RADIATION SAFETY

I. IONIZING RADIATION

A. BASIC POLICY

All laboratory operations must be planned to prevent exposure of personnel to ionizing radiation above the limits stated in this safety manual, which give radiation dose equivalent limits for both radiation workers and non-radiation workers.

In addition to these basic regulations, it is also JSU 's policy that exposure to ionizing radiation associated with laboratory operations be maintained "as low as reasonably achievable" (ALARA). The ALARA policy means that subject to programmatic requirements and economic limitations, radiation dose equivalents to employees and radiation levels at the perimeter fence should be the minimum attainable. This policy requires that each operation involving radioactive material or the production of radiation be evaluated individually to ensure that the resultant personnel exposures are as low as is reasonably achievable.

For external radiation, protection is provided by time and distance restrictions, source intensity limitations, and shielding. For internal radiation., protection is normally provided by preventing the escape of radioactive material into the working environment. All JSU work: with radionuclides must be restricted to locations designed specifically for such work.

B. PROTECTION GUIDES FOR IONZING RADIATION

1. General

The protection guides for the control of external and internal dose equivalents are based on the standard listed in Department of Energy (DOE) Order 5480.11 (fable 1). Supervisors must ensure that the ALARA policy is followed. Assistance in this regard is available from the Health Department and JSU Radiation Safety Committee.

2. Protection Guides for External Radiation

Whole-body dose equivalent increments of over 100 mrem (1 mSv) received in short periods must be avoided. This is a restriction that requires a review of the operation- not a limit for occupational workers. Consult with Health Department or JSU Radiation Safety Committee personnel when it appears likely that certain procedures can lead to a dose equivalent accumulation of over 100 mrem (1 mSv) in a single exposure or in a series of exposure occurring in a few days.

Table 1. Radiation protection standards: limiting values for assessed dose for occupational workers.

Occupational stochastic effectsa	5 rem (annual effective dose equivalent)	50mSv
Nonstochastic effectsb Lens of eye	15 rem (dose equivalent)	150mSv
Extremity	50 rem (dose equivalent)	500mSv
Skin of the whole body	50 rem (dose equivalent)	500mSv
Organ or tissue	50 rem (dose equivalent)	500mSv
Fetus for entire pregnancy	0.5 rem (annual effective dose equivalent)	5mSv

a Stochastic Effects. Malignant and hereditary disease for which the probability of an effect occurring, rather than its severity, is regarded as a function of dose without a threshold for radiation protection purposes.

b Nonstochastic Effects. Effects such as the opacity of the lenses of the eyes for which the severity of the effect varies with the dose and for which a threshold may exist.

3. Protection Guides for Internal Radiation

It is JSU's policy that all radioactive control areas be kept as free as possible of airborne radioactivity and contamination. Where inhalation or ingestion of radionuclides is possible the JSU protection guide must be followed. The protection guide for the control of internal dose equivalent at JSU is based on the DOE Annual Limit on Intake (ALI) values. The ALI is that quantity ~f a single radionuclide that. if inhaled or ingested, would irradiate a person to the limiting value for control of the workplace. The derived air concentration (DAC) is the quantity obtained by dividing the ALI for any given radionuclide by the volume of air breathed by an average worker during a working year. DAC are listed in DOE Order 5480.11, Attachment 1.

The DACs are intended to ensure that no significant injury will occur after continual exposure at that level for many years. Nevertheless, personnel must not be exposed for extended periods at the limit values when reasonable means exist for avoiding such exposure.

When the DAC value (which is based on continuous exposure for one year) is exceeded, the exposure time must be limited. If external radiation is also present, the permissible internal concentration values must be reduced to prevent the dose to the whole body or to a particular organ from exceeding the combined basic dose limits.

Maintaining airborne radioactivity below DACs often involves sophisticated enclosure systems and careful experimental planning. Failure of a control system for an experiment involving a large amount of radioactivity could result in exceeding the DACs both on site and off. Therefore, operations involving unencapsulated radioactive material must be planned with Radiation Safety
Committee's assistance.

4. Workers under 18 Years of Age

This age limit applies to all workers at JSU including employees, guests, students, and contractor personnel.

