

RF Radiation Safety For Broadcasters



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RF Radiation Safety

Sources, Biological Effects, Standards, and Safe Work Practices





Topics

- Overview
- Sources of RF energy
- Biological effects
- Standards
- · Potential hazards
- RF Hazard Protection Equipment
- RF Safety Signs



Overview of RF Safety Issues



- RF energy can cause excessive body heating if a person is exposed to relatively high concentrations of energy as occurs inside a microwave oven.
- Exposure to RF energy below the threshold has no impact on the body—the body deals with tiny amounts of heat from RF in the same way it adjusts to temperature changes.



Overview of RF Safety Issues



- RF energy can cause shocks and burns at low frequencies, such as near AM radio stations and HF communications antennas.
- The eyes are especially vulnerable to concentrated levels of RF energy at microwave frequencies. Waveguide leaks are a significant hazard for anyone in close proximity to the site of the leak.



Job Site Hazards



- · FM Radio and TV Broadcast Antennas
- · Wireless Communications Antennas
 - Cellular & PCS
 - Fire, police, emergency, and other 2-way antenna systems such as SMR
 - Paging systems
- AM Radio Antennas
- · High-Power Microwave System Antennas
 - Satellite uplink
 - Weather radar
- Waveguide Leaks (eye hazard)



Potentially Hazardous Locations



- Towers
 - All FM and TV installations
 - Wireless systems at the same elevation as omni-directional antennas and in front of sector antennas
- Rooftops
 - Wireless systems at the same elevation as omni-directional antennas and in front of sector antennas
 - FM radio antennas
 - Satellite-uplink antennas
- Ground
 - Near waveguide should it be open or leak
 - Satellite-uplink antennas if you get in the beam
 - AM detuning networks (burn hazard)
 - AM Towers (burn hazard)



Potentially Hazardous Locations cont'd



AM Antennas

- Serious burn hazards at tower, feed line, and inside tuning huts
- High-Power Waveguide Systems
 - Potential eye hazard within 3 feet of any junction or section of flexible waveguide if there is a leak







Responsibilities & Liabilities



- As a licensee regardless of where the emitter is located—your own property or a shared site like Mt. Wilson, Sutro Tower, or Sears Tower.
- As an employer.
- As a company that hires contractors.
- As a company that has visitors.





Electromagnetic Radiation

Electromagnetic radiation covers the entire spectrum from RF radiation to cosmic rays.



Types of Radiation



- Radio Frequency (RF) energy and the energy from most of the light frequencies is a form of nonionizing radiation. It is distinctly different from ionizing radiation. The primary concern with nonionizing radiation is tissue heating.
- Ionizing radiation can be very dangerous. The most common sources are from X-ray equipment and radioactive materials that product gamma rays. Ionizing radiation can cause damage to DNA.



Forms of Radiation Summary



Non-Ionizing Radiation

Mechanism of injury: Tissue heating and burns

- The primary concern with RF radiation is tissue heating. Effects are not cumulative.
- Shocks and burns are a concern at the lower RF frequencies, for example, at an AM tower site.

Ionizing Radiation

Mechanism of injury: Permanent biological changes to molecular structure. Effects are *cumulative*.

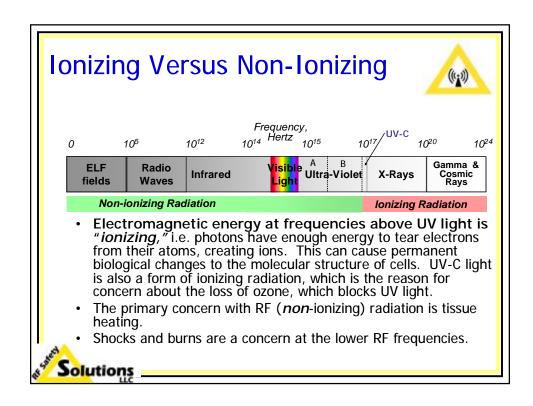
Solutions

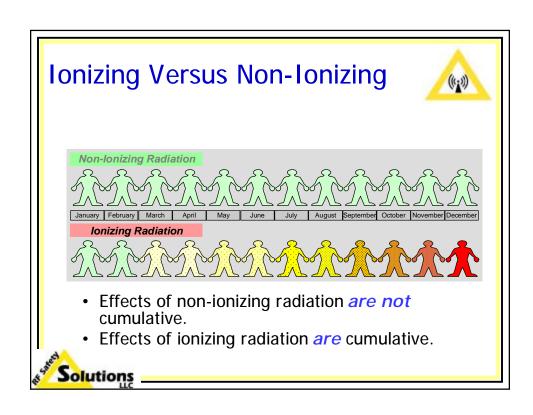
Defining an Electromagnetic Wave



- Frequency—most common definition for people working in electronics
- Wavelength
 —most common way of defining light frequencies, also used in electronics
 {λ (meters) = 300/f (MHz)}
- Energy—most common way of defining the higher "frequency" sources of energy such as Xrays and gamma rays {E_(energy) = h x f, where "h" is a constant}









Biological Effects

Radio Frequency Energy and the Human Body



RF Energy & the Human Body



- Research conducted in the 1960s and 1970s revealed that a human body functions as an antenna when exposed to RF energy.
- There are several variables that determine how effective an antenna you are.
- The better an antenna you are, the more energy you absorb.



The Human Body as an Antenna



- The three factors that are most important in determining how effective an antenna you represent are:
 - § Your height versus the frequency/wavelength.
 - § Your position versus the polarization of the field. You absorb the most when your orientation matches the field. Most wireless systems have vertical polarization which aligns well with a person that is standing.
 - § How well grounded you are.



Energy Absorption Versus Frequency



- Average-sized adults absorb the most energy (i.e. make the best antennas) in the frequency range of about 75 to 95 MHz (TV Channels 5 & 6 and FM radio).
- If you are well grounded, you make a good antenna at half the frequency.
- A well-grounded average-size adult makes a very good antenna at about 42 MHz.

