

Occupational Cancer Protection by most Recommended International Administrative Control

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Abstract

Background and purpose: Microwave and radio waves are a class of non-ionizing beams that have a variety of applications in different environments, and uncontrolled exposure to these beams can lead to cancer. This study aims to review the most managerial measures recommended by international organizations to control occupational exposure to these beams. **Methods:** All reference organizations were identified concerning the research topic. Then, keywords were designed based on the PICO principle. All published documents such as governmental documents, legal rules or regulations, reports, guidelines, manuals were retrieved. In addition, searches were made in two databases (BING and GOOGLE). Then, retrieved documents were screened for duplication and relevancy, and quality of work. All documents providing management measures were utilized for this analysis. Documents with incomplete and obscure information were not utilized. **Results:** The results of this study showed that several national and international institutions are active in the field of occupational protection against radiation and microwave radiation. The proposed management controls are varied by the organizations involved and include 15 enforcement actions, including maintenance, safety, and warning signs, environmental monitoring, compliance with exposure limits, access restriction and reducing energy output are the most recommended measures. **Conclusion:** Exposure, maintenance, and access restrictions have been the most common management control proposed. Among international institutions, the ILO has provided the most diverse and detailed management advice and controls.

Keywords: Management Controls- Non-ionizing Beams- radio beams- microwave beams- International Organizations

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Introduction

Microwave and radio waves are a group of non-ionizing beams operating in various sectors such as telecommunications, military, fixed and mobile communications systems, radar and marine navigation systems, satellite communications, computer networks, air traffic, radio and television transmitters, and so on. Medicine is used like diathermy [1-2].

Uncontrolled occupational exposure to this radiation can cause thermal and non-thermal injury to workers. Therefore, it is necessary to control the exposure of employees [3]. Management practices include control measures that are at the bottom of the pyramid of risk

control after engineering methods. Management controls, meanwhile, emphasize changing operating procedures. In this category of controls, the processes and operating procedures used by employees are changed. Management measures have been easily implemented in many cases and they are much less expensive than engineering methods. On the other hand, it can control occupational exposure with lower cost and acceptable efficiency compared to personal protective equipment that is restrictive and not easily accepted by employees [4]. This study seeks to examine, using a descriptive review, the management measures recommended by international organizations

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Table 1. Summary of Management Controls Recommended by International Organizations

Row	Title of the proposed action	Abbreviation of the proposing organization
1.	Inspection	ILO-OSHA
2.	Medical monitoring	ILO-OSHA
3.	Employee participation	ILO-OSHA
4.	Safe working instructions	ILO-OSHA
5.	Compliance with standards	ILO-OSHA
6.	Maintenance	ILO-OSHA-FCC-EPA
7.	Locking and labeling	ILO-OSHA
8.	Signs of safety and alarms	ILO-FCC-ICNIRP
9.	Environmental monitoring	ILO-OSHA-FCC
10.	Employers' Responsibility	ILO-OSHA
11.	Exposure limits	OSHA-ACGIH-ICNIRP-IEEE-FCC
12.	Limit access	ILO-ICNIRP-FCC- Canada. Environmental Health Directorate
13.	Reduce energy output	O-FCC- Canada. Environmental Health Directorate
14.	Observe distance and control exposure time	ILO-OSHA
15.	Education	ILO-OSHA

for the control of occupational exposure to non-ionizing radiation - with emphasis on radio and microwave radiation. Therefore, the following organizations and their proposed management measures will be introduced.

Analysis method

At first, the areas of science related to the subject of research were identified to determine organizational and information resources. Reference agencies were then researched on the subject and searched for keywords (without any time limits in English) using the relevant keywords that were designed based on the PICO principle. Population keywords: Radiofrequency, Microwave, Non-Ionization Radiation, Occupational, Worker, Airline Worker, Navy Worker, Police Officer, Weather Worker, TV and Radio Transmitter, Oven, wireless.