No one, including students, under age 18 may be employed in, or be allowed to enter Controlled Areas so as to receive over 0.1 rem (0.001 Sv) per year from the sum of the committed effective dose equivalent from internal irradiation and the annual effective dose equivalent from external irradiation. (The committed effective dose equivalent is the dose projected to be received by a tissue or organ over a 50- year period after an intake of a radionuclide into the body.)

The following guidelines apply to anyone under age 18 working in controlled areas:

· Each case is handled individually.

· The program for each person must be outlined in writing with a listing of the proposed work areas and time schedule.

· A supervisor for each person must be designated.

· The proposed work area and work schedule must be approved by Radiation Safety Committee in advance .

. In general, persons under 18 years of age may not work in certain buildings and areas such as storage place that contains large quantities of radioisotopes, and machines producing ionizing radiation. Consult Radiation Safety Committee for the current status of any work area.

5. Woman Employees and Pregnancy

The National Council on Radiation Report No. 53 recommends, and the DOE concurs, that during the entire pregnancy the maximum dose equivalent to the embryo-fetus from occupational exposure of the expectant mother should be no more than 0.5 rem (5 mSv). JSU policy requires that all employees working in radiation areas, as well as their supervisors, must be informed of the exposure standard for a fetus.

It is JSU policy, however, that no woman be denied a job or work assignment solely because of this recommendation.

When an employee learns she is pregnant, she must inform her physician of the expected date of childbirth. Woman planning to become pregnant also should consult with her physician. The physician shall discuss her work environment with her and will determine whether any changes in her work environment or job responsibilities should be made to ensure her and her baby's good health. All new employees must be informed of the risks of radiation exposure during pregnancy.

6. Nonemployees

The dose equivalent received by members of the public during direct on-site access must not exceed 0.1 rem (1 mSv) per year from the committed effective dose equivalent from internal irradiation plus the effective dose equivalent from any external irradiation. In all cases, the ALARA policy must be followed.

Contractor personnel are the responsibility of their employers, who are obligated by contract to comply with all pertinent JSU safety regulations and requirements, including restrictions on personnel under 18 years of age.

C. PERSONAL RADIATION MONITORING

1. Radiation Workers- General

Radiation worker is an occupational worker whose job assignment involves operation of radiation producing devices or works with radioactive materials or who is likely to be routinely occupationally exposed above 0.1 rem (l mSv) per year.

All radiation workers at JSU must participate in radiation protection training and in the JSU's (future if applicable) bioassay program (i.e., whole-body counter and radiochemical analyses of urine samples), its personal dosimetry program, or both. However, persons working only with low-energy beta emitters (e.g., 3H, 14C, *35S)* are not included in the whole-body counter program.

Radiation workers exposed to external ionizing radiation will be issued a personal dosimeter, which records their exposure to radiation. Radiation workers exposed to radioisotopes with sources:

· 100 mrem (1.0 mSv) per year effective dose equivalent to the whole body
· 5 rem (0.05 Sv) per year to the skin
· 5 rem (0.05 Sv) per year to anyone of the extremities
· 1.5 rem (0.015 Sv) per year to the lens of the eye

2. External Radiation Exposure- Personal Dosimetry Program

Personal dosimeter are issued to monitor the radiation dose equivalent from occupational exposure.

Wearers get replacement of the film badge monthly. Supervisor must explain dosimeter exchange procedures to all new employees.
Gamma dosimeters are issued to those who work with the following radiation-producing items:

· X-ray generators
• Irradiators
• Radioisotopes (does not apply to exclusive users of low-energy beta emmiters, such as 3H, 14C, and *35S)*

In addition, anyone having the potential for occupational exposure will also receive a gamma dosimeter monthly.

Finger dosimeters must be worn by experimenters whenever they handle concentrated amounts of radioisotopes (other than soft-beta emitters, such as 3H, 14C, or *35S).* The dosimeters must be monitored monthly or quarterly by dosimetry services.

a. Wearing of Personal Dosimeters

All "badged" workers must wear their personal dosimeters in controlled areas and are encouraged to wear their personal dosimeters at all times when at the laboratory areas.

The preferred location for wearing a single dosimeter is the upper torso, where it will give the best estimate of the whole-body dose equivalent If wearing the dosimeter on the upper torso is impractical and the whole -body radiation exposure is from omnidirectional, penetrating radiation, the dosimeter may be carried anywhere on the person.

