

RF Safety on Roof Tops

During the last 24 months in Canada, the existing and newly licensed mobility operators have been building their networks to support 4G services at an unprecedented rate and will so for the next few years. As a result of this increase in cell site activity, many landlords and tenants are suddenly aware of the changes happening on their roof tops and with the increased public awareness of potential health hazards associated with radio frequency (RF) emissions, many are questioning whether these changes on the roof tops are safe. The photographs below show typical antenna installations on a few roof tops in Greater Vancouver.



Industry Canada and Health Canada addresses the issue of maximum allowable exposure to RF emissions in Safety Code 6 (SC6.) As part of SC6, the last licensed RF operator making changes at a site is responsible to certify to ensure that the aggregate of all RF emissions from the roof top site are safe. This includes the emissions from their antennas plus emissions from those of co-located third parties. On roof tops where multiple antenna arrays from multiple operators exist, the SC6 site certification is an on-going activity, especially given the number of changes to the antenna systems needed to optimize RF coverage.

What is Safety Code 6?

SC6 is a set of specifications developed by Health Canada and enforced by Industry Canada to define limits for the safe exposure of humans to radio frequency emissions from all emissions from all antenna systems at any given site. Health Canada and Industry Canada have defined limits for safe exposure for humans to near and far field radio frequency emissions in the following documents issued in October 2009:

- (HC Pub. 091029) Limits of Human Exposure to Radio frequency Electromagnetic Energy in the Frequency Range from 3 kHz to 300 GHz - Safety Code 6 (2009)
- (HC Pub. 091031) Technical Guide for Interpretation and Compliance Assessment of Health Canada's Radio frequency Exposure Guidelines

The Code distinguishes safe limits for those trained individuals working on RF systems and those with no training, the "general public." Exposure limits for the general public are five times lower than that for the RF worker. In the 2009 edition of the Safety-Code 6 guidelines, Health Canada further defines sites as "controlled" and "uncontrolled" where "uncontrolled" replaces previous definitions for the general public. Ambiguities still exist for roof top radio sites where access is strictly controlled but where non-telecommunication workers, such as HVAC, window washers, roofers, painters, elevator maintenance and building maintenance workers conduct work. From the SC6 definitions in the 2009 edition, anyone accessing the roof top without adequate RF training should be evaluated for exposures in the same manner as the general public. Exposure limits on roof tops, therefore, default to maximums set for the general public.

Besides defining safe exposure limits for the general public and for RF workers within controlled and uncontrolled environments, SC6 also defines exposure criteria within three RF environments: within the body itself, within the near field of an antenna aperture and within the far field of an antenna aperture. The first aspect is SAR - the specific absorption rate and pertains to effects caused when a person is within 20cm of an antenna. SAR is a measure of the rate at which electromagnetic energy is absorbed in the body. For radio sites where access to the antenna systems is controlled and where technicians know not to stand too close to antenna systems for any length of time, SAR is generally not an issue and typically not addressed in SC6 certification of radio sites.

The second aspect of SC6 refers to effects caused by exposure to near-field emissions. It is near field emissions that cause the greatest potential for hazard on roof tops. For typical frequencies encountered at radio sites, near field effects refer to those effects encountered within 0.5m - 1.0m of the aperture of the antenna for dipole and whip style antennas and for parabolic dish antennas, to those effects encountered many meters from the aperture. Field strength behaviour within the near field region of antennas is very complex and difficult to model mathematically. This is especially true of mobility, UHF and VHF antenna arrays. For these types of antenna systems, the most accurate means to establish near field effects is by measuring the near field exposure with accredited test equipment.

The third aspect to SC6 refers to effects caused by exposure to far-field emissions. In the far field, electric field strength, magnetic field strength and power density are interrelated by mathematical expressions and can be easily calculated.

Safety Code 6 Certifications - Calculated or Measured Approaches

SC6 certification of a site is conducted by professional radio engineers using either a "calculated" or "measured" approach. Pros and cons exist for both approaches.