Output keywords

Occupational control, control in workplace, occupational prevention, Non-Ionization Radiation protection, Non-Ionization Radiation control.

Then the information published by related organizations that were published in the form of a Government Document, Legal Rule Or Regulation, Publication, Report, Guideline, Manual.

To ensure more comprehensive results, in addition to the target organizations' site, a search was conducted on two external databases (BING and GOOGLE) and the information of the target organizations was collected in the form of the above and related to the research subject. After this step, the process of reviewing, screening, and removing duplicate or irrelevant information was performed. Then related resources were restored (using a checklist and finding other related resources) among the related material. After providing the full text of the relevant material, the process of translating and extracting the relevant research information was carried out with the focus of service providers and their recommended

management measures. It is worth mentioning that in this study, inclusion and exclusion criteria were considered. Information that was incomplete or related to other non-ionizing beams or whose emission organization was unknown was excluded. Since this study included studies that were necessarily published by reference organizations in the form of the above, so are studies such as animal studies, descriptive studies (case, contextual, continuous, cross-sectional, and concordant), empirical studies (types Clinical and analytical trials, meta-analysis, and systematic reviews were not included in this study.

Discussion

This section introduces common international organizations and management controls published by them on occupational exposure to non-ionizing radiation - with emphasis on radio and microwave radiation.

Organization

Some international bodies, such as the International Committee for Non-ionizing Radiation Protection (ICNIRP), Canada. Environmental Health Directorate and the US Department of Labor Health and Safety (OSHA), have specific control programs for radiation and microwave protection. It is accepted and used by many countries. Control measures in workplaces to reduce employee exposure to microwave radiation include engineering controls, management controls, and personal protective equipment [5-7]. The International Committee for Non-Ionizing Radiation Protection works on the effects of these rays on human health and their control, as well as on the development of exposure standards [7].

The committee considers the safeguards necessary for staff, including engineering, management, personal protection programs, and medical monitoring. It also emphasizes that, first, engineering controls should be used to reduce the number of electromagnetic fields emitted by

Table 2. Summary of the Most Widely used Management Controls Recommended by International Organizations

Row	Some features/examples of suggested action	Abbreviation of suggesting the organization
1. Exposure limits	Observe the six-minute time limit with the power density of 10 milliwatts / cm ² in the frequency range of 100 MHz to 100 GHz Observe the six-minute time limit of the power density of 10 milliwatts / cm ² in the frequency range of three to fifteen GHz	OSHA - ACGIH-ICNIRP-IEEE-FCC
2. Limit access	Access trained and qualified staff to radiation sources, use nets to prevent unauthorized employees from attending, use a permanent and permanent locking system for facilities that have been installed for a month or more, install prohibited signs. On the equipment and equipment in operation, the use of locking and labeling systems, the use of physical barriers (such as walls) to ensure that different people are away from radiation sources, the designation of hazardous areas	O-ICNIRP-FCC-Canada. Environmental Health Directorate
3. Maintenance and repair	Perform maintenance and maintenance according to standard operating instructions, use of qualified and trained personnel, disconnection of all electrical power supplies, training of maintenance personnel, proper installation of protective shields after repair and maintenance.	ILO-OSHA-FCC-EPA
4. Reduction of energy output	Reduction of output power of the generator/transmitter device, shutdown of the device when the output intensity is high, repair or replacement of worn transmitter systems, closure of the cabinets of the voltage amplifier and ampere transmitters of the microwave transmitter, reduction of the number of transmitter, one or more outgoing Transmitter from operating circuit, selection of standard equipment with low radiation power, interruption or loss of equipment during maintenance operation, guidance for antenna radiation to the outlet of the workshop, use of antenna circulation limiting devices	O-FCC-Environmental Directorate Canada. Health
5. Safety signs and warnings	Clear marking of dangerous areas, use of individual monitors, use of audible and visual alarms	LO-FCC-ICNIRP
6. Peripheral monitoring	Installation of warning signs on moving beam generating systems above the permissible level, installation of safe working instructions at safe distance from the permissible beam moving beam system, measuring the intensity of radio fields during work activities, assessing exposure levels in the surrounding environment Dangerous areas	ILO-OSHA-FCC

