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

STAC – Personal RF Monitor Best Practices

(General Guidelines)

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

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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STAC – Personal RF Monitor Best Practices

(General Guidelines)

This document is designed to provide an overview of important information that Canadian tower and communications workers should be aware of before using a personal RF monitor or working around RF emitting equipment. This document is designed to duplicate information that should be provided to all workers who intend to work around RF emitting equipment during their introductory RF training.

Tower or communications workers seeking more information about RF safety or RF training opportunities are asked to please contact the Structure, Tower & Antenna Council (STAC) at info@stacouncil.ca

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(General Guidelines)

1. Introduction

Personal RF monitors are an important tool in the communications tower industry, as they allow individuals who work near operating, or potentially operating, antennas to determine whether they are being exposed to radiofrequency (RF) emissions that exceed the limitations specified by Health Canada, as outlined in the Safety Code 6 standard. These limits – which were most recently updated in 2015 – establish safe human exposure levels for RF emissions between 3 kHz and 300 GHz.

The potential hazard when working around RF emissions stems from the fact that electromagnetic waves caused by moving electric charges all carry energy. These wave particles are commonly called **photons**. Their energy level increases at higher frequencies and is measured in **electron volts** (eV).

At frequencies that far exceed 300 GHz, the photon energy levels are high enough to cause changes to the chemical bonds of atoms. This causes the atom to be charged or "ionized," and emissions above this approximate frequency are called "**ionizing**" waves.

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

The main hazard associated with non-ionizing emissions is their potential to warm the human body, particularly when exposed to high-powered emissions over an extended period of time. For this reason, Safety Code 6 identifies two sets of RF limitations. These are:

- **uncontrolled 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); and
- **controlled 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).

For the remainder of this document, general references to Safety Code 6 limits will refer to the controlled limits unless explicitly stated otherwise.

The intent of this document is to provide communication tower workers with information necessary to safely and confidently use a personal RF monitor in accordance with Safety Code 6 guidelines. This document is designed to provide general guidelines, and not all of the information contained within will necessarily be applicable to all situations or to all personal RF monitor devices. For more detailed information about a specific type of personal RF monitor, please consult the device manufacturer or its manufacturer's guidelines.

2. Benefits and Practical Uses of an RF Monitor

General Benefits for Users

The primary purpose of an RF monitor is to measure the approximate level of RF emissions in the workplace environment in which the monitor is being used, and to provide warnings when those emissions approach, meet or exceed the limits established in Safety Code 6.

Monitor users benefit from these measurements and related warnings in several ways, the most important of which is that they immediately become aware of potential risks to their person if they enter a worksite location that contains emissions that approach or exceed Safety Code 6 limits. By providing users with both audible and visible feedback relating to an otherwise invisible hazard, RF monitors can help employees limit the amount of time they spend in **RF "hot zones."**

Personal RF monitors can also provide reassurance to users working around antennas if they are uncertain as to whether they will be exposed to emissions above Safety Code 6 limits in that location. Armed with a properly calibrated personal monitor, experienced RF or tower workers can find peace of mind in the knowledge that their monitor will alert them if RF emissions exceed those limits. This should enable the worker(s) to better concentrate on the task at hand.

Specific Applications for Users

Some common uses of personal RF monitors include:

- Identification of potential "hot zones" on towers and rooftop sites;
- Reducing risk of over-exposure caused by emissions from unknown neighbouring sites in environments with multiple towers and transmitters;
- Verification that antennas/transmitters have been shut down and remain off when workers are present;
- Verification of ground-level RF emissions in a controlled or uncontrolled environment;
- Conducting a preliminary sweep of a work environment to identify potential hazards;
- **Data logging**, available with some personal monitors, is also used to record a worker's exposure levels throughout the usage period.

3. Features of an RF Monitor

A product designed to be an RF monitor should include the following features and capabilities:

- Frequency Range: covering the minimum and maximum frequencies that could be encountered.
- Measurement range: measure in unit applicable to Safety Code 6 - 2015
- Display: easily readable and understandable
- Audible alarm: must be loud enough for workers to hear if activated
- Battery operated: rechargeable or replaceable batteries
- Battery Low indicator
- Simple to use: must be a non-intrusive device that allows the user to perform their required duties
- References Safety Code 6 2015

4. Using an RF Monitor

Selecting the Right Monitor

It is important that those working near RF emissions ensure they are using the correct personal monitor for the specific job they need to complete. The two most important factors in picking the correct monitor are the monitor's frequency range and its measurement display.

