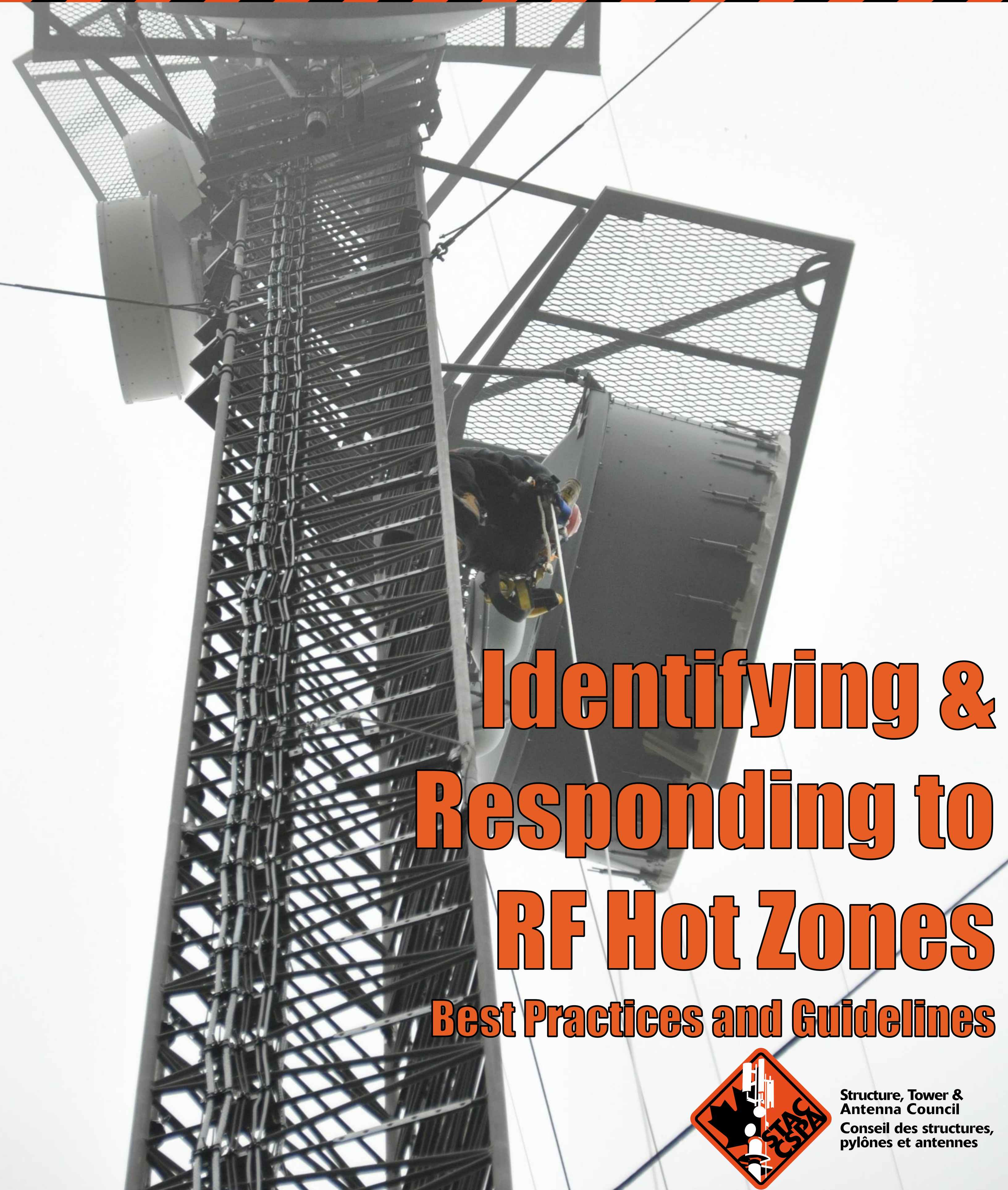

Identifying & Responding to RF Hot Zones

Best Practices and Guidelines

STAC CSPA

Structure, Tower & Antenna Council
Conseil des structures, pylônes et antennes

Structure, Tower & Antenna Council
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The Structure, Tower and Antenna Council (STAC) helps ensure communications antennas in Canada continue to be constructed with the highest regard to worker safety.

STAC is a non-profit Council of the Canadian Wireless Telecommunications Association, representing and providing a collaborative forum for Canadian wireless communications carriers, tower owners/operators, tower and rooftop equipment engineering service suppliers, and wireless communication facilities construction and maintenance contractors.

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Identifying & Responding to RF Hot Zones
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Index

1. Introduction

1.1. Purpose and Scope

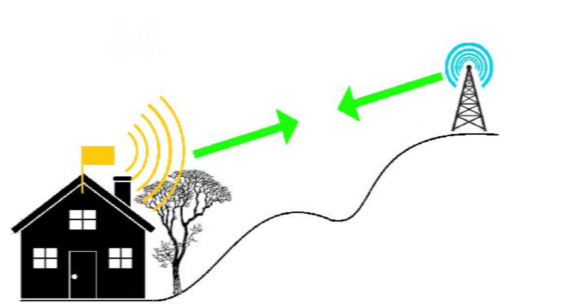
The technology that drives wireless communications relies on **radiofrequency** – or “RF” – emissions. The health of all Canadians is protected by the exposure limits of Health Canada’s Safety Code 6. Through this policy Health Canada has established, and continues to maintain, general exposure limits that ensure a wide safety margin for Canadians with regard to RF emissions from wireless network equipment and handsets.

As they maintain the infrastructure which supports our wireless networks, communications and tower workers may be exposed to RF on a near daily basis. While the towers and antenna sites must all operate within the wide safety margins mandated by Health Canada, it is still important for workers to know and understand how to identify potential safety hazards. Members of the STAC RF Awareness Committee have created this document to serve as a resource for those who work around radiofrequency-emitting equipment in order to help those workers protect themselves, their colleagues and the general public.

This document is intended for use by workers in the Canadian communications or tower industries who work around RF antennas in the 3 kHz to 300 GHz range.

This document uses the expertise and observations of experienced workers to help define industry best practices for identifying **transmission antennas** and other common RF equipment, and for determining whether such equipment or equipment installations pose a potential safety hazard.

There may be additional situations where RF energy may be present or additional types of RF emitting equipment that exist in the Canadian market and which are not covered in this document. Workers who cannot find information in this document about a specific installation or situation are encouraged to contact the project site owner for site-specific RF safety information.



The image above depicts a wireless signal from a home communicating with a nearby tower.

This document is designed to augment RF safety documentation currently available for the Canadian market by providing a quick-reference resource to supplement conventional RF Awareness training. It does not, however, replace conventional RF Awareness training. STAC members are encouraged to consult established authorized sources to ensure complete RF Awareness training.

1.2. Related STAC Documents

Related RF Awareness resources created by the STAC RF Awareness Committee include:

- STAC Personal RF Monitor Best Practices (General Guidelines)

2. Introduction to RF

2.1. What is RF?

RF energy is one form of **electromagnetic energy** that is a component of the **electromagnetic spectrum,** covering microwaves, visible light and X-rays, as well as many other types of energy emissions. RF energy, sometimes called "RF emissions," "RF waves" or "RF fields," is generated when a source current, such as a transmitter, is fed to an antenna. This current excites electrons within the antenna and the energy moves outward in the form of an electromagnetic wave.