generating devices to an acceptable level of exposure. [7]. This committee is recognized as a non-governmental organization in the field of non-ionizing radiation protection for the World Health Organization (WHO), the International Labor Organization (ILO) and the European Union (EU) and with other international bodies such as the International Committee Electrotechnical (IEC), European Committee for Electrotechnical Standards Development (CENELEC), International Lighting Committee (CIE) and International Organization for Standardization (ISO) have various collaboration. It also provides consulting services to the International Association for Radiation Protection (IRPA) [8-9]. The International Committee for Non-Ionizing Radiation Protection, in its Second Practical Guide to Employee Protection against Radiation and Microwave Radiation, provides nine occupational exposure control techniques including controlled and unregulated enclosures, supervisory controls, proper installation of equipment Indicates, confined sources, non-enclosed sources, warning signs and labeling, enclosure control and labeling of supplies and accessories. A review of the above nine measures shows that most of these

recommendations fall under the category of management controls [10].

Common management controls from the perspective of international organizations

A review of the management controls recommended by the proposed organizations showed that according to Table 1, these measures can be categorized into fifteen different groups, out of which six are among the most widely used management practices recommended by international organizations. These are recommended (Table 2), which will be described below.

Maintenance procedure

Inspections and studies conducted by the US Environmental Protection Agency and the US Federal Communications Commission show that employees who repair and maintain AM radio towers are most likely to be over-exposed [11-12]. The International Labor Organization, therefore, declares that the maintenance of radio broadcasting resources should be carried out following standard guidelines. Sometimes it is necessary to

remove the relevant panels during maintenance to access the cabin. This should only be done by people who have received specialized training in the use of this equipment and are aware of the potential hazards and how to protect against these beams. It also recommends cutting off all power supplies that power radio devices before any repair is done. After the repairs are completed, all components, including the protective shields required, must be installed and installed before the power connection. The organization emphasizes that maintenance personnel should be made aware of the necessity and importance of properly installing all connectors, office panels, and doors so that they believe they are necessary. Any defect in the positioning of a protective shield may leak high levels of radio waves and allow direct access to 5000 volts or more inside the generator. It is worth noting that contact with these high voltages is fatal. Although shielding is the first and foremost safety measure to control exposure to radiation, safety care involving appropriate maintenance processes can significantly reduce the amount of employee exposure [11]. The US Occupational Safety and Health Administration has used maintenance as one of the principles of its nine-year protection program so that the ninth principle of its occupational protection program recommends the proper installation of appropriate shields after repairs and maintenance [13-14].

Safety and warning signs

According to the recommendation of the International Labor Organization, radio-hazard areas should be marked with appropriate signs and obstacles. These safety signs must be identifiable and readable within three meters. [11]. According to the US Federal Communications Commission, individual radio monitors can be used as a valuable component of a safety program to protect employees from excessive exposure to these beams. These devices can detect the risk of people being in a radio field with an intensity exceeding the maximum permissible limit and acting as a reliable detector. The commission insists that the performance of the alarms be audible or audible. The US Federal Communications Commission recommends the use of these devices in all workplaces, especially in areas with multiple transmitters, and emphasizes that these devices can only be used as alarms and cannot provide protection [15-16]. The International Committee for Non-Ionizing Radiation Protection, in its Practical Guide entitled "Employee Protection against Radiation and Microwave Radiation," states that management controls such as the use of audible and visual alarms should be used in combination with engineering controls [7]. The ILO also points out in its Guide to Protecting Employees from Radiation and Microwave, that portable and portable systems capable of generating excessive exposure levels should have warning signs and that such signals Also be visible. It is also emphasized that these signs must be following the installation instructions and be installed at a distance from the system where the exposure level is below the permitted level [10].

