[Insert Site Name]

Non-Ionizing Radiation Safety Program

(This document has been developed as a guideline to help companies who have Non-Ionizing Radiation (NIR) sources and must comply.)

1. PURPOSE

The purpose of the non-ionizing radiation safety program is to ensure the safe use of Non-Ionizing Radiation (NIR) sources and to meet the expectations of the Standards.

2. SCOPE

This procedure has been established for operations and employees working at the [SITE NAME].

The use of non-ionizing radiation sources or equipment will be allowed only in a manner that is safe for all employees, contractors and visitors at [SITE NAME]. Non-ionizing radiation includes all sources of electromagnetic radiation with wavelengths greater than 100 nm such as lasers, microwaves and ultraviolet radiation.

3. RESPONSIBILITIES

<u>[SITE NAME]</u> Site Management

3.1 Management will:

- Ensure NIR safety and health controls and programs are implemented.
- Ensure compliance with & Standards, Country and local rules and regulations.
- Ensure NIR program is integrated into site safety programs and committees.
- Appoint and empower a NIR Coordinator

3.2 Supervisors/Team Leader and users [NAMES]:

- Ensure that NIR sources or equipment are used safely.
- Provide appropriate PPE (eg., eye and body protection) and ensure that it is worn when necessary.
- Ensure that all staff using equipment is trained in the procedures necessary for safe operation of NIR sources.
- Submit written procedures for use of any NIR sources and equipment when requested by NIR COODINATOR.
- Notify Health Services staff and NIR COODINATOR in case of an incident, accidental or potential over-exposure to NIR.
- Ensure that any malfunctioning piece of equipment which presents a potential hazard is removed from service immediately.
- Ensure that only authorized individuals operate NIR or have access to controlled/restricted areas.
- Ensure that all proper warning signs are posted.

- Notify NIR COODINATOR before ordering NIR sources to ensure the site inventory is accurate and up-to-date and a risk assessment may be completed.
- Promote medical surveillance requirements where appropriate.

3.3 Employees' Responsibilities:

- Follow supervisor and NIR COODINATOR instructions for safe operation of equipment.
- Immediately inform his or her supervisor and NIR COODINATOR of any potentially hazardous source of NIR or hazardous aspects of his or her operation.
- Wear proper eye protection and protective clothing as required when working with sources such as ultraviolet, laser, and high-intensity visible light, which are capable of causing eye damage.
- Immediately terminate any work that is deemed unsafe or could lead to personal injury.
- Notify the supervisor and Occupational Health immediately in case of incident or accidental exposure to NIR that may cause personal injury. Complete NIR COORDINATOR investigation assessment.

3.4 [NIR COORDINATOR NAME] Responsibilities:

- Assist the supervisor in defining or identifying hazardous equipment, outlining safe practices and selecting appropriate protective equipment.
- Review and approve written procedures for the use of NIR sources when required.
- Maintain an inventory of all potentially hazardous NIR sources.
- Support inspection program for any/all potentially hazardous NIR radiation sources.
- Provide training for users as required/requested.
- Coordinate with medical/occupational health in providing medical monitoring when indicated.
- Suspend use of a machine if it is deemed to present a clear and present danger to the health and safety of staff.
- Maintain other appropriate details in support of the site's NIR program like risk assessments, surveys/inspections, regulatory requirements, etc.

4. REQUIRED PROGRAM ELEMENTS

4.1 Facility Design and Controls

Limiting NIR hazards and exposure are expected to be accomplished primarily through engineering design and controls. Appropriate controls should be incorporated into a structure, facility or local process. New designs should focus on containment and include the use of shields, curtains or enclosures. Consult Appendix B for guidance on a specific source of NIR.

4.2 Administrative Procedures

Protective measures (e.g., step by step instructions, use of signs/labels, etc.) are expected to be incorporated into written operational procedures to control or further limit employee exposures. Before a system or equipment that uses or emits NIR radiation is used for the first time, the operating procedures should be reviewed by the area supervisor. The NIR Coordinator should be consulted to assist in developing administrative controls and procedures. If the system changes or modifications are made to equipment, the operating procedures should be re-evaluated to ensure that the controls are still appropriate and aligned with manufacturer's recommendations. Consult Appendix B for guidance on a specific source of NIR.

4.3 Warning Signs and Labels

Area and equipment safety signs and labels are expected to be part of the practices to ensure the safe use of NIR. The NIR Coordinator should be consulted to assist in identifying the necessary signs and/or labels to use which are determined by the source and characteristics of the NIR.

4.4 Personal Protective Equipment

If engineering designs have not fully contained the NIR and levels that approach exposure limits exist after administrative controls have been established, appropriate personal protective equipment (PPE) is expected to be utilized. A wide variety of PPE is available to protect employees from NIR. The NIR Coordinator should be consulted to assist in identifying the need for PPE. Consult Appendix B for guidance on a specific source of NIR.

4.5 Assessments, Surveys and Monitoring

All sources of NIR are expected to be assessed for hazards/risks. The specific assessment and level of evaluation (quantitative vs qualitative) will depend on the type of NIR, the properties/characteristics of the machine or process and the level of containment or controls implemented. In general, a quantitative assessment would only be required for an open source of NIR. The assessment shall be documented and maintained by the NIR Coordinator. Additional surveys and monitoring may be necessary but, will depend on the NIR Coordinator's assessment of the source and its use. Consult Appendix B for guidance on a specific source of NIR.

4.6 Incidents

The site's emergency response plan is expected to include procedures/provisions to control risks associated with NIR that may be impacted or part of the event/incident. In the event of an incident, site emergency response procedures should be executed and the NIR Coordinator should be notified and part of the response.

4.7 Inventory & Records

An inventory and other records associated with all NIR sources are expected to be maintained. Each department/area should partner with NIR Coordinator to identify and maintain and inventory. The NIR Coordinator should ensure that all regulations are met associated with the disposal of all NIR sources. The inventory and NIR source details should align with the template provided in Appendix C.

4.8 Training

Training is expected to ensure that all users and affected employees understand and recognize the hazards of working with or around sources of NIR. Training should include a practical "hands-on" session, and an instructional "class room" orientation that focuses on general concepts, safe procedures, and hazard recognition. The training should be commensurate to the hazard potential and address the following, as appropriate: Basic concepts and definitions; Engineering controls; Protective administrative controls; Personal Protective Equipment; Specific operating procedures; Monitoring procedures; Applicable regulations and/or guidelines; Health effects; Medical surveillance; and Emergencies, incidents, and injuries.

Periodic retraining should be provided following an initial orientation.

4.9 Medical Monitoring/Surveillance

Employee health monitoring is expected to be part of the NIR program and will be determined if necessary based on the assessments that have been completed and any applicable regulatory requirements.