Ch.	f (MHz)	Ht.
6	82-88	5′9″
5	76-82	6'2"
4	66-72	6′11″

Basic Antennas



- Dipole antennas are very common, somewhat directional antennas.
- The length of a dipole antenna is typically a little less than half a wavelength (λ/2).
 Dipole antennas are not grounded.
- A quarter-wave antenna is grounded at one end. It is resonant at half the frequency of a dipole of the same dimensions.



The Human Body as an Antenna · Under most conditions, you function as a lossy, wide dipole antenna. (You are lot less conductive and much wider than a thin metal rod!) If you are grounded, your body becomes a quarter-wave antenna. Quarter-wave antennas work best at half the frequency of a dipole Thin, lossless of the same length. dipole antenna body 2-3 Ohms ~360 Ohms Solutions

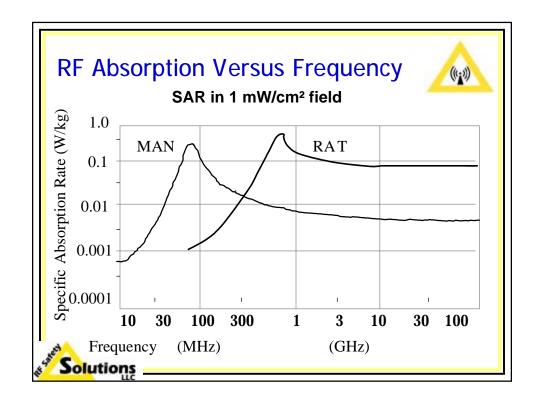
Specific Absorption Rate (SAR)

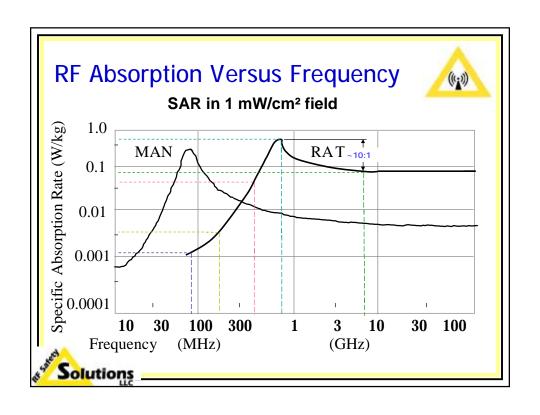


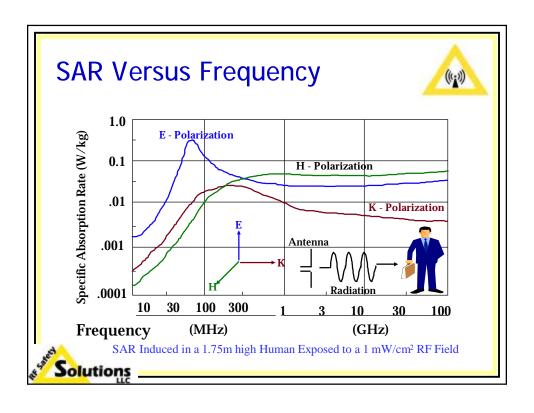
- The rate of absorption of energy into the body.
- The method used to quantify the effects of electromagnetic fields on the body.
- The basis for all modern standards.



SAR measured in W/kg







Whole Body Resonance



Subject	Ht (m)	Ht (in)	f _{R (Isolated)}	f _{R (Grounded)}
Adult male	1.75	69	86 MHz	43 MHz
NBA player	2.29	90	66 MHz	33 MHz
Infant	0.5	20	300 MHz	150 MHz

Where λ (m) = 300/f (MHz); assumes a dipole = $\lambda/2$

Solutions



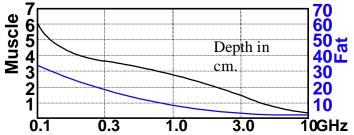
SAR Is Not Everything

Other important biological concepts include:

- -Penetration depth
- -Time averaging
- -Spatial averaging
- -Partial-body heating







- § The higher the frequency, the shallower the penetration, regardless of the material.
- § You tend to sense shallow penetration because that is where your nerves are. You tend not to notice deep penetration from lower frequencies.

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Time Averaging

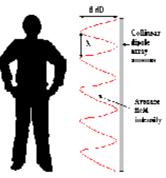


- Because the primary effect is thermal, exposure is averaged over time.
- People can take very short term exposure to extreme cold or heat that they cannot otherwise tolerate.
- In most standards the averaging time is six minutes, which is close to the thermal regulatory response time of the human body.

Spatial Averaging



- Measurements are averaged over an area equivalent to the vertical cross-section of the human body.
- Although this diagram shows the field levels from a collinear dipole array, typical of wireless antennas, the RF field levels in the reactive near field of a parabolic reflector antenna also varies by up to 6 dB (4:1).





Partial-body Heating



- Partial-body heating is important under some conditions. There are different resonant frequencies for your whole body, your head, and your eyes.
 - Your head makes a very good cell phone antenna.
 - Your eyes make very good microwave-band antennas.
- The limbs can tolerate higher levels since the body's circulatory system acts as a coolant with the remainder of the body functioning as a radiator. (typically 20:1 higher).
- The basic limits apply for the eyes and testes due to the poor blood flow of these organs.



SAR Versus Metabolic Rate



- How much heat can a body absorb before adverse affects are felt?
- At what levels can permanent biological damage occur?



Typical SAR Levels



Activity Level	SAR Level	
Sleeping	1 W/kg	
Fast Walk/Light Run	2.0-2.5 W/kg	

Specific Absorption Rates (SAR)



SAR Level*	Situation/Limit
5.0	Permanent damage can occur with whole body heating.
4.0	At this level, people feel ill but the effects are not permanent.
0.4	FCC limit for Occupational/Controlled exposure (10:1 safety factor).
0.08	FCC limit for General Population/Uncontrolled exposure.
1.6	Cell phone limit for the head.