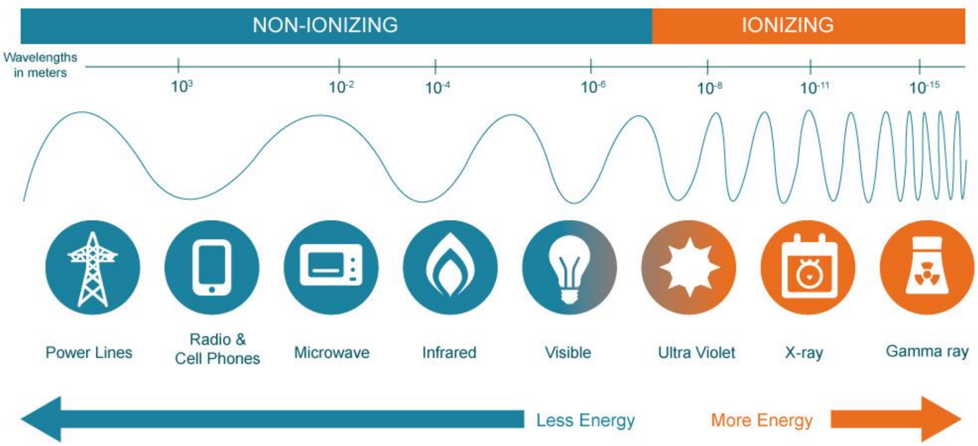
RF energy has electric and magnetic components. Its strength can be described by each component. The units "**volts per metre**" (V/m) and "**amperes per metre**" (A/m) are used to express the "electric" and "magnetic" field strength components respectively. Another common way to describe the RF energy strength is by power density or the power per unit area, e.g. "**watts per square metre**" (W/m^2).[1]

2.2. Biological Effects

All electromagnetic waves, including radiofrequencies, are classified according to their frequency and potential impact on the human body as either “ionizing” or “non-ionizing.”

At frequencies that exceed 300 GHz, the photon energy levels of electromagnetic waves are high enough to cause changes to the chemical bonds of atoms. This causes the atom to be charged or “ionized,” and these types of emissions are called “**ionizing**” waves. These types of waves are typically associated with x-rays and gamma rays.

Conversely, photons carried by lower range frequencies – such as cellular radiofrequencies and microwave – carry considerably less energy and do not cause chemical bond changes to atoms. These frequencies, including all frequencies used for the wireless and broadcast industries, produce what are called “**non-ionizing**” waves.



The chart above shows examples of the ionizing and non-ionizing ranges based on frequency.

[1] Definition sources from Industry Canada: http://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/sf08792.html#s1

Related biological effects for potential over-exposure of each type of wave are as follows:

Non-Ionizing (RF, microwave)

- Heating of body surface and tissue
- Raised body temperature
- Accumulation of charge on the body surface
- Disturbance of nerve & muscle responses
- Blurred vision
- Vertigo
- Nausea

Ionizing (x-rays, gamma rays)

- Radiation sickness
- Genetic mutation (cancer)
- Genetic damage and organ failure
    - Skin redness
    - Hair loss
    - Radiation burns
    - Acute radiation syndrome

2.3. Safety Code 6

RF emissions are regulated in Canada under Health Canada's **Safety Code 6**, which establishes safe human exposure level limits and ensures a wide safety margin for RF emissions between 3 kHz and 300 GHz.

Safety Code 6 identifies two sets of RF limitations. These are:

- **uncontrolled environment** limits, which establish safe RF exposure levels for areas and locations in which the individuals present do not have any control over the RF emissions or the length of time they are exposed to those emissions (ie: locations that are accessible to members of the public);
- **controlled environment** limits, which establish safe RF exposure levels for areas and locations in which the individuals present do have control over the RF emissions or the length of time they are exposed to those emissions (ie: restricted areas around communication towers).

Health Canada published the most recent update to Safety Code 6 in 2015, establishing lower limits for emissions in certain frequencies.

3. Working With RF

3.1. Exposure Levels

Though the design and management of all antenna sites ensures exposure is well within the Safety Code 6 limits, the work environment in close proximity to some antennas may mandate extra precautions.

For the purposes of this document, an RF "**hot zone**" is defined as any area that is subject to RF emissions exceeding the designated Safety Code 6 controlled limits relating to the specific frequencies on which antennas are emitting at that location. As a result, it is necessary to determine both the **transmission frequencies** in use and the approximate **transmission power** on each of those frequencies in order to determine whether a specific location is exposed to hot levels of RF emissions. Notably, the presence of either a single high-powered antenna or multiple lower-powered antennas can equally cause a site to exceed Safety Code 6 limits.

The above image features a co-located site with multiple tenants. On site like this, workers must consider all operating antennas to effectively calculate RF exposure levels.

For example, when Safety Code 6 states that 18.82 W/m^2 is the safe, maximum power density at the 850 MHz frequency for a duration of up to six minutes, then any location that is exposed to more powerful emissions on that frequency for six minutes or longer would be considered "hot." Similarly, any equipment that is emitting signals at a power exceeding the Safety Code 6 limits for the specific frequency on which they are transmitting would also be considered "hot" for the purposes of this document.

Finally, it is important to note that active transmissions on different frequencies must all be considered when determining whether a location is hot. Many sites have multiple antenna arrays that simultaneously emit RF energy at a variety of different frequencies and power outputs. While there are various methods to measure exposure levels, the cumulative values are most easily calculated when using power density (W/m^2) when working with several frequency ranges.

When calculating power density for the purposes of Safety Code 6 the percentages of each maximum value are added and must combine to be lower than 100% to be considered safe. For example, an area that is exposed to emissions representing 50% of the Safety Code 6 limit at 850 MHz as well as 60% of the limit at 2000 MHz would be considered to be exposed to 110% of maximum emissions and would be considered a hot location.

3.2. Precautionary Approach

It is important that individuals and crews working around RF emitting equipment adopt a precautionary approach to RF emissions to help ensure their safety. This means that workers should always assume that RF-related hazards are present on a job site until confirmed otherwise.

Some steps that workers can take as part of a precautionary approach are outlined in the following section of this document. These actions also represent important steps that workers should take to confirm that RF-related hazards have been properly mitigated before beginning work on a site.

3.3. Standard Job Site Precautions

As is the case with other known hazards, it is important that workers take proactive steps to protect themselves from RF hot zones, starting even before they enter a job site. The following is a brief description of preventative steps that workers can take to protect themselves and their colleagues:

3.3.1. Ensure that you and your crew have the required RF training: All workers who work on or near potentially active towers or antennas should have training on the information in Safety Code 6 (2015). In some cases, site-specific RF training may also be necessary; such as antenna identification, RF survey reviews and **lockout/tagout** procedures. Always be sure to have at least one member of your team contact the client or site-owner to determine if the site you are working on has site-specific RF training requirements.

