

# **AC 2007-1115: THE IMPORTANCE OF RADIOFREQUENCY SAFETY INTO OCCUPATIONAL SAFETY COURSEWORK**

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# **The Importance of Radiofrequency Safety into Occupational Safety Coursework**

## **Introduction**

Many consumer and industrial products and applications make use of some form of electromagnetic energy<sup>10</sup>. One type of electromagnetic energy that is of increasing importance worldwide is radiofrequency (RF) energy, including radio waves and microwaves, which is used for providing telecommunications, broadcast and other services. In the United States, the Federal Communications Commission (FCC) authorizes or licenses most RF telecommunications services, facilities, and devices used by the public, industry, and state and local governmental organizations. According to law, “the Federal Communications Commission (FCC) is required by the National Environmental Policy Act of 1969 to evaluate the effect of emissions from FCC-regulated transmitters on the quality of the human environment”<sup>3</sup>.

Because of its regulatory responsibilities in this area the FCC often receives inquiries concerning whether there are potential safety hazards due to human exposure to RF energy emitted by FCC-regulated transmitters. The FCC states, “at the present time there is no federally mandated radio frequency (RF) exposure standard. However, several non-government organizations, such as the American National Standards Institute (ANSI), the Institute of Electrical and Electronics Engineers, Inc. (IEEE), and the National Council on Radiation Protection and Measurements (NCRP) have issued recommendations for human exposure to RF electromagnetic fields.”<sup>4</sup> Using these standards, the FCC has created a de facto federal standard under 73CFR1.1310 under which it enforces “maximum permissible exposure (“MPE”) limits applicable to facilities, operations, or transmitters.” OSHA specifically recognizes RF hazards in OSHA standard 29 CFR §1926.550 (a) (15) (vii), Cranes and Derricks, but fails to set in place any standards. It also provides a general discussion of a variety of RF hazards on its web site, but defers to the FCC for guidance on maximum permitted exposures<sup>17</sup>. However, the Canadians are much more specific on these matters, and a wide ranging set of standards and regulations are set out in the Health Canada Safety Code 6<sup>9</sup>.

Typical safety programs, both undergraduate and graduate, do not explore issues related with RF hazards and safety. Without federal regulations and enforcement, the topic is usually disregarded and thus creating future safety professionals without any knowledge of the possibilities of RF hazards at the future employment. This paper will discuss what is radiofrequency, how radiofrequency is used, regulatory agencies and compliance issues in regards to radiofrequency and finally research of Safety, Health and Environmental programs across the United States.

## **Background**

Radio waves and microwaves are forms of electromagnetic energy that are collectively described by the term "radiofrequency" or "RF." RF emissions and associated phenomena can be discussed in terms of energy, radiation, or fields. Radiation is defined as the propagation of energy through space in the form of waves or particles<sup>1</sup>. Electromagnetic radiation can best be described as waves of electric and magnetic energy moving together (i.e., radiating) through space<sup>3</sup>. These waves are generated by the movement of electrical charges such as in a conductive metal object or antenna. For example, the alternating movement of charge (i.e., the current) in an antenna used by a radio or television broadcast station or in a cellular base station antenna generates electromagnetic waves that radiate away from the "transmit" antenna and are then intercepted by a "receive" antenna such as a rooftop TV antenna, car radio antenna or an antenna integrated into a hand-held device such as a cellular telephone. The term "electromagnetic field" is used to indicate the presence of electromagnetic energy at a given location. The RF field can be described in terms of the electric and/or magnetic field strength at that location.

Electromagnetic waves can be characterized by a wavelength and a frequency. The wavelength is the distance covered by one complete cycle of the electromagnetic wave, while the frequency is the number of electromagnetic waves passing a given point in one second<sup>4</sup>. The frequency of an RF signal is usually expressed in terms of a unit called the "hertz" (abbreviated Hz). One Hz equals one cycle per second. One megahertz (MHz) equals one million cycles per second.