During off hours, the dosimeter may be taken home or stored in areas with relatively low background radiation. For example, most office areas shall meet this requirement. The dosimeter must not be worn during medical or dental x -rays, nuclear medical procedures, or radiation therapy- it must not be used to monitor other radiation exposures. It is important to notify Radiation Safety Committee and Dosimetry Service if such exposure occur.

In addition, personal dosimeters should not be carried during air travel, which can impose radiation readings on the dosimeter that do not reflect true occupational exposures. JSU personnel, e.g., staff and guests, who might receive radiation exposures while working at other facilities will be issued dosimeters by other facilities.

Other potential for ingestion shall participate in the (future) bioassay program. JSU requires monitoring of radiation workers who have the potential to exceed anyone of the following doses from external sources:

· 100 mrem (1.0 mSv) per year effective dose equivalent to the whole body

· 5 rem (0.05 Sv) per year to the skin

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b. Monitoring Responsibility

Each radiation worker is responsible for wearing an issued dosimeter in accordance with this policy.

c. Penalty for Non-return of Dosimeter

Wearers are responsible for following safety procedures and for returning the dosimeter as prescribed. Supervisors are responsible for enforcing this procedure. Anyone who does not return his/her dosimeter during the prescribed period, his/her supervisor will receive a written reminder. After two periods of delinquency, the supervisor will be notified and the individual may be removed from any radiation work. Replacement costs of lost film badges and their holders may be charged to the individual's program account.

3. Internal Radiation Exposure (Bioassay Program)

Participation in the JSU bioassay program is strongly recommended for radiation workers who handle dispersible radionuclides; such workers have to provide bioassay samples, as appropriate. The bioassay program consists of whole-body counter and radiochemical analyses of urine samples. In all cases of known exposure to internal radiation, e.g., by ingestion, inhalation, or puncture wound, the absorbed dose equivalent must be estimated by the most-appropriate method available. Biological elimination rates of radioisotopes must be monitored as long as these rates are relevant If an employee has worked in an area where internal deposition of radionuclides is possible, the termination physical examination must include a bioassay.

4. Radiation Reports to Employees

Personnel in the personal dosimetry program receive an annual report of their radiation exposure. Employees may obtain information at any other time by checking with Safety Division. Personnel in the bioassay program receive a report after each laboratory analysis.

D. MONITORING THE WORKING ENVIRONMENT

1. On-Site Monitoring

a. Policies & Procedures

The external radiation intensity of radiation-producing machines must be measured periodically and whenever a significant change is made in the equipment or mode of operation. The following procedures must be carried out in areas containing radioactive material:

- Employees using radioactive materials must conduct and record radiation surveys to ensure that the radiation controls are adequate. External radiation must be measured and areas must be surveyed for contamination before, during, and after all daily operations and after any suspected spill This includes surveying the work area and all work surfaces, the floors, equipment, and personnel Radiation Safety Committee must be notified of radiation levels or contamination that could cause significant personnel exposure. The Committee will advise and aid in difficult or unusual daily operations,

will help in planning procedural changes, and will be in charge of post-radiation-incident operations.

- Continuous air sampling must be performed within areas where there is the potential for airborne radioactive contamination and in ventilation exhaust systems serving such areas.

- Each month, radiation contamination surveys of all radioisotope work areas must be made by each relevant laboratory personnel. External radiation must also be measured to evaluate personnel exposures and to determine adequacy of protection.

Certain areas at ISU are designated as controlled areas in order to protect employees from exposure to radiation. either external or internal. Within Controlled Areas, radiological areas are identified by signs bearing the universal radiation symbol and the words such as "Caution Radiation Area", and ~'Caution Radioactive Materials". Radiation warning signs are posted on the advice of Radiation Safety Committee. Radiation Areas refer to any area in which an individual can receive a dose equivalent greater than 5 mrem (50 J1Sv) in 1 hour at 30 cm from the radiation source or from any surface through which the radiation penetrates. The "Caution Radioactive Materials" warning sign is used in areas and rooms where radioactive material is present and on containers in which radioactive material is being transported, stored, or otherwise used. Before entering any radioactive area, workers must find out from the local area supervisors, the location and nature of potential radiation hazards in order to ensure proper radiation safety.

b. Radiation Detecting Instruments

Each radioactive laboratory maintains radiation detection and measuring instruments that are assigned to controlled areas as needed. The Committee aids in the selection of portable instruments. Usually these instruments are delicate and expensive, and individuals who use them must be trained in their use and must be familiar with their limitations.

