Chapter 16

Safety in Amateur Radio

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Basic 1993

Morse code 5wpm 1994

Morse code 12 wpm 1995

Advanced 1998

Objectives:

- By the time we are finished here, you should be aware of the hazards you can encounter in Amateur Radio and
- Be familiar with basic safety precautions that need to be observed
- Have begun to use a “safe” way of thinking
- (some hazards are more controllable than others)

- This hobby does have its elements of risk as we shall see.
- A hearty dose of common sense is recommended.

What will be covered

Ref: The Canadian Amateur Radio Study Guide for the Basic Qualification.

- **16-1 Power sources**
- **16-2 Station Safety Ground**
- **16.3 Power Requirements**
- **16.4 Electrical Safety**
- **16.5 Dangers of Electricity**
- **16.6 Antenna Safety**
- **16.7 Tower Safety**
- **16.8 Lightning Protection**
- **16.9 Exposure to RF (Safety Code 6)**
- **16.10 Soldering**

Basic Principles of Safety (1)

There are **seven basic lessons** that sum up what we must learn

– Handle AC power sources with caution and always employ safety grounds

– Make sure that your station's power requirements can be handled by your AC circuits

– Exercise special safety precautions when working with high voltage circuits

Basic Principles of Safety (2)

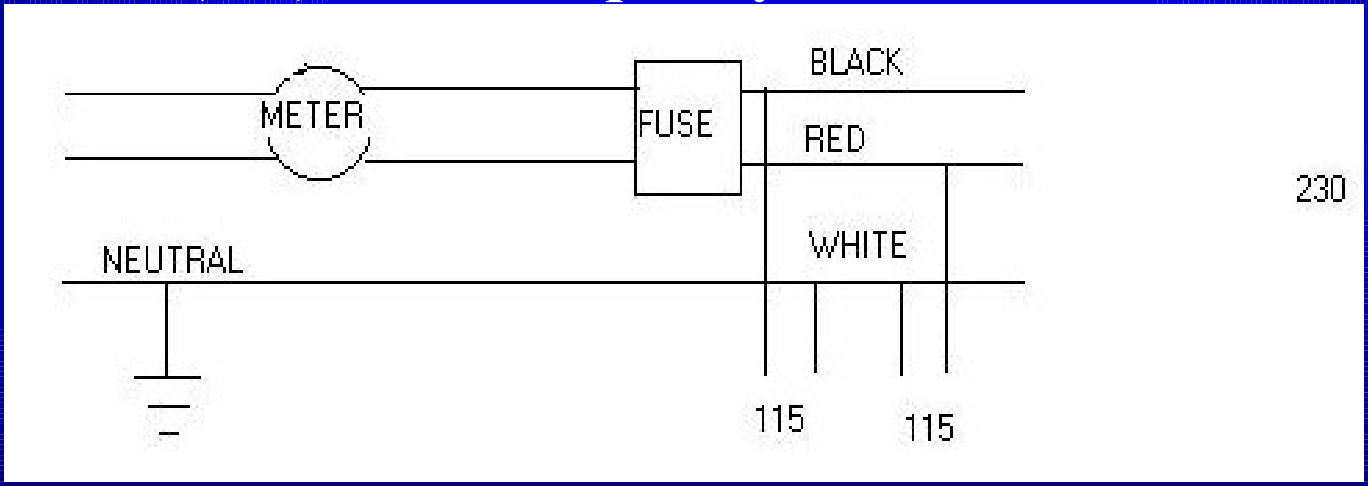
- When working outdoors with antenna systems,
*avoid contact with electrical lines
*use safety systems when climbing
-Take steps to avoid lightning strikes and to minimize damage when they occur
- Avoid exposure to RF
- Be cautious when using tools, solder and chemical agents

16-1 AC Power sources

Most amateur radio equipment depends upon standard 115 V AC power source,
although high power linear amplifiers often use 220V
Modern AC is a three-wire single-phase system where ***single-phase*** means…***a system energized by a single AC voltage***
Home circuits provide about 1500 Watts

16-1 Power sources

- **House current**
  - **The standard voltage source supplied to homes in Canada (the mains) is**
    - **three-wire (plus a ground)**
    - **single-phase system.**
    - **(AC) is at a frequency of 60 Hz.**

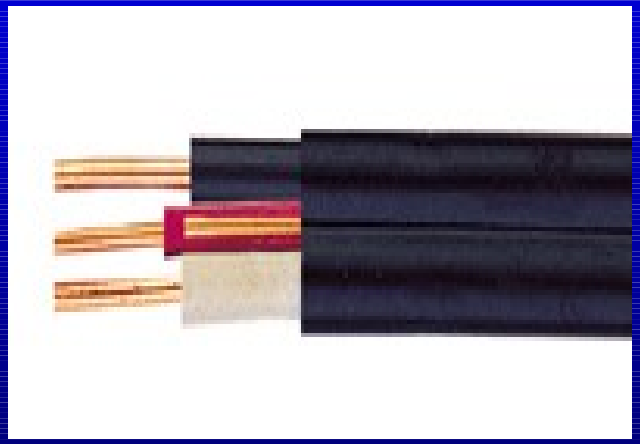


House current

- The red and black wires (live or hot wires) are at high potential to ground and to each other.

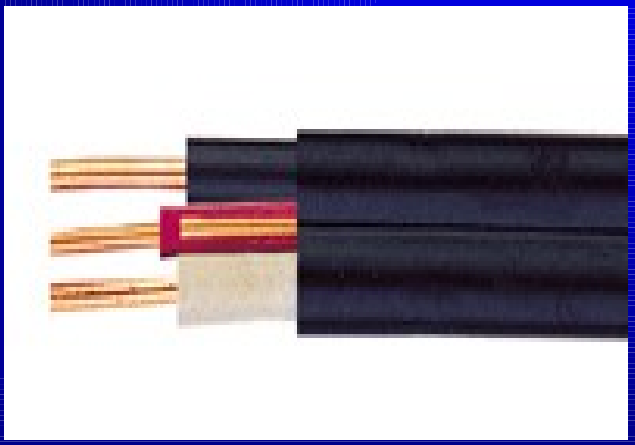
House current

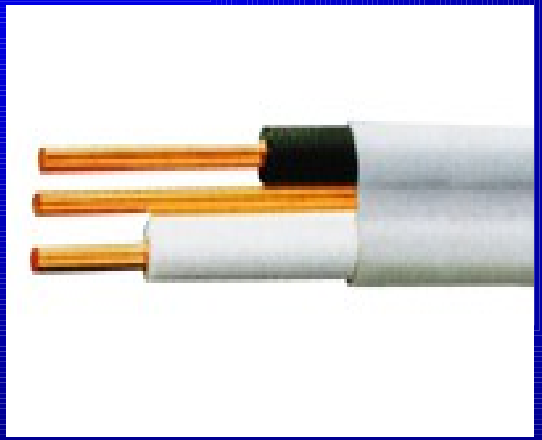
- The third (white) wire is neutral
  - It is grounded at the distribution transformer.
  - It is grounded to the cold water pipe or to a ground electrode in the residence.
  - The neutral wire is at, or very near, ground potential.



House current

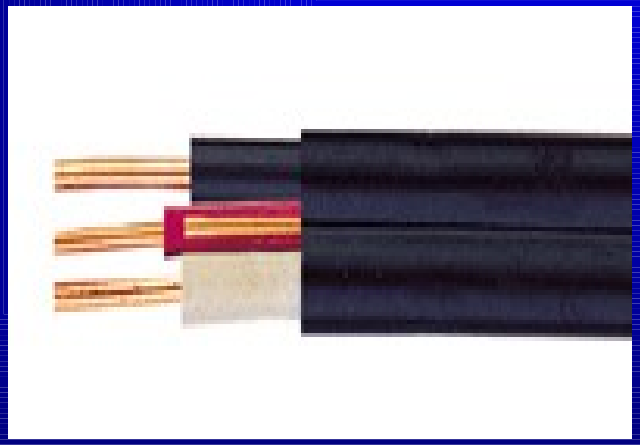
- The ground wire (bare) is for safety purposes and connects to the neutral at the house service entrance.
- It is also attached to all electrical boxes and receptacles.