4.10 Program Evaluation

The NIR Coordinator is expected to evaluate the effectiveness of the program on a routine basis but, not to exceed every 3 years. The Coordinator will inform site management, site safety committee(s) and take corrective action where defects are found in the program.

5. REFERENCES

Additional details are available at a variety of international associations and professional organizations that specialize in various aspects of radiation safety. Consider seeking information from these organizations:

- **International Commission on Non-Ionizing Radiation Protection**
- **Health Physics Society**
- **Laser institute of America**

Website links are available at the homepage -> see Industrial Hygiene -> radiation

APPENDIX A - Definitions

Non-ionizing Radiation (NIR) - is a term generally applied to all forms of electromagnetic radiation whose primary mode of interaction with matter is other than producing ionization. Non-ionizing radiation refers to electromagnetic radiation with wavelengths exceeding 100 nanometers (nm) equivalent to quantum energies below 12 electron volts (ev). Non-ionizing radiation can be subdivided into a number of categories that are wavelength (λ) or frequency (f) dependent:

ultraviolet radiation	100 nm <= λ <= 400 nm
visible radiation	400 nm <= λ <= 760 nm
infrared radiation	760 nm < λ <= 1 mm
radio-frequency/microwaves	300 hertz <= f <= 300 gigahertz
extremely low frequency	f <= 300 hertz

For the purpose of this manual, static electric and magnetic fields, ultrasound, and lasers are considered forms of non-ionizing radiation.

Health Services - The local medical department that partners with operating company personnel and EHS to provide necessary medical care and surveillance where and when appropriate.

Environment, Health and Safety (EHS) - The local department that partners with operating company personnel in the protection of the environment and the prevention of occupational injuries and illnesses.

Non-ionizing Radiation (NIR) Safety Coordinator – The site/company contact identified to coordinate and implement the non-ionizing radiation safety program

Supervisor/Team Leader - The individual responsible for operations in a particular area.

APPENDIX B - Technical Information and Details

Ultraviolet Radiation

Introduction

Ultraviolet radiation is a form of non-ionizing electromagnetic radiation. Ultraviolet (UV) radiation occupies the portion of the electromagnetic spectrum between the wavelengths of 100 and 400 nanometers (nm).

UV radiation exists naturally and is produced by many man-made sources. Life has evolved under the daily exposure to UV radiation from solar radiation and sunlight. UV radiation that comes from the sun and space exhibits a broad spectrum of intensity and wavelength. Many factors influence the exposure level of UV radiation at the earth's surface including: altitude above sea level, geographical latitude, time of year, presence or absence of dust, and pollution. Sources of man-made UV radiation extend across the UV wavelength spectrum. Several man-made sources include incandescent lamps, welding, fluorescent lighting, germicidal and tanning lamps.

Basic Concepts

Electromagnetic radiation can be described as a "wave" that consists of an electric field and a magnetic field. Electromagnetic radiation is usually characterized by wavelength, frequency and/or photon energy. Ultraviolet radiation behaves according to the laws and principles of geometrical optics and is specifically characterized by wavelength. The term wavelength refers to a distance in a line of advance of a wave from any point to a like point on the next wave; it corresponds to the distance traveled by the wave during one cycle. A wavelength (λ) is usually measured in angstroms or nanometers.

$$\lambda = c/f$$ where

λ = wavelength
c = velocity of light
f= frequency

The International Commission on Illumination (CIE) divided the UV spectrum into three wavelength bands primarily due to biological effects. The 315 - 400 nm wavelength band is designated as UV-A, 280 - 315 nm is designated as UV-B, and 100 - 280 nm as UV-C. Wavelengths below 180 nm are of little practical biological significance since they are readily absorbed in air. Sources of UV-A are used for dentistry and tanning, UV-B is used for fade testing and photocuring of plastics, and UV-C is used for germicidal purposes.

Biological effects from UV radiation vary with wavelength, exposure level, and duration of exposure. In general, adverse effects are limited to the skin and eyes. Erythema (e.g., the reddening of the skin in sunburn) is the most commonly observed effect on the skin. Erythema is a photochemical response of the skin normally resulting from overexposure to wavelengths in the UV-C and UV-B bands. Exposure to UV-A alone can produce erythema, but only at very high radiant exposures. Chronic exposure to UV radiation may accelerate the skin aging process and increase the risk of developing skin cancer.

Elevated exposures of UV-B and UV-C radiation may adversely effect the eye and cause photokeratitis and/or conjunctivitis. A sensation of "sand in the eyes" and reddening of facial skin usually occurs within 6-12 hours of the exposure, with the symptoms and discomfort lasting up to 48 hours. UV radiation exposure rarely results in permanent ocular injury, although cataracts have been produced in animals by exposure to UV radiation in the UV-B and UV-A bands.

Regulations and/or Guidelines

Guidelines on UV radiation exposure have been established by the International Radiation Protection Association (IRPA) and adopted by the American Conference of Governmental Industrial Hygienists (ACGIH). The ACGIH publishes the UV radiation exposure limits in their Threshold Limit Values (TLV) booklet annually.

Using the current guidelines, it is expected that repeated exposure at or below the current guideline will not cause adverse health effects. These values apply to all UV radiation sources except UV lasers. These values do not apply to UV radiation exposure of photosensitive individuals or of individuals concomitantly exposed to photosensitizing agents. It should be emphasized that many individuals who are exposed to photosensitizing agents (ingested or externally applied chemicals, e.g., in cosmetics, foods, drugs, industrial chemicals, etc.) probably will not be aware of their heightened sensitivity.

Facility Design and Controls

Limiting UV radiation exposure should be accomplished primarily through engineering design and controls. Appropriate shielding, such as glass, plastic, or other UV radiation absorbing materials, should be incorporated into a structure or facility. New designs should focus on containment and include the use of shields, curtains or baffles.

Protective Administrative Controls/Procedures

Protective measures should be incorporated into the operational procedures to further limit employee exposures. Before a system or equipment that uses or emits UV radiation is used for the first time, the operating procedures should be reviewed by the area supervisor. NIR COODINATOR should be consulted to assist in developing administrative controls and procedures. If the system changes or modifications are made to equipment, the operating procedures should be re-evaluated to ensure that the controls are still appropriate.

Personal Protective Equipment (PPE)

If engineering designs have not fully contained the UV radiation and levels that approach the guidelines exist after administrative controls have been established, appropriate personal protective equipment is required. A wide variety of PPE is available to protect skin and eye exposure from UV radiation. The use of everyday clothing and hats as protective clothing is effective for protecting skin from UV radiation. In some situations, skin creams or ointments designed to protect the skin from UV radiation may also be used.