*Watts per kilogram of body mass.



Why a 10:1 Safety Factor



- Rate assumes room temperature—if RFR exposure occurs at high temperature, the body already has a thermal load.
- Hot spots can occur within the body, especially in the human resonance range.
- · Not everyone is young or healthy.
- The individual may be engaged in a physically stressful task, such as climbing a tower, that generates heat by itself.



Overexposure Symptoms*



As time and/or energy level (intensity) increases, an individual is likely to experience:

- · First, an overall feeling of warmth; and
- Then, symptoms similar to overexertion (perspiration, elevated body temperature, labored breathing).
- Some symptoms (nausea, headache) are often mistaken for the flu. Many people report getting a metallic taste in the mouth.
- Severe cases have the same effects as heatstroke.



*From significant levels of RF energy

Permanent Damage



- Permanent biological damage can occur when cells are destroyed.
- Human cells begin to die at a temperature of 107° Fahrenheit. This is the reason people with high fevers are often packed in ice if the temperature goes too high.



Permanent Damage



- If a small percentage of the cells in an organ are damaged, the body often repairs itself.
- If the damage is extensive, then the damage becomes truly permanent.



Eye Damage



- Exposure to RF an RF field level of 50 mW/cm² for 10 minutes has been documented to cause cataracts.
- Higher levels of RF energy can cause severe eye damage. One well-documented case at Johns Hopkins resulted in the loss of both color vision and night vision after a 10 minute exposure to a waveguide leak.



Medical Implants



- If you have a medical implant with electronic circuitry, it may be vulnerable to electromagnetic interference in RF fields.
- Devices such as cardiac pacemakers, medical monitoring equipment, and pumps may malfunction at field levels <u>far</u> below the FCC MPE exposure limits.



Medical Implants



- If you have a medical implant with electronic circuitry:
 - Ask your doctor for his permission to work at an RFR site and what symptoms you might exhibit should your implant malfunction.
 - Advise your health and safety manager that you have a medical implant, what advice your doctor recommends regarding working in an RFR site, and what symptoms you might present if it should malfunction. People should be able to recognize the symptoms if you experience a problem.





Standards & Regulations

The communications industry in the United States must comply with the Federal Communications Commission (FCC) Regulations that cover RF radiation safety.



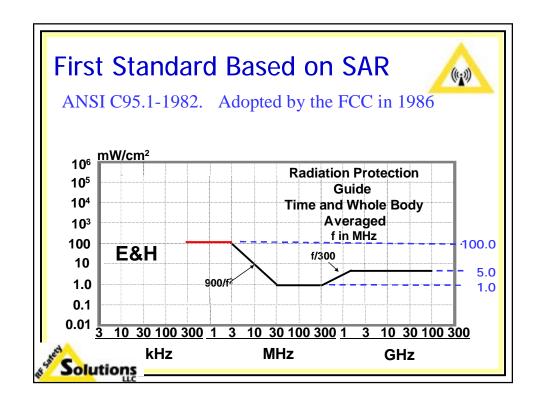
Compliance Requirements

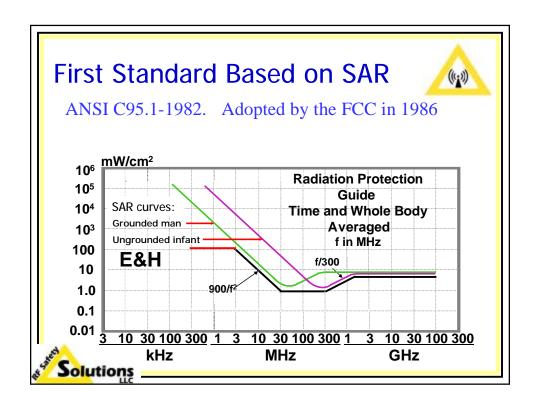


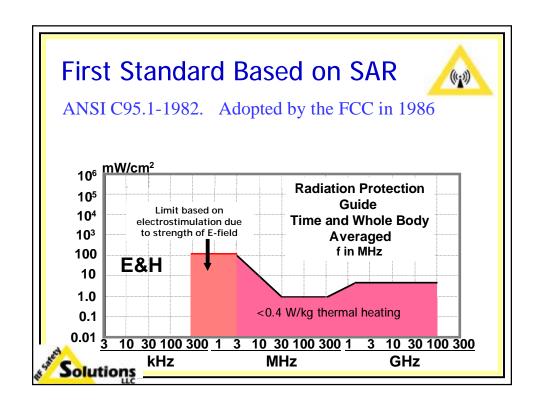
Stations must:

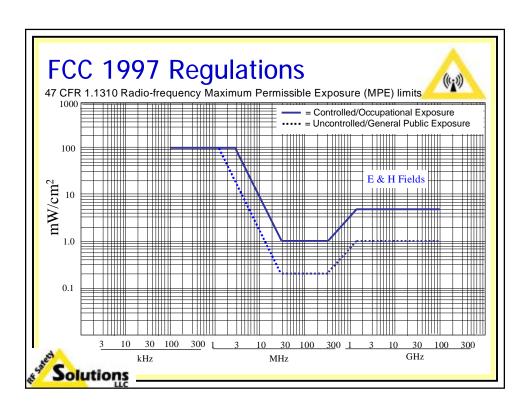
- Comply with FCC Regulations for public areas.
- Comply with FCC Regulations regarding employees and contractors.
- Comply with OSHA Regulations regarding employees.