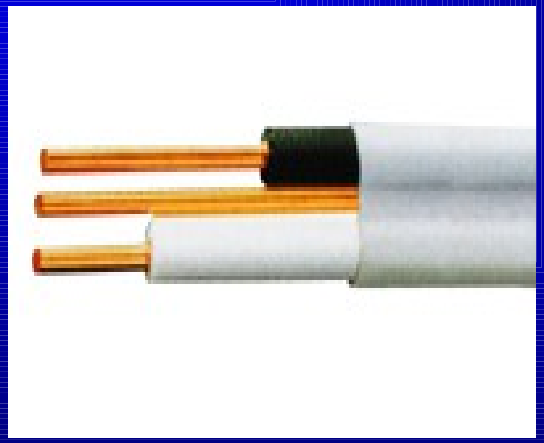




House current

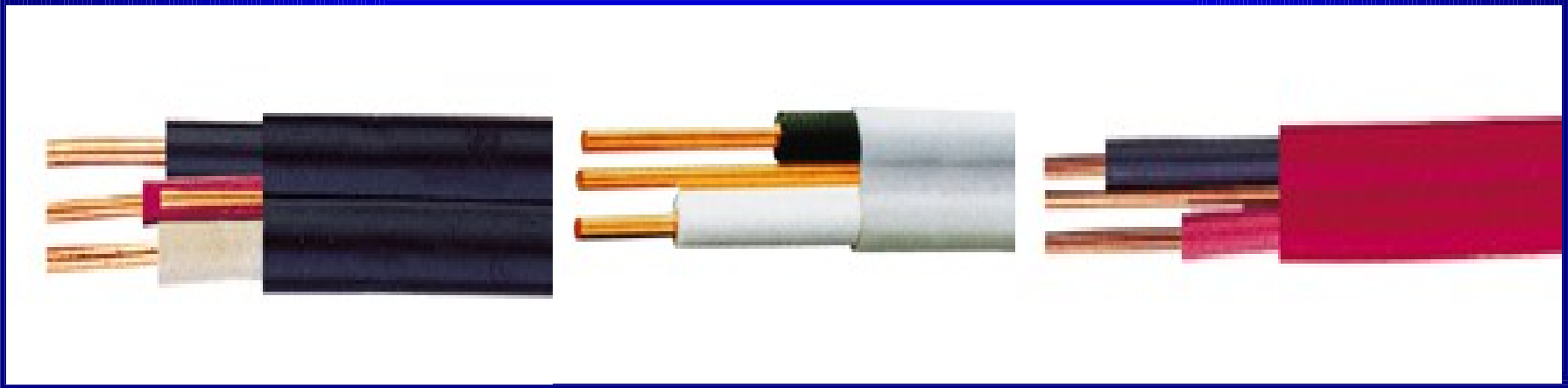
- The voltage across the two hot wires is 230 VAC and
- voltage between either hot wire and the neutral wire is 115 VAC





House Current

- **Lighting and small appliance circuits are on 115 VAC/ 15 A circuits.**
- **Large appliances (stoves and dryers) are on 230 VAC circuits.**
- ***The 230 V value may fluctuate over quite a range.***



16-2 Station Safety Ground

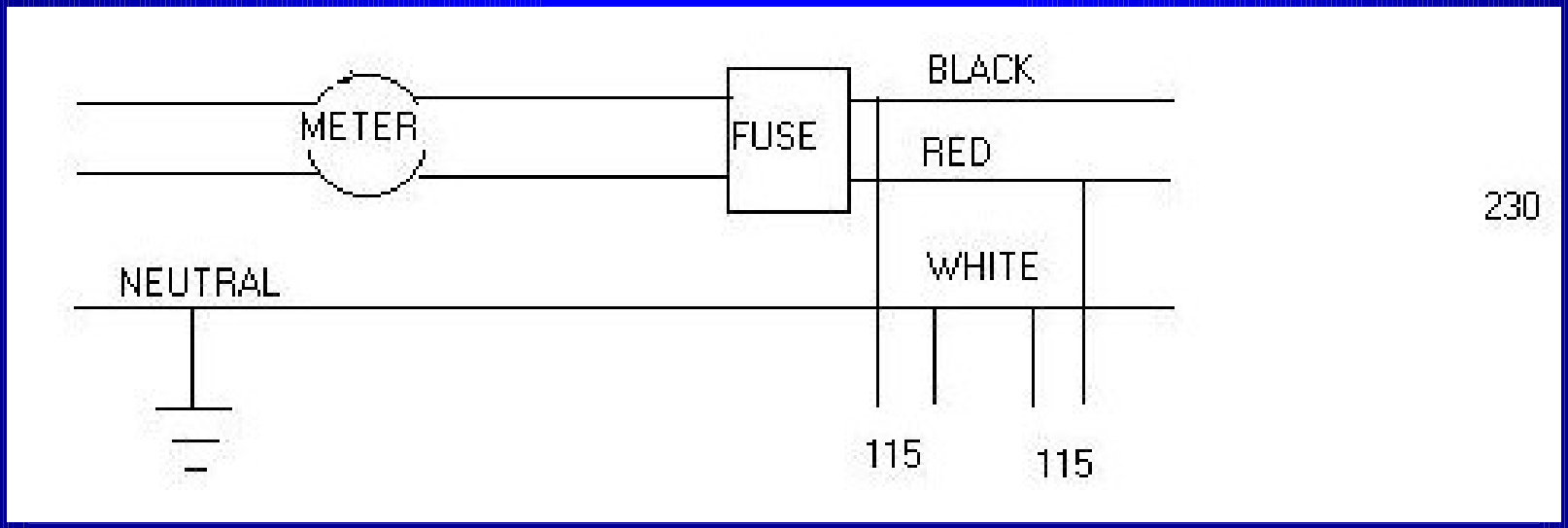
- Dangerous voltages can be shorted to a metal case without blowing a fuse. Thus a **direct** ground is needed.
- Use three-wire power cords and receptacles

16-2 Station Safety Ground

- In the radio shack, use a common ground system, such as:
  A copper bus bar that is connected to an outside ground rod, 10 or 12 feet in length
- The wire to ground should be #6, while equipment to bus bar connections can be #14 wire or braid.
- Use the jacket of old RG8U or RG-213, and good hardware

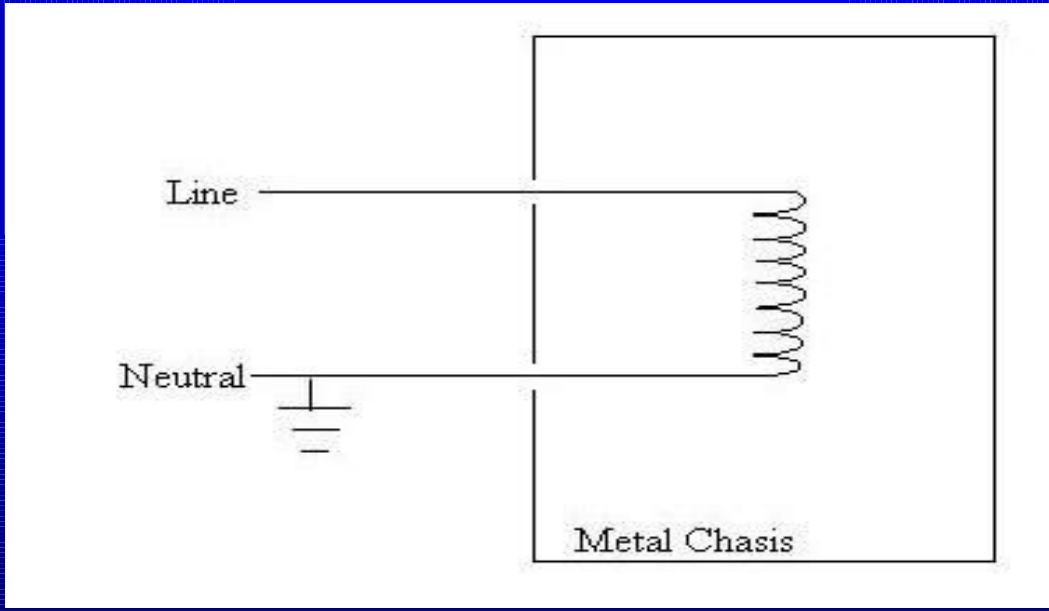
16-2 Station Safety Ground

- Although the neutral wire is shown as grounded, it cannot be considered a substitute for a safety ground.