Most UV radiation is shielded by common eyewear such as sunglasses and prescription lenses. Common glass does not offer complete protection against UV-A, but it is very effective against UV-B and UV-C. Tinted eyewear is often quite effective against UV-A. Eye protection for intense UV radiation sources, such as arc welding, is generally characterized by shade number, a variation of optical density. The specific welding process will determine the necessary shade protection number. It is suggested that you start with a shade too dark to see the weld zone and go to a lighter shade until there is a sufficient view of the weld zone.

Monitoring/Measurements

Because of the variables (e.g., spectral nature of light, the spatial nature of light and measurement geometries) involved in light and UV radiation measurement, it is difficult to accurately quantify exposure levels. All UV radiation sources that are not fully contained/shielded and produce levels that exceed the action level (action level = 50% of the applicable exposure limit/guideline) must be evaluated. A direct reading UV radiation radiometer may be used to evaluate the UV radiation levels. The use of UV film badges may also be used to further evaluate UV radiation and integrate the UV exposure. NIR COODINATOR should be contacted to assist with monitoring or to help characterize exposure levels.

Visible Energy

Introduction

The visible energy portion of the electromagnetic spectrum occupies the region between 400 and 750 nanometers (nm). Intense visible energy or radiation is emitted from the sun, artificial light sources, arc-welding processes, etc. Visible radiation may include the entire spectrum of color and appear as "white light," or be emitted as a specific color or wavelength.

Basic Concepts

Visible radiation is characterized by wavelength and lighting intensity. Irradiance (E) is used to quantify the intensity or power per unit area of visible radiation. Irradiance is typically measured in watts per square centimeter (W/cm^2). Illumination is the direct measure of visible radiation falling on a surface and is measured in units of candles (cd). The term radiance (L) is also used to describe visible radiant power output per unit solid angle per unit area ($W/sr\text{-}cm^2$).

Well balanced levels of visible radiation are essential in establishing safe working conditions. Although intense visible radiation has the potential to cause thermal or photochemical injuries to the eyes, the biggest concern usually arises from poor or inadequate lighting.

Regulations and/or Standards

Guidelines on visible radiation have been established by the American Conference of Governmental Industrial Hygienists (ACGIH). The ACGIH publishes visible radiation exposure limits in their Threshold Limit Value (TLV) booklet annually.

Using the current guidelines, it is expected that repeated exposure at or below the current guideline will not cause adverse health effects. Detailed spectral data may be required to fully evaluate the occupational exposure if the source exceeds 1 cd/cm^2.

Facility Design and Controls

Typical industrial lighting and other sources of visible radiation should not require specific engineering designs and controls. If intense visible radiation must be limited, a less powerful source should be considered. If the intensity must be further reduced, containment or shielding, such as colored glass or plastic, should be considered.

Protective Administrative Controls/Procedures

If necessary, protective measures should be incorporated into the operational procedures to further limit employee exposures. Before a system or equipment that uses or emits intense visible radiation is used for the first time, the operating procedures should be reviewed by the area supervisor. The NIR Coordinator should be consulted to assist in developing administrative controls and procedures. If the system changes or modifications are made to equipment, the operating procedures should be re-evaluated to ensure that the controls are still appropriate.

Personal Protective Equipment (PPE)

If engineering designs have not fully contained the visible radiation and levels that approach the guidelines exist after administrative controls have been established, appropriate personal protective equipment is required. Eye protection for intense visible radiation sources, such as arc welding, is generally characterized by shade number, a variation of optical density. Densely colored eyewear, used to filter visible radiation generally in the blue light region, can be quite effective. It is suggested that you start with a shade too dark to see the weld zone and go to a lighter shade until there is a sufficient view of the weld zone. The specific welding process will determine the necessary shade protection number.

Monitoring/Measurements

Because of the variables (e.g., spectral nature of light, the spatial nature of light and measurement geometries) involved in UV and visible radiation measurement, it may be difficult to accurately quantify exposure levels. Any visible radiation source that may produce exposure levels exceeding current guidelines must be evaluated. If intense visible radiation cannot be contained using engineering controls and employee exposure cannot be limited through administrative controls and personal protective equipment, measurements should be performed. Results may be useful for refining the established administrative controls. A direct reading visible radiation radiometer may be used to evaluate the levels. The NIR Coordinator should be contacted to assist with monitoring if exposures are suspected to exceed the action level (action level = 50% of the applicable limit/guideline), or to help characterize exposure levels.

Infrared Radiation

Introduction

Infrared radiation (IR) occupies the portion of the electromagnetic spectrum between the wavelengths of 0.75 and 3000 micrometers (mm).

Infrared radiation is produced, to varying degrees, by a surface that has a higher temperature than an exposed or receiving surface. Transfer of energy or heat occurs whenever radiant energy emitted by one body is absorbed by another. Infrared radiation is perceptible as a sensation of warmth on the skin.

Typical industrial applications for IR radiation include: drying and baking of paints and other protective coatings, forging, thermal aging, conditioning surfaces, spot and localized heating, and dehydrating of textiles, paper, leather, and food.

Basic Concepts

Similar to visible energy, infrared radiation is generally characterized by wavelength and irradiance (E) or radiance (L). Similar to UV radiation, the International Commission on Illumination (CIE) has divided the IR spectrum into three wavelength bands. The 0.76 mm to 1.4 mm wavelength band is designated as IR-A, 1.4 - 3 mm is designated as IR-B, and 3 - 1000 mm as IR-C. Nomenclature also commonly used includes each of the wavelength bands and their proximity to visible energy. The Near IR includes wavelengths between 0.76 and 2.5 mm, Intermediate IR includes 2.5 - 25 mm, and the Far IR includes 25 - 1,000 mm.

Biological effects from IR radiation vary with wavelength, exposure level, and duration of exposure. In general, adverse effects are limited to the eyes and skin. Acute skin burns and skin pigmentation changes are possible from IR radiation. Eye injuries may result in retinal burns, thermal injury of the cornea, and possible delayed effects upon the lens of the eye (i.e., cataracts).

Regulations and/or Guidelines

Guidelines on IR radiation exposure have been established by the American Conference of Governmental Industrial Hygienists (ACGIH). The ACGIH publishes the IR radiation exposure limits in their Threshold Limit Values (TLV) booklet annually. Using the current guidelines, it is expected that repeated exposure at or below current guidelines will not cause adverse health effects.

Facility Design and Controls
Limiting IR radiation exposure should be accomplished primarily through engineering design and controls. Appropriate shielding, such as tinted glass, plastic or other IR radiation absorbing materials, should be incorporated into a structure or facility. New designs should focus on containment and include the use of shields, curtains or baffles.

Protective Administrative Controls/Procedures
Protective measures should be incorporated into the operational procedures to further limit employee exposures. Before a system or equipment that produces IR radiation is used for the first time, the operating procedures should be reviewed by the area supervisor. The NIR Coordinator should be consulted to assist in developing administrative controls and procedures. If the system changes or modifications are made to equipment, the operating procedures should be re-evaluated to ensure that the controls are still appropriate.