STAC Recommended Precautions:

- Ensure that you and your crew have the required RF training;
- Look for existing signage;
- Request information from the site-owner, if available;
- Complete and RF assessment form;
- Complete a visually inventory of antennas on site;
- Check on lockout/tagout procedures/indicators;
- Identify other nearby antennas;
- Test RF emissions at ground level using approved and calibrated RF monitor(s).

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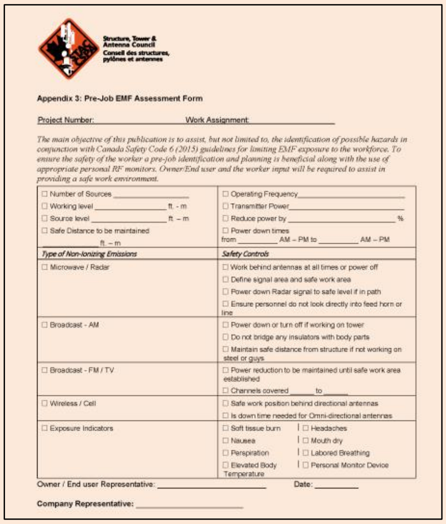
3.3.2. *Look for existing signage:* Workers approaching or accessing job sites with RF emitting equipment should look for existing RF signage posted by the site owner, which can provide an indication of expected RF levels on the site. See sections 5.5 and 6.3 of this document for more information about RF signage.

3.3.3. *Request information from the site-owner, if available*: In addition to information contained within a site's RF signage, site-owners increasingly have access to more detailed information about the RF transmissions on or around their site, and may have this information available upon request. Data you may consider requesting, when available, includes:

- An inventory of active antennas on the site, including the frequencies they use and their typical and maximum **effective radiated power**;
- A survey of the site's radiation patterns that maps out specific locations on the site that may be exposed to RF emissions exceeding the Safety Code 6 controlled limits; and
- An inventory of other potential RF hazards on the site, if applicable.

3.3.4. *Complete an RF assessment form*: RF assessment forms are designed to ensure that all sources of potential RF-related safety hazards are taken into consideration on a job site. More specifically, these forms are designed to aid workers in thinking about the potential hazards they could encounter during any given job, and to document that those hazards have been taken into consideration when planning work activities. As such, comments in this form may also be included or incorporated into a job-hazard assessment form.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Appendix 3: Pre-Job EMF Assessment Form

Project Number: ______ Work Assignment: ______

The main objective of this publication is to assist, but not limited to, the identification of possible hazards in conjunction with Canada Safety Code 6 (2015) guidelines for limiting EMF exposure to the workforce. To ensure the safety of the worker a pre-job identification and planning is beneficial along with the use of appropriate personal RF monitors. Owner/End user and the worker input will be required to assist in providing a safe work environment.

☐ Number of Sources ______ ☐ Working level ______ ft. - m ☐ Source level ______ ft. – m ☐ Safe Distance to be maintained ______ ft. – m	☐ Operating Frequency ______ ☐ Transmitter Power ______ ☐ Reduce power by ______ % ☐ Power down times from ______ AM – PM to ______ AM – PM
Type of Non-Ionizing Emissions	*Safety Controls*
☐ Microwave / Radar	☐ Work behind antennas at all times or power off ☐ Define signal area and safe work area ☐ Power down Radar signal to safe level if in path ☐ Ensure personnel do not look directly into feed horn or line
☐ Broadcast - AM	☐ Power down or turn off if working on tower ☐ Do not bridge any insulators with body parts ☐ Maintain safe distance from structure if not working on steel or guys
☐ Broadcast - FM / TV	☐ Power reduction to be maintained until safe work area established ☐ Channels covered ______ to ______
☐ Wireless / Cell	☐ Safe work position behind directional antennas ☐ Is down time needed for Omni-directional antennas
☐ Exposure Indicators	☐ Soft tissue burn ☐ Headaches ☐ Nausea ☐ Mouth dry ☐ Perspiration ☐ Labored Breathing ☐ Elevated Body Temperature ☐ Personal Monitor Device

Owner / End user Representative: ______ Date: ______

Company Representative: ______

This image depicts a sample RF or "EMF" assessment form. This form can be found in Appendix 2 to this document.

Whenever possible, workers should begin completing an RF assessment form for each job prior to arriving at the job site to address any hazards that may be encountered at the time of arrival and to ensure that all proper PPE and barriers have been considered in the safety plan. This requires gaining access to information provided by the site owner, as discussed in section 3.3.3 above. However, RF assessment forms cannot be finalized until after workers have arrived on the job site and confirmed that all RF hazards have been accounted for appropriately.

Please see Appendix 2 to this document for a sample RF assessment form.

3.3.5. *Complete a visual inventory of antennas on site:* In addition to noting all relevant signage at a work site, workers should pay specific attention to the antennas in or facing the zone(s) where they will be spending time. It is important to assume that all antennas are live and transmitting until it can be confirmed they are not (e.g. via logout/tag out procedures described in section 3.3.6).

When arriving at any job site where broadcast equipment exists, particular care is advisable, including potentially taking a visual inventory of all RF-emitting equipment at the site. If there is any transmitting broadcast equipment that is different from the associated RF assessment form, the worker should note the discrepancy and follow their company procedures for updating/correcting available information as appropriate.

3.3.6. Check on lockout/tagout procedures/indicators: Lockout/tagout procedures are used to indicate and communicate that specific antennas (and other potentially hazardous equipment) are shut down temporarily. Under these procedures, an individual who shuts down an antenna is tasked with tagging the power control system to indicate that the antenna has been powered down. These tags should include a standardized label that includes the following information:

- Why the lockout/tagout is required (repair, maintenance, etc.).
- Time/date of application of the lock/tag.
- The name of the authorized person who attached the tag and lock to the system.

Note: Only the authorized individual who placed the lock and tag onto the system is the one who is permitted to remove them. This procedure helps ensure that the system cannot be started up without the authorized individual's knowledge.

Importantly, workers should always assume that all antennas are active. Until they have confirmed the status of any specific antenna, it should be locked-out and tagged.

Where physical lockout/tagout procedures are not feasible or achievable, an alternative safety plan must be put into place to ensure the hazard is controlled.

3.3.7. Identify other nearby antennas: Workers must take into consideration the possibility that antennas on nearby sites will have sufficient power output to exceed Safety Code 6 exposure limits and include those antennas in their RF hazard assessment using appropriate mitigation strategies, as necessary.

If a hazard is identified on a neighbouring site, it is important to contact the tower owner to initiate proper lockout/tagout procedures or employ other accepted countermeasures.

It is important to assume that all antennas on neighbouring sites are transmitting until it can be confirmed that they are not.

3.3.8. Test RF emissions at ground level using approved and calibrated RF monitor(s): Just prior to entering a site, crews should activate their RF monitor(s) to determine the approximate RF emissions at ground level. If the RF monitor(s) indicate unexpectedly high levels of emissions, contact the site owner immediately and work to determine the cause of those emissions. See section 4.1 of this document for more information about the use of personal RF monitors.

4. Protective Measures

4.1. Personal RF Monitors

Personal RF monitors are an important tool in the communications industry, as they give workers an approximate value of RF strength in a given location and provide an alarm when those values potentially exceed Safety Code 6 limits.