Different forms of electromagnetic energy are categorized by their wavelengths and frequencies. The RF part of the electromagnetic spectrum is generally defined as that part of the spectrum where electromagnetic waves have frequencies in the range of about 3 kilohertz (3 kHz) to 300 gigahertz (300 GHz)<sup>16</sup>. Microwaves are a specific category of radio waves that can be defined as radiofrequency energy where frequencies range from several hundred MHz to several GHz<sup>4</sup>.

Ionization is a process by which electrons are stripped from atoms and molecules<sup>2</sup>. This process can produce molecular changes that can lead to damage in biological tissue, including effects on DNA, the genetic material. This process requires interaction with high levels of electromagnetic energy. Those types of electromagnetic radiation with enough energy to ionize biological material include X-radiation and gamma radiation<sup>4</sup>. Therefore, X-rays and gamma rays are examples of ionizing radiation.

The energy levels associated with RF and microwave radiation, on the other hand, are not great enough to cause the ionization of atoms and molecules and RF energy is, therefore, is a type of non-ionizing radiation<sup>4</sup>. Other types of non-ionizing radiation include visible light, infrared radiation and other forms of electromagnetic radiation with relatively low frequencies. Often the term radiation is used to apply to ionizing radiation such as that associated with nuclear power plants. Ionizing radiation should not be confused with the lower-energy, non-ionizing, radiation with respect to possible biological effects, since the mechanisms of action are rather different<sup>4</sup>.

The portion of the spectrum lying below the "RF" is commonly referred to as ELF, and includes the electromagnetic field from power lines, motors, electric blankets and the like. Often confused

with RF by the lay public, the mechanisms of impact on the body are considered quite different. ELF safety is not a focus of this paper.

### **How RF Energy is Used**

Probably the most important use for RF energy is in providing telecommunications services to the public, industry and government. Radio and television broadcasting, cellular telephones, personal communications services (PCS), pagers, cordless telephones, business radio, radio communications for police and fire departments, amateur radio, microwave point-to-point radio links and satellite communications are just a few of the many applications of RF energy for telecommunications<sup>3</sup>. Microwave ovens and radar are examples of non-communications uses of RF energy.

Also important are uses of RF energy in industrial heating and sealing where electronic devices generate RF radiation that rapidly heats the material being processed in the same way that a microwave oven cooks food. RF heaters and sealers have many uses in industry, including molding plastic materials, gluing wood products, sealing items such as shoes and pocketbooks, and processing food products<sup>3</sup>. There are a number of medical applications of RF energy, including a technique called diathermy, that take advantage of the ability of RF energy to rapidly heat tissue below the body's surface. Tissue heating "hyperthermia" can be beneficial in the therapeutic treatment of injured tissue and cancerous tumors<sup>10</sup>. Medical uses of RF energy also include pacemaker monitoring and programming. The use of RF energy is ubiquitous in the scientific research community, and some of the most hazardous manifestations are found in such areas as particle research, where RF powers in the multiple megawatt range are generated.

### **Hazards of RF energy**

Heightened awareness of the expanding use of RF technology has led some people to speculate that "electromagnetic pollution" is causing significant risks to human health from environmental RF electromagnetic (EM) fields. Potential health effects of electromagnetic fields have been of scientific interest since the 1800s and have received particular attention in the past 40 years. People have raised concerns about power lines, common household electrical wiring appliances, motor driven instruments, computer screens, telecommunications, broadcast facilities, mobiles phones and their base stations. In manufacturing, concerns have been raised about electricity generating equipment, resistance welders, induction and dielectric heaters, plasma etchers, and radio frequency identification systems. In the field of medicine concern has been raised about magnetic resonance imaging and many other diagnostic and therapeutic instruments.

In addition to the biological effects of radio frequency radiation there is also the effect of RF on circuitry in a variety of devices found in the modern workplace. These concerns, although different in mechanism and standards are also important to a thorough education in RF safety. Such effects are known to affect medical equipment used by patients such as electric wheelchairs, cardiac and intravenous monitors, and electronic thermometers<sup>20</sup>. Recent incidents affecting alarm and control systems at nuclear plants have resulted in Nuclear Regulatory Commission ordered actions to change frequencies of certain communications equipment<sup>8</sup>. A recent activity audited the susceptibility of cable braking systems on a popular amusement park

“terror ride” for improper operation due to a nearby communications repeater<sup>21</sup>. In another instance the operation of a nearby industrial heat sealer caused a computerized material cutting knife (on the other side of a wall) to self-operate, putting fabric workers at hazard<sup>21</sup>.