2. Entry-Control Program

I An appropriate entry-control program must be established for radiation areas. The level of control must be consistent with the degree of hazard. Signs, control devices (e.g., locks) on entrances, conspicuous visual and/or audible alarms, and/or administrative procedures must be used as appropriate to control personnel entry into restricted areas. Personnel must never attempt to enter a radiation area without permission and without being fully familiar with the operational safety rules for that particular facility.

3. Protective Enclosures

The primary control of unencapsulated radioactive material is through confinement in a suitable enclosure provided with appropriate ventilation. The enclosure is designed to provide control of airborne radioactivity commensurate with the hazard. (See section on Fume Hoods below).

E. REQUIREMENTS FOR OFF-SITE CONTROL

The ISU policy on radiation exposure at ISU boundary and release of radioactivity off site is that the levels be reduced to the lowest reasonably achievable amounts within economic and programmatic considerations.

1. Protection Guides for Off-Site Environment

The radiation standards for protection of the public in vicinity of ISU facilities are as follows (natural background and medical exposures excluded):

a. Dose Limits

All pathways

	Effective Dose Equivalent	
	(mrem/yr)	(mSv/yr)
Occasional annual exposure	500	5
Prolonged period of exposure (longer than 5 years)	100	1

No individual organ may receive an annual dose equivalent of over 5 rem/yr (50 mSv/yr).

All pathways

	Effective Dose Equivalent	
	(mrem/yr)	(mSv/yr)
Whole-body dose	25	0.25
Any organ or tissue	75	0.75

b. Action Levels

To prevent an individual in the general population from receiving more than 100 mrem/yr (1 mSv/yr) effective dose equivalent, a JSU administrative action level is established at 10 mrem/yr (0.1 mSvlyr) (excluding medical and natural background exposures) for routine JSU operations. This dose value is not a limit but an administrative reporting level intended to ensure that the 100- mrem/yr limit is not exceeded.

2. Off-Site Monitoring

Air, water, and sewage will be sampled occasionally on site for ionizing radiation and toxic chemicals by Safety personnel to evaluate

- the effect of the laboratory operations on the environment the effectiveness of on-site controls in limiting the radioactivity released by the JSU

- laboratories to the area around the site

External radiation is monitored at the JSU boundary to evaluate the JSU's control of university produced radiation leaving the site. This monitoring program is adopting those described in "PUB-3000 The LBL Health and Safety Manual".

F. EXPOSURE TO RADIATION IN AN EMERGENCY

Specific criteria and judgement factors for emergency situations (in which the yearly occupational dose limit maybe exceeded) are set forth for three categories of risk-benefit considerations, i.e., actions involving the saving of human life, the recovery of deceased victims, and the protection of health and property. Details are found in DOE Order 5480.11. Immediate assistance may be obtained from Health Department locally.

G. RADIOACTIVE MATERIALS

1. General

For optimum safety and economy, Safety Committee must review plans for all new facilities (and alterations to existing facilities) involving radioactive materials at the earliest possible opportunity. Operations involving radioactive materials are restricted to those buildings (or areas within buildings) designated by the Committee for such usage; such operations may only be carried out by trained personnel.

All chemical and mechanical operations on radioactive material must be designed to prevent the spread of radioactive contamination out of the radiological work area. Each proposed use of enclosures or fume hoods must be reviewed in advance by the Committee with respect to the type of operation and the amount of radioactive material to be used. The Committee must be consulted before the initial use, or a significant change in use, of radioisotopes.

2. Radiological Assistance

Radiological assistance normally is available Monday through Friday, 8:00 a.m. to 5:00 p.m. Assistance outside these hours is available but must be arranged at least one week in advance. This is especially important during the Christmas-New Year shutdown.

3. Training in Radioisotope Safety and Waste Disposal Procedures

Any work with a radioisotope (except sealed sources) is prohibited unless the worker is trained in specific procedures approved by the Committee. Supervisors must ensure that employees in their groups comply with this requirement.