Personal Protective Equipment (PPE)
If engineering designs have not fully contained the infrared radiation and levels that approach the guidelines exist after administrative controls have been established, appropriate personal protective equipment is required. PPE is available to protect the skin and eyes from IR radiation exposure. Everyday clothing (e.g., cotton) can be effective for protecting skin. Most IR radiation is effectively shielded by common eyewear, such as sunglasses and tinted prescription lenses, but should not be worn as PPE without a proper evaluation.

Monitoring/Measurements
Any IR radiation source that may produce exposure levels that exceed current guidelines must be evaluated. Measurements must be performed if there is IR radiation that cannot be fully contained using engineering controls and the PPE and administrative controls have not reduced unnecessary IR radiation to acceptable levels (e.g., very strong warming sensation to the skin observed by employee). A direct reading IR radiation radiometer may be used to evaluate the radiation levels. NIR COODINATOR should be contacted to assist with monitoring if exposures are suspected to exceed the action level (action level = 50% of the applicable exposure limit/guideline).

Radio-frequency Radiation and Microwaves

Introduction
Radio-frequency (RF) radiation and microwaves are defined as electromagnetic radiation in the frequency range of 3 kHz to 300 GHz. RF is arbitrarily defined for the range between 3 kHz to 300 MHz, and microwaves occupy the range from 300 MHz to 300 GHz. Wavelengths associated with RF and microwaves can be as short

as a few millimeters or up to hundreds of meters.

RF and microwaves are being used in many different applications, such as welding, heating, drying, sterilization, broadcasting, etc. Sources of RF and microwaves may emit a single frequency or a large band of frequencies. Specific applications in an industrial setting may include the use of RF to seal bottles on a manufacturing assembly line, or the use of a microwave oven to dry chemicals associated with a pharmaceutical/drug formulation.

Basic Concepts

Radio-frequency radiation and microwaves are generally characterized by frequency. The term frequency describes the number of "wave" cycles per second passing a fixed point along the direction of propagation. One cycle is represented as the period in which the magnitude of the electric field vector varies from zero through its maximum value, back through zero to its minimum value, and finally back to zero. The unit of frequency is Hertz (Hz).

$f = c/\lambda$ where λ = wavelength
c = velocity of light
f = frequency

The following terms can be used to further characterize sources of RF radiation and microwaves and the environments where they are used:

electric field strength (E) - a field vector quantity that represents the force (F) on a positive test charge (q) at a point divided by the charge. Electric field strength is expressed in units of volts per meter (V/m).

magnetic field strength (H) - a field vector quantity that is equal to the magnetic flux density divided by the permeability of the medium. Magnetic field strength is expressed in units of amperes per meter (A/m).

power density (S) - power per unit area normal to the direction of propagation. This is usually expressed in units of watts per square meter (W/m^2).

averaging time (T_{avg}) - the appropriate time period over which exposure is averaged for purposes of determining compliance with the maximum exposure limit.

controlled environment - locations where there is exposure that may be incurred by persons who are aware of the potential for exposure as a condition of employment.

<u>uncontrolled environment</u> - locations where there is the exposure of individuals who have no knowledge or control of their exposure.

<u>near field region</u> - a region, generally in proximity to an antenna or other radiating structure, in which the electric and magnetic fields do not have a substantially plane-wave character but vary considerably from point to point.

<u>far field region</u> - the region of the field of an antenna where the angular field distribution is essentially independent of the distance from the antenna. In this region, the field has a predominantly plane-wave character.

Radio-frequency radiation and microwaves may interact with matter and be transmitted, absorbed, or reflected. Glass acts as a transmitter and during interactions only a small amount of the energy is lost. Metals reflect (shield) RF radiation and microwaves, while water is a common absorber. As RF radiation and microwaves pass through a material, energy is lost to the medium through heating from ionic currents induced by the electric field and through the vibration of polar molecules, such as those in water, under the influence of the changing electric field. The rate of heat generation in an absorber, such as tissue, is inversely proportional to the square of the penetration depth. Tissue not only absorbs RF radiation and microwaves but acts as a transmitter and a reflector.

Biological effects due to RF radiation and microwaves have been divided into thermal and nonthermal effects. Most of the documented harmful biological effects in humans from microwaves are attributed to hyperthermia. These effects include damage to the eyes and the testicles. Both of these tissues absorb RF radiation and microwaves, are unable to dissipate energy efficiently and, therefore, are more susceptible to heating.

Although the biological mechanisms for nonthermal effects are not clearly understood, many effects have been observed during animal studies in the laboratory. Effects that have been confirmed in laboratory studies with animals at high doses include developmental abnormalities, behavioral changes, and teratogenic effects. Epidemiological studies in human populations have failed to demonstrate a clear relationship between RF radiation and microwaves and either cancer or birth defects. A review of the current published studies on nonthermal effects indicates the experimental findings to be contradictory and inconclusive.

<u>Regulations and/or Guidelines</u>
Regulations and recommendations for the protection of workers and members of the public from potentially harmful effects of radio-frequency and microwaves have been made by numerous international and professional organizations and regulatory agencies. Unless local, state, or country-specific regulations require more restrictive exposure limits, all and companies shall be required to meet the maximum limits for

controlled and uncontrolled environments identified in the standards developed by the Institute of Electrical and Electronics Engineers (IEEE). The IEEE standards, C95.3-1991 and C95.1-1991, are recognized as an American National Standard (ANSI).

Facility Design and Controls

In view of our limited knowledge and understanding of all biological effects associated with RF radiation and microwaves, unnecessary exposure should be minimized. Engineering designs and controls should be the primary mechanism to reduce RF radiation and microwave exposures. Shielding against magnetic fields can be accomplished with ferromagnetic materials such as iron or steel. Attenuation of electric field intensity is accomplished through the use of solid metal shields. Shields and/or interlocking systems should be considered for existing structures or facilities. New designs should focus on complete containment and the integration of metal shields or other attenuation materials.

Protective Administrative Controls/Procedures

Protective measures should be incorporated into the operational procedures to further limit employee exposures. Before a system or equipment that uses or emits RF radiation or microwaves is used for the first time, the operating procedures should be reviewed by the area supervisor. NIR Coordinator should be consulted to assist in developing administrative controls and procedures. Administrative controls may include: posting warning signs, establishing procedures for excluding unauthorized persons, or identifying unsafe areas. If the system changes or modifications are made to equipment, the operating procedures should be re-evaluated to ensure that the controls are still appropriate.