Workplace monitoring

The US Department of Health's Occupational Safety and Health Administration, in its nine protection program, emphasizes measuring the intensity of radio fields in extended work activities and identifying hazardous areas. [13]. In this regard, the International Labor Organization also emphasizes environmental measurements to identify hazardous areas and recommends that, if there are areas of exceeded permissible intensity, areas known as "radio-hazard areas" should be identified around each source, and Workers in these areas should be warned. Besides, the US Federal Communications Commission also emphasizes conducting exposure assessments in the areas adjacent to hazardous areas and enforcing laws and procedures regarding compliance with exposure limits. [13]. Studies show that the most protective measures used to control occupational exposure to high-frequency non-ionizing radiation are the use of management measures. [10-15]. One of the types of management controls that are widely used in this area is exposure limitation. The US Occupational Safety and Health Administration has set the effective power density limit for a maximum of 0.1 hours for a frequency range of 10 MHz to 100GHz, in milliwatts/cm². In 2008, the American Society of Industrial Health Professionals announced a threshold value for microwave beams in the frequency range of three to fifteen GHz, 10 milliwatts / cm² for six minutes of exposure [5]. The Society of Electrical Engineers has also set the milliwatts / cm² as the maximum occupational exposure limit for a frequency range of three to fifteen GHz [15-16]. One of the proposed control measures by the US Federal Communications Commission in compliance with maximum exposure limits. The commission recommends that employees be assessed for the exposure time allowed, and not violate the six-minute standard. This period applies to employees who are passing through an exposed area. But it is not suitable for personnel such as repairs and maintenance whose work is longer. In such a case, the working time should be divided into smaller time intervals so as not to exceed the exposure limit [13].

Access restriction

Occupational exposure of employees to radio fields in workplaces or other controlled environments poses different problems than exposure to the general public. Restricting access to high-intensity radio fields is one of the management control measures that can be used as a safeguard to protect the safety and health of employees. The US Federal Communications Commission says this may not always be possible. In some cases, employees may be working too close to radio sources, which can sometimes (depending on the level and timing of exposure) make it difficult to comply with exposure standards [13]. The commission recommends that areas exposed to radio and microwave radiation should be restricted and accessible only to staff who have been given the necessary training and awareness and that protective measures have been applied [11]. Besides, the US Federal Communications Commission also emphasizes conducting exposure assessments in the areas adjacent

to hazardous areas and enforcing laws and procedures regarding compliance with exposure limits [13].

Exposure limit

Studies show that the most protective measures used to control occupational exposure to high-frequency non-ionizing radiation are the use of management measures. [10-15]. One of the types of management controls that are widely used in this area is exposure limitation. The US Occupational Safety and Health Administration has set the effective power density limit for a maximum of 11 hours for a frequency range of 10 MHz to 100 GHz, in milliwatts per cm². In 2008, the American Conference of Governmental Industrial Hygienists (ACGIH) announced a Threshold Limited Values (TLVs) for microwave beams in the frequency range of three to fifteen GHz, 10 milliwatts / cm² for six minutes of exposure [5]. The Institute of Electrical and Electronics Engineers (IEEE) has also set 10 milliwatts / cm² as the maximum occupational exposure limit for a frequency range of three to fifteen GHz [14-15]. One of the proposed control measures by the US Federal Communications Commission in compliance with maximum exposure limits. The commission recommends that employees be assessed for the exposure time allowed and not violate the standard six-minute limit. This period applies to employees who are passing through an exposed area. But it is not suitable for personnel such as repairs and maintenance whose work is longer. In such a case, the working time should be divided into smaller time intervals so as not to exceed the exposure limit [13].