4. Safe Work Practices

All personnel who work with radioactive materials are assigned a personal dosimeter and must wear it when working in a controlled area. Locks are mandatory on doors to rooms where radioactive materials are present. Mouth pipetting, eating, drinking, or smoking when

working with radioisotopes is prohibited. Do not pour liquid radioactive waste (LAW) into sanitary drains. If this is done by accident, notify Safety Committee immediately.
Air sampling services must be provided next to any work station where potentially dispersible radioactive materials are being handled or where radioisotopes are stored. When leaving any radioisotope area, employees must check for personal contamination by thorough monitoring with a portable survey meter. All equipment and furniture in a Controlled Area and all items going to reclamation must be tagged by the Committee with a "NO ACTNITY DETECTED" tag before removal. Storage areas, fume hoods, and contaminated or radioactive items must be labeled with a "CAUTION. RADIOACTNE MATERIAL" sticker.

5. Fume Hoods

Fume hoods are designed to protect the operator by providing directional air flow. Fume hoods are not adequate for operations that might result in atmospheric radioactive contamination. For such . operations enclosures such as glove boxes must be used. A lab coat, disposable gloves, and other appropriate safety attire must be worn at all times when working at a hood, or wherever a chance of contamination exists.

If radioactive material must be kept in a hood for short periods, it must be safely packaged and well shielded For storage for more than a month the material should be forwarded to the Safety Committee to choose a safe place for storage. A warning tag or sticker identifying the radioactive isotope, level of activity, date, etc., must be affixed in a prominent location outside the hood.

Large quantities of flammable, explosive, or pyrophoric materials must never be stored in hoods, but rather in approved storage lockers. These materials, in any quantity, must never be stored in hoods containing radioactive materials.

Acids, solvents, and heat sources can damage the inside surfaces of hoods, making any needed decontamination difficult. Always use protective coverings such as sheet plastic, absorbent paper, or heat-resistant materials as working surfaces.

The sliding front window of fume hoods protect against splashing chemicals and unexpected reactions and controls air velocity at the front of the hood The recommended minimum air velocity of 100 fpm is achieved by matching the arrow on the side of the vertical sash with the arrow on the frame.

Periodically, hood ventilating systems must be shut down for maintenance or repair. Before any hood ventilating system is shut down, the occupants of the room must be notified. The hood sash must be in its most closed position during shutdown, and a sign stating CAUTION-HOOD OUT OF SERVICE-DO NOT USE must be placed on the front of the hood. This sign must remain in place until service is restored, at which time the occupants of the room must be notified. Construction and maintenance requires that the principal investigator or supervisor renders the hood as free as possible of radioactive and chemical contamination before hood repairs or modifications are begun.

6. Packaging and Disposing of Radioactive Waste

Liquid radioactive waste (LA W) must not be poured down sanitary drains. If this is done

accidentally, immediately notify the Committee Chairman. Radioactive wastes are handled separately from all other wastes and are shipped via disposal services to an appropriate disposal site. Because of Department of Transportation (DOT) requirements, all radionuclide users, with the assistance of the Disposal Services must characterize and minimize radioactive waste.

Good housekeeping in hoods, and laboratories is essential; the buildup of radioactive waste must be kept to a minimum. The radionuclide user must provide the suitable waste containers, e.g., 2.5-gallon carboys, etc. As soon as containers are filled, call Safety Division to collect them. Do not overfill any radioactive-waste container.

Explosives, flammable or highly toxic chemicals must not be discarded with radioactive dry waste. Sharp objects such as hypodermic needles, spitzers, scalpels, etc., must be placed in protective containers before disposal. Infectious waste must be autoclaved, neutralized, or otherwise treated before its release to the waste-handling facility. Dry active waste (DA W) must contain no more than several milliliters of liquid per can. DA W cans must not be used for nonradioactive waste.

To minimize waste production, every effort must be made to reduce the overall volume of radioactive mixed waste. Mixed waste is radioactive waste plus other hazardous substances and its disposal is much more costly.