Personal Protective Equipment (PPE)

Personal protective equipment (PPE) is not a viable alternative to engineering designs and/or administrative controls. Currently no PPE is available to "protect" a person from an exposure in areas where RF radiation and/or microwaves are present or being utilized.

Monitoring/Measurements

Measurements must be performed if there is RF radiation and/or microwaves that cannot be fully contained using engineering controls, or if there is leakage suspected from a sealed/enclosed source. Before carrying out a survey, it is important to identify as many of the characteristics of the sources as possible and estimate their likely propagation characteristics in the area being monitored. These emitter and site characteristics include:

- frequency;
- power levels;
- modulation characteristics, e.g., peak and average values, waveform, etc.;

- number of sources;
- spurious frequencies or harmonics;
- intermittence of output;
- antenna information, e.g., size, bandwidth, gain, orientation, etc.;
- existence of absorbing or scattering objects;
- areas normally occupied by people;
- external or uncontrolled areas.

Prior to making measurements, one should estimate the expected field strengths and determine the type of instrument required. Surveying RF radiation and/or microwaves is very complex and requires a complete understanding of the electromagnetic field environment. All persons conducting a survey must be familiar with the monitoring equipment and the complications associated with the source(s) and area(s) being evaluated. NIR Coordinator should be contacted to assist with monitoring if exposures are suspected to exceed the action level (action level = 50% of the applicable exposure limit/guideline), or to help characterize exposure levels.

Common household microwave ovens have built-in safety features that should prevent any leakage. As a general recommendation, visual inspections can be performed to ensure door hinges, door seals, and latch mechanisms are working properly. The oven should not operate with the door ajar or the latch mechanism not making full contact. The oven should be kept clean to prevent food materials from affecting the door gasket and leading to potential leakage.

Power Frequency - Electric and Magnetic Fields

Introduction

Electric power systems typically utilize 50 or 60 Hz alternating current (AC) frequencies to operate. Associated with the use and/or production of this extremely low frequency (ELF) electric power are electric and magnetic fields. These fields emanate from many different equipment, including power lines, substations, transformers, and many common pieces of equipment in manufacturing, administrative or research environments.

Basic Concepts

Electric and magnetic fields associated with power frequencies are created by electric charges. The electric field component results from the strength of the charge, while magnetic fields result from the motion of the charge. Everything that has an electric charge has fields associated with it. The magnetic field of the earth, which makes a compass needle point north, is made by flowing charges or currents in the earth's molten interior. The molecules in our bodies and in all other living and non-living things are held together by fields. Electric and magnetic fields are in us, around us, and throughout every aspect of our lives.

The strength of an electric field, measured in units of volts per meter (V/m), depends on the voltage of the object creating it. As an example, a "high" voltage power line usually produces stronger electric fields than a lower voltage power line. Current does not have to be flowing in an object for an electric field to exist. If equipment is plugged in, but not operating, it may still produce an electric field. Since magnetic fields, commonly measured as magnetic flux density in units of millitesla (mT), are created only when current is flowing, equipment that is plugged in but turned off does not produce magnetic fields.

Fields that occur in the same place can interact and magnify, or diminish. The strength of fields depend on many factors, such as the location of the source(s), location of nearby objects and their structural characteristics, the electrical conditions, etc.

<u>Biological Effects</u>
Electric fields associated with 50/60 Hz power have very little ability to penetrate building structures or even human skin. Magnetic fields, on the other hand, easily penetrate buildings and people. Because power-frequency electric fields do not penetrate the body, it is generally assumed that any biologic effect from routine exposure to power-frequency fields is due to the magnetic component of the field or the currents that these magnetic fields induce in the body.

Power frequency electric and/or magnetic fields do not appear to cause cancer or other adverse health effects but have been observed to influence and affect cells and cellular systems. From a review of scientific literature, it is apparent that gaps exist in our knowledge. More information and data are needed to answer unresolved questions concerning potential biological effects from power-frequency fields. Future scientific research and epidemiological studies may expand our understanding and influence the current conclusions of the health effects associated with power-frequency fields.

<u>Regulations and/or Guidelines</u>
Guidelines on limits of exposure to 50/60 Hz electric and magnetic fields have been adopted by the International Radiation Protection Association/International Non-Ionizing Radiation Protection Committee (IRPA/INIRC). Based on an objective analysis of currently available information, it is expected that repeated exposure to these guidelines will not cause adverse health effects.

<u>Facility Design and Controls</u>
Most 50/60 Hz electrical systems and equipment (i.e., equipment that requires 110,

220 or even 440 volts and 20 to 50 amps) found throughout research, manufacturing, and administrative environments should not produce significantly high electric and/or magnetic fields. Before facility designs are influenced or engineering controls are recommended, NIR Coordinator or another technical resource should be consulted to assess the equipment and/or system(s). If exposure to power-frequency electric and magnetic fields must be limited, virtually any conducting surface will provide substantial shielding of electric fields. Magnetic fields are significantly more difficult to shield. Small areas can be shielded by the use of Mu metal (a nickel-iron-copper alloy), but Mu metal shields are prohibitively expensive. Larger areas can be shielded with less expensive and less effective metals, but an extremely thorough technical understanding of the area and environment is required. Containment and shielding may be facility design options, but administrative controls should be used as a more feasible and practical approach to reducing exposures.

Protective Administrative Controls/Procedures

Protective administrative measures that include "prudent avoidance," such as minimizing time spent in areas or around sources and maximizing the distance to a source, should be incorporated into the operational procedures to limit employee exposures. Operating procedures for electrical equipment and areas that have multiple electrical systems should be reviewed by the area supervisor. NIR Coordinator should be consulted to assist in developing administrative controls and procedures. If the system changes or modifications are made to equipment, the operating procedures should be re-evaluated to ensure that the controls are still appropriate.

Personal Protective Equipment (PPE)

Personal protective equipment (PPE) is not a viable alternative to engineering designs and/or administrative controls. Currently, no PPE is available to "protect" a person from an exposure from power-frequency electric and magnetic fields.

Monitoring/Measurements

Measurements must be performed if there is a potential for exposure levels to exceed the action level (action level = 50% of the applicable limit/guideline). A direct reading power-frequency field strength meter may be used to evaluate the electric and/or magnetic fields associated with 50/60 Hz power. NIR Coordinator should be contacted to assist with monitoring if exposures are suspected to exceed current guidelines, or to help characterize exposure levels.

Static Magnetic Fields

Introduction

Static magnetic fields exist naturally and, depending on the geographic location, vary from approximately 30 to 70 microtesla (uT). An average person rarely experiences strong static magnetic fields (e.g., millitesla to tesla). Recently, there has been significant development of new technologies using static magnetic fields that may lead to more significant exposures. In a research environment, nuclear magnetic resonance (NMR) spectroscopy utilizes superconducting magnets to investigate the chemical and physical properties of compounds at the molecular level. In medicine, magnetic fields are used in magnetic resonance imaging (MRI) systems to image tissues and organs of patients with extremely good resolution. These systems rely on powerful magnets that generate intense magnetic fields that may impact on the individuals that work with or around them.