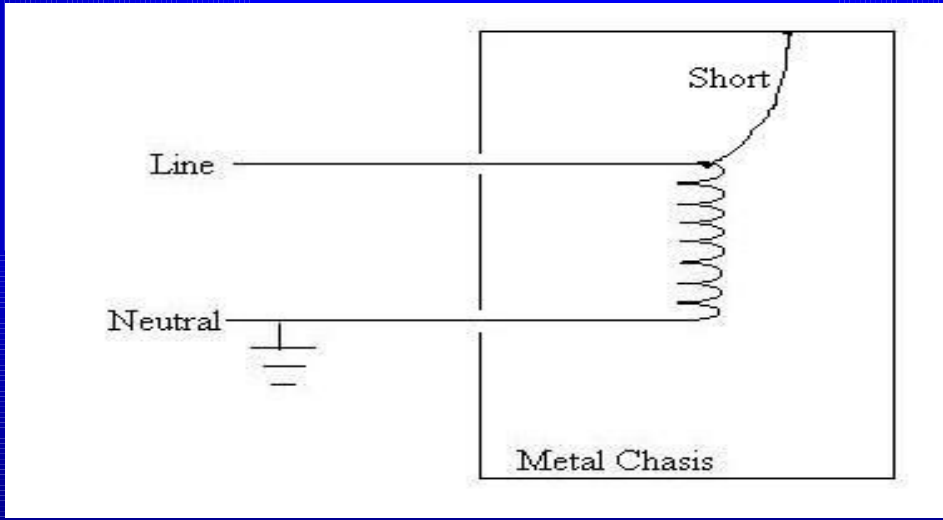
16-2 Station Safety Ground

- This is a simplified representation of a 115 V circuit feeding an Amateur transceiver, or any appliance with a metal case
- (The metal case is not connected to anything)



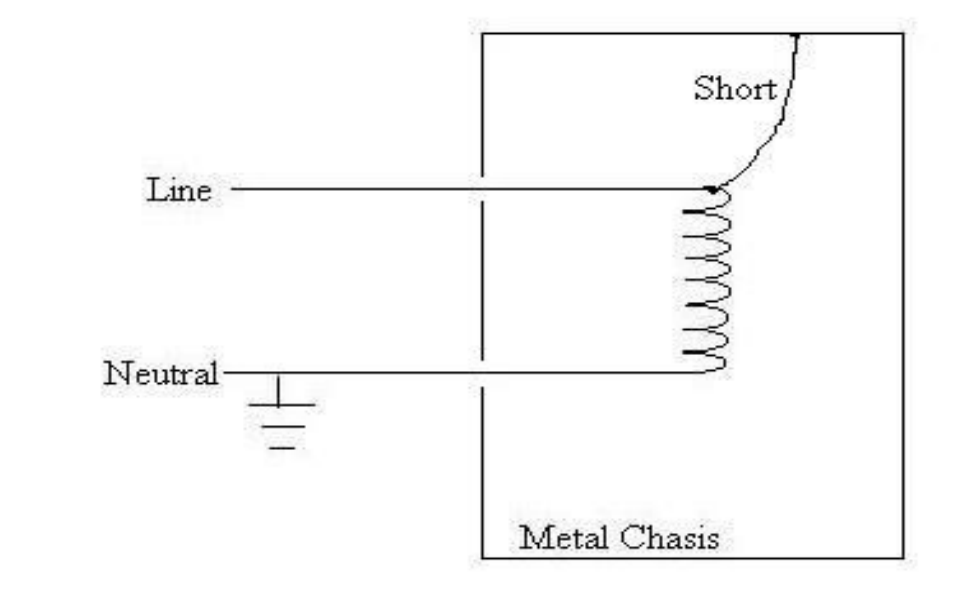
16-2 Station Safety Ground

- A short circuit has developed between the line or hot side of the power transformer and the chassis, thus putting the case at a potential of 115 V.



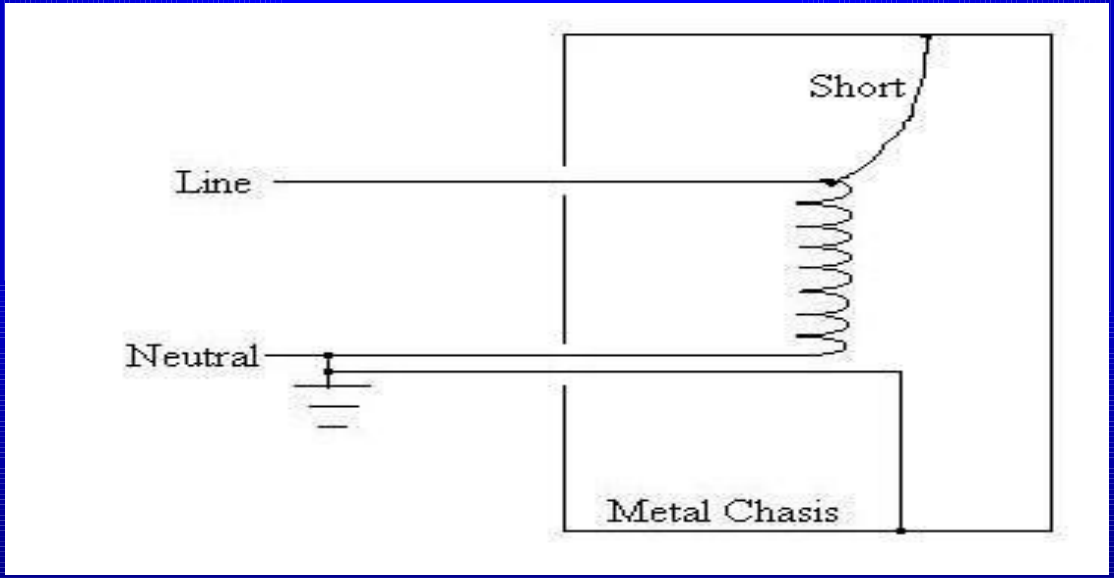
16-2 Station Safety Ground

- This does not cause the fuse to blow,
- current still flows through the primary side of the power transformer,
- (The metal case is not connected to anything except the short. The chassis is now live!)



16-2 Station Safety Ground

- a third or ground wire is added
- current flows from line, to the metal case, and through the ground wire to the common neutral to ground
- the fuse or circuit breaker will blow



16-2 Station Safety Ground

- **it is essential that any metal cabinets** containing voltages above 40 to 50 volts, DC or AC, **be grounded** to prevent the possibility of electrical shock.
- This can best be achieved by ensuring that three-wire power cords are used with three-wire receptacles
- **This includes your power supply your 2 meter rig is powered from.**

16-2 Station Safety Ground

- The electrical supply ground is not intended for RF grounding or as a sink for lightning strikes.
- An additional station safety ground should be installed, comprised of a large copper strip which serves as a tie point for ground leads connected to all metal cabinets in the station.