Crews should always ensure that they have at least one working and properly calibrated personal RF monitor before entering a job site, as indicated in section 3.3.7 above. Workers should also verify that the personal RF monitors they intend to use are verified to cover all of the frequency ranges at which emissions may be present during each job, and that these monitors are calibrated to the Safety Code 6 limits established in 2015.

While it is not specifically necessary that each individual worker have their own personal monitor, consideration should be given as to whether separate monitors are to be provided to workers or teams of workers who may be exposed to significantly different emissions levels, possibly including those who are working on different parts of a tower/site, or at different heights.

Personal RF monitors should be turned on and operated according to their specific manufacturer instructions at all times while on a work site where there could be RF emissions exceeding Safety Code 6 limits.

For more information about personal RF monitors and their operations, please consult the *STAC – Personal RF Monitor Best Practices (General Guidelines)* document.

4.2. Additional or Alternative Protective Measures

In addition to RF monitors, some companies or individuals also recommend use of some or all of the following additional or alternative protective measures under certain circumstances. Please note that these additional/alternative measures should always be used in conjunction with a personal RF monitor.

<u>**Safety Code 6 (2015) and Personal RF Monitors**</u>

Manufacturers of the following personal RF monitors have agreed to provide a certificate with each Canadian purchase attesting that the monitor is calibrated to Safety Code 6 (2015) limits.

FieldSENSE 2.0

MVG EME Guard XS – SC6

EME Guard XS 40 GHz – SC6

Nardalert S3

WaveMon Broadband-8-SC6

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4.2.1. RF Survey

One way to develop an understanding of the RF emissions a worker could be exposed to on any given work site is to complete an **RF survey**, which provides a measured or calculated snapshot of the RF levels experienced at different locations on a site. This information can then be used to verify which areas on a site are safe work locations in accordance with Safety Code 6, including the specific heights on a tower at which it is safe or unsafe to work. This raw data can also be used to create an “RF survey map” – which indicates locations that are determined to be RF hot zones – or to create power-reduction scenarios that would allow for safe work inside those hot zones. Importantly, while a survey only determines RF levels present at the time the survey is conducted, those levels are generally expected to remain relatively constant unless affected by the installation, removal or malfunction of nearby antennas.

Calculated RF surveys are used to estimate RF emissions in a location based on an examination of nearby antenna systems, power levels and configurations. Using the reported or known outputs of those nearby antennas, an RF engineer can determine the combined theoretical RF emissions that affect any given location within reach of those antennas’ signals.

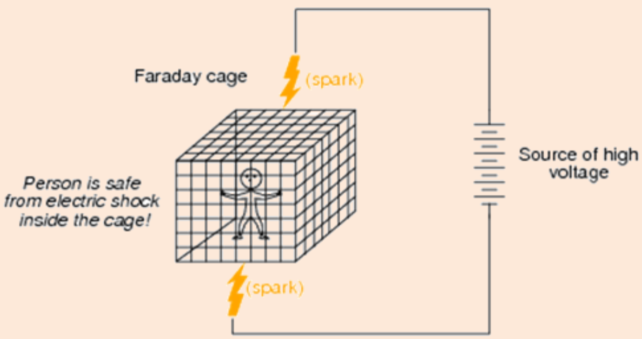
However, because calculated RF surveys and maps are only capable of determining theoretical RF emissions, one cannot assume that they are completely accurate. As such, workers must still use personal RF monitor(s) even when working at locations that have been deemed as safe through a calculated RF survey.

Though more accurate than calculated surveys, measured RF surveys are often seen as cost-prohibitive and are typically only used in rare circumstances, such as when there is a known issue with a site that can interfere with RF-emitting equipment. Measured RF surveys are completed using specialized equipment, and must always be completed by specially trained RF surveying experts. Personal RF monitors cannot be used to produce an accurate RF survey.

Both calculated and measured RF surveys are typically only conducted on sites that are likely to surpass Safety Code 6 limits to begin with, such as broadcast sites. Please note that calculated RF surveys are not capable of accurately estimating RF emissions in the “near-field” locations close to antennas. Please see Appendix 1 of this document for resources with information about **near-field** and **far-field** emissions.

4.2.2. RF Suits

One way to protect individual workers from excessive RF emissions is through the use of an **RF suit**, which includes multiple articles of specially designed clothing that reduce the effects of RF emissions, including coveralls, gloves, socks and a full-head mask. By cloaking an individual in head-to-toe coverage of RF-resistant material, RF suits are intended to create a “**Faraday cage**” around the individual and significantly reduce their exposure to RF emissions.



The above image depicts a Faraday cage, which provides the concept for an RF Suit.

While RF suits are capable of greatly reducing a user’s exposure to RF emissions, there are a number of important factors to consider regarding their use, particularly since they are most typically used in RF hot zones. Some of these factors, and related precautions, include:

- Reduced visibility due to the need for an RF mask, which can reduce a user's ability to work safely or identify other potential safety hazards;
- Extreme temperatures can exist inside an RF suit because they create an enclosed thermal environment that does not allow body heat to escape easily, potentially causing a worker to overheat;
- Minor rips or tears can create gaps in an RF suit's coverage, resulting in reduced protection and an increased likelihood of burn-related injuries. For this reason, each component of an RF suit must be inspected very carefully prior to each use. Caution should also be taken when wearing or transporting an RF suit near sharp objects that can cause rips or tears;
- Gloves and socks used as part of an RF suit must provide uninterrupted coverage without any gaps as any exposed skin is likely to result in burn-related injuries to the user;
- Some RF suits cannot be cleaned without risk of degrading the effectiveness of the suit. Always consult the suit manufacturer before attempting to clean an RF suit;
- RF suits do not provide effective protection against burns caused by direct contact with electrical currents – "contact current burns" – such as those that can be experienced on high-powered AM radio sites in particular;
- RF suits do not reduce the RF emission exposure of external PPE, such as fall protection equipment, so it is important to ensure that users select equipment that is approved for use in high RF environments as per the equipment manufacturers' instructions. At the time of publishing this document, there has been no comprehensive study on the effects high-RF environments have on fall protection equipment. As such, it may be advisable to contact the fall protection equipment manufacturer to discuss the suitability of their equipment in such environments.

The image above depicts an example of an RF suit.

It should be noted that as with all PPE, the integrity of any RF suit should be closely monitored for damage. At this time, there is no known and reliable method to measure RF exposure inside an RF protective suit as there is no known personal RF monitor designed to the current Canadian limits advertised to be used in conjunction with RF suits. If using an RF monitor in conjunction with an RF protective suit, it must used as per the manufacturer's recommendations.

4.2.3. Other PPE

Other types of PPE that can be used to protect workers from burns or injuries on high-RF sites include electrically rated gloves and voltage testers.

Electrically rated gloves should be used whenever a tower is suspected of carrying a voltage, and can be used to either confirm or deny whether that voltage exists. Because safety climb cables and other tower components can carry an **induced current** on high-powered sites and AM broadcast sites, it is possible for

The image above depicts an example of electrically rated gloves.

those components to conduct/re-transmit RF energy and create a burn hazard. While electrically rated gloves can help protect workers against these types of burn hazards, it is important to ensure that the specific gloves chosen are capable of protecting users against the suspected voltage to which they could be be exposed.