Basic Concepts

As described earlier, magnetic fields result from the movement of electric charge (electric current). A magnetic field can be represented as a vector and may be specified as magnetic field strength (H), or as magnetic flux density (B). Magnetic flux density, expressed in teslas (T), is the most common quantity used to define static magnetic fields.

The magnitude of the force F acting on an electric charge q moving with a speed of v in a direction perpendicular to a magnetic flux density B is given by the expression:

$$F = q\,v\,B$$

The direction of the force is determined from the vector product of the charge, velocity and magnetic flux density and is always perpendicular to the direction of the flow of electric charge. The magnetic flux density is accepted as the most relevant quantity for relating magnetic field effects.

The existing evidence from experiments with laboratory animals indicates an absence of significant effects at static magnetic flux densities up to 2 tesla. It has been reported that humans exposed to a 4 T magnetic flux density could experience sensory effects (e.g., vertigo, nausea), but numerous other studies have failed to be conclusive or reveal any significant health effects.

Similar to our understanding of power-frequency fields, it is apparent that gaps exist in our knowledge. More information and data are needed to answer unresolved questions concerning potential biological effects from static magnetic fields. Future scientific research and epidemiological studies may expand our understanding and influence the current conclusions of the health effects associated with static magnetic fields.

Regulations and/or Guidelines

Guidelines on limits of exposure to static magnetic fields have been adopted by the International Radiation Protection Association/International Non-Ionizing Radiation Protection Committee (IRPA/INIRC) and by the American Conference of Governmental Industrial Hygienists (ACGIH). Based on an objective analysis of currently available information, it is expected that repeated exposure to these guidelines will not cause adverse health effects.

ADDITIONAL CONSIDERATIONS MUST BE MADE FOR PEOPLE WITH CARDIAC PACEMAKERS, FERROMAGNETIC IMPLANTS AND IMPLANTED ELECTRONIC DEVICES. These internal devices and implants have been found to be influenced by magnetic fields. People that have these implanted devices must have clearance by a physician before entering into areas that exceed the action level (action level = 50% of the applicable exposure limit/guideline).

Facility Design and Controls

The use of engineering designs and controls must be evaluated to limit exposures to static magnetic fields. As described earlier, magnetic fields are difficult to shield. Small areas can be shielded by the use of Mu metal (a nickel-iron-copper alloy), but Mu metal shields are prohibitively expensive. Larger areas can be shielded with less expensive and less effective metals but an extremely thorough technical understanding of the area and environment is required. Containment and shielding may be facility design options but administrative controls should be a primary consideration as a more practical approach to reducing exposures.

Protective Administrative Controls/Procedures

Any area that has a magnetic flux density that exceeds the action level (action level = 50% of the applicable exposure limit/guideline) must be posted with a warning sign. All locations, within a posted area that exceed the guidelines, require an evaluation of time and distance parameters. These locations must have warning labels that designate the level and appropriate stay times.

Protective administrative procedures must include precautions that limit the potential for flying objects caused by the forces on ferromagnetic tools and objects. Protective measures should also include "prudent avoidance," such as minimizing time spent in areas or around sources and maximizing the distance to a source to minimize employee exposures. Warning signs must be posted in all areas exceeding the guidance above. Operating procedures for equipment and areas where static magnetic fields are present must be reviewed by the area supervisor. NIR Coordinator should be consulted to assist in developing administrative controls and procedures. If the system changes or modifications are made to equipment, the operating procedures should be re-evaluated to ensure that the controls are still appropriate.

Personal Protective Equipment (PPE)

Personal protective equipment (PPE) is not a viable alternative to engineering designs and/or administrative controls. Currently, no PPE is available to "protect" a person from an exposure from static magnetic fields.

Monitoring/Measurements

Measurements must be performed if there is a potential for exposure levels to exceed current guidelines. Measurements must be performed to help define the levels and the appropriate guidance in all areas (inside posted areas and outside building structures) where high static magnetic fields are suspected. A direct reading gauss/tesla meter may be used to evaluate the magnetic flux densities associated with static magnetic fields. NIR COODINATOR should be contacted to assist with monitoring if exposures are suspected to exceed the action level, or to help characterize exposure levels.

Ultrasound

Introduction

Ultrasonic energy or ultrasound is mechanical vibration or sound with a frequency greater than 20,000 hertz (Hz). Ultrasound is used in a wide variety of industrial processes including cleaning, mixing and emulsification, and has become extremely important in medicine for surgical, therapeutic and diagnostic applications. There are increasing numbers and varieties of consumer devices that use airborne ultrasound, including door openers, remote controls, and pest repellers. These devices also have application in industry.

Basic Concepts

Ultrasound, like sound, is transmitted as wave energy. Once a sound wave has been generated, it continues in its original direction until it is either reflected, refracted, or absorbed. The intensity of sound is determined by the length of oscillation of the particles conducting the waves. The greater the amplitude of oscillation, the more intense the sound. Airborne ultrasound intensity is usually quantified in terms of sound pressure level (SPL) in decibels (dB) using the following equation:

$$\text{SPL (dB)} = 10 \log^{10} (I/I_r)$$

As indicated, a decibel is a relative unit that is a comparison of the relative intensity of two sound beams expressed logarithmically using the base 10. Note that doubling the intensity (I) increases the SPL by 3 dB.

Most of the ultrasound energy that impacts the human body is reflected. Hair is a strong absorber, but the most sensitive organ to airborne ultrasound is the ear. Research has indicated that losses of hearing are not likely below the current guidelines (see Tables below). Although effects such as nausea, headaches, and fatigue have been observed in areas where elevated levels of airborne ultrasound are present, existing data suggest that no adverse effects should occur at levels up to 110 dB.

Regulations and/or Guidelines

Guidelines on limits of exposure to airborne ultrasound have been adopted by the International Radiation Protection Association/International Non-Ionizing Radiation Protection Committee (IRPA/INIRC). Based on an objective analysis of currently available information, it is expected that repeated exposure to these guidelines below will not cause adverse health effects.

Facility Design and Controls

Limiting exposure to airborne ultrasound should be accomplished primarily through the use of engineering designs and controls. Containment and shielding should be incorporated into a structure or facility design, if necessary.

Protective Administrative Controls/Procedures

Protective measures should be incorporated into the operating procedures to further limit employee exposures. Before a system or equipment that produces ultrasound is used for the first time, operating procedures should be reviewed by the area supervisor. NIR Coordinator should be consulted to assist in developing administrative controls and procedures. If the system changes or modifications are made to equipment, the operating procedures should be re-evaluated to ensure that the controls are still appropriate.