It should also be noted that secondary workplace effects of RF energy can produce fire and explosions in materials subject to intense field intensities. The military has extensive standards exemplified in their HERO (ordinance effects), HERF (fuels effects) and other standards<sup>11</sup>.

In recent years, there has been considerable discussion and concern about the possible hazards of radiofrequency/microwave (RF/MW) radiation. The only demonstrated injurious biological effects of RF energy are from tissue heating. According to a United States Department of Labor, “At sufficiently high power densities, RF/MW energy can cause thermal effects that can cause blindness, and sterility”<sup>17</sup>. Other hazards include contact shocks and RF burns. These can result from the electric currents which flow between a conducting object and a person who comes into contact with it while they are exposed to RF fields. “Although it was known that RFR could cause electric shock in the body or burns in tissue under certain circumstances, specific exposure limits were not included in previous standards for human exposure to RFR...noted that such effects were considered in choosing the 300-kHz lower frequency limit of the present ANSI (1982) standard”<sup>15</sup>.

Non-thermal effects, such as alteration of the human body’s circadian rhythms, immune system and the nature of the electrical and chemical signals communicated through the cell membrane have been demonstrated by a few researchers<sup>10</sup>. However, none of this research has conclusively proven that RF radiation causes adverse health effects beyond those thermally induced<sup>19</sup>. In the meantime, standards-setting organizations and government agencies continue to monitor the latest experimental findings to confirm their validity and determine whether alterations in safety limits are needed in order to protect human health<sup>19</sup>.

Studies have shown that environmental levels of RF energy routinely encountered by the general public are typically far below levels necessary to produce significant heating and increased body temperature. However, there may be situations, particularly workplace environments near high-powered RF sources, where recommended limits for safe exposure of human beings to RF energy could be exceeded. In such cases, restrictive measures or actions may be necessary to ensure the safe use of RF energy.

## **Regulatory Agencies**

Various organizations and countries have developed exposure standards and guidelines over the past several decades. In North America and most of Europe, exposure standards and guidelines have generally been based on exposure levels where effects are considered harmful to humans’ occur<sup>19</sup>. Safety factors are then incorporated to arrive at specific levels of exposure to provide sufficient protection for various segments of the population. For example, the IEEE/ANSI current standard assumes a safety factor of five for workplace exposure, and ten for general public exposure.

In the United States, although the Federal Government has never developed RF exposure standards, the FCC has adopted and used recognized safety guidelines for evaluating RF environmental exposure since 1985.<sup>19</sup> Federal health and safety agencies, such as the Environmental Protection Agency (EPA), the Food and Drug Administration (FDA), the National Institute for Occupational Safety and Health (NIOSH) and the Occupational Safety and Health Administration (OSHA) have also been actively involved in monitoring and investigating issues related to RF exposure. The State of North Carolina is on the brink of legislating regulations to protect tower workers from harmful exposure.

For example, at the manufacturer level, the FDA has issued guidelines for safe RF emission levels from microwave ovens, and it continues to monitor exposure issues related to the use of certain RF devices such as cellular telephones and medical equipment. NIOSH conducts investigations and health hazard assessments related to occupational RF exposure. The EPA has, in the past, considered developing federal guidelines for public exposure to RF radiation. However, EPA activities related to RF safety and health are presently limited to advisory functions. For example, the EPA now chairs an Inter-agency Radiofrequency Working Group, which coordinates RF health-related activities among the various federal agencies with health or regulatory responsibilities in this area. OSHA is responsible for protecting workers from exposure to hazardous chemical and physical agents. OSHA also provides guidance on RF safety and also conducts health and safety inspections and issues citations related to occupational RF exposure.

In 1971, a federal RF radiation protection guide for workers was issued by OSHA based on the 1966 American National Standards Institute (ANSI) RF exposure standard. However, the OSHA regulation was later ruled to be advisory only and not enforceable<sup>16</sup>. Presently, OSHA enforcement actions related to RF exposure of workers are undertaken using OSHA's "general duty clause," which relies on the use of widely-supported voluntary "consensus" standards.