For the calculated approach, Industry Canada published procedures and how to calculate near field effect of parabolic antennas but recommends that for dipole arrays and whip antennas near field effects be measured. For tower installations, RF hazards for the general public occur in the far field of the antenna apertures and the calculated approach is the simplest means to determine SC6 limits. In fact, testing exposures along the tower length is often not possible due to strict Workers Compensation rules limiting engineers from climbing towers unless they have special tower climbing certifications and insurance. Because of the difficulty to certify towers along the tower length, many tower riggers are equipped with personal RF safety meters which flag to the rigger those hot spots on the tower where hazards exist.

The biggest challenge with the calculated approach is the collection of accurate data. In sites shared with other RF operators, a list is developed of all other tenants and their antenna systems, output powers and frequencies. And even with this listing of information, there always concern over accuracy as operators tend not to keep their as-built data current with their licensed data. For the many unlicensed systems prevalent at shared radio sites, data collection is exceedingly difficult as it involves contacting each unlicensed operator and asking for the information. For the measured approach, Engineers use Industry Canada recognized test equipment and conducts site walks. This approach is the most practical and economical for roof top sites.

What happens if the RF Emissions at Site Exceed Limits Set By Safety Code 6?

Health Canada requires that each radio site be labelled to indicate the degree of radiation hazard and stipulates three levels of warning signs, notice, warning and danger. Each sign indicates the nature and degree of hazard associated with a given location. Each hazard is indicated by a symbol, and its degree is indicated by the shape and colour of the symbol.

In general, signs are a difficult issue due to the public's increasing concern over the hazards of radio frequency emissions. It is important to alert the public to potential danger but not create panic. Consequently, the optional first level "notice," usually a white sign as shown in an antenna Vancouver installation on a roof top below, is rarely used in Vancouver as the RF emissions from the culprit antennas are within limits set for the general public. The second and third signage levels however must be deployed. When the RF emissions exceed limits set for the general public on roof tops, the second level SC6 signs, usually orange, must be posted in positions to clearly highlight the potential hazard. When RF emissions exceed limits set for RF workers, the third level, a red warning sign must be posted on the site entrance and the operator whose equipment

is operating at the high emissions must post access procedures for individuals working on the rooftop which includes fencing off the culprit antennas and de-rating the power to the culprit antenna arrays.



Who is responsible to ensure sites are safe for RF emissions?

Strictly speaking, the last RF operator to make a change to the radio site is responsible for ensuring that the site meets the requirements of SC6. This is an honour system with little or no enforcement and no central repository to file the SC6 reports. Given the fierce competition for wireless services, it is less likely now that an RF operator will inform others of antenna changes at a radio site due to potential competitive advantage those changes may make. In the case of mobility operators, most use software tools to predict the emission effects of their antenna arrays against SC6. Each operator does not account for the aggregation of their emissions with that of other operators at the site. Furthermore the predictive software tools tend not to model the uniqueness of each installation - i.e. the effects of the surface behind the antenna and antenna back lobes. The most accurate means to review the effects of emissions on a roof top with multiple RF tenants is by measurement.

So who tracks and asks for the certifications?

Industry Canada requires new operators to ensure their sites meet SC6 as part of the initial licensing process. Beyond this stage, all safety code 6 reporting testing is honour based. The managers of the roof tops - landlords, property managers, strata owners etc, collectively referred as roof top managers - are ultimately responsible to ensure that the roof top is safe for all those accessing it. Fall arrest procedures and equipment are common place. The same argument can be made for RF safety. And just like designing roof tops and specifying roof top access to minimize fall hazards, roof top managers can request that their RF tenants design RF installations as safe for the general public. Property managers, strata owners, concerned citizens, all roof top managers, can all request their roof top to be tested to SC6. In fact, we recommend to roof top managers

that every time one of their RF tenants on the roof top requests a change to their antenna arrays, that the tenant produce a SC6 certificate for the site upon completion. Also during the contract renewal process, we recommend that the roof top manager require from the renewing tenant, a SC6 certificate for the site. Ultimately we would like to see the SC6 certificate posted at the entrance to each site in the same manner as fall arrest procedures certifications are today.

Who should conduct SC6 certifications?

Anytime there is a question of the general public being at risk for a safety hazard, it is imperative that the safety risk be assessed by an accredited professional engineer with expertise in the area of question. For SC6, it is important that the testing and certification is performed by a professional radio engineer. The certificate itself should be stamped and dated. The photographs below show Planetworkers testing sites to SC6 in various roof top sites around Vancouver.



- Susanna Reardon