Waste must be segregated on the basis of its radioactive material content, physical form, and chemical content (see form attached). Consult the Committee for specific guidance. Practices that reduce waste include the following:

- Separation of nonhazardous waste from radioactive waste
- Segregation of waste having a half-life less than 45 days
- Minimizing amounts of radioactive chemicals ordered
- Evaporation or neutralization of the waste
- Recycling, reusing, or neutralizing chemicals

Scintillation vials can be accepted by the waste handling personnel unopened if packaged in "cement sack" contained in a poly bag supported in a i5-gallon galvanized waste can. The activity of the liquid must not exceed 0.02 J,lCi/ml. To facilitate waste disposal, vials should be segregated by radioisotope and/or half-life. Whole animals and tissue samples must be kept frozen until picked up for waste disposal. The radioactive waste tag must accompany each waste package transferred to the disposal services and must be filled out completely and signed by the waste generator.

7. Procurement of Radioactive Material

Purchase of radioactive materials is made first through the employee's department chairman, who authorizes a requisition for purchase and sends it to Safety Division for review. If approved, the requisition will be sent to the JSU Purchasing Department Incoming radioactive shipments are received by Safety Division and delivered to the researcher. Recipient must sign a receipt for acceptance of radioactive materials.

8. Transportation and Shipment of Radioactive Material

All incoming and outgoing shipment of radioisotopes must be made by the Safety Transportation Group. A person wishing to ship radioactive materials from the University must fill out a Hazardous Material Request for Shipment. After approval by Safety Division, the material must be properly packed, recorded, with assistance from Safety officer before shipment. Transfer of radioactive materials outside of immediate JSU control involves potential financial liability and personal-hazard problems in addition to possession of the required license. In addition, these materials are the property of the Mississippi State Government and must be accounted for in accordance with established procedures.

Requests for any of the above types of transfers of radioactive materials must be fully explained on the Hazardous Materials Request for Shipment, available from the Safety Division. At least five working days should normally be allowed for processing the request for transfer.

Inter-building transportation within campus of radioactive material or equipment is made by Safety Transportation except for certain special cases in which individuals may hand-carry certain low level, well-contained items, with prior approval by Safety Division.

9. Storage of Radioactive Material

Radioactive materials that are not being used (exclusive of material that has become radioactive by bombardment with neutrons or charged particles, called "induced-radioactive material"), must be stored in a secure area such as

• building or room locked during off-hours,

• lockable, fire-retardant safety boxes or air-filtered cabinets, designed to be earthquake resistant.

Radioactive research equipment that is too large to be stored at the laboratory should be arranged to be stored at designated warehouse area, provided that

• the level of radiation at the surface of the package does not exceed 2 mr/hr, and/or

• the only alpha emitters present are fixed, low level (100 dpm/cm2) alpha emitters such as 226Ra, 232Th, or 238U, and

• the package has been monitored and tagged by Safety Officer

Unsuitable storage areas include bench tops, desk drawers, fume hoods, and wooden cabinets or lockers.

10. Decontamination of Radioactive Equipment

Articles that are of sufficient value to be recycled can be given to Safety Division for decontamination. Proper packaging and identification of these items must be done by a Safety Officer before they can be removed from the laboratory. Decontaminated equipment

will be released to the user when any radioactive residue can not escape into the air or be transferred by contact or when there is no hazard from external radiation levels.

11. Contaminated Precious Metals

Radioactively contaminated precious metals must be kept separate from non-contaminated precious metals. Consult Safety Division for information and for disposal of contaminated metals.

12. Release of Materials and Equipment from Radiological Area

Contaminated equipment and materials from radiological areas (e.g., laboratories) for conditional use in controlled areas must be released following the procedures as follows:

• materials must be treated as being radioactive.

• Contaminated material must be cleaned as thoroughly as practical before release.

• materials must be routinely monitored for proper contamination control and clearly labeled or tagged

• The records for release of potentially contaminated materials must describe the property, the date of the last monitoring operation, the name of the person who performed the monitoring operation, the type and identification number of the monitoring instrument(s) used, and the results of the monitoring operation

13. Radioactive Sealed Source Procedures

A radioactive sealed source is any container of radioactive material fabricated so that the contents will not be released under normal conditions. Safety Division is responsible for overseeing all aspects of the procurement and use of radioactive sealed sources. Such sources may be brought to JSU from another laboratory only with prior approval of Safety Division.