The General Duty clause is located in Section 5(a)(1) of the Occupational Safety and Health Act, and states, "Each employer shall furnish to each of his employees employment and a place of employment which are free from recognized hazards that are causing or are likely to cause death or serious physical harm to his employees."<sup>18</sup> The General Duty Clause has an important use for workers. Sometimes there is a hazard, but OSHA has no specific rule or standard dealing with it. Under the General Duty Clause, the employer has an obligation to protect workers from serious and recognized workplace hazards even where there is no standard. Employers must take whatever abatement actions are feasible to eliminate these hazards. If an employer fails to do this, OSHA can inspect and issue a citation under the General Duty Clause. "Consensus" standards are not OSHA regulations. However, consensus standards provide guidance from their originating organizations related to worker protection, and may be referenced by OSHA inspectors for informational purposes.

When faced with the task of updating its rules and adopting new guidelines, the FCC considered a large number of comments submitted by industry, government agencies and the public<sup>3</sup>. In particular, the FCC considered comments submitted by the EPA, FDA, NIOSH and OSHA, which have primary responsibility for health and safety in the Federal Government. The guidelines that the FCC adopted were based on the recommendations of those agencies, and the

agencies have sent letters to the FCC supporting its decision and endorsing the FCC's guidelines as protective of public health.<sup>3</sup>

In its 1996 Order, the FCC noted that research and analysis relating to RF safety and health is ongoing and changes in recommended exposure limits may occur in the future as knowledge increases in this field. In that regard, the FCC will continue to cooperate with industry and with expert agencies and organizations with responsibilities for health and safety in order to ensure that the FCC's guidelines continue to be appropriate and scientifically valid. "On August 1, 1996, the Commission adopted the NCRP's recommended Maximum Permissible Exposure limits for field strength and power density for the transmitters operating at frequencies of 300 kHz to 100 GHz. In addition, the Commission adopted the specific absorption rate (SAR) limits for devices operating within close proximity to the body as specified within the ANSI/IEEE C95.1-1992 guidelines"<sup>19</sup>.

Certain applicants are required to routinely perform an environmental evaluation with respect to determining compliance with the Commission's exposure limits. The FCC states, "Major RF transmitting facilities under the jurisdiction of the FCC, such as radio and television broadcast stations, satellite-earth stations, experimental radio stations and certain cellular, PCS and paging facilities are required to undergo routine evaluation for RF compliance whenever an application is submitted to the FCC for construction or modification of a transmitting facility or renewal of a license. Failure to comply with the FCC's RF exposure guidelines could lead to the preparation of a formal Environmental Assessment, possible Environmental Impact Statement and eventual rejection of an application."<sup>19</sup> Beyond this, the FCC Rules impose a continuing duty to ensure operating facilities are in compliance and a not a danger to workers or the general public. Substantial fines are imposed for failing to comply with radio frequency radiation ("RFR") maximum permissible exposure ("MPE") limits applicable to facilities, operations, or transmitters<sup>5,6,7</sup>.

The FCC's policies with respect to environmental RF fields are designed to ensure that FCC-regulated transmitters do not expose the public or workers to levels of RF radiation that are considered by expert organizations to be potentially harmful. Therefore, if a transmitter and its associated antenna are regulated by the FCC, they must comply with provisions of the FCC's rules regarding human exposure to RF radiation. In its 1997 Order, the FCC adopted a provision that all transmitters regulated by the FCC, regardless of whether they are excluded from routine evaluation, were expected to be in compliance with the new guidelines on RF exposure by September 1, 2000.

## **Compliance and Enforcement**

The Federal Communications Commission (FCC) would generally handle RF hazards/compliance issues that dealt primarily with communications, and OSHA will generally handle RF hazards that are not communication based. Examples of locations/sources of where RF hazards may be found include: interference with medical devices, amateur radio, cellular phone base stations and hand held cell phones, heating and sealing devices, microwave ovens, radio broadcast antennas, and traffic radar devices<sup>16</sup>.