Personal Protective Equipment (PPE)

After engineering designs and administrative controls have been completely evaluated, personal protective equipment (PPE) may be used. Since the ear is the most sensitive organ, personal hearing-protective devices are the most appropriate equipment to be used. These devices range from aural inserts or earplugs to complete enclosures. NIR Coordinator should be consulted to assist in selecting the most appropriate equipment for the particular application.

Monitoring/Measurements

Before any monitoring is pursued, NIR Coordinator should be consulted to characterize the source and environment and assess the potential levels.

Lasers

Introduction

The term laser is an acronym for **L**ight **A**mplification by **S**timulated **E**mission of **R**adiation. Lasers produce a very intense beam of "light". Unlike ordinary light, laser light is only one wavelength, travels in one direction and is coherent. These and other characteristics of lasers have led to their use in a wide variety of industries. Just a few of the many different applications that lasers can be used for include: surgery and diagnosis in medicine, navigation and guidance in the military, fiber optics, copying and printing in commerce, spectroscopic and other analytical procedures in research, and common industrial purposes such as cutting, drilling, and welding.

Basic Concepts and Definitions

Lasers consist of three basic components: an **active medium**, an **excitation mechanism**, and an **optical cavity**. The active medium or laser medium is a collection of atoms, molecules, or ions that can absorb energy from an outside source and re-emit the energy in the form of laser light. The medium can be a solid, liquid, gas, or a semiconductor.

The active medium must be excited for a laser beam to be generated. This excitation mechanism causes electrons to jump to higher energy levels. When the excited electrons fall to a lower energy level, the energy difference between the two levels is released in the form of light. As described, this system would produce light, but it would be emitted in all directions and behave like ordinary light. A laser beam also has an optical cavity that consists of two mirrors that are placed at opposite ends of the active medium. The mirrors reflect the light back and forth, and the intensity is amplified. One of the mirrors reflects 100 percent of the light, the other reflects only a fraction of the light. The fraction of the light that is not reflected is transmitted out of the optical cavity as a laser beam.

Characteristics used to describe a laser typically include the following:

- beam power or pulse energy outputs;
- beam diameter;
- beam divergence;
- operational mode: pulsed or continuous wave;
- exposure time, pulse duration and/or pulse repetition frequency;
- wavelength;
- beam optics and beam path;
- maximum anticipated exposure duration;
- maximum permissible exposure.

These characteristics and other laser terms are defined in the section that follows.

Accessible Emission Limit (AEL) - The maximum accessible emission level permitted within a particular hazard class. AEL = MPE x Area of Limiting Aperture; Units = joules or watts.

Aversion Response - Reactionary movement of the eyelid or head to avoid an exposure to a noxious stimulant or bright light. It is normally defined as 0.25 seconds for the purposes of laser safety.

Beam Diameter - The diameter of the beam usually as it exits the laser.

Beam Divergence - The spread of the beam typically expressed in milliradians.

Continuous Wave (cw) - The output of a laser which is operated in a continuous rather than a pulsed mode. A laser operating with a continuous output for a period   0.25 seconds is regarded as a cw laser.

Diffuse Reflection - A change of the spatial distribution of a beam of radiation when it is reflected in many directions by a surface or medium.

Energy (Q) - The capacity for doing work. Energy content is commonly used to characterize the output from pulsed lasers and is usually expressed in joules (J).

Hazard Class - A number, either 1, 2a, 2, 3a, 3b, or 4, which reflects a laser's capability of injuring personnel. The number depends on the accessible radiation during operation.

Intrabeam Viewing - The viewing condition whereby the eye is exposed to all or part of a laser beam.

Irradiance (E) - Quotient of the radiant flux incident on an element of the surface by the area of that element (watts/cm^2 or W/cm^2).

Joule (J) - A unit of energy. joules = watts x second.

Laser Safety Officer (LSO) - One who has the authority and training necessary to monitor and enforce the control of laser hazards and effect the knowledgeable evaluation and control of laser hazards.

Laser System - An assembly of electrical, mechanical, and optical components which includes one or more lasers.

Limiting Aperture - The maximum diameter of a circle over which irradiance or radiant exposure can be averaged.

Maintenance - Routine up-keep on a laser normally performed by the users. Procedure shall have minimal impact on user.

Maximum Permissible Exposure (MPE) - The level of laser radiation to which a person may be exposed without hazardous effect or adverse biological changes in the eye or skin. The MPE varies with the target (eye or skin), wavelength, and anticipated exposure duration. Expressed in terms of radiant exposure (J/cm^2) or irradiance (W/cm^2).

Nominal Hazard Zone (NHZ) - The nominal hazard zone describes the space within which the level of the direct, reflected, or scattered radiation during normal operation exceeds the applicable MPE. Exposure levels beyond the boundary of the NHZ are below the appropriate MPE level.

Operation - That time when the laser is producing laser radiation (lasing).

Power - The rate at which energy is emitted, transferred, or received (watts= joules/sec).

Pulse Duration - The duration of a laser pulse; usually measured as the time interval between the half-power points on the leading and trailing edges of the pulse.

Pulsed Laser - A laser which delivers its energy in the form of a single pulse or a train of pulses and the duration of each pulse is less than 0.25 seconds.

Q-Switched Laser - A laser emitting short (<>30 ns), high powered pulses by using a Q-switch.

Radiant Exposure (H) - Surface density of the radiant energy received (Joules/cm^2).

Radiant Flux - Power emitted, transferred, or received in the form of radiation (Watts).

Repetitively Pulsed Laser - A laser with multiple pulses of radiant energy occurring in sequence with a pulse repetition frequency (prf) >= 1 Hz.

Service - The non-routine servicing of the laser creating a potential situation of exposure to laser radiation.

Specular Reflection - A mirror-like reflection.

Temporary Laser Controlled Area - The area identified where removal of panels or protective housing, overriding of protective interlocks, or entry into the NH2 becomes necessary and the accessible laser radiation exceeds the applicable MPE.

Transmittance (T) - The ratio of total transmitted radiant power to incident radiant power.

Watt (W) - The unit of power or radiant flux. Watts = Joules/second.

Wavelength - The distance between two successive points on a periodic wave which have the same phase.

Laser Classification

A laser is classified according to the ability of the primary laser beam or reflected laser beam to cause biological damage to the eye or skin during intended use (see Biological Effects).

All lasers should be classified by the manufacturer. If a laser or laser system does not have a label that denotes its class, contact NIR Coordinator (acting as LSO) to assist in classifying your laser. Once the class is known, refer to the appropriate safety guidance section for any applicable requirements and recommended precautions. Some general designating factors of each class and their associated potential hazards are outlined below.