FCC MPE Limits for Radio and TV



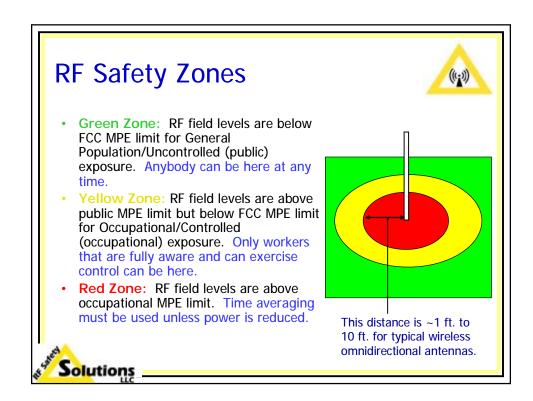
Exposure	FM/VHF TV	AM	Time Average
Occupational	1.0 mW/cm ²	100 mW/cm ²	6 minutes
General Population	0.2 mW/cm ²	100 mW/cm ²	Not allowed

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Qualifying to Use Occupational Limits



- Company should be operating under an RF safety program.
 - Workers must be fully aware and able to exercise control over their exposure to RF fields.
 - Access must be limited to those only workers (defined above).



Fully Aware Workers



The phrase *fully aware* refers to workers who:

- Have received both written and verbal information regarding RF radiation.
- Have received training that includes how to control or mitigate RF radiation exposure.



Workers Who can Exercise Control



The phrase *exercise control* refers to workers who:

 Understand how to use administrative controls and engineering controls to reduce their exposure level. These controls include time averaging, RF personal monitors, and RF protective clothing.



FCC Five Percent Rule



- The FCC can and has issued Notices of Apparent Liability (NALs) and subsequent fines where multiple licensees combine to exceed the MPE limit for an area:
 - Mt. Wilson: 3 FMs and a TV station
 - Park Tower Building in Tampa: an FM and a TV station
- Any station that contributes more than 5% of the applicable MPE limit* is equally guilty.
 - Park Tower: \$25k for TV station and \$20k for the FM.
 - Mt. Wilson: one FM was at 80% of MPE limit while the other 3 where deemed to be 10 to 12%. Each station was fined \$10k, even though one station contributed far more.



* Public or occupational limits



Antenna Characteristics

Low gain antennas are more dangerous than high gain antennas!



Antenna Designs



- The majority of antennas that you are likely to encounter fall into two categories. If you understand the characteristics of these antennas, you should be able to understand the potentially hazardous locations near these antennas.
 - Reflector antennas are used in satellite uplink antennas such as SNG trucks, point-to-point microwave systems, and radar antennas.
 - Collinear dipole array antennas are used in most wireless systems, FM radio, and television broadcast. There are directional and omni directional versions of these antennas. Directional antennas are used on all cellular towers.



Antenna Gain



- Antenna gain is a measure of the antenna's ability to focus energy.
- · Gain becomes important in the far field of an antenna.
- The distance from the antenna to where the far field begins depends on the design of the antenna and the frequency.
 - It is about 8 to 20 feet for most wireless antennas.
 - It ranges from 75 feet to thousands of feet for typical satellite-uplink antennas.

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Field Intensity versus Distance



- Far Field: Energy in the far field drops off inversely as the square of the distance. In other words, at twice the distance, the intensity is spread out over 4 times the area so the intensity is ¼ as strong. At 10 times the distance, the level is down to 1%.
- Radiating Near Field. The energy drops off linearly with distance. At twice the distance, the energy level is ½, not ¼ as it would be in the far field.

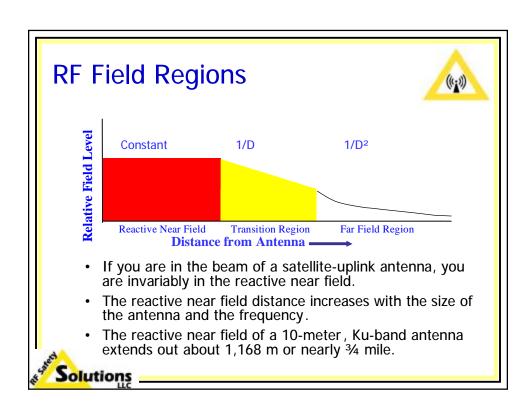
Reflector Antennas



- Reflector antennas, such as satellite uplink antennas, confine their energy to a cylindrical beam.
- The larger the diameter, the higher the gain of the antenna. Gain only becomes a factor in the far field which is hundreds of feet away for all but the smallest antennas (210 ft for a 1.5-meter Ku-band antenna)
- In the reactive near field, where you are most likely to be exposed, S is calculated by dividing the input power by the cross-sectional area.
- Therefore, a 2-meter antenna has 4% of the area of a 10-meter antenna and a field strength that is 25 times higher!

S=Equivalent Power Density





Formulas



The assumed power density anywhere in the reactive near field (SRNF) is calculated by dividing the power into the antenna (P) by the area (A) and multiplying by both the reflector efficiency (E_{Ref}) and a factor of 4.

$$S_{RNF} = P/A \times 4 E_{Ref}$$

Use 3 instead of 4 x E. This assumes a 75% reflector efficiency

- This is the formula approved by the FCC for use in calculating RF field levels in the reactive near field of reflector antennas.
- The distance that the reactive near field extends from the antenna (L_{NF}) increases in direct proportion both to the square of the antenna diameter and to the frequency.

$$L_{NF} = D^2/4l$$



Note: Area (A) is calculated based on the two-dimensional area of a circle equal in diameter to the antenna.



Job Site Hazards



Broadcaster Check List



Potential RF exposure areas and equipment:

- Broadcast transmission antennas: On tower is always a hazard for FM, TV, and AM. Ground level is rarely a safety issue except for AM but can be a compliance issue.
- Rooftops where you may have repeaters and/or cameras can have high RF field levels.
- SNG trucks: antennas and potential waveguide leaks.
- Weather radar: potential waveguide leaks.



Tower Climbing is the Major Risk



- Personal monitors should be used by anyone climbing a tower with TV or FM antennas on it or on nearby towers.
- Power reduction is often needed but even when systems are shut down there is always the danger that the systems will be turned back on. It has happened *countless* times.
- Many towers with wireless services antennas can have high RF fields at certain elevations.