16-2 Station Safety Ground

- Connect station ground to metallic cold water pipe,
- Better still, connect to an outside ground rod,
- Use a heavy, number 6 or larger, copper wire,
- Grounding leads to individual equipment should be at least 14 gauge,
- Keep all wires as short as practical,
- All connections must be made with nuts, bolts, spade terminals or clamps if necessary.
- Use similar materials for all hardware, wire, etc,
- Ground rods are made out of copper-clad steel, the standard is 3.25 m (10 feet) .

16-2 Station Safety Ground

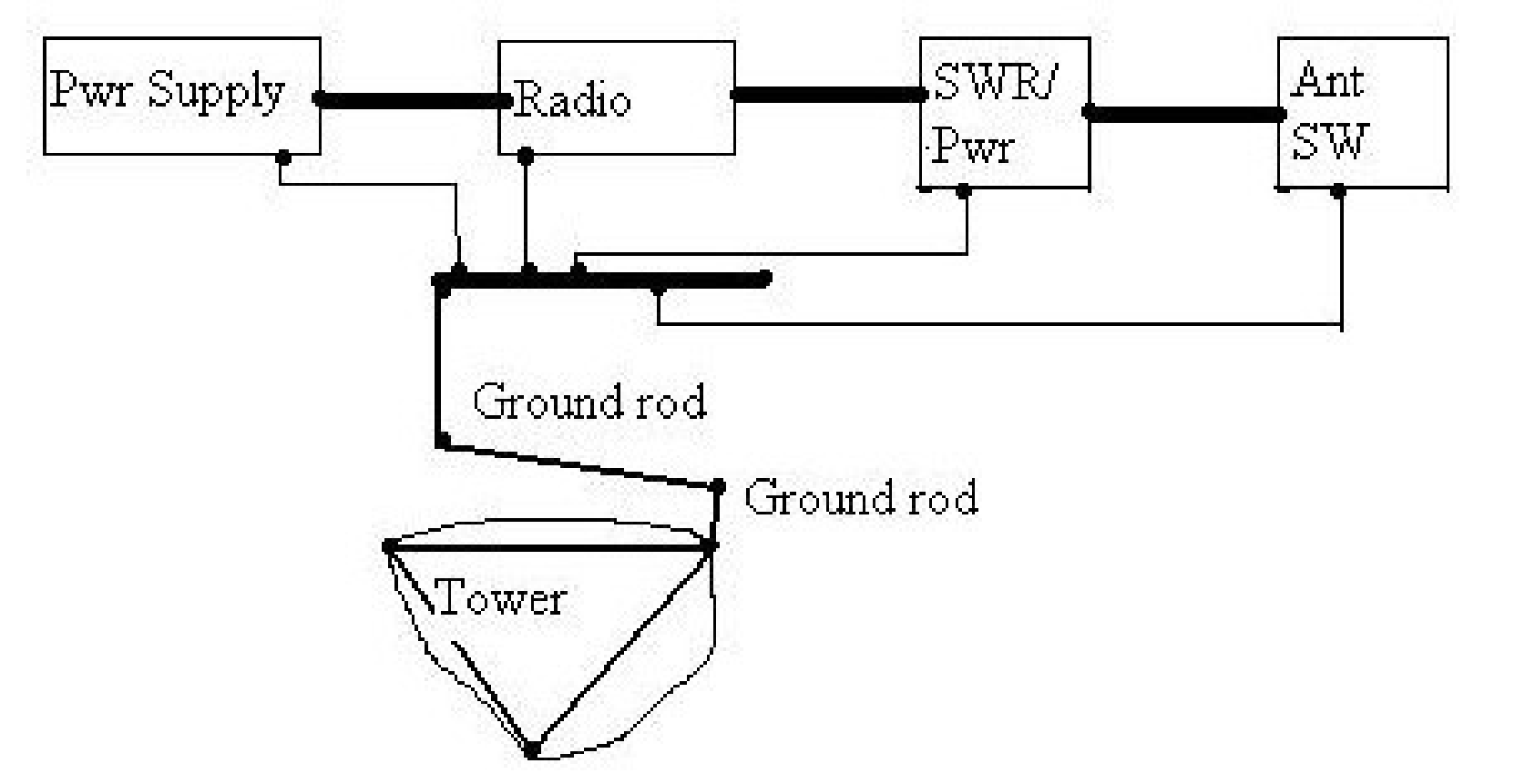
- **Stray** RF causes interference and other problems
- The remedy is having:

1) properly shielded station equipment that is
2) all tied together with a particular type of ground

- An ***RF Ground*** is defined as "…a low-impedance path for RF to reach the earth or some other ground that dissipates, rather than radiates, RF energy."
- In most stations the safety and RF ground are provided by the same system

16-2 Station Safety Ground

- All grounding systems should be tied together



16.3 Power Requirements

- Depends on what you are planning on running.
- If you are able to plan your electrical supply in your room, more than you *presently* need is better than not enough.

16.3 Power Requirements

• Light duty installations can work off of ordinary circuits, e.g. low power HF, VHF or UHF stations

• Heavy duty installations must work off of **separate circuits**. Each 120 V circuit is rated at 1500W

- When using a high power linear amplified one should use a 230VAC circuit

• **Do not install over rated fuses**, e.g. 30 A when 15 or 20 A are specified

• Easy access to a station circuit breaker is a good idea.

16.4 Electrical Safety

- precautions must be taken by anyone who wants to look inside his or her commercially-built rig.
- You are not permitted to build or modify your transmitter unless you have the Advanced Qualification, but, you may maintain it.
- If you are not sure what you are doing, ask for assistance!
- Whenever possible never work alone

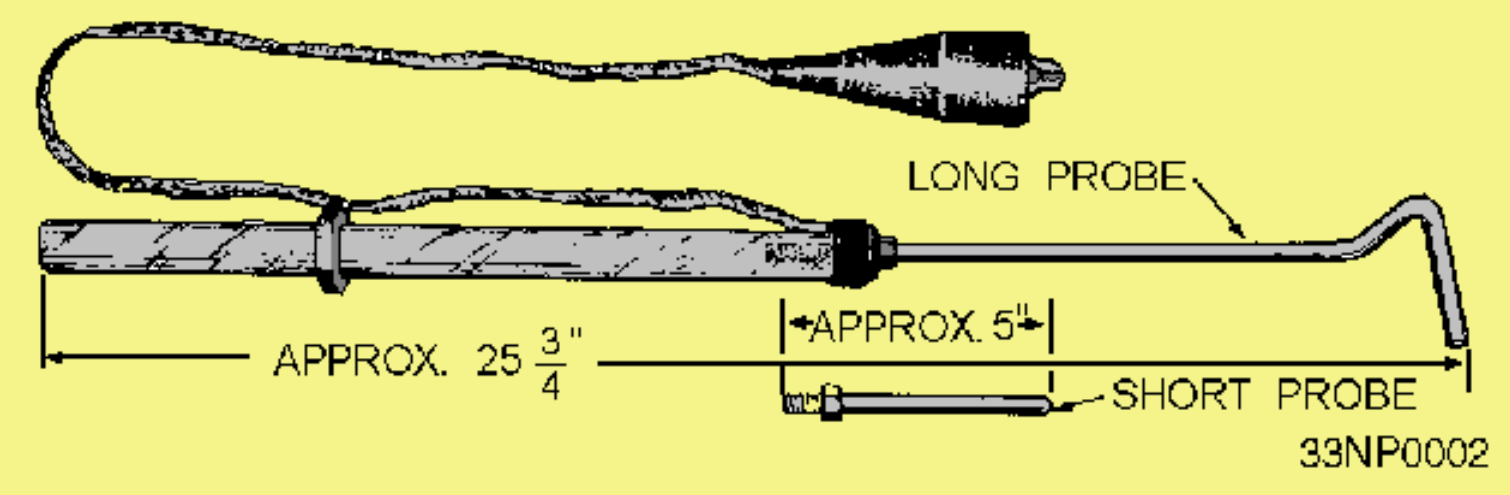
16.4 Electrical Safety

If you really must, then:

- Remove the power cord from the electrical outlet.
- Wait at least 3 minutes for the capacitors in the high voltage supply to discharge.
- Remove the equipment cover.
- Place one hand in a pocket .
- Drain off filter capacitors using a shorting probe.