Threshold Limited Values (TLVs)

Occupational exposure of employees to radio fields in workplaces or other controlled environments poses different problems than exposure to the general public. Restricting access to high-intensity radio fields is one of the management control measures that can be used as a safeguard to protect the safety and health of employees. The US Federal Communications Commission says this may not always be possible. In some cases, employees may be working very close to radio sources, which can sometimes (depending on the level and timing of exposure) make it difficult to comply with exposure standards [13]. The commission recommends that areas exposed to radio and microwave radiation should be restricted and accessible only to staff who have been given the necessary training and awareness and that protective measures have been applied. They can be exposed to certain criteria and criteria. The US Federal Communications Commission recommends that transient exposure to these types of radiation should receive additional training and awareness, including other exposure conditions such as occupational exposure [13].

The International Committee for Non-Ionizing Radiation Protection, in its Practical Guide entitled "Employee Protection against Radiation and Microwave Radiation," states that management controls such as access restrictions should be used in conjunction with engineering controls and should, as far as possible, be used. The priority of control measures in the use of engineering and

management controls [9].

The use of grids, the prevention of staff presence and activity in places with high levels of exposure are other access restrictions that are part of the management controls proposed by the International Labor Organization. The organization also cites permanent locking systems as another way to restrict access and states that installations that have been in use for a month or more should have all the barriers to controlling restricted workplaces. All permanent locking systems are also installed on them. [10]. An internal lock is a piece or set of components that, when activated, interrupts the transmission of radio or microwave sources (such as magnetron in microwave ovens or radio transmitters) [16]. In this regard, the Department of Health's Environment Department of Canada, in a document entitled Safety Code No. 6, entitled "The limits of exposure to electromagnetic fields in the frequency range of 10 MHz to 300 GHz" and its edited version (99-EHD-237) The 1999 release highlights the restriction of access. The Office states that all signs and obstructions indicating the boundaries and boundaries of the forbidden places must be installed for any device and equipment to be installed while in operation. Besides, all internal locking systems must be permanently and permanently installed on the equipment to prevent accidental and unwanted radiation to other areas [11]. The US Occupational Safety and Health Administration recommends restricting traffic in hazardous areas by using lock-and-mark procedures and warning signs in its nine-point protection program. The third principle of its protection plan emphasizes the need to identify and control hazardous areas [13]. The International Labor Organization says physical barriers can also be used to make sure other people stay out of radio-hazard areas. For these barriers to be effective, it should be noted that barriers are not easily portable and are sexually selective and non-conductive. The use of electrically conductive materials in physical barriers can lead to the induction of electrical currents from radio sources on them and ultimately to shock or burns. In such cases, natural barriers such as walls are preferred [11].

Minimizing the RF Energy Leakage

In addition to observing the permissible exposure time, the US Federal Communications Commission points to other measures to control occupational exposure to microwave and radio beams, such as reducing power and turning off the device when its output radiation is high. It is worth noting that replacing or repairing transmitter systems is one of how the intensity of the radio beam is greatly increased. The commission's recommendations include reducing power or Radiofrequency Shielding in environments where there are multiple transmitters. This can be a very important and effective safeguard until the work permits are issued. In other words, in such environments, due to the high power available, the transmitter power must first be reduced and then the work required for the issuance of work permits [13].

The commission also states that the cabinet doors should be closed when the transmitter is turned on because

the power available in the booster cabs is too high and the current of the microwave transmitter can be high. It is worth noting that where there are multiple transmitters of high-intensity radio beams, it is possible to expose people to these types of radiation when the transmitter is not in use and is completely switched off. Therefore, the Commission emphasizes that if several high power transmitters are close to each other, the exposure level should be assessed and if the exposure level exceeds the permissible limit, the number of transmitters should be reduced to below the standard energy level. One or more transmitters can be unloaded from the circuit, or the transmitter can reduce the amount of energy emitted by any beam in each transmitter [13]. The International Labor Organization points to the selection of appropriate equipment as another measure to reduce the energy output of microwave and radio beams. According to the organization, selecting equipment that has less radiation power can reduce staff exposure and insist that equipment and equipment should be installed in such a way that people's exposure is reduced as much as possible. This principle refers to ALARAP law [10]. The law reduces the level of risk to the extent that it is reasonable and practicable [15].