Broadcast Antennas



- FM radio and television antennas generate very intense RF field levels. The high field levels can extend out hundreds of feet in front of the antenna.
- There are often very high RF fields directly below these antennas. Some broadcast sites have significant RF field levels on the ground.



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AM Stations • AM stations can generate very high RF field levels, especially near the base and under wide-spaced self-supporting towers. RF burns are a very serious concern. • They a can occur if you touch the tower or the feed. Remember that at an AM station, the tower is the antenna!

AM Stations



There are three RF safety concerns associated with AM towers:

- Burns: Touching the tower, feed line, or the tuning circuits can result in very serious burns.
- 2. Induced and Contact Current: If you climb the tower, current will flow through your body. Extremely high SAR levels can occur in the wrists and ankles and cause serious joint damage.
- 3. High Field Strengths: Although the human body is not an effective antenna at AM frequencies, the area near the base of towers should be avoided due to the very high field strengths, if for no other reason than compliance with FCC Regulations.



AM Stations



- Climbing hot AM towers is *not* recommended if the power in the tower is more than 500 Watts. Even at 500 Watts, there is a risk. The level of risk at a fixed power level is dependent on several factors, especially frequency, tower height, and your relative location on the tower. Shorter towers and higher frequencies are worse.
- In addition to the burn hazard, there is a risk of the climber being subjected to very high induced current levels, especially in the wrists and ankles. In essence, the climber becomes part of the antenna and current flows through his or her body. The mechanism is a combination of the body acting as an antenna and as a branch path for the current in the tower.

Climbing Adjacent AM Towers



- Even climbing a deenergized tower in a directional array (or one that is close to other stations) you can still experience severe shocks and burns as well as induced currents while on the tower.
- In the absence of specific modeling, do not climb an adjacent tower when the hot tower is energized by more than 5 kW.*
- · Modeling is highly recommended.

*Computer models developed by Tom Jones of Carl T. Jones Corp.



Procedure* for Adjacent Towers



When climbing an indirectly energized tower in an array, i.e. the energy is being received, not fed from the transmitter:

- Short the tower to allow people to get on or off so that the shock and burn potential is eliminated.
- 2. Once everyone is on the tower, it is strongly recommended that the tower be detuned to reduce the amount of induced current.
- 3. Short the tower when exiting.

*Procedure recommended by Tom Jones



Folded Unipole AM Antennas



- This design is often used where an FM antenna is mounted on the top of the tower.
- The broadcast element is made up of a series of wires parallel to the tower structure.
- There is a ring near the bottom of the tower where the vertical wires are connected. If you touch this ring you will get burned!
- The AM system must be turned off when climbing the tower!



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ENG Trucks



- RF field levels are insignificant anywhere below 8 feet above the ground, even with the mast at zero elevation, providing that the antenna is not pointed below horizontal.
- Antennas should never be pointed below the horizontal and energized.
- Personnel should never be on the roof of the truck or climb up the ladder with the antenna energized unless the mast is elevated at least 7 feet.



ENG Truck





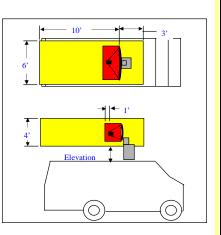
- Very high RF field levels are present near the feed horn of the antenna.
- Never put your head near the radiating side of the feed horn.

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Typical ENG Truck Safety Zones



- Yellow zones may have RF fields above the FCC's limits for General Population/Uncontrolled Environments.
- Red zones may have RF fields above the FCC's limits for Occupational/ Controlled Environments.



Typical SNG Trucks



- RF field levels are insignificant anywhere below 8 feet above the ground, even with the antenna at the minimum elevation angle.
- Personnel should never be on the roof or the truck or climb up the ladder with the antenna energized. The main beam of the antenna generates high RF fields that can exceed the FCC limits for Occupational/ Controlled Environments.



SNG Truck



- High RF fields are present in the main beam of the antenna.
- Extremely high fields are present near the feed horn.
- Never get in the main beam of the antenna.

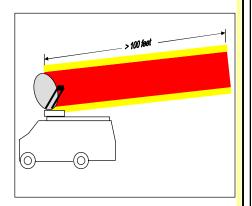




SNG Truck Safety Zones



- Never get in the main beam of the antenna.
- Never aim the beam of the antenna at a building.
- Follow lock out/tag out procedures carefully.



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Building Rooftops



- Broadcasters should consider where their news crews and technical personnel are deployed. Some rooftops—perhaps the one where your repeater is located—are loaded with wireless services antennas.
- The RF exposure potential on rooftops can be significant.



Building Rooftops



Options:

- 1. Wear an RF personal monitor
- 2. Stay a minimum of 10 ft. from all omni-directional "whip" antennas and 20 feet from the radiating side of all directional "sector" antennas if you are at the same elevation. You can get closer providing that you use time averaging as described later.
- 3. If there is an FM broadcast antenna on the roof, do not go there without an RF personal monitor.

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Typical PCS/Cellular Installation



Directional "sector" antennas are rated for coverage of either 90° or 120°. These are the half power beam widths. Assume that there is significant radiation throughout the forward hemisphere up to 20 feet distance.



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Rooftop with Sector Antennas



 Rooftops that contain only sector antennas around the perimeter like this one do not have significant RF field levels.