Because of the potential hazards and toxicity of radioactive sources, every user of radioactive sources must have radiation training from Safety Division or Health Department and must comply with the regulations prescribed below. Requests for sources can only be initiated by a principal investigator or senior staff scientist. The user and his/her supervisor must be responsible for the control of the source.

When a radioactive source is needed, the Safety inventory of stored sources is checked for suitable sources. If none is found, a purchase order is completed and signed by the requestor. Safety Division keeps a copy and sends the other copies to the Purchasing Department. When the sources arrive from the manufacturer/vendor, the package will be sent to Safety Division, which inspects the package for contamination or damage and verifies, using the purchase order, that the source was correctly packaged and shipped. All radioactive sources must be assigned a JSU inventory number, except short-half-life sources fabricated, and used exclusively, in the fabricator's research area.

a. Classification of Sources

Radioactive sources are classified according to relative hazard. Normally, the relative hazard of a source is determined by the number of ALIs contained in the source. The Annual Limit on Intake (ALI) is the quantity of a single radio nuclide that, if inhaled or ingested in 1 year, would irradiate a person to the limiting value for control of the workplace.

There are two classes of sources:

Class
A-- Less than 20 ALI

B-- 20 or more ALI

Report all missing sources to the Safety Division.

All JSU source users, including guests, are responsible for knowing the location and maintaining the integrity of their sources at all times. Each source user remains responsible even if the source is loaned to another person. A sign-out sheet must be maintained at the storage safe or cabinet, with a person responsible for issuing the source and controlling the key or combination.

A lockable cabinet (preferably fire safe) bearing the sign CAUTION RADIOACTIVE MATERIALS must be provided for all sources not in use. Research equipment that contain sources must have a radiation sign, with the source identification, affixed to it. This research equipment should be made as secure as possible, for example, kept in a locked area. The user of a JSU numbered source must not alter, transfer, or destroy the source without approval of the Safety Division. Sources left unattended in authorized areas will be and stored by Safety Division. A confiscated source will not be released to its assigned user without authorization by the Director of the Safety Division.

Class A sources are inventoried annually and class B sources semiannually: a letter and list of assigned sources is sent to each source assignee. Assignees with Class A sources (those below 20 ALI) certify their knowledge of the current location and condition of each source by circling its JSU number and returning the list to the Safety Division Office.

Individuals with Class B sources must present them for inventory by Safety Division when requested at a specified date and time. Class B sources will be inspected for their integrity and checked for leakage. Any source found to be defective in any way will be returned to Safety Division for proper disposal. Safety Division maintains records of these procedures.

b. Storage and Disposal of Sources

When a source is no longer needed, the user may turn in the source or have it temporarily stored through arrangement of Safety Division office. When a source is no longer useful, or fails the safety check, it must be returned to Safety Division for disposal.

H. DOCUMENTATION OF ALARA PROGRAM

The following are used to document the ALARA (as low as reasonably achievable) program:

Personal dosimetry exposure reports-- if a personal dosimeter exceeds 50 mrem on a monthly report, an investigation is initiated. Investigations of dosimeters exceeding 100 mrem (1 mSv) must be completed within one week. .

Hand dosimetry exposure reports-- researchers who potentially could receive hand exposures approaching 5 rem (50 mSv) per year are required to have TID hand dosimeters. Monthly reports should be studied by the Safety Division. When hand doses reach a level of 0.5 rem for more than one month, investigations are initiated.

Air sampling data reports-- air samples taken within worksites are immediately scanned for radioactivity.

I. EMERGENCY PROCEDURES FOR RADIOACTIVE SPILLS

In cases of suspected area or personnel contamination or abnormal exposure to penetrating radiation, evacuate all personnel and quarantine the area; avoid tracking contamination; retain all personnel in a safe area; and immediately notify the Safety Division, and preserve the scene. Do not attempt decontamination. Give as many details of the incident as possible to the Safety Division person in charge of the clean-up operation. This information will be used for investigation reports and accident analysis. Never attempt to clean up a spill without the advice or assistance of a Safety Division representative. Preservation of the scene is necessary until the Safety Division can establish the seriousness of the spill.