The **frequency range** of the monitor should be verified prior to the monitor's use to ensure it covers all potential signals in the work area. This means the monitor must be able to detect emissions not just on the specific frequencies used by the tower or antennas that the worker is working on, but also all other transmit frequencies potentially in use in the vicinity.

Some typical frequencies that tower workers may be exposed to and the related technologies used on those frequencies are as follows:

- Radio: 540 - 1610 kHz (AM), 88.1 - 107.9 MHz (FM)
- Television: 50 - 1000 MHz
- Cellular: 700 MHz, 850/1900 MHz, 1700/2600 MHz, 1700/2100 MHz, 3500 MHz
- Paging: 140-170 MHz, 450 MHz, 900 MHz
- Microwave: 300 MHz – 300 GHz
- Government technologies: 2 MHz – 30 MHz
- Satellite retransmitters: 2 GHz – 12 GHz

Please note that this list is not inclusive of all frequencies and technologies in use in Canada.

The **measurement display** of the monitor must be calibrated to the Safety Code 6 limits, as revised in 2015. While previous versions of these Canadian limits mostly aligned with corresponding U.S. limits as identified by the U.S. Federal Communications Commission (FCC), the revised Safety Code 6 limits vary significantly from U.S. limits at certain frequencies. As such, all personal monitors purchased prior to 2015 are no longer acceptable for use in Canada. Additionally, many monitor models that are popular internationally are similarly unsuitable for Canadian use. As of the time of this publication, there was no known remedy to recalibrate any of these older monitors for acceptable use under the 2015 limits, typically requiring companies to replace those units entirely.

Appendix 1 to this document contains information on some personal RF monitors whose manufacturers have demonstrated or stated are compliant with the current Safety Code 6 limits.

Finally, because Safety Code 6 is a **"frequency shaped standard,"** it is typically important to ensure that all personal RF monitors used on Canadian work sites can provide a **"shaped response."** This should be confirmed on the monitor's packaging or in its unique user guide. For more information about frequency shaped standards, please review the glossary section of this document.

Pre-Use Inspection

It is pivotal that a worker ensures that their personal RF monitor is in working condition prior to using the monitor on a job site. Pre-use inspections should be completed whenever a worker is entering a work site, whether it is the start of their workday or after returning from a break.

A thorough pre-use inspection includes each of the following elements:

1. Verify unit is within calibration
   i. FieldSENSE 2.0
      - Calibration expiry date is tagged on the bottom face of each unit
   ii. MVG EME Guard XS-SC6
      - • Calibration Expiration Date is tagged alongside the Serial Number with the user guide that accompanies each unit
      - • Products may be registered online so factory can remind customer of upcoming calibration cycles
   iii. Narda S3
      - Upon power-up, the unit displays the calibration date of the mainframe and of the sensor. If either are out of calibration, the date will appear in RED and the unit will beep and vibrate three times to warn the user.
      - Calibration information can also be verified in the unit's menu or via software.
      - A sticker is placed on the rear of the mainframe with its calibration date.
      - A sticker is placed on the inside edge of the sensor with its calibration date.
2. Verify battery is charged
   i. FieldSENSE 2.0
      - Low battery indicator found just above on/off switch on front face of each unit
   ii. MVG EME Guard XS-SC6
      - • Battery indicator found on front face of each unit
   iii. Narda S3
      - Upon power-up, the unit will display the battery level. If the level is too low for operation…an alarm will sound
      - During use of the unit, a battery icon appears on the screen (similar to a cellphone). When the battery reach 20% life left, the icon will turn RED. When the battery reaches 10% life left an LED and audible alarm activates.
3. Visually inspect unit for external damage such as cracks or missing pieces
4. Verify operation
   - Some units may have a self-test as part of the power-up sequence
   - A simple two-way radio can be used as a test source to verify the unit responds (note: this is not a true reading, but simply a quick test)

Wearing a Monitor

This section provides information relating to RF monitors that are specifically designed to be worn on a user's body. An off-the-body monitor or **"leakage detector"** should be held at arm's length, attached to an extension handle or placed on a bench, work surface, or test stand during use. This helps ensure the user's body does not interfere with the monitor's normal operations.