Also, cutting or lowering the power of equipment during repairs can be used as a technique to reduce power output levels and control maintenance and maintenance personnel [10]. Besides, simplifying business processes is one of the effective measures that can reduce energy balance and exposure. In this way, the operational steps in the work processes are reduced. In other words, complex and lengthy work processes are divided into several small and simple work processes [13]. To implement the technique of reducing energy output, the ILO recommends that workplaces that may be directed outside the workplace to be exposed to antenna radiation be reduced to reduce the energy level reached to employees. If this was not possible, exposure standards should be complied with. Antennas may be used to restrict circulation or reduce the power of radio beams in the workplace if needed to prevent increased employee exposure [10]. It is noteworthy that the Department of Health's Environment Department of Canada also mentioned and used the above recommendations in its safety document to protect employees' occupations against these beams [11].

In conclusion, the findings of this study showed that several national and international bodies, such as ILO, OSHA, FCC, ICNIRP, EPA ACGIH, IEEE, and the Canadian Department of Health's Department of Environmental Health are working to protect against occupational radiation such as radio and microwave radiation. Also, the findings of this study showed that the proposed management measures varied by the organizations concerned and were presented in fifteen different groups including inspection, medical monitoring, staff participation, safe work guidelines, standards compliance, maintenance, locking, and labeling. , Safety signs and alarms, environmental monitoring, employer responsibility, compliance with exposure limits, access restrictions, reduced energy output, distance observation,

and training. Some organizations offer solutions in limited areas, such as the IEEE and ACGIH, which merely recommend compliance with exposure limits, while others, such as the International Labor Organization and the US Department of Labor Health and Safety, offer more. They have provided various management controls so that the two organizations have made numerous suggestions and recommendations in almost all of the management practices presented in this study (Table 1). In the meantime, the International Labor Organization has proposed the most comprehensive and varied management measures, proposing fourteen control strategies. The survey of organizations and management controls presented in this study shows that some control measures are of particular importance so that the organizations that are most active in the field of occupational protection against radio and microwave radiation are considered. Exposure limits (recommended by five entities), maintenance (recommended by four entities), and access restrictions (recommended by four entities) were among the most cited management controls, which were considered by most active organizations. (Table 1). An internal literature review showed that the document "Conditions for Working with Radio and Microwave Radiation" published by the Iranian Atomic Energy Organization in 2008 shows that the document implements more than two hundred types of management control measures recommended by international reference organizations. , Emphasized that include observing the limits of exposure to radiation and the general public, assigning duties and responsibilities (including license holder, health physicist, responsible person, and staff), environmental monitoring (measuring radio and microwave fields), installing warning signs and hazards (In different areas and on the device), observe the regulations for installation and installation of equipment D. Inspection of work centers with sources of radio and microwave radiation, reduction of energy output (in radar and telecommunication systems regulations) maintenance and repair (in microwave oven regulations), access restrictions, exposure time control, and compliance standards and regulations. Therefore, this national document can be made one of the most comprehensive guidelines for protection against radio and microwave radiation, taking into account the requirements of medical monitoring, staff participation, safe working procedures, locking and labeling, and training.

It is worth noting that the variety and usability of the management controls presented in this study are such that they can be used not only in different work environments but also to control many of the harmful factors in the workplace. It is therefore recommended that the results of this study be incorporated into health policy-making in the field of radiation health and safety, as well as a simple training guide to familiarize managers, health and environmental experts with current management controls that are recommended by international organizations, to be used. It is also recommended that future studies examine the impact of applying other management strategies such as the use of special diets (such as antioxidants) and exercise to introduce them to international organizations.

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