16.4 Electrical Safety

- **SHORTING PROBE.**



16.5 Dangers of Electricity

- Most fatal electric shocks could be avoided if the necessary precautions were taken.
- If necessary to work on *a live* rig, stand on rubber mat with one hand in a pocket
- Do not rely on interlock mechanisms
- Never work alone, and think about engaging an expert!

16.5 Dangers of Electricity

- House voltages of 115 VAC can kill you under the right circumstances
- 30 VDC can kill you
- the Van de Graff generator which produces very high electrostatic voltages, well above 10 000 V will make your hair stand on end and that's about it.
- **SO WHAT'S THE DIFFERENCE???**

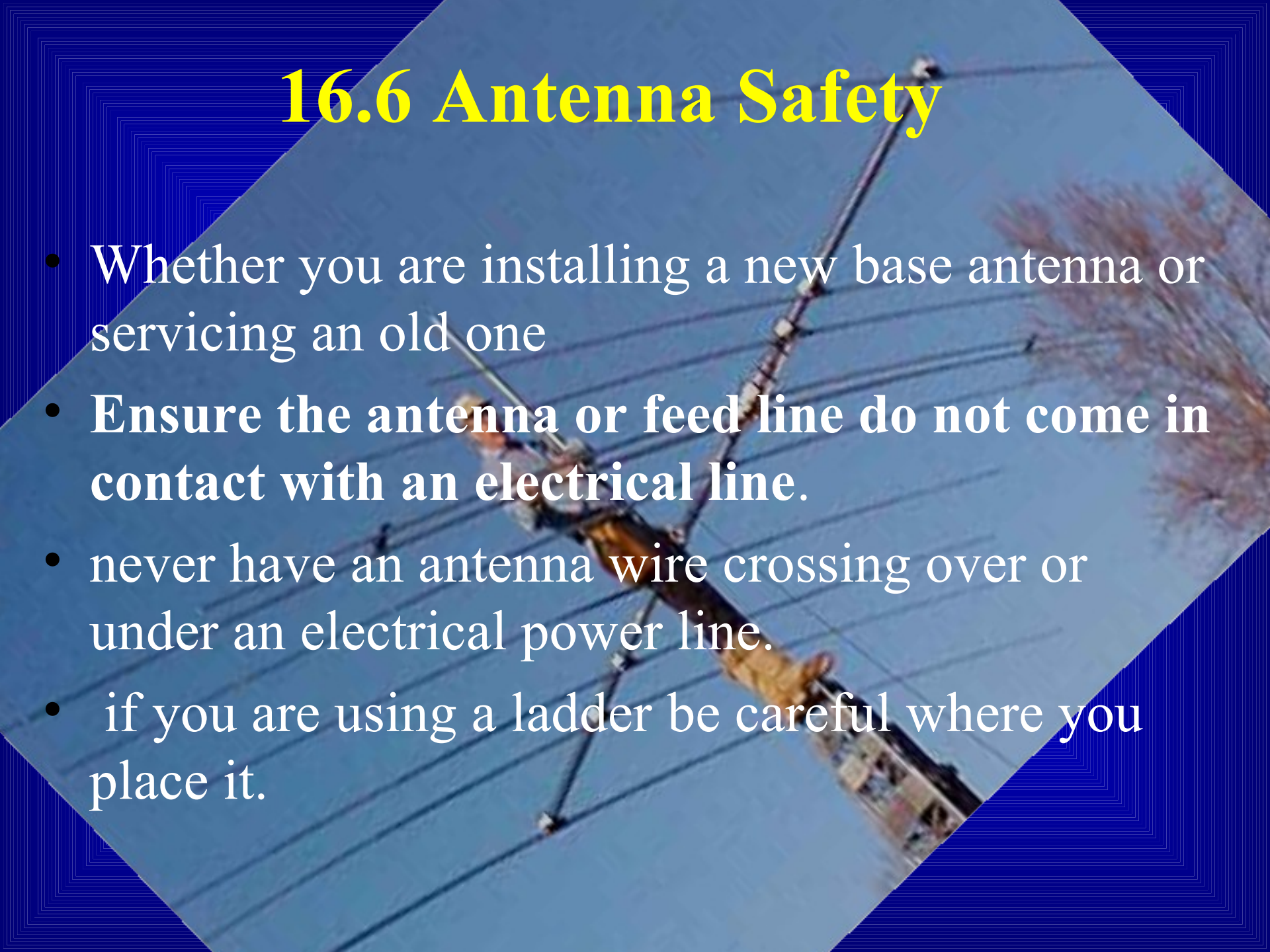
16.5 Dangers of Electricity

- Current of 1 - 2 mA (0.001 - 0.002 A) can be felt
- 10 mA (0.010 A) we feel pain.
- 10 mA - 100 mA (0.010 A - 0.100 A) it get worse - muscular paralysis, severe physiological shock, extreme difficulty breathing.
- 100 mA - 200 mA (0.100 A - 0.200 A) death is likely as the heart can be fatally affected

16.5 Dangers of Electricity

- If you come upon someone who has received a severe electric shock
- WHAT DO YOU DO??
- turn off the source of current
- ENSURE YOU DO NOT ENDANGER YOURSELF
- remove the victim from contact with the current source

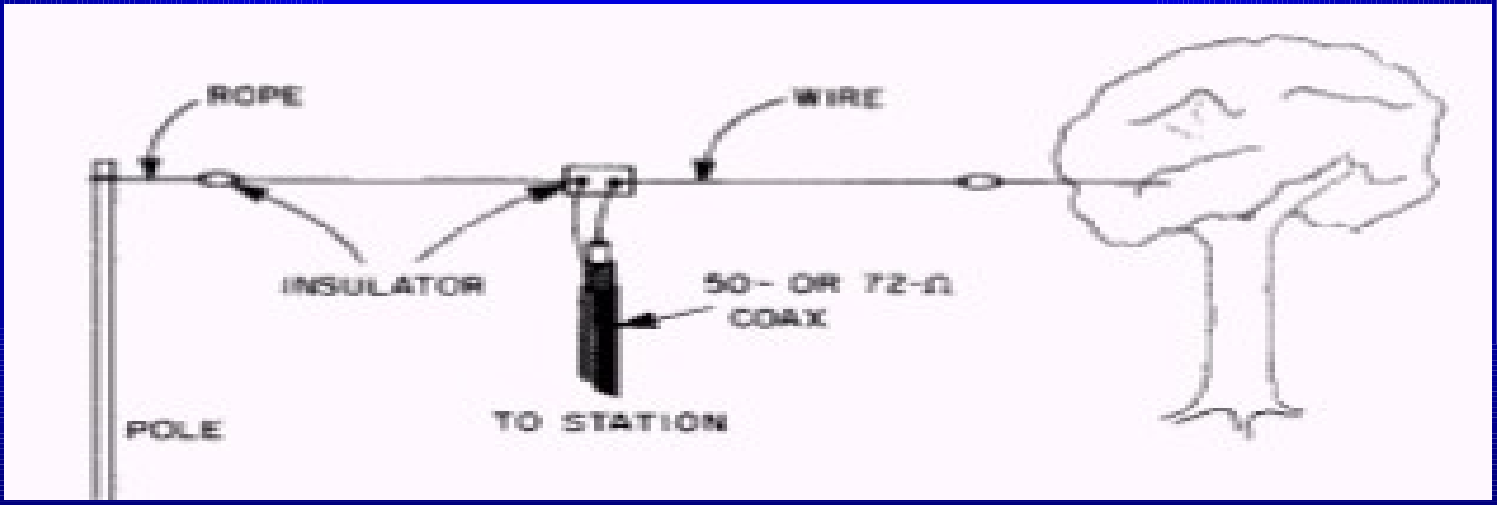
16.6 Antenna Safety



- Whether you are installing a new base antenna or servicing an old one
- **Ensure the antenna or feed line do not come in contact with an electrical line**.
- never have an antenna wire crossing over or under an electrical power line.
- if you are using a ladder be careful where you place it.