Please see **Appendix 2** to this document for more information about **"On-the-Body"** and **"Off-the-Body" monitors**.

An RF monitor should be placed on the chest or waist of the user. It can be clipped to a belt, placed in a breast pocket or attached to a climbing harness. The specific method of mounting will vary depending on the accessories included with the monitor and the work location of its use. Caution should be used if wearing a nylon jacket with a monitor. If the jacket is allowed to flap in the wind, it may cause an electrostatic buildup on the monitor.

If a user is confident there are no sources of RF energy that could strike them from the front, it is acceptable to wear the unit on their back, such as through the use of a belt clip attachment. This will alert the user should a transmitter be keyed up behind them. One example of when this technique may be appropriate is when working on an antenna at the edge of a rooftop when there are no transmitters in front of the worker(s).

Mitigating Potential Damage

A personal RF monitor is a critical tool in the safety of the worker exposed to RF emissions and as such should be treated as a key piece of safety equipment. The monitor should be handled with care during both usage and storage to mitigate any potential damage to the unit rendering it non-serviceable.

The following are a few simple steps to follow in order to minimize any possible damage to the unit and extend the serviceable life of the equipment:

- Always follow the specific manufacturer's outlined procedures and care of the specific unit being used. This information is usually contained in a booklet that comes with the monitor at the point of purchase. If not, contact the device manufacturer to request this information.
- Always try to store the unit in a cool, dry area. Excessive heat or cold may change the operation of the unit or effectively damage the sensor. Most personal RF monitors have an ambient temperature operating range and will not work accurately unless within that range.
- When preparing the unit for operation, allow the unit the necessary time to become acclimatized to the working environment if there is a drastic temperature change from the storage area to the work area. This should take approximately 20 minutes and will also help reduce condensation accumulated on the unit during operation.
- When not in use, personal RF monitors should always be stored in a shock and vibration-resistant case. Excessive shock or vibrations during transport could unknowingly damage the unit. Most manufacturers will supply or recommend a proper carrying case.
- When attached to the worker's body during use, a personal RF monitor should be placed in an area that has minimal movement while the worker is working. For example, if a worker is continually moving their right arm while tightening hardware, the monitor should not be placed in the path or motion of the worker's right arm. In this example, it would be better for the worker to place the unit on the left side of their body.
- Some harnesses or work gear are made with conductive alloys such as aluminum or stainless steel. Personal RF monitors should not be placed in direct contact with these surfaces during operation.

A personal RF monitor is a piece of personal safety test equipment and should always be treated as such. There should be established and documented periodic inspections and unit testing outside of the regular calibration sequence. This will help to determine if there are drastic changes in the unit reading within a **calibration cycle** and will help to determine if the unit has a premature failure or fault.

Mitigating False Readings

Since metal objects can gather and hold RF energy, the user should try to keep their monitor at a minimum of 20 cm from such objects. This will help prevent a false reading due to signals being coupled to the monitor.

Conditions such as electrical storms, and blowing snow or ice pellets can create static electricity. Weather that can produce static electricity will introduce false readings to the monitor and must be considered before use.

Limitations of Personal Monitors

As with all other types of personal protective equipment, it is important for users to understand the limitations of personal RF monitors to ensure they are used safely. Some of the more notable limitations include:

- A personal RF monitor is not designed to protect the user in any way, and is strictly limited to warning or alarming the user of the presence of RF energy;
- Some personal RF monitors do not provide any feedback to the user if the RF energy is below the limit threshold, which can cause some users to falsely believe the monitor is malfunctioning;
- Personal RF monitors can malfunction and fail to alarm a user when needed, particularly if the device has been damaged, the calibration date has expired, or if the batteries are low;
- Personal RF monitors base their calculations on an average reading and are affected by their position on the body. The actual RF conditions at any point on the body may be quite different than the average provided by the monitor;
- A personal RF monitor cannot alert the user to concentrated point sources or RF energy unless placed directly in front of the source.
- Personal RF monitors will not function correctly when placed inside/under a personal RF protective garment (such as an RF suit/coveralls). They may also not have the alarm range to be useful when placed outside of an RF garment.
- Some personal RF monitors may not be sensitive to all frequencies. The user must know the frequency range their monitor is designed for and its limitations. Users must decide if their monitor is suitable for the application for which it is used.
- Personal RF monitors are electronic devices that may fail, lose battery power, or become damaged and are not a replacement for adequate training.

