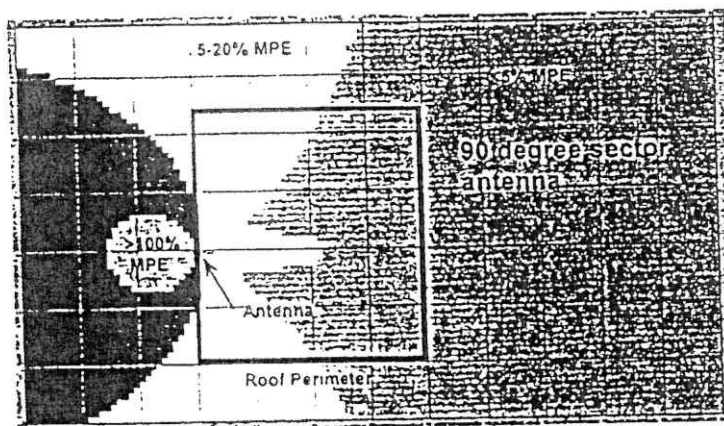


Using a walking path around the perimeter of the roof to avoid strong RF fields.

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RF Fields Behind Directional Antennas are Usually Very Weak

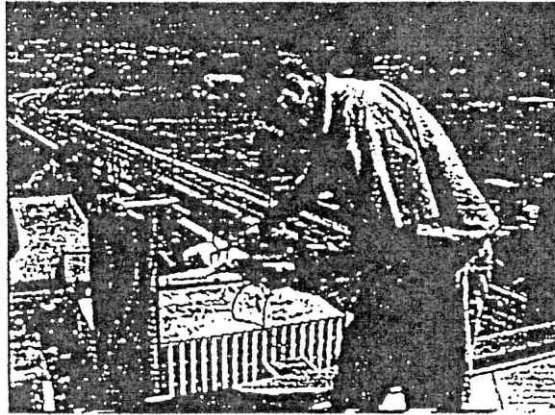


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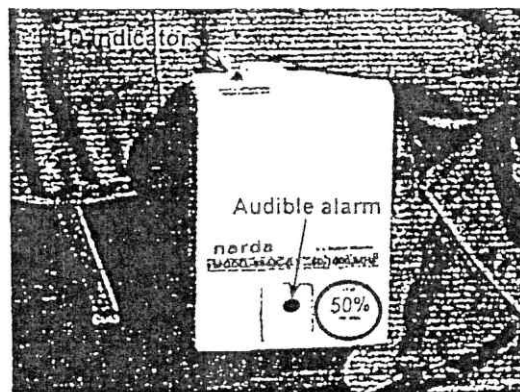
Back Lobe Fields, Even with Low Antenna Mounting are Generally Not a Problem



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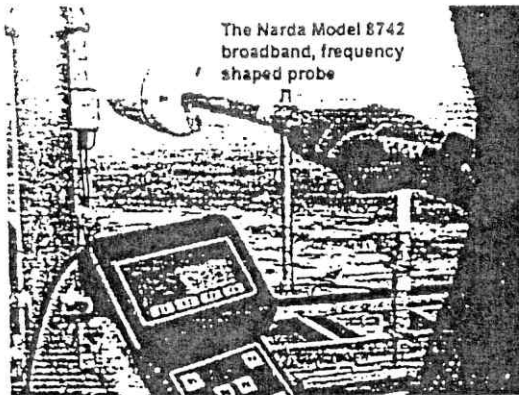
Personal Monitors Can Provide Positive Feedback on Antenna RF Status



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Using a Broadband, Isotropic Field Probe to Measure RF Fields at an Antenna Site



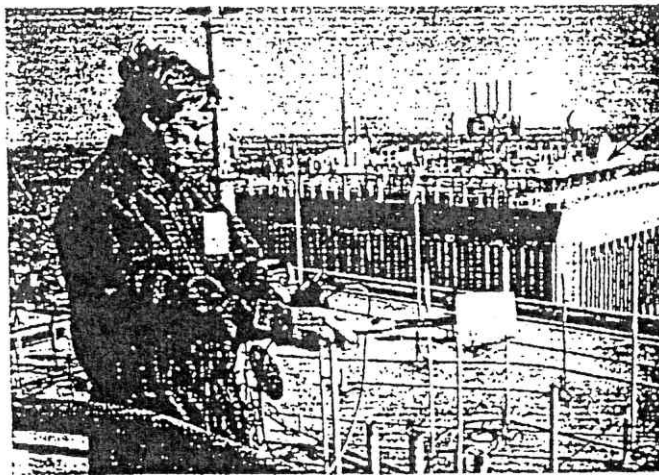
The Narda Model 8742
broadband, frequency
shaped probe

The Narda Model
8718 digital meter

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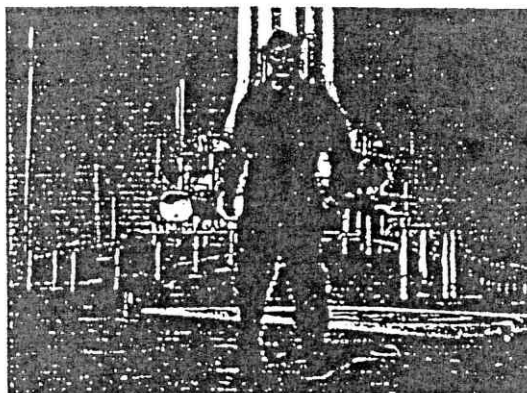
Las Vegas, Nevada

On Top of the WTC North Tower



South Tower
observation
deck

New Fabrics Containing Microscopic Stainless Steel Fibers Can Substantially Reduce RF Exposure



The Naptex™ RF protective suit from NSP, Germany

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Worker Wearing an RF Protective Suit During Tower Work

Hood assembly
necessary when 800 MHz
or higher fields exceed
300% of MPE



The KW-GARD™ RF
protective suit from Euclid
Garment Manufacturing Co.,
Kent, Ohio

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Las Vegas, Nevada, USA

General Elements of the WTC RF Safety Program

- Providing employee EME awareness;
- Using RF safety signs to help identify areas of excessive RF fields;
- Use of personal monitors;
- Use of protective clothing where applicable;
- Emphasizing work practices, as appropriate, for eliminating excessive RF exposure;
- Encouraging input from employees to arrive at most practical and effective ways of performing certain jobs with minimum potential RF exposure.

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Two Important Components of the WTC Program



WTC RF Safety Committee
This committee provides overall guidance relative to RF safety at the WTC.



WTC RF Safety Officer
This individual is your point of contact for any questions regarding RF safety during your work.

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Your Part in Making the WTC RF Safety Program Effective

- Review, know and follow guidelines;
- Use safe working practices defined by the program and your employer- This is no different than any other requirement for working safety such as using caution when working around high voltage equipment or machinery.
- Consult with the WTC RF Safety Officer- This individual is your point of contact for any questions regarding RF safety during your work.

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Site Guidelines Placard You Will See on the 1 WTC Roof Wireless Communications Site



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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