16.6 Antenna Safety

- The ends of wire dipoles and inverted vees have high RF voltages that can burn.
- Ensure ends of wire antennas are positioned well above the ground so that they do not come in contact with people or animals.



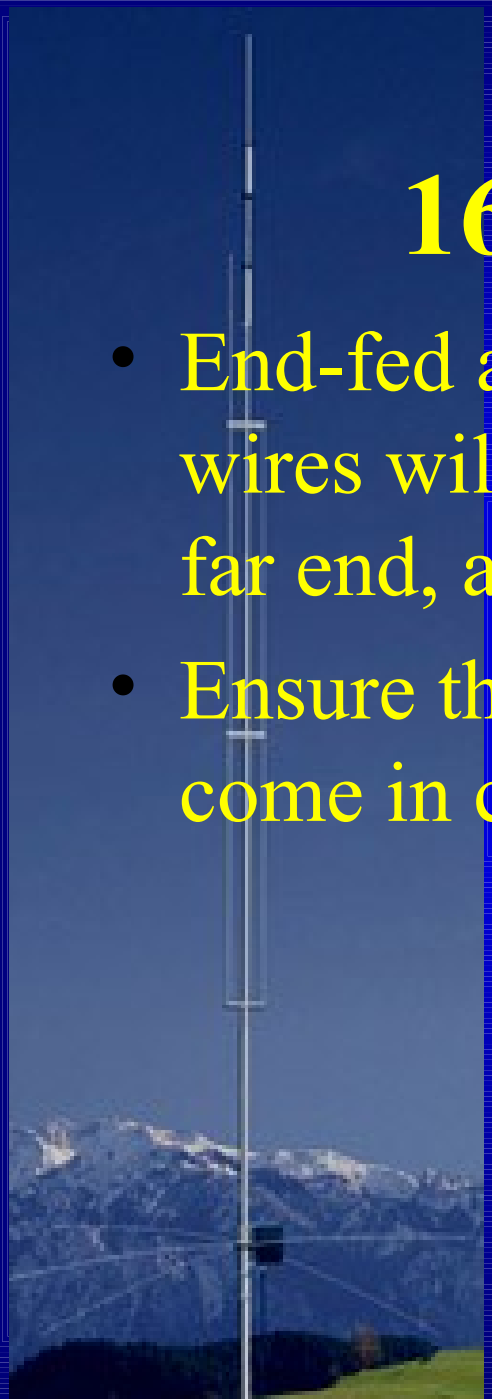
16.6 Antenna Safety

- Beam antennas, or Yagis, should be high enough so you are not sending RF directly at someone else's home.
- Beams can achieve ERPs of 15 – 25 kw so do not aim them into some one's home

- can destroy home entertainment devices, TVs, etc

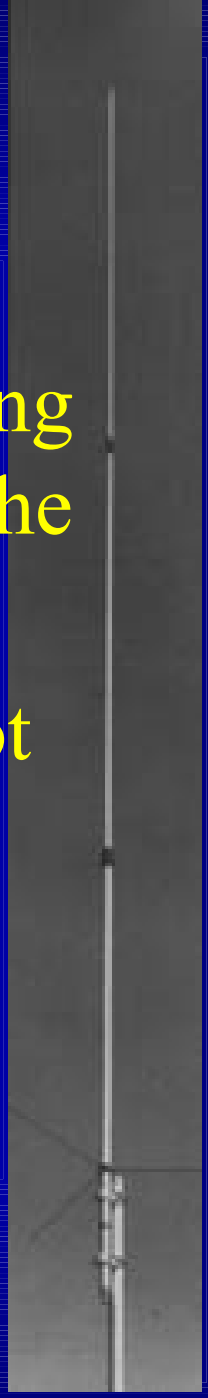
- plays havoc with garage door openers

- This is more important at higher frequencies (we'll see this later)



16.6 Antenna Safety

- End-fed antennas such as verticals and long wires will also have high RF voltages at the far end, and possibly at other places.
- Ensure they are located so that they do not come in contact with people or animals.