5. Job-Site Awareness

While a personal RF monitor is an important element of any RF safety toolkit, it is imperative that communication tower workers utilize safe practices and procedures as well in order to ensure they are not unknowingly exposed to RF emissions that exceed Safety Code 6 limits.

One of the most important practices that every tower worker should follow is the use of a "**pre-job assessment form**," which should be completed prior to beginning any work on the tower. Completed forms should then be shared with representatives of all parties involved in the tower work, including the site owner/operator and any/all contractors and sub-contractors working on the site or with control over the operation of any transmitters.

An example of a standard pre-job assessment form can be found in Appendix 3 to this document.

6. Questions about RF Monitors

While this document aims to provide users of personal RF monitors with background information about the use and function of those monitors, it is important to understand the limitations of this information, as it is not expected to provide users with in-depth knowledge of the science behind RF monitors.

If a member of the public questions a worker about their use of a personal RF monitor or about tower emissions more generally, STAC recommends that workers direct those questions to their immediate supervisor or to a trained health and safety officer within their company.

Glossary of Terms

Calibration cycle	The period between a personal RF monitor's routine calibration dates, typically a one or two-year period as indicated in the manufacturer's instructions.
Controlled limits	A restriction on the intensity of RF emissions a person can be exposed to in a location where exposure may be incurred only by persons who are aware of the potential for exposure as a condition of employment.
Data logging	A function provided by some personal RF monitors that allows users to record the monitor's average and actual emission readings over an extended period time.
Electromagnetic radiation	A form of energy emitted by accelerating electric charges, that exhibits wave-like behavior as it travels through space.
Electron volts	A unit of energy equal to the work done on an electron in accelerating it through a potential difference of one volt.
Frequency range	The minimum and maximum frequency over which an RF monitor is capable of detecting and measuring signals
Frequency shaped standard	A set of formal guidelines that provide different RF exposure limits based on the specific electromagnetic frequencies in use in any given location. A frequency shaped standard attempts to mitigate the increased hazards to persons caused by specific frequencies that produce waves roughly equivalent in height to the human body by requiring comparatively reduced power on transmissions over those waves.
Ionizing waves	Electromagnetic radiation that carries enough energy to free electrons from atoms or molecules, thereby ionizing them.
Leakage detector	See "Off-the-body monitor"
Measurement display	The standard or limits against which a personal RF monitor measures RF emissions. The necessary measurement display for monitors used in Canada is Safety Code 6 (2015).
Non-ionizing waves	Electromagnetic radiation that does not carry enough energy to free electrons from atoms or molecules.

Off-the-body monitor	An RF monitor designed to be used when placed on the ground or a platform, as opposed to while held by its operator. These monitors are typically referred to as “isotropic” monitors and are capable of detecting RF emissions originating from any direction.
On-the-body monitor	An RF monitor designed to be held or worn by its operator while in use. These monitors are typically non-isotropic, meaning they will only detect RF emissions originating from specific directions.
Pre-job assessment form	A standard checklist designed to help crews and workers identify potential hazards and their controls prior to work commencing on a job. An example of an RF-specific pre-job assessment form can be found in Appendix 3 to this document.
Photons	Particles representing a quantum of light or other electromagnetic radiation.
RF hot zone	A highly localized area of relatively intense radio-frequency radiation that manifests itself in two principal ways: (1) The presence of intense electric or magnetic fields immediately adjacent to conductive objects that are immersed in lower intensity ambient fields (often referred to as re-radiation), and (2) Localized areas, not necessarily immediately close to conductive objects, in which there is a concentration of radio-frequency fields caused by reflections and/or narrow beams produced by high-gain radiating antennas or other highly directional sources. In both cases, the fields are characterized by very rapid changes in field strength with distance. RF hot spots are normally associated with very nonuniform exposure of the body (partial body exposure). This is not to be confused with an actual thermal hot spot within the absorbing body.
Safety Code 6	The RF exposure limit standard used in Canada, as issued by Health Canada. This standard was last updated in 2015.
Shaped response	A characteristic of some personal RF monitors that allows them to identify varying emission intensity limits for different radiofrequencies, and to provide frequency-appropriate exposure limit warnings based on those varying emission intensity limits.
Uncontrolled limits	A restriction on the intensity of RF emissions a person can be exposed to in a location where exposure may be incurred by persons who are unaware of the potential for exposure or unable to influence control over that exposure.