The researcher has found three instances where OSHA has issued citations and fines for RF violations under the General Duty Clause<sup>22</sup>. In December 1997, OSHA fined Mad River Canoe, Inc. located in Vermont (Inspection 124431990 ) \$7,500, for exposing employees operating dielectric heaters to radiofrequency (RF) radiation in excess of the American Conference of Governmental Hygienists (ACGIH) 1997 Radiofrequency and Microwave Radiation Threshold Limit Values (TLV). In November 1998, OSHA fined D.L. Markley & Associates, Inc. located in Illinois (Inspection 302110010) \$1,500, for exposing employees to a high level radio frequency (RF) in excess of the recommended safe level as set forth in IEEE-C 95.1-1991 IEEE Standard for Safety Levels with respect to Human Exposure to Radio Frequency electromagnetic fields. The most recent violation was in March 2000, OSHA fined Rite Hite Corporation located in Iowa (Inspection 300375409) \$1,300, for exposing employees who were operating the Kabar 15000FS RF Heat Sealer to radio frequency radiation above the maximum permissible exposure level as defined by the American Conference of Governmental Industrial Hygienists in the 1997 TLVs and BEIs Threshold Limit Values for Chemical Substances and Physical Agents Biological Exposure Indices and the American National Standards Institute (ANSI)/ Institute of Electrical and Electronic Engineers (IEEE) C95.1-1991.

Prior to 2002, the FCC had apparently not placed a high priority on RF safety compliance. However, a rising chorus of public concern over the proliferation of cellular towers and perceived RF hazards from these towers moved the FCC to issue its 2000 compliance warning. Ironically, the first victims of this stepped up enforcement were radio broadcast stations. Heretofore, FCC compliance actions focused on the requirement to submit studies prior to operation to meet NEPA requirements, and a few actions against AM stations for failure to maintain fences around their towers to prevent RF contact burns<sup>21</sup>.

In an article titled RF Safety Compliance<sup>14</sup>, written by Richard Strickland and published in *Mission Critical Communications*, June 2003 issue (<http://www.mccmag.com>), Mr. Strickland states,

*“On November 18, 2002, the FCC issued a historic first fine for an RF safety violation: An FM radio station received a Notice of Apparent Liability and Forfeiture (NAL) and a \$10,000 fine. Four days later, the second NAL was issued to a different FM station, along with another \$10,000 fine. Insiders say that many more fines will follow. Two years ago, RF safety issues were not even on the checklist for FCC inspectors. Today every inspector has a fourteen-point RF safety checklist to follow for every site that they visit. Current plans for inspectors include implementing a comprehensive training program and equipping them with survey instruments. At the same time that the FCC has been stepping up its enforcement of RF safety issues, there have been developments at the state level. Two states have passed legislation that requires any company operating antenna systems on towers to have an RF safety program. These new regulations are being challenged so their future is uncertain. While these new regulations may yet be rescinded, some authorities believe that these requirements will evolve into national requirements. And although OSHA activity has been limited, their position has been made clear regarding the need for RF safety programs.”*

There have been other FCC compliance actions since 2002, the most recent being particularly instructive of their apparent current course. In February 2007, the FCC levied fines totaling \$45,000 on three radio stations in Florida and Hawaii citing “willful and repeated violation” of the Commission Rules by failing to comply with radio frequency radiation maximum permissible

exposure<sup>5,6,7,12</sup>. The violations created unsafe conditions for rooftop workers, yard workers, and the passage of the general public. It was found that the stations failed to prevent access to areas with excessive MPE due to unclear or missing warning signs, lack of gates and other barriers, and/or failure to provide worker training in RF safety. In a “first”, the FCC determined that one station only contributed 5% of the RF problem, but was fined the full amount as the larger contributor<sup>8</sup>. (C) The FCC policy is essentially a “joint and several” compliance liability for contributors above 5% of a violation. It is apparent that the FCC is taking an orientation much more safety oriented, rather than earlier actions which recognized technical rules violations.