Class 1
Definition - Very low power, exempted lasers.
Potential Hazard - Under normal operating conditions, there are no laser radiation hazards.

Class 2
Definition - Low power visible lasers intended for a specific use where the output is not intended to be viewed.
Potential Hazard - Continuous exposure is not usually hazardous.

Class 3
Definition - Medium power lasers (visible and invisible) usually with power outputs up to 500 mW.
Potential Hazard - These can pose a hazard if viewed directly. This includes intrabeam viewing or specular reflection. Except for the higher powered class 3 lasers, diffuse reflections should not present a hazard.

Class 4
Definition - High power lasers (visible and invisible) with power outputs greater than 500 mW.
Potential Hazard - These pose hazards from direct viewing, specular reflections, or possibly diffuse reflections. The possibility of additional hazards such as fire and skin hazards may also be present.

Enclosed Lasers
Definition - Sometimes, a higher classed laser can be classified as a lower class (usually class 1) by embedding the laser or laser system in an enclosure. This enclosure must ensure zero access and that during normal operation and maintenance, the enclosed laser output conforms to the definition members of the lower class (i.e., a totally enclosed class 4 laser can become a class 1 if there is no way an individual can be exposed to hazardous levels of laser radiation during normal operation or maintenance).

Potential Hazard - The potential hazard corresponds to the lower class for which the embedded laser is classed. However, the potential hazard is greatly increased when the laser is being serviced. Embedded lasers shall be serviced only by trained and qualified individuals.

Biological Effects

A laser has multiple hazards associated with its operation that can impact on an operator or an individual working in the area. This section will focus on those biological effects that are created by the laser beam. The two critical organs that may be impacted by the laser beam are eyes and skin.

A laser beam has the potential to injure several different structures of the eye and lead to temporary or even permanent adverse effects. In general, this depends on the absorption of energy in a specific tissue for a particular wavelength. In the ultraviolet (UV) region between 180 and 315 nm, the beam is absorbed at the cornea and may lead to photokeratitis, commonly called "welder's flash". In the near UV region, between 314 and 400 nm, energy is absorbed more by the lens of the eye and may contribute to cataracts. Retinal effects are possible when the laser emission occurs in the visible and near-infrared spectral regions (0.4 to 1.4um). In these regions, the laser beam is transmitted through the cornea and lens and is focused to a spot on the retina. The focusing significantly increases the intensity of the beam and a burn may result. Increasing the wavelength to the infrared (IR) region, between 1.4 and 3.0 um, a laser penetrates to the lens and may contribute to cataracts. IR between 3.0 um and 1 mm becomes absorbed by the cornea and water in the ocular media of the eye and may cause a corneal burn or the ocular media to become opaque.

Because the eye is so susceptible to damage from laser radiation, effects on the skin receive less emphasis. However, repeated or even a single exposure to certain laser beams can cause significant skin damage and permanent adverse effects. Similar to the eye, the absorption of energy by the skin is wavelength dependent. Skin burns may occur in any acute exposure from a high energy laser. The burn does not differ from ordinary thermal or solar burns that are caused by the rise in skin temperature. Other effects on the skin that have been observed result from lasers beams in the UV region. Short term effects, such as increased pigmentation and photosensitive reactions, may occur. Long term effects, that include skin cancer and accelerated aging, may also occur. Most of the data has been based on acute exposures. At the present time biological effects associated with long-term exposure to laser radiation are still unclear.

Regulations and/or Standards

The approach to laser safety standards has been to classify lasers by their hazard potential. Each of the classes requires appropriate controls that are based on the characteristics of the laser beam and its ability to produce injury to personnel. This approach has been incorporated into the most recent American National Standards

Institute's (ANSI) Z136.1 Safe Use of Lasers standard. Based on this standard, all lasers must be classified and have appropriate control measures in place. The following lists most of the requirements for the respective classes:

Facility Design and Engineering Controls
The purpose of laser control measures is to reduce the possibility of eye or skin injury from exposure to the laser beam. When instituting laser control measures, the first consideration must be facility design and engineering controls. These features may be built into the laser by the manufacturer or designed into the installation by the authorized user. The laser class will dictate the minimum required controls to be included in a system and other recommended controls. Engineering controls to be considered in all laser systems, if applicable, should include: protective housing; safety interlocks; beam enclosures; beam shutter or attenuator; remote interlock connectors; key/computer switch controls; emission delay; warning systems; remote monitoring, etc.

Protective Administrative Controls/Procedures
Protective administrative controls should be incorporated into the operational procedures to further limit the possibility of an exposure to a laser beam. Before a laser is used for the first time, the operating procedures should be reviewed by Management/Team Leader. NIR Coordinator (acting as LSO) should be consulted to assist in developing administrative controls and procedures.

Written Operating Procedures
Required for class 3 and 4 laser systems, written operating and alignment procedures must be approved by the NIR Coordinator (acting as LSO) before the system is used for the first time. These procedures describe step by step instructions for normal use and maintenance.

Area Posting/Signs
There are several types of area postings used to alert people outside of a laser location to the potential hazard of the laser in the room/area. All signs must be posted conspicuously near all the entrances to the laser location.

Personal Protective Equipment (PPE)
After engineering designs and administrative controls have been completely evaluated, personal protective equipment may be considered. Extensive PPE is available to protect eyes and skin from laser beam radiation.

Protective Clothing
If exposure to laser beam radiation may exceed the MPE for the skin, protective clothing must be utilized. UV lasers and Class 4 lasers pose the most serious threat of skin injury. Tightly woven clothing should provide adequate protection from UV laser diffuse reflections. For all Class 4 lasers, the protective clothing must be able to adequately attenuate the beam and be fire resistant.

Non-Beam Hazards

Hazards other than the laser beam exist and can be significant with high power lasers. Authorized users should consult with NIR Coordinator (acting as LSO) about these additional hazards when setting up and/or modifying their laser. There are electrical, compressed gas, and laser dye hazards. Electrical hazards include shock, fire, and explosion. All lasers and electrical circuits should be properly grounded and located away from any flammable materials.

Medical Monitoring/Surveillance

All authorized users of class 3 and 4 lasers should be enrolled in a laser-medical surveillance program. The program consists of a baseline eye exam, an exit eye exam, and exams following any accidental exposures. (See Global Health Medical Surveillance Guidelines for Ionizing and NonIonizing Radiation.) A list of those employees who are using or going to use lasers of class 3 and 4, should be provided to health services by NIR Coordinator (acting as LSO) or management in order to enroll them in the laser medical surveillance program.

Appendix C – Inventory Form

Non-Ionizing Source/Category (Laser, UV, IR, etc.)	Equipment description (manufacturer, model, frequency/wavelength)	Location	Description of use - Any precautions taken?	Primary contact, phone # and any other comments.