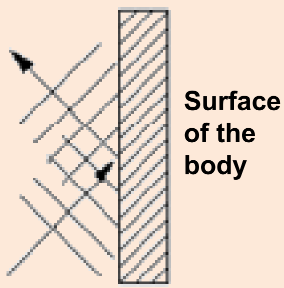
Appendix 1: On-the-Body vs. Off-the-Body Monitors

<u>On-the-Body Monitors</u>

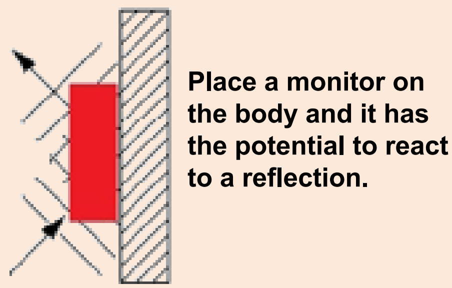
An RF Monitor for use on the body should be shielded to prevent reflections and potential erroneous measurements.

The monitor should be designed so as to take into account the presence of the user's body as a source for reflection. If the monitor detects both the "incident" wave and the "reflected" wave, it may produce an erroneous reading. If the reflected wave is in-phase with the incident wave it can add to it and cause a reading that is much higher than reality. The opposite can also happen, where the reflected wave could be completely out of phase with the incident wave. In these cases, the waves would cancel each other out and a monitor would read zero.

REFLECTION



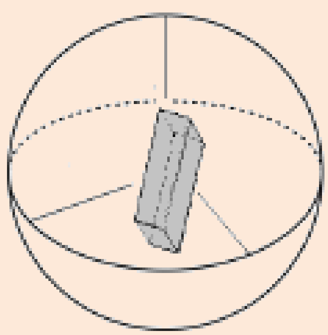
REFLECTION



Note: The present of a "belt clip" or "pouch" does not always mean a monitor is suitable for use on the body.

<u>Off-the-Body Monitors</u>

Although not required, an off-the-body monitor – or "leakage detector" – can be isotropic, meaning that it has the advantage of detecting signals from all directions.



A non-isotropic monitor may be used as a leakage detector and held off the body as long as the user understands the manner in which the unit will detect signals. Note, a leakage detector is not a formal engineering tool and should not be used to conduct surveys.

Appendix 2: Commercially Available Safety Code 6 (2015) Compliant Personal RF Monitors*

Nardalert S3	**Fieldsense 2.0**	**MVG EME Guard XS - SC6**
		
Battery: Lithium USB charge Approx. 25 hours per charge	**Battery:** 2 x AAA Approx. 6-12 months	**Battery:** 2 x 1.5 V Approx. 50 days
Measurement: E Field	**Measurement:** E & H Field	**Measurement:** E Field
Calibration Interval: 4 years mainframe 2 years Sensor	**Calibration Interval:** 2 years	**Calibration Interval:** 2 years
Alarms: LED display 2 programmable alarms	**Alarms:** Visual 2%, 5%, 10%, 25%, 50%, 100%, +200% Audible 50%, 100%, +200%	**Alarms:** LED display 2 tone alarms
Weight: 230 grams	**Weight:** 115 grams	**Weight:** 120 grams
Frequency Range: 100kHz to 50GHz	**Frequency Range:** 50 MHz to 6 GHz	**Frequency Range:** 80 MHz - 6 GHz

**Please note that this appendix will be updated as necessary to reflect new or additional monitors that are confirmed as being properly calibrated in accordance with Safety Code 6 (2015) limits.*

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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: ___________________________

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