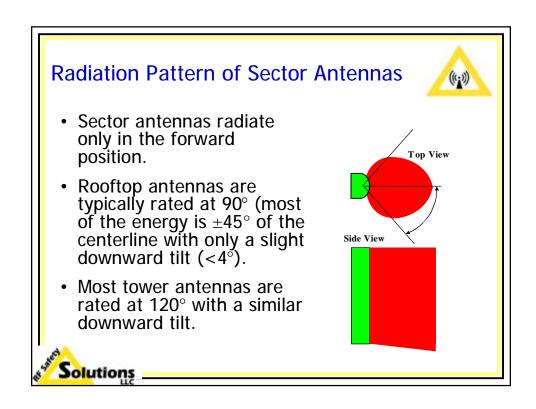
Solutions

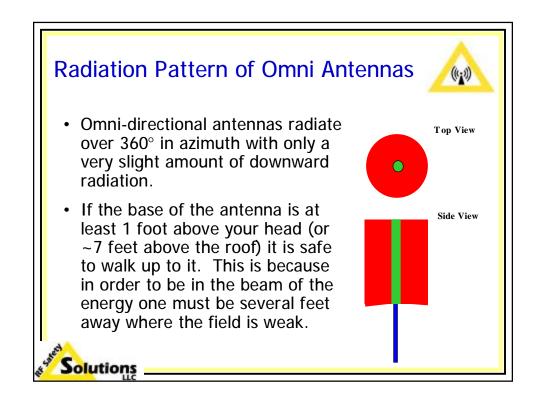
Omni-directional Wireless Antennas



- These omni-directional antennas might be receiving antennas or transmitting antennas.
 Expect transmission levels to change rapidly over time. Maintain minimum of ten feet clearance.
- Be careful of FM radio antennas that are sometimes located on rooftops.





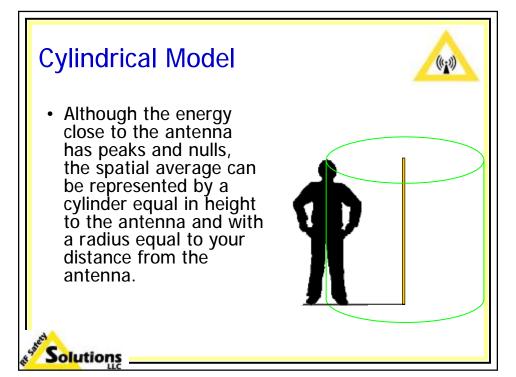


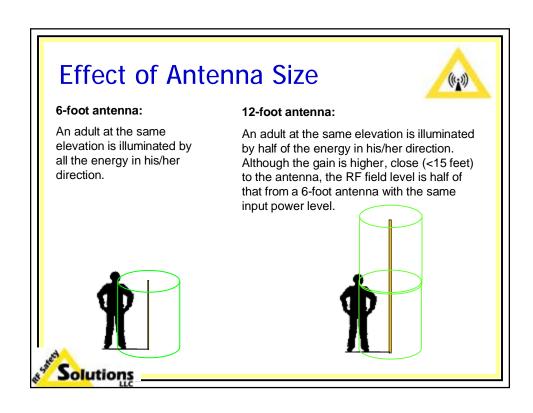
Estimating Field Strength

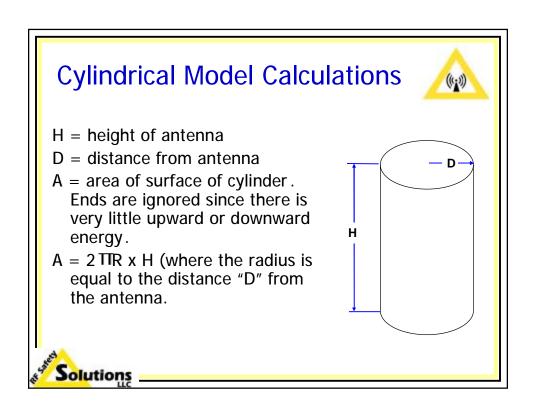


- The spatially-averaged field strength that you may be exposed to can be calculated using the "cylindrical model".
- It is appropriate for all typical co-linear dipole array antennas, both omni-directional whip antennas, and directional or sector antennas.
- The method is very accurate for situations where you are at the same elevation as the antenna.
- The method is appropriate in the near field of the antenna, typically 8 to 15 feet for most wireless antennas.









Typical Calculations



- A = 2 π x 1 x 1.8 with a person 1 meter away from a 6-foot omni antenna. Therefore, the area is 11.3 m²
- S = P/A so if the input power to the base of the antenna is 300 Watts:

S equals $26.5 \text{ W/m}^2 = 2.65 \text{ mW/cm}^2$

- If it is a sector antenna:
 - Multiply by 3 for a typical 120° tower antenna
 - Multiply by 4 for a typical 90° rooftop antenna

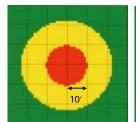
S = equivalent power density measured in W/m²

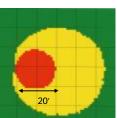


Safe Distance Analysis



- The worst case antennas are 6 feet high and operate in the VHF band, typical of many 2-way radio and SMR systems. These antennas are mounted at roof level.
- The two plots show the RF field levels from 6 ft. omnidirectional and 90 degree sector antennas operating at 150 MHz with 400 Watts input.
- •Red areas exceed Occupational/Controlled limits
- •Yellow areas exceed General Population/Uncontrolled limits.
- •Grid lines on 10 ft. centers.







Safe Distance Analysis



- The minimum distances of 10 feet from a whip antenna and 20 feet from a sector antenna are worst-case because:
 - The analysis assumes that the antennas are operating at VHF frequencies, like many two-way radios and the antennas are 6 feet or shorter.
 - Taller antennas and those systems operating at cellular, most paging, and PCS frequencies are result in a lower exposure in terms of MPE



Effects of Elevation



- The plots on the next slide are all of a typical 6-foot high cellular 90 degree sector antenna with an input power level of 400 Watts. The difference is the elevation of the base of the antenna. When it is at 0 feet, you are directly opposite the antenna.
- Legends:
 - Areas in red have spatially averaged fields that exceed the occupational MPE limit.
 - Areas in yellow exceed the public MPE limit but are below the occupational limit.
 - Areas in green are below the public limit.
 - Grid lines are 10 feet apart.