For more information about electrically rated gloves, please consult Grainger.com at https://www.grainger.com/content/qt-electrical-safety-gloves-inspection-262.

Much like electrically rated gloves, **voltage testers** can be used to protect workers from induced current burns on high-RF sites. A voltage tester, or "digital volt meter" can be used to determine whether a cable is carrying an induced current or to test the current on a guy wire. If an induced current is detected, workers may be able to apply a ground to the line to "bleed off" the induced current, allowing safe contact with the wire or cable. If working with an AM detuning ring, refer to site-specific safety instructions for this procedure.

Notably, voltage testers should only be used in conjunction with electrically rated gloves.

5. Identifying Hot Zones

5.1. Identifying RF Emitting Equipment

This section contains information about the various types of RF emitting equipment that tower and communications workers may find during the course of their work. Because different types of equipment create different types of hazards, it is highly recommended that workers familiarize themselves with each type of antenna identified below. Ideally, each RF worker should receive orientation that includes recognition of various antenna types during their RF training.

Notably, most of the antennas listed below are designed to operate within acceptable RF limits except for FM broadcast, broadcast panels and VOR antennas. Workers should always assume that antennas are turned on and that they are attached to a transmitter, unless confirmed that they are powered down or are receive-only antennas.

5.1.1. Omni Directional

- Typical Use(s): Radio communication (various types)
- Precautionary Approach: From all directions
- Antenna Pattern: Omni-directional
- Frequency Ranges: 170-1100 MHz
- Notes: Can include electrical down-tilting/up-tilting

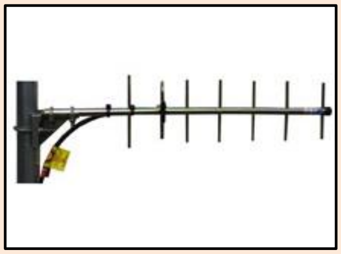
5.1.2. Microwave Dishes-Flat panel antennas

- Typical Use(s): Point-to-point communications, cellular applications (some flat panels)
- Precautionary Approach: From in front of antenna
- Antenna Pattern: Directional (from front)
- Frequency Ranges: 300 MHz – 300 GHz

5.1.3. FM broadcast

- Typical Use(s): FM Broadcast
- Precautionary Approach: From all directions
- Antenna Pattern: Omni-directional
- Frequency Ranges: 30 – 300 MHz
- Notes: Potential for high-power emissions

5.1.4. Directional Yagis



- Typical Use(s): SCADA, cellular
- Precautionary Approach: From the front *(small collector indicates front of antenna)*
- Antenna Pattern: Directional (in direction of main arm)
- Frequency Ranges: 3 MHz – 3 GHz

5.1.5. PCS Directional

- Typical Use(s): Cellular
- Precautionary Approach: From the front and sides
- Antenna Pattern: Directional
- Frequency Ranges: 710 MHz – 3 GHz
- Notes: Often has electrical beam shaping for reflector and tilt settings

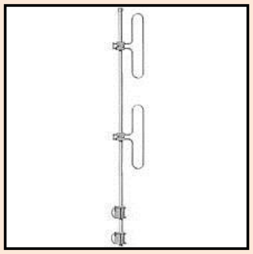
5.1.6. Fixed Reflector Directional

- Typical Use(s): Cellular
- Precautionary Approach: From the front
- Antenna Pattern: Directional (from the front)
- Frequency Ranges: 300 MHz – 3 GHz

5.1.7. Enclosed Dipoles

- Typical Use(s): Cellular
- Precautionary Approach: From the front or side depending on reflector setting
- Antenna Pattern: Directional
- Frequency Ranges: 746-960 MHz

5.1.8. Exposed Dipoles



- Typical Use(s): UHF, VHF, Ham radio
- Precautionary Approach: From all directions
- Antenna Pattern: Directional, bidirectional or omnidirectional
- Frequency Ranges: 27-512 MHz

5.1.9. Broadcast panels

- Typical Use(s): TV broadcast
- Precautionary Approach: From in front
- Antenna Pattern: Directional
- Frequency Ranges: 470-860 MHz
- Notes: Potential for high-power emissions

5.1.10. Ground plane

- Typical Use(s): Ham radio
- Precautionary Approach: From all directions
- Antenna Pattern: Omni-directional
- Frequency Ranges: 144 MHz, 440 MHz

5.1.11. Ham radio

- Typical Use(s): Ham radio
- Precautionary Approach: From all directions
- Antenna Pattern: Model dependent
- Frequency Ranges: 500 kHz – 30 MHz (short wave) and 1 MHz – 64 GHz
- Notes: Various designs; may not resemble photo

5.1.12. Doppler

- Typical Use(s): Aviation, meteorology
- Precautionary Approach: From all angles
- Antenna Pattern: Omnidirectional or fixed array
- Frequency Ranges: 1-2 GHz
- Notes: Sites can be hidden, potential for high-power emissions

5.1.13. VOR (VHF Omnidirectional Radio Range)

- Typical Use(s): Aircraft navigation
- Precautionary Approach: From all directions
- Antenna Pattern: Omnidirectional
- Frequency Ranges: 108-118 MHz
- Notes: Potential for high-power emissions

5.1.14. Military shortwave

- Typical Use(s): Radio communications
- Precautionary Approach: From all directions
- Antenna Pattern: Omnidirectional
- Frequency Ranges: 1.6-30 MHz
- Notes: Typically only located on military sites, potential for high-power emissions

5.1.15. Stealth Antennas

- Typical Use(s): Cellular
- Precautionary Approach: From all directions
- Antenna Pattern: Directional or omnidirectional
- Frequency Ranges: 710 MHz – 3 GHz
- Notes: Site can be hidden

5.2. Identifying Damage to Equipment

Damaged antennas and other RF emitting equipment can pose a unique hazard to communications workers if that equipment is no longer capable of operating as intended. In particular, certain types of damage can cause RF emitting equipment to “leak” emissions causing unexpected alarms raised by a personal RF monitor.

Workers should specifically consider whether the following types of damage are visually evident on any RF emitting equipment, both during their pre-climb inspections and while climbing the tower and completing work.

5.2.1. Corrosion: Corroding or corroded RF equipment or equipment-connectors can result in **RF leaks** occurring at the corroded area(s). This is most likely to occur in coastal areas where the risk of corrosion is heightened by the presence of salt water, but can also occur in non-coastal areas.

Use a personal RF monitor to determine if corroded equipment has resulted in an RF leak by holding the active monitor directly in front of the corroded portion of the equipment. Measured RF emissions that exceed expectations could be indicative of a leak.

5.2.2. Improper Termination: Improperly terminated equipment or connections can also result in RF leaks. This issue is most frequently seen on microwave installations – which can leak at the horn or waveguide as a result of missing bolts or an improperly sealed gasket – though loose connections can cause leakage on any type of installation. A loss of pressure on a pressurized microwave system can be indicative of a missing or weak seal on a microwave connector, or the connections have been over-torqued or under-torqued. Broadcast antennas and their transmission lines, in particular, have many bolted connections where leaks can occur. These systems typically operate at a very high-power level, making any leak more hazardous.