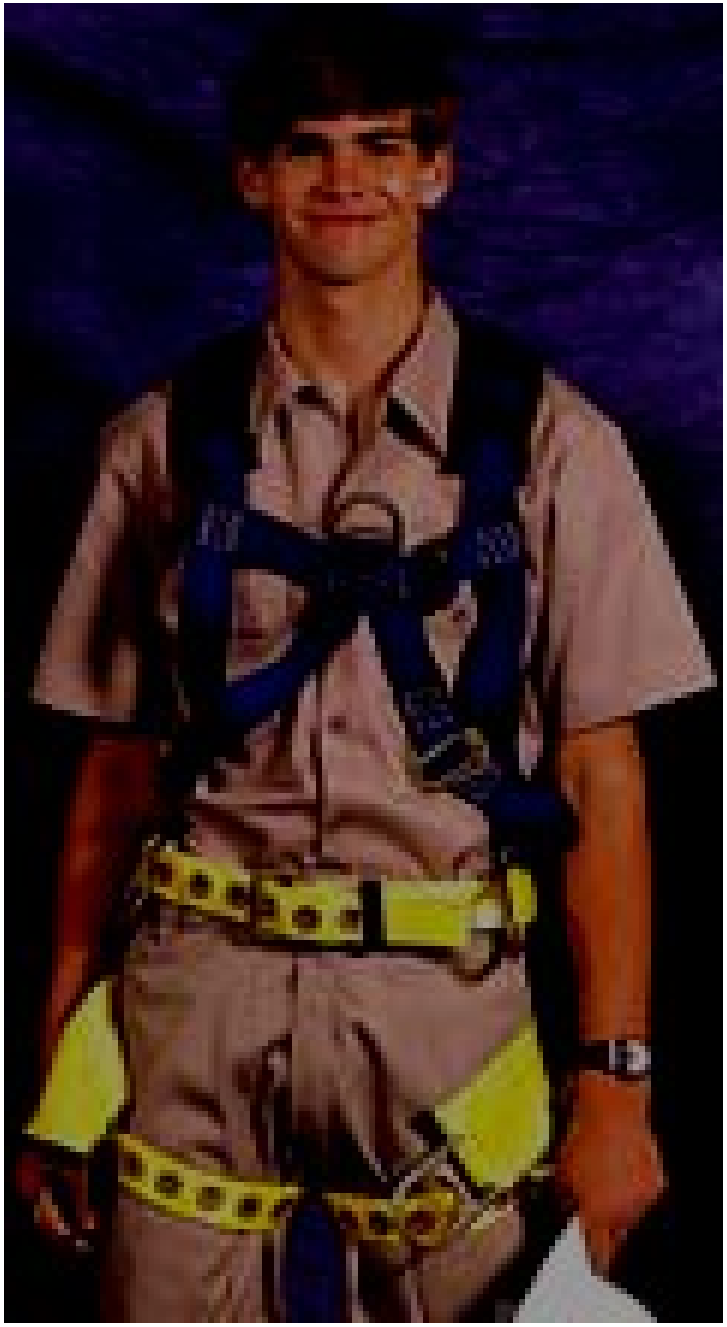
16.7 Tower Safety

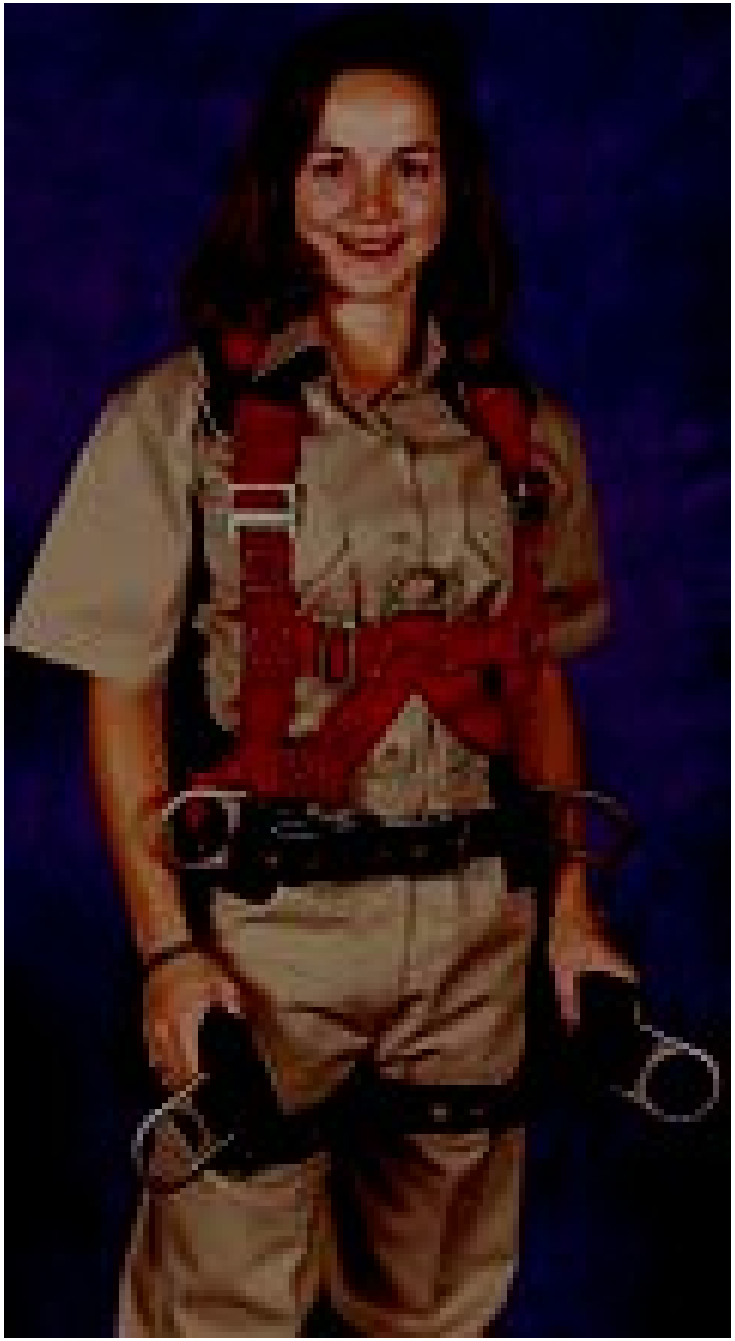
Towers are used to mount beams and to secure wire antennas at greater heights

- If you plan on putting up a tower, find someone that is experienced for help and advice.

16.7 Tower Safety

- If you are going to climb a tower, you must have the proper gear;
  - Fall Arrest gear will save your life
  - Positioning gear will hold you in place so both hands are free
- Check your gear for signs of weakness prior to use:
- torn leather, frayed webbing, missing rivets and stitches are not acceptable.

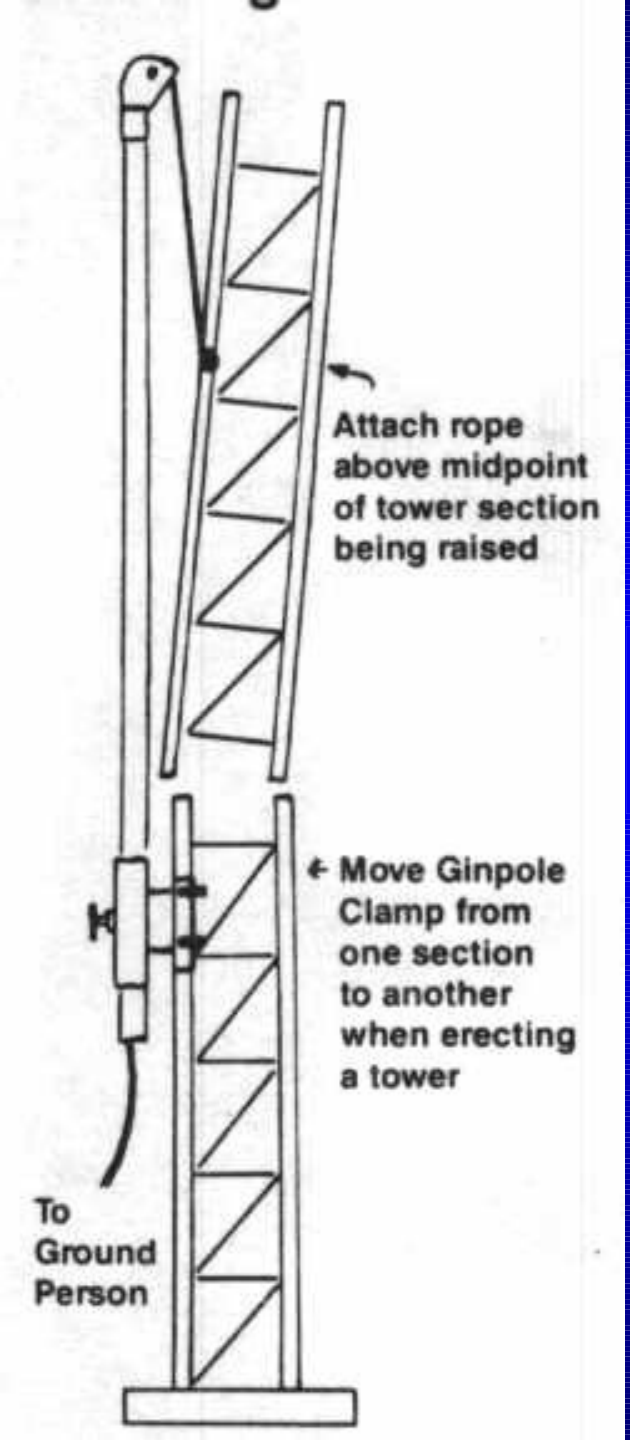




16.7 Tower Safety

- **GROUND CREW**
- Safety on the ground is important too
- Always wear a hard hat.
- Never stand around at the base of the tower
- If you really must be at the base, let the climbers know you are there
- A wrench dropped from a height of 15 m can do a lot of damage!

Crew safety requires vigilance and use hard hats.



16.7 Tower Safety

- When erecting or dismantling a tower the gin pole is sometimes used
- It can be moved up the tower as each new section is raised.
- The gin pole hooks over the tower cross struts and is clamped or tied in place.
- The pulley on the end allows a rope to be passed through it to raise or lower sections of tower.

16.8 Lightning Protection

Unless you have proper lightning protection measures adopted, severe damage will occur in the event of a direct lightning strike on your system. We must take suitable precautions to:

1) Minimize the possibility of a direct strike on the antenna system.
2) Minimize damage caused in the event of a direct strike.
3) Minimize the damage caused by a nearby strike, even if some distance away.
4) Minimize the damage caused by a build-up and subsequent discharge of static electricity on the antenna system.

16.8 Lightning Protection

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4) Minimize the damage caused by a build-up and subsequent discharge of static electricity on the antenna system.

16.8 Lightning Protection

- **Damage from a lightning strike on an antenna system can be reduced if the system is suitably grounded.**

Although grounding is definitely a requirement, it does not guarantee no damage will occur at all!