## **Training and Education**

The best ways to minimize liability risk are to keep people from getting hurt and to be fully compliant with all regulations and with applicable guidelines. An essential component of compliance is the implementation of an effective RF safety program which includes training and education. Reduction in RF exposures can be accomplished through the implementation of appropriate administrative, work practice, and engineering controls. These various controls are the elements of an RF Protection Program, and should be a part of an employer's comprehensive safety and health program. In complex environments, an audit of RF generators and susceptible populations and devices is very important. A variety of RF measurements and/or computer modeling simulations are frequently necessary for an effective RF Protection Program. For example, OSHA's website on radiofrequency and microwave radiation contains a document which outlines the elements of a comprehensive RF Protection Program and the role of RF measurements in implementing the program. However, an appropriate program is highly location and process driven, and should be fully assessed by an RF safety professional.

Academic safety programs should address radiofrequency safety in their course of study. Future safety professionals will need to be cognizant of the possible radiofrequency hazards and what should be included in an effective RF program. There has been more attention given to RF hazards and as noted in this paper, there have been compliance and regulatory implications for companies that ignore these types of hazards. Safety educators need to examine trends and address them in the classroom so their students are equipped with the best and most comprehensive knowledge of safety and thus should include topics such as radiofrequency effects.

## **Survey Response Rate**

The entire survey was developed and the results were managed using the software SelectSurveyASP Advanced. An email notification about the survey was developed and a weblink to connect to our server in order to complete the survey was included in the email. The notification was sent to a total of 108 potential respondents. These individuals were identified from American Society of Safety Engineer's (ASSE) website. Emails were gathered from the College and University Directory webpage on ASSE's webpage. There were nine undeliverable emails and two additional emails sent. Two of the respondents referred a colleague to better answer the survey and thus were added to the usable total.

The response rate was 31.6% for all respondent groups combined. This is based on 32 usable responses returned from 101 valid email notification recipients.

## Results

Research questions asked the demographics of the respondents, if their degree designated an entire class to Radio Frequency, if they taught Radio Frequency as a part of course, and if Safety, Health and Environment courses should discuss Radio Frequency safety. Information presented in Tables 1 through 3 highlights descriptive statistics (frequency).

### *Demographics*

There were two research questions that asked:

1. What type of safety and health degree does your institution have?
2. What is the level of education of this degree?

The respondent could answer could only pick one answer that was closest to their degree and answers for type of safety and health programs were: Occupational Safety, Environmental Health, Occupational and Environmental Health and Safety, Fire Protection, Industrial Hygiene, Hazardous Material Management, Environmental Quality, Work Environment Policy, Safety Studies (Safety Sciences), Industrial Technology and other.

There were 30 total responses from this question (two skipped the question). Occupational Safety degree had the highest response rate at 47% and Occupational and Environmental Health and Safety had the second highest response rate at 23%. The respondents that listed other could enter in their program and the two responses stated “Engineering with a minor in Occupational Safety” and “Risk Control”.

Table 1

*Type of Safety and Health Degree*

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Response	f	Count
Occupational Safety	47.0%	14
Environmental Health	10.0%	3
Occupational and Environmental Health and Safety	7.0%	7
Fire Protection	3.0%	1
Safety Studies (Safety Sciences)	3.0%	1
Industrial Technology	7.0%	2
Other	7.0%	2

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There second research question that asked the level of education of this degree. The respondent could answer could only pick one answer and answers include: Associates of Applied Science, Bachelor of Science, Master of Science, Doctorate, and Certificate.

There were 32 total responses from this question. Bachelor of Science had the highest response rate with over 50 percent (56%), while Master of Science had 8 respondents (25%) and Associated of Applied Science had a 16% response rate.

Table 2

*Level of Education of the Degree*

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Response	f	Count
Associates of Applied Science	16.0%	5
Bachelor of Science	56.0%	18
Master of Science	25.0%	8
Doctorate	3.0%	1
Certificate	0.0%	0

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*Radio Frequency Taught in Courses*

The next two research questions asked if there was an entire class designated for Radio Frequency and if Radio Frequency was taught as part of another course. The respondent could answer “Yes” or “No” for the first question.

There were 30 total responses from the question regarding if there was an entire class that was designated for Radio Frequency (two skipped the question). All respondents reported that there was not a class designated for Radio Frequency (100%).