5.2.3. Improperly Assembled: Improperly assembled antenna equipment can also result in an RF leak, particularly if bolts are missing around the antenna shroud, or if there are any gaps between any of the bolts and the shroud. While this problem is more typical to larger microwave antennas that are assembled in the field, it is best to inspect all new and existing antennas for improper assembly before assuming they are safe.

5.2.4. Other Damage to Equipment*:* Much like improperly installed equipment, damaged RF equipment can also cause RF leaks, depending on the nature of the damage. Damage caused by falling ice or vandalism – including from bullets fired at tower lighting systems – are the most common causes of damage to equipment that causes RF leaks, and can affect antennas, connectors, shrouds, jumper lines, waveguide lines or any other component of an RF system.

Common Types of Equipment Damage to Watch Out For

- Corrosion
- Improper termination
- Improper assembly
- Damage from falling ice
- Damage from vandalism
- Other RF leaks

5.3. Installing New Equipment

One of a worker's primary concerns when installing new antennas or other RF emitting equipment is to ensure that they are not inadvertently creating new hazards for other workers or the general public. This includes RF-related hazards, as well as burn hazards and working-at-heights hazards. Some general tips to avoid these hazards when installing new equipment include:

- Ensure that all RF equipment being installed is assembled correctly and is in working condition;
- Ensure that antennas are installed at a safe elevation where they won't be pointing at anyone directly (typically at least 3 metres above the highest point at which someone might be standing);
- Ensure that installed antennas are not pointing at a location that could create a hazard, such as an access door;
- When working close to AM sites, ensure that all metal components (such as shelters, fences and towers) are grounded at the time of their installation to avoid induced-current burns;

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- In some cases, high RF zones can interfere with the advanced electronics of material handling devices (such as cranes, forklifts, helicopters and other lifting devices). It is best to consult the handling equipment manufacturer's instructions or an engineered procedure to ensure proper safe operation of this equipment;
- Ensure all AM detuning rings are installed as per a qualified engineer's specific instructions to avoid induced-current burns;
- Contact the qualified engineer responsible for the job immediately if it appears that any part of the installation cannot be completed as per the work order instructions;
- Speak up if you see something that doesn't appear safe.

5.4. Working on Existing Installations

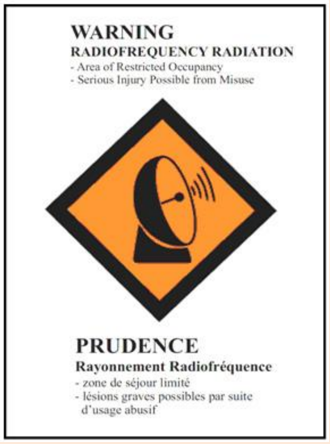
When working on existing installations, workers must take caution to protect themselves and those around them against potential RF hot zones. This includes taking precautions against corroded, improperly assembled or other damaged equipment, as indicated in section 5.2 of this document. Additional tips to avoid potential hazards include:

- Ensure your personal RF monitor is calibrated and operating correctly before attending a job site, and ensure the monitor is turned on prior to entering the site. When working on a rooftop, personal RF monitor(s) should be activated before opening the door to the rooftop;
- Familiarize yourself with the types of antennas on the job site, including any satellite uplinks;
- Be aware that some high-powered antennas may need to be temporarily powered down before crews can access a site safely. Any such antennas should be identified during pre-job planning, and steps should be taken to coordinate with the antennas' operators to reduce or disable power to the antennas during the work period;
- Ensure that all RF-emitting devices on the site are powered-off at all times when completing work that involves adding, removing or modifying electrical grounding systems. This will reduce the risk of induced current burns or electrocution;
- When working on municipal poles, be aware that some poles may have **small cell** installations that include active RF antennas;
- Use extra caution when completing antenna work in a man lift, which typically includes positioning a worker directly in front of one or more antennas. Be sure to confirm whether the work can be performed safely while the antennas are active before doing so and always use a working and properly calibrated personal RF monitor.

The image above depicts a typical microwave installation with varying frequencies and transmission power settings in an environment where corrosion may be prevalent.

5.5. Exposure Warning Signage

The federal industry department requires that any site in Canada that is known to transmit emissions exceeding Safety Code 6 limits must have access control to deter members of the public from entering the site, as well as demarcation/warning signs to advise workers and members of the public that the site is an RF hazard. The department requires that any such sign meet the following requirements:



The image above depicts an example of an RF hazard warning sign

- signs must be at least 20 cm by 30 cm (approximately 8 inches by 12 inches) in size;
- signs must be written in both French and English;
- a sufficient number of signs must be installed on and/or around the affected areas;
- the height, size and locations of the signs must allow the signs to be visible and noticeable from any normal angle of approach to the affected areas irrespective of seasonal snow cover or vegetation obstructions; and
- metallic signs and posts are not recommended near AM broadcasting sites.

While the industry department recommends that these warning signs match the one depicted here, signs may differ from site to site.

6. Responding to Hot Zones

6.1. Post-Exposure Response (Time and Distance)

While the nature of communications and tower work requires that workers will occasionally be required to work within or travel through a worksite area that may exceed Safety Code 6 limits, it is typically possible to identify these occasions in advance and to implement appropriate plans to limit each workers' exposure. As highlighted elsewhere in this document, however, there is a small possibility that workers will unknowingly find themselves working in an area that surpasses these limits, and it is incumbent on all workers and crews to know how to respond if they ever do.

If workers are exposed to RF emissions exceeding Safety Code 6 limits, they may begin to feel some of the biological effects identified under non-ionizing emissions in section 2.2 of this document. Whether a worker will feel these effects will be largely determined by the level of emissions they are exposed to, and the duration of their exposure.

The first line of defence against most of these effects is to cool down the workers' body using two basic tools: time and distance. Because RF and microwave emissions are non-ionizing, workers who begin to feel the effects of RF exposure can quickly reverse these effects by removing themselves from the area where emissions exceed Safety Code 6 limits, and by remaining outside of the exposure area for a period of time. For this reason, workers should always be on the lookout for signs of RF exposure in themselves and their colleagues whenever they are working around RF emitting equipment.

Any worker who believes they are experiencing symptoms of overexposure should immediately remove themselves from the exposure area. Common industry practice suggests that the worker should be removed from the exposure area for *at least* the same amount of time as they were in that area. Workers who may have been overexposed to RF emissions should never return to an exposure area while still feeling the effects of any overexposure symptoms. Returning too early – such as before their body is completely cooled – may make workers more susceptible to experiencing symptoms again, only much more quickly than previously.

Other steps that workers should take after being exposed to RF emission levels that exceed Safety Code 6 limits include:

- Hydrate themselves;
- Move to a cool/shady environment;
- Remove any excessive PPE that may reduce the body's ability to shed heat;
- Watch for signs of heat stress or heat stroke;
- Treat localized RF burns in accordance with company safety management program or first aid procedures;
- Call emergency services if necessary. Remember: if in doubt, get it checked out.