Waveguide Leaks



- The eyes are particularly vulnerable because the limited blood flow provides limited circulatory cooling.
- Leaks, although not especially common, are acute problems that can occur at any time.
- Even a few watts of energy can be a concern *if* it is concentrated in a very small area.
- Energy drops off rapidly with distance—even two feet spacing is enough under most conditions with the equipment broadcast personnel are liable to encounter.



Waveguide Leaks



- Some waveguide leaks are very obvious.
- Most waveguide leaks are very difficult to see.
 - Cracks in flexible waveguide covered by rubber.
 - Loose flange connections and breaks in welds.



Flexible waveguide removed from 1.5-meter, Ku-band SNG truck antenna where 300 Watts was leaking out.

Omni-directional Wireless Antennas



 This is one of the "horrible examples" of RF hazards on building rooftops. These are all omni-directional antennas and it impossible to avoid them while on the roof. You should not go onto a roof like this without wearing an RF personal monitor. This roof even has an FM antenna!



Solutions

Point-to-Point Microwave Antennas



- These are highly directional, low power (1-2 Watts) microwave point-topoint systems. They are normally not an RF hazard even when directly in front of them.
- For example, a 4-foot antenna with an input power of 5 Watts has an average field level that is about 32% of the MPE limit for public exposure.



Solutions .

Calculating a Microwave Antenna



- Assume a 4 ft diameter antenna (1.2 m)
- Area = 4π = 1.16 m²
- $S = P/A \times 3 = (5/1.16) \times 3 = 12.9 \text{ W/m}^2$
- S = 1.29 mW/cm² for a 5 Watt microwave point-topoint antenna. The average power is only ¼ of this level!
- The vast majority of these antennas are a maximum of 2 Watts. When you consider spatial averaging, the exposure level is even lower.

Solutions

Rooftop FM Antennas



- Some rooftops contain FM radio antennas.
- The RF field levels near the entrance door to this roof are >300 % of the FCC's MPE limits for Occupational/ Controlled exposure and are dangerous.



Using Time Averaging



- Time averaging is a very useful tool to use on rooftops and when climbing towers when only wireless services antennas are involved.
- It is not safe to try to climb quickly past an FM or TV antenna.
- It is rare for the field levels even very close to a wireless services antenna to exceed 400 to 500% of the MPE limit for Occupational/Controlled exposure.



Using Time Averaging continued



The following limits assume that you are not exposed to substantial RF field levels for the remainder of the 6 minute interval:

- You can be exposed to a field strength of up to 600% of the occupational MPE limit for 1 minute.
- You can be exposed to a field strength of up to 300% of the occupational MPE limit for 2 minutes.
- You can be exposed to a field strength of up to 200% of the occupational MPE limit for 3 minutes.





RF Hazard Control Equipment

RF Personal Monitors
RF Protective Garments



RF Hazard Protection Equipment



- RF personal monitors
- RF protective garments/suits (also referred to as "PPE", Personal Protective Equipment)

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Applications for Monitors & Suits



- Personal monitors warn when you are getting too close or conditions have changed (somebody switched to aux antenna, a waveguide has sprung a leak, or the calculations failed to consider reflections)
- Suits can allow you to work in high RF fields.



Using RF Personal Monitors



Wear RF personal monitors:

- When climbing any tower with broadcast antennas.
- Working in front of any transmitting antenna even though it is thought to be shut off. This includes fixed satellite antennas and truck-mounted antennas.
- At any time that lockout, tagout procedures are in use as a redundant safety measure.



Monitor Limitations and Use



- Monitor sensors are directional. They sense fields in the forward hemisphere. They do not pick up fields from behind.
- Always wear the monitor on your torso facing forward. This is especially important at microwave frequencies where there is concern over leaks and eye damage.

Solutions

Available RF Personal Monitors Narda Safety Test Solutions has 99% of the RF personal monitor market with its Nardalert XT (~75%) and the RadMan (~25%) monitors. Both the Nardalert XT and the RadMan are broadband monitors with shaped frequency response. Available from distributors such as RF Safety Solutions.

SafeOne™ Personal RF Safety Monitor



- The SafeOne[™] is a low-cost European monitor introduced in mid-2008.
- Rated performance is 400 MHz to 3 GHz. It has extremely limited specifications with wide tolerances.
- It is almost totally non-responsive at VHF. In other words, if you are near a VHF communications antenna, an FM radio antenna or low band TV antenna, it may never sound an alarm even if you are exposed to extremely high RF fields!



There is no On/Off switch.



Monitor Comparison



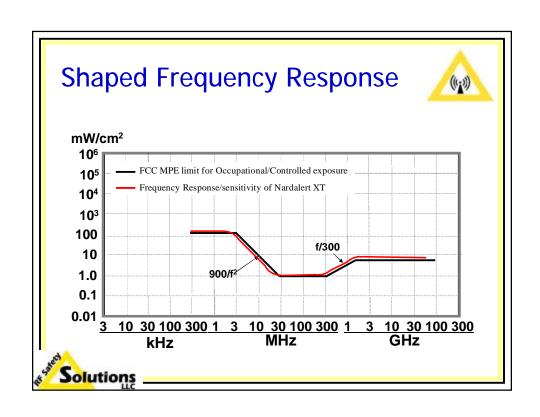
- The Nardalert XT is by far the most accurate and has a number of unique features.
- The RadMan is oversensitive and sometimes responds to static but it does protect you.
- If you are on a shared site, ignore what anybody reports that their SafeOne is indicating.



Shaped Frequency Response



- Monitor automatically weights and sums all signals and gives the total in percent of occupational MPE limit.
- Its sensitivity tries to follow a standard using techniques similar to filter design by using RC circuits.
- Each monitor design follows a particular standard or regulation. A monitor designed for the FCC standard has a different frequency response than one designed for the Canadian (Safety Code 6) standard.