16.8 Lightning Protection

The ground system system:

1) As close to the tower as possible, drive a 3 metre-long ground rod into the soil beside each leg. Using #4 or #6 gauge copper wire, and suitable connectors, connect all legs together, and to all ground rods.
2) An electrical supply store should have the necessary material.
3) The this ground system should also be connected to the copper cold water system in the house, to the station ground, and to the electrical service ground.
4) If there is a ground plane, radial system, or counterpoise for the antenna connect it too.

16.8 Lightning Protection

- If the soil is very shallow the tower base should be connected to a #12 or #14 conductor, which goes around the yard,which acts as a counterpoise. The counterpoise is securely attached to radials 3 - 4 m long. Connect the other ends of the radials to large pieces of conductive metal buried in the soil, such as old water tanks, car radiators, etc. The energy released by a lightning strike is colossal. Anything which will dissipate it will help.

16.8 Lightning Protection

- At the base of a vertical or end-fed antenna connect an RF choke between the antenna feed point and ground. Alternately you should securely ground the bottom of the antenna when not in use.

16.8 Lightning Protection

- There are devices which can be inserted in the feed line. Such trade names as the "Transi-Traps".
- They conduct from the inner conductor of the coax to the shield any voltage which may build up as a result of static electricity. Under certain weather conditions this build-up can be quite substantial. Read the manufacturer's' claims and install as instructed.

16.8 Lightning Protection

- **Every line coming in, EXCEPT ground, should be disconnected from the equipment when the station is not in use. (Physically disconnect all feed lines)** ***A coaxial switch will not survive a direct strike.***
- **Disconnect the rotator cable.** ***Install a multi-pin connector in the rotator control line at the controller.***
- **Unplug all power cords from electrical outlets.** ***A strike on or adjacent to the incoming electrical line can cause considerable damage.***
- **Disconnect your telephone and modem**

Never operate if there are electrical storms in the vicinity!

16.9 Exposure to RF

- The **energy content** of any portion of the electromagnetic spectrum is directly proportional to the frequency at which it was radiated - *the higher the frequency the higher the energy content*.
- A microwave oven transmitter is tuned to 2.450 GHz.
- You are protected from its emissions because the chassis of the unit forms a Faraday cage or shield which confines the microwave energy.
- The door has an electrical interlock so when the door is opened, and the security of the Faraday cage is breached, the oven shuts off.

16.9 Exposure to RF

- Most of us will probably not operate in microwave frequencies, but there is still RF energy associated with the frequencies we operate in.
- One popular medical tool is the diathermy, which uses RF energy to provide "deep heating" of tissue beneath the skin. RF diathermy operates around 27.12 MHz, which is just below the 10 meter band (CB band).

16.9 Exposure to RF

- Older units operated just below the 20 meter band at around 13.56 MHz.
- Microwave diathermy units operate at 915 MHz and 2.450 GHz, (the same as your oven at home).
- Current equipment can produce heat in tissues, raising the temperature from 37˚C up to 42˚C.
- The RF energy produced by diathermy units can also be reflected to other parts of the body by metal in the body such as bone pins, dental fillings, etc.

16.9 Exposure to RF

- If nothing else, the previous two slides should convince you that your equipment is capable of producing RF energy which can heat your tissue.
- The tissue of the eye seems to be the most susceptible to damage from heating from RF energy.
- Ham radio operators have a wide variety of frequencies to operate in.

16.9 Exposure to RF

- Anything you can do to cut down your exposure to RF energy is probably good advice.
- When operating with a handheld radio, do not hold it close to your head when transmitting.
- A speaker microphone or a headphone - boom microphone combination are good investments.
- Keep the antenna away from your body and away from others while transmitting.

16.9 Exposure to RF

- When working on or around any transmitting type antennas, ensure your transmitter is off, and the power supply is disabled.
- Antennas such as long-wires (for HF operation)may have a current node (high RF field strength). You could get burned.
- If you work with transmitters in the microwave frequencies, 900 MHz to 300 GHZ, stringent safety procedures must be in effect for obvious reasons - you can really be cooked!

16.9 Exposure to RF

- When working on antenna or the wave guides, (which are pipe-like transmission lines used for microwaves) be sure you are not in the path of the RF energy.

16.9 Exposure to RF

- The gain of a directional beam type antenna can increase the effective output of your radio transmitter by increasing the **Effective Radiated Power** (ERP).
- ERP is calculated by multiplying the transmitter output by the db gain of the antenna, ie 5w X 9db gain = 45 W ERP

16.9 Exposure to RF

- The gain of an antenna, especially at VHF and UHF frequencies, can increase the **power density** in the preferred direction substantially over the rated transmitter output power.
- **power density (S):**Power per unit area normal to the direction of propagation, typically expressed in units of watts per square meter (W/m2) or microwatts per square centimeter (?W/cm2).

16.9 Exposure to RF (Safety Code 6)

- Safety Code 6 sets safe exposure limits for individuals working on sources of radio frequency fields (8 hours a day)
- This is considered as a **controlled environment.**
- The limit for these people was set by dividing the threshold amount of exposure by 10.

16.9 Exposure to RF (Safety Code 6)

- For people who are not working in this environment (the general public) the threshold amount was divided by 50.
- This is considered as an **uncontrolled environment.**
- The limits were established from the results of experiments on biological organisms.
- These experiments identified the lowest level of exposure (called a threshold) that could produce potentially harmful effects.

16.9 Exposure to RF (Safety Code 6)

The regulations and guidelines covering the subject of RF Safety are published by **Health Canada**, in a document we call **"Safety Code 6“ (Updated in 2009)**

- **The document describes the limits of human exposure to radiofrequency electromagnetic fields in the Frequency Range from 3 KHz to 300 GHz**
- Amateur radio stations are technically required to comply
- All but our most-high-powered transmissions do comply in most well-designed stations
- Some very high-powered transmissions require extra care and attention to antenna placement and protection

16.9 Exposure to RF (Safety Code 6)

- The code is referenced in the Canada Labour Code.
- Industry Canada requires operators of radio communication and broadcast facilities to follow Safety Code 6.
- Canadian provinces and territories have generally adopted the Safety Code 6 exposure recommendations.

16.9 Exposure to RF (Safety Code 6)

- Through its procedures, Industry Canada requires that all operators of radio and television broadcast stations, cellular, land mobile, amateur radio and other radio frequency emitters, ensure that the radio frequency fields produced by their installations do not exceed the maximum levels contained in Health Canada's Safety Code 6.

16.9 Exposure to RF (Safety Code 6)

- Health Canada recently measured the level of radio frequency field exposure around a number of cellular transmitting facilities. They found that the levels are well below the limits specified in Safety Code 6.

16.10 Soldering

- Be careful while soldering.
- A 150 W iron, necessary to solder PL-259 connectors, can get pretty hot and stay hot for quite a while after it is unplugged.
- Use a rest for the iron when you put it down.
- A hot iron on the wrong surface can start a fire.
- Molten solder on your skin is not a great thrill

16.10 Soldering

Soldering involves high heat and the potential of burns and fire in the shack

Fumes from solder expose one to lead and the aldehydes contained in flux vapours

Cleaning agents, lubricants and other chemicals present a hazard too

Compulsive behaviour causing one to ignore family and other responsibilities!! Remember, it is a hobby!

16.10 Soldering

- Do not solder while wearing your pajamas!
- The iron will retain heat for quite a while
- Hot solder burns and will stick to your skin
- Use a proper holder when putting down the iron
- Never solder around small children….Hot solder may be called something other than solder if it burns you.

16.11 The Last Word!

- USE COMMON SENSE!
- THINK SAFETY!
- WORK SAFELY!
- GET FIRST AID TRAINING QUALIFICATIONS!
- IF YOU ARE NOT SURE...ASK!