Signs of Over-Exposure to Non-Ionizing Emissions

- Heating of body surface and tissue
- Raised body temperature
- Accumulation of charge on the body surface
- Disturbance of nerve and muscle responses
- Blurred vision
- Vertigo
- Nausea

Finally, it is worth noting that workers should always remove themselves from a high RF-exposure area first and then determine how best to address the hazard from a safe distance.

6.2. Reporting

Any time a worker discovers an area that exceeds the Safety Code 6 limits and is not marked or designated as such, they must immediately inform their foreman or site supervisor, who should relay this information to everyone else on site. Foremen/site supervisors should also ensure the site owner is made aware of the hazard, and should follow their specific company policy or job-site protocol to ensure that detailed information about the hazard is communicated to an appropriate representative of the site owner in a timely manner.

6.3. Flagging the Hazard

While responsibility for determining when and how to rectify unmarked/undesignated sites exceeding Safety Code 6 limits will ultimately lie with the site owner or antenna license holder, responsible tower crews should also take steps to ensure that RF hazards are properly identified, as doing so can help ensure that other workers visiting the site will not inadvertently expose themselves to those hazards.

Crews that discover any such hazards should use their personal RF monitor(s) to identify the suspected outer boundaries of the high-RF exposure area, ensuring that any area that may exceed Safety Code 6 limits is considered within the hazard area. Some industry professional recommend that red caution tape can also be used to mark off the hazard area, taking care to ensure the tape is easily visible from each possible access point.

7. Conclusion

Thanks to advancements in human understanding of radiofrequencies and RF hazard mitigation, working around RF transmitting equipment need not ever pose a risk to any worker, so long as crews follow proper precautions. Similarly, thanks to the non-ionizing nature of RF and microwave emissions, any worker who is inadvertently exposed to an RF hot zone should now be able to recognize the symptoms of over-exposure and identify a safe response.

8. Frequently Asked Questions

The following Frequently Asked Questions and the related answers were originally posted on the federal Industry Department's website, and have been copied verbatim as they appeared there in October, 2017. Only questions that directly relate to the information contained in this booklet have been included.

Review the entire list of Frequently Asked Questions here: http://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/sf08792.html#s5

Q. *What amount of radiofrequency (RF) exposure is considered safe?*

A. Exposure to RF energy at levels below the regulatory limits is considered to be safe. These limits are based on the lowest exposure level at which the potential harmful effects to humans could occur. Safety factors are then incorporated to arrive at recommended exposure levels for protection of the general public.

Q. *What is time averaging and how does it apply to exposure?*

A. Health Canada's guideline document and most other RF exposure standards specify "time-averaged" maximum exposure limits. The purpose is to "smooth out" the short-term highs and lows of the exposure intensity to arrive at an "average" with which to compare to the limit. The averaging time is the time period over which exposure is averaged. The averaging time should not be interpreted as the maximum allowable exposure time. As per Health Canada's guideline document, it is permissible to exceed the recommended exposure limits for short periods of time as long as the average exposure over the averaging time (0.1 hour or 6 minutes) does not exceed the limit.

Q. *What is the difference between a biological effect and a health effect?*

A. A biological effect occurs when a change can be measured in a biological system after an introduction of some type of stimulus (e.g. RF energy). The observation of a biological effect, in and of itself, does not necessarily suggest the existence of a health effect. A biological effect only becomes a health effect when it causes detectable impairment of health. According to the World Health Organization, health is "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity."

Q. *How were the radiofrequency (RF) exposure limits established?*

A. The limits specified in Health Canada's RF guideline document were established from the results of hundreds of studies over the past several decades where the effects of RF energy on biological organisms were examined. These limits are similar to other national and international standards that are based on established effects. All recognized standard-setting bodies use the same scientific data and a similar general approach to develop safety guidelines. Differences in interpreting the biological effects under certain exposure conditions sometimes result in small differences in the exposure limits. These small differences will not affect a person's health. Canada's exposure limits are among the most stringent guidelines that are based on established effects.

Q. *What is the precautionary principle and when should it be used?*

A. The precautionary principle is a public policy approach for risk management of possible, but unproven, adverse health effects. The extent of the precautionary principle ranges from monitoring scientific developments and providing information to stronger measures, such as lowering exposures. The increasing public concern over the RF health issue has led to demands for industry and regulatory authorities to apply the precautionary principle to the use of cell phones and the proposed construction of new broadcasting and radiocommunication installations.

The application of the precautionary principle should be proportional to the level of risk and its associated uncertainty, the severity of the outcome and the level of societal benefit. In the context of RF energy from broadcasting and radiocommunication installations and apparatus, health risks from exposure below the limits specified in Health Canada's guideline document have not been established. Therefore, if precautionary measures are introduced to reduce exposure levels, it is recommended that they be made voluntary.

Levels of public exposure to RF energy from radiocommunication installations are typically thousands of times below those specified in health-based exposure standards.

Q. *How does Industry Canada ensure that radiocommunication and broadcasting installations respect its regulatory limits for the protection of the public from radiofrequency (RF) energy?*

In rare cases where Industry Canada believes that regulatory limits for the protection of the general public might be exceeded, the Department will immediately approach the proponent or operator. If the operator wishes to continue transmitting, or if the proponent wishes to continue with the proposal, Industry Canada will work with them to ensure that the installation complies with the regulatory limits. Asking for RF field measurements to demonstrate compliance is one of several methods that Industry Canada may employ. Once the installation is built, the proponent will be required to take measurements to demonstrate compliance and to take immediate action to bring the installation into compliance with the regulatory limits should the measurement results show non-compliance.

Q. *I have a question about Health Canada's RF exposure guideline. Who should I contact?*

A. For more information on the guideline, contact:
Consumer and Clinical Radiation Protection Bureau
Health Canada
Email: CCRPB-PCRPCC@hc-sc.gc.ca

Appendix 1 – Resources

General Safety Code 6 Resources (Government Resources)

- Safety Code 6 (2015) - Limits of Human Exposure to Radiofrequency Electromagnetic Energy in the Frequency Range from 3 kHz to 300 GHz
- Technical Guide for Interpretation and Compliance Assessment of Health Canada's Radiofrequency Exposure Guidelines
- TN-261 — Safety Code 6 (SC6) Radio Frequency Exposure Compliance Evaluation Template (Uncontrolled Environment Exposure Limits)

STAC Documents*

- STAC – Personal RF Monitor Best Practices
- STAC – Radio Frequencies & Microwaves (Guidelines)

*Must be logged in to the STAC Members website to access these resources. Please contact info@stacouncil.ca to request access or to reset your login credentials.

Near-field vs. Far-field

- TN-261 — Safety Code 6 (SC6) Radio Frequency Exposure Compliance Evaluation Template (Uncontrolled Environment Exposure Limits): Annex A – General Antenna Theory
- What's The Difference Between EM Near Field And Far Field?

Personal Monitor Manufacturers/Distributors**

- Gap Wireless (distributor of Wavecontrol products)
- Interfax Systems (distributor of Narda products)
- fieldSENSE (distributor of fieldSENSE products)
- Microwave Vision Group (distributor of MVG products)

** Please review *STAC Personal RF Monitor Best Practices* for more information personal RF monitors that are compliant with Safety Code 6 (2015) limits according to manufacturer attestation and documentation. While each of the companies listed manufactures or distributes at least one personal RF monitor that is compliant with the current Canadian limits, not all monitors sold by these manufacturers/distributors are designed for use in Canada or are compliant with those limits.