Shaped Response & Multiple Sources



- If you are exposed to the energy from two antennas at different bands, the exposure is automatically evaluated.
- For example, if the total energy from an AM station with a top-mounted FM antenna is 5 mW/cm², the exposure concerns vary depending on the distribution of energy from the two antennas.



Multiple Source Example



- Assume the total RF field level is 5 mW/cm² and distributed in two extreme examples:
 - 1. 4.9 mW/cm² from the AM antenna and 0.1 mW/cm² from the FM antenna.
 - 2. Reverse the distribution.
- Your total exposure in the two examples are (in percent of the occupational MPE limit):
 - 1. 14.9% (4.9/100 + 0.1/1.0)
 - 2. 490% (0.1/100 + 4.9/1.0)

A Nardalert XT monitor would either have the 10% indicator flashing or would "peg" with all 5 lights and the full-scale sound used for field levels of >200%.



RadMan RF Personal Monitor



- Rated: shaped to the FCC Occupational /Controlled MPE limits from 2 MHz to 40 GHz.
- <u>Functional Range:</u> ~40 MHz to ~12 GHz. In this range the monitor works but normally alarms at ½ to ½ of the levels that it should alarm at. (overestimates by 3-6 dB)
- Single LED lights in front, audible alarm. (Cannot see lights when worn)
- · Tends to alarm from static.
- Data logging models available.



Solutions

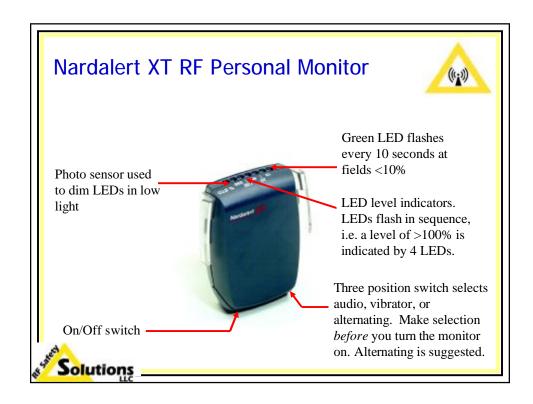
Nardalert XT* RF Personal Monitors



- 100 kHz to 100 GHz operation covers essentially the entire usable RF spectrum.
- Frequency response is "shaped" to conform to the FCC's MPE limits for Occupational/ Controlled Environments. Indicators and alarms are in "Percent of Standard".
- Monitor averages and updates on a one second basis.



*Recommended by and available from RF Safety Solutions.



Nardalert XT RF Personal Monitors



- Five indicator LEDs flash in sequence.
 - 10% Yellow LED indicates levels from 10% to 19.9%.
 - 20% Yellow LED indicates levels from 20% to 49.9%.
 - 50% Red LED indicates levels from 50% to 99.9%.
 - 100% Red LED indicates levels from 100% to 199.9%.
 - 200% Red Led indicates levels 200% and higher!
- Two audio alarms.
 - Steady tone from 50% to 199.9%.
 - Warble tone for levels 200% and higher.



RF Protective Suits

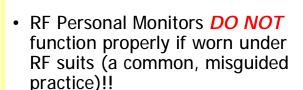


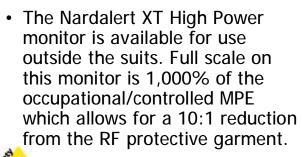
- Stainless wire (10-25%) blended with Nomex.
- Provides >10 dB of protection at most frequencies (concerns at AM band).
- Protection is only about 3:1 w/o hood.
- Hood is required above 800 MHz under all conditions.
- Conductive socks must be worn and in conductive contact with suit for energy to "drain" off the body.





Suits and Monitors



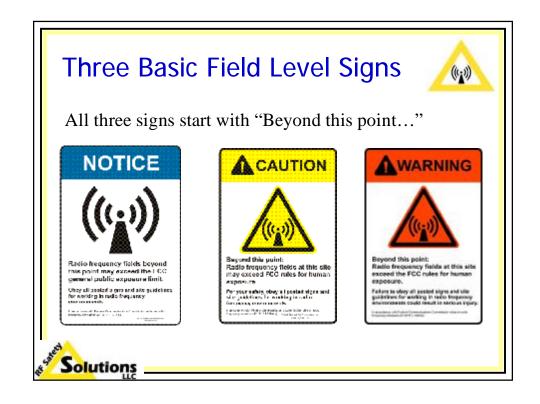






Contact RF Safety Solutions for pricing





RF Safety Signs—The Basics



- · Do NOT over sign!
- Install signs so it is clear by what is meant by "Beyond this point"
- Use special "Tower CAUTION" signs for just about any tower site except for AM towers.
- Use special burn hazard signs for all AM towers.



NOTICE Sign



- States that "Beyond this point" fields may exceed the public MPE limit.
- Most sites, other than AM, can use this sign at the gate as sort of a prewarning even if the field levels on the ground are below the public limit.



CAUTION Sign



- States that "Beyond this point" fields may exceed the human MPE limit. (human = occupational/controlled MPE limit)
- Sites where some areas on the ground exceed the occupational limit should use this sign. Few sites need this sign.



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WARNING Sign



- States that "Beyond this point" fields exceed the human (occupational) MPE limit.
- If you have this sign, it means nobody should enter the area unless power is reduced.
- It is extremely rare to need or want to use this sign but it is not uncommon to see it.



Tower CAUTION



- States that "on the tower, near some of the antennas that fields may exceed the human limit."
- This is the ideal sign for virtually every tower site, other than AM towers.



Solutions

DANGER Burns Sign



- All AM sites should have both field level and burn signs.
- Burns are a hot button with FCC inspectors.
- Note that the action word is DANGER, which is a higher threat than WARNING.



Solutions .

Guy Wires Sign



 Rarely needed but if you don't have an insulator near the bottom of your guy wires as well as one at the top, you may have an issue.



Solutions





RF Radiation Safety

Common Sense and Following Procedures Help Keep You Safe