The next research question asked if Radio Frequency was taught as a part of another courses. There were 32 responses to this question. The responses were 15 (47%) “Yes” and 15 (47%) “No”; however, there were two responses that stated “Yes and list the courses”. This would bring the total of “Yes” responses to 53.1%.

*Should Radio Frequency be Taught in Courses*

The next research questions asked if Radio Frequency should be discussed in Safety, Health, and Environmental courses. The respondent could answer “Yes” or “No”. There were 30 total responses from the question regarding (two skipped the question). Of the responses, 73% thought Radio Frequency should be taught in Safety, Health, and Environmental courses.

The final section of the survey was a comment section that allowed the respondents to provide any additional thoughts on the survey or about Radio Frequency in Safety, Health, and

Environmental education. There were 18 total responses from this section and are reported in Table 3.

Table 3

*Comments*

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I answered "no" to #5, but am interested in learning more about this topic.

Level of detail (sic) in our classes is low at BS level and a combination with Fire Protection. Probably "right" would be a course that covered the electromagnetic spectrum with respect to effects on humans and control measures.

Having worked as a consultant to the FAA and as an insurance safety consultant, I have a good appreciation of the need for some discussion of this type of hazard.

The subject is mentioned within the topic of electromagnetic radiation hazards; however, the subject is not presented in great detail because of the lack of understandable material. i.e. for those without a background in physics.

Radio Frequency (sic) is a specialized part of OHS. An awareness level should be taught and if the practitioner (sic) needed more information then research would help them in their pursuits

We offer an environmental engineering degree and teach design courses involving water/wastewater, air pollution, bioremediation, air chemistry, hydraulics, and public health

Northeastern State University's student section of the American Society of Safety Engineers did a large research project on this topic last year. The students actually purchased meters and surveyed many of the most popular hangouts on campus and then developed a map of areas considered high based on current literature.

While an important topic, few safety curriculums could afford to devote an entire course to radio frequency safety. It is much too focused a topic to merit a separate course

This topic is not viewed by industries that I am involved with nor are my colleagues interested in this topic with the seriousness of other hazards.

We also have MS and PhD programs in Environmental Health and Occupational & Environmental Health Sciences. However, I restricted my responses too our undergraduate program, with which I am most familiar. If you would like a definitive response with regard to our graduate programs, I suggest that you contact ...

Table 3

*Comments (continued)*

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Response

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Minimal coverage as part of the broad topic of non-ionizing radiation.

Taught as a minor topic

It is one of those topics that can be very important depending on the target market for students. In general in my experience (sic) this has not been an issue.

I think the subject would be appropriate in some programs, but not ours.

I have not seen substantive studies linking radio frequency exposure to adverse health effects.

Discussion appropriate for .5 - 1.0 class

How about those that are doing something in the field drop we that do not some information.

This is not a topic with which I am very familiar, so I'm not certain as to the validity of its inclusion in our courses; however, it is something I will now be researching, after completing this survey!

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### **Implications and Conclusion**

Of the 101 potential respondents, 32 participants completed the survey for a response rate of 31.6%. This is slightly below the typical email survey response rate of 36.83%<sup>12</sup>. The results of this study are important in that the data collected emphasizes a need for further research in the area of Radio Frequency and higher education. Although over 50% already teach Radio Frequency as part of another Safety, Health, and Environment courses, over 70% of the responses stated that Radio Frequency should be taught in these courses. This shows a discrepancy of over 20%. Radio Frequency Safety research is limited and even more limited when it comes to governmental regulations, but as incidents, accidents, and compliance and enforcement increases, the need to instruct future safety practitioners will grow.

This research shows that safety programs should address radiofrequency in their course of study. Future safety professionals will need to be cognizant of the possible radiofrequency hazards and

what should be included in an effective RF program. There has been more attention given to RF hazards and as noted in this paper, there has been compliance and regulatory implications for companies that ignore these types of hazards. Safety educators need to examine trends and address them in the classroom so their students are equipped with the best and most comprehensive knowledge of safety and thus should include topics such as radiofrequency.

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