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Appendix 2: Pre-Job EMF Assessment Form

Project Number: ______________________ Work Assignment:

The main objective of this publication is to assist, but not limited to, the identification of possible hazards in conjunction with Canada Safety Code 6 (2015) guidelines for limiting EMF exposure to the workforce. To ensure the safety of the worker a pre-job identification and planning is beneficial along with the use of appropriate personal RF monitors.

☐ Number of Sources ___________________ ☐ Working level __________________ ft. - m ☐ Source level ___________________ ft. – m ☐ Safe Distance to be maintained ______________ ft. – m	☐ Operating Frequency___________________________ ☐ Transmitter Power_____________________________ ☐ Reduce power by ___________________________ % ☐ Power down times from __________ AM – PM to __________ AM – PM
Type of Non-Ionizing Emissions	*Safety Controls*
☐ Microwave / Radar	☐ Work behind antennas at all times or power off ☐ Define signal area and safe work area ☐ Power down Radar signal to safe level if in path ☐ Ensure personnel do not look directly into feed horn or line
☐ Broadcast - AM	☐ Power down or turn off if working on tower ☐ Do not bridge any insulators with body parts ☐ Maintain safe distance from structure if not working on steel or guys
☐ Broadcast - FM / TV	☐ Power reduction to be maintained until safe work area established ☐ Channels covered ______ to ______
☐ Wireless / Cell	☐ Safe work position behind directional antennas ☐ Is down time needed for Omni-directional antennas
☐ Exposure Indicators	☐ Soft tissue burn | ☐ Headaches ☐ Nausea | ☐ Mouth dry ☐ Perspiration | ☐ Labored Breathing ☐ Elevated Body Temperature | ☐ Personal Monitor Device

Owner/End user and the worker input will be required to assist in providing a safe work environment.

Owner / End user Representative: ___________________________ Date: ___________

Company Representative: ________________________

Glossary

Amperes per metre (A/m)	A common unit of measurement to express the rate of flow of electrical current (A) over a unit of distance (m).
Controlled environment	Limits that establish safe RF exposure levels for areas and locations in which the individuals present do have control over the RF emissions or the length of time they are exposed to those emissions (ie: restricted areas around communication towers). This includes areas where the RF field intensities have been adequately characterized by means of measurement or calculation and exposure is incurred by persons who are: aware of the potential for RF field exposure, cognizant of the intensity of the RF fields in their environment, aware of the potential health risks associated with RF field exposure and able to control their risk using mitigation strategies.
Effective radiating power (ERP)	A unit of measurement to express the combination of the power emitted by the transmitter and the ability of the antenna to direct that power in a given direction. It is equal to the input power to the antenna multiplied by the gain of the antenna.
Electrically rated gloves	An Insulated rubber glove that protects the wearer from accidental electrical contact. Gloves are selected based on the intended voltage protection and the associated protective glove classification.
Electromagnetic spectrum	The range of frequencies (the spectrum) of electromagnetic radiation and their respective wavelengths and photon energies. This frequency range is divided into separate bands, and the electromagnetic waves within each frequency band are called by different names; beginning at the low frequency (long wavelength) end of the spectrum these are: radio waves, microwaves, infrared, visible light, ultraviolet, X-rays, and gamma rays at the high-frequency (short wavelength) end.
Faraday cage	An enclosure used to block electromagnetic fields by utilizing a continuous covering of conductive material or in the case of a Faraday cage, by a mesh of such materials.
Far-field	The space beyond an imaginary boundary around an antenna, where the angular field distribution begins to be essentially independent of the distance from the antenna. In this zone, the field has a predominantly plane-wave character.
Hot zone (already defined in Sec 3)	Any area that is subject to RF emissions exceeding the designated Safety Code 6 controlled limits relating to the specific frequencies on which antennas are emitting at that location.
Induced current	A moving or changing magnetic field will generate an electric current in a current loop, or a voltage traveling across the ends of a current loop. Essentially known as electromagnetic induction, the

	current or voltage produced is called an induced current or an induced voltage.
Ionizing	Emissions that carry enough energy to liberate electrons from atoms or molecules, thereby ionizing them. Ionizing emissions are made up of energetic subatomic particles, ions or atoms moving at high speeds (usually greater than 1% of the speed of light), and electromagnetic waves on the high-energy end of the electromagnetic spectrum.
Lockout/tagout	Lockout is the physical isolation of energy from a system through the use of locks to ensure the system remains in the intended safe mode. Locks must include information that identifies the owner of the lock. Tagout of a system involves attaching or using an information tag or indicator to explain why the lockout or tagout is required, time of application, and the name of the authorized person who attached the lock and/or tag. Tagout is often used when locks are not practical (e.g. de-energizing transmission lines).
Near-field	A volume of space close to an antenna or other radiating structure, in which the electric and magnetic fields do not have a substantially plane-wave character, but vary considerably from point to point at the same distance from the source.
Non-ionizing	Any type of electromagnetic radiation that does not carry enough energy to completely remove an electron from an atom or molecule.
Radiofrequency (RF)	A rate of oscillation in the range of about 3 kHz to 300 GHz, which corresponds to the frequency of radio waves typically used in radio communications.
RF leaks	The unintended release of RF energy, typically by means of a damaged, faulty or improperly installed cable, connector, antenna or transmitter.
RF suit	Protective clothing consisting of a full body suit with associated hood, gloves and socks, and which is used to reflect RF signals in areas where RF overexposure may be present. See also: Faraday Cage.
RF survey	A survey conducted to evaluate the source and strength of electromagnetic energy in a specific area where there is concern about human exposure to RF.
RF transmission frequencies	Any of the electromagnetic wave frequencies that lie in the range extending from below 3 kilohertz to about 300 gigahertz and that include the frequencies used for communications signals (as for radio and television broadcasting and cell-phone and satellite transmissions) or radar signals.

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RF transmission power	The power density of active antenna transmissions across any frequency as received by a surface per unit area. Typically measured in watts per square metre (W/m^2).
Safety Code 6	A Canadian guideline document published by Health Canada and written to prevent adverse human effects in both controlled and uncontrolled environments specific to maximum levels of human exposure to RF fields frequencies between 3 kHz and 300 GHz.
Small cell	Any low-powered cellular radio system that operates in licensed or unlicensed spectrum and has a limited range (usually less than 5 km).
Transmission antenna	Any antenna that transmits an RF signal.
Uncontrolled environment	Limits that establish safe RF exposure levels for areas and locations in which the individuals present do not have any control over the RF emissions or the length of time they are exposed to those emissions (ie: locations that are accessible to members of the public). Any area where any of the criteria defining the controlled environment are not met.
Voltage tester	A piece of electronic test equipment used to determine the presence or absence of AC or DC voltage such as for checking equipment under test or for checking batteries, respectively.
Volts per metre	A common unit of measurement to express the electrical potential between two points (V) averaged over a unit of distance (m).
Watts per square metre	The amount of power (or energy per second) that flows across a square metre surface, as depicted as a unit of power density.