J. RADIATION SAFETY TRAINING

1. All Employees

All new workers who may enter a controlled area must receive an orientation in radiation safety within one month of their initial hire. This orientation is part of the mandatory new-employee health-and safety orientation. In addition, current employees who enter controlled areas. Even though they are not radiation workers. must have radiation safety training commensurate with their job responsibilities. Supervisors must make arrangements with the Safety Division Office to schedule the required training. Retraining must be provided when there are significant changes to radiation protection policies and procedures that affect general employees.

2. Radiation Workers

Radiation workers must be given safety training sufficient to familiarize the worker with the fundamentals of radiation protection and the ALARA process. Training should include both classroom and applied training, and be commensurate with job assignments. Retraining must be provided at least every two years or when radiation protection policies or procedures are changed.

The training may be concurrent with assignment as a radiation worker; otherwise, the training must precede assignment as a radiation worker. The knowledge of radiation safety fundamentals possessed by radiation workers must be certified by examination

before an unsupervised assignment Training should emphasize procedures specific to an individual's job assignment Training not specific to a facility may be waived provided that this training has been received at another institution. Retraining is required at least every two years and when policies or procedures are changed.

II. NONIODIZING RADIATION

A. ULTRAVIOLET RADIATION

The results of exposure to ultraviolet (UV) radiation are similar to sunburn. Since there is a measurable period between exposure and development of injury, deep burns may be caused without immediate discomfort The severity of the burn depends upon the spectrum of the radiation in the UV region~ the intensity ~ and the time of exposure.

Considerable eye discomfort can be produced by exposure to radiation below about 3100 A. The absorption of this radiation by the outer layer of the eye (cornea and conjunctiva) produces conjunctivities, which occurs 4 to 8 hours after exposure and may last several days.

Most lamps used for general lighting emit little or no UV radiation so that in typical lighting installations there are no harmful effects. However, certain special-purpose lamps are designed to emit UV radiation. Some industrial processes, such as welding, also produce considerable amounts of UV radiation. In these cases certain precautions must be taken.

Protective glasses must be worn by all personnel when they may be exposed to UV radiation. Furthermore, opaque shielding should be used around welding areas to protect other personnel working nearby.

B. MICROWAVE RADIATION

1. General

Microwaves are radiowaves in the electromagnetic spectrum between the lower-frequency broadcast radio waves and infrared radiation. Microwave frequencies range from approximately 10 kilohertz to 300 gigahertz.

Typical sources of microwave radiation are microwave ovens for cooking food. The primary effect of exposure to microwave energy is thermal (heating), with the depth of heating frequency dependent. Above 3,000 megahertz, heating occurs primarily within the skin. Below 3,000 megahertz microwaves can penetrate the skin and heat the underlying tissues. Serious damage may occur in these tissues without warning because this area of the body has fewer nerve endings to sense overheating. In general, the higher the frequency the lower the potential health hazard.

The exact biological effects of microwave radiation at low power levels have not been established. However, at high power levels there is substantial evidence linking microwave exposures to eye cataracts and gonadal damage. In addition to biological effects, flammable gases and vapors confined inside metallic objects may ignite when exposed to microwave radiation.

The threshold limit values (1L V s) for microwave radiation are shown in the following Table 2.

Table 2. Radiofrequency/microwave threshold limit values

Frequency	Power Density	Electric Field Strength Squared (V2/M2)	Magnetic Field Strength Squared (A2/m2)
10kHz to 3 MHz	100	377,000	2.65
3 MHz to 30 MHz	900/f2	377Ox.900f/2	900/(37.7xf2)
30 MHz to 100 MHz	1	377	0 0.027
100 MHz to 1 GHz	f/100	3770xf/l00	f/(37.7x100)
1 GHz to 300 GHz	10	37,700	0.265

*f= frequency in MHz

These TLVs refer to radiofrequency (rf) and microwave radiation in the frequency range from 30 Hz to 300 GHz, and they represent conditions under which it is believed workers may be repeatedly exposed without adverse health effects. The 11.. Y s shown are selected to limit the average whole-body specific absorption rate (SAR) to 0.4 W/kg in any six-minute (O.l-hr) period for 3 MHz to 300 GHz. Between 30 kHz and 3 MHz the average whole-body SAR is still limited, to 0.4 W/kg, but the plateau at 100 m W/cm2 was set to protect against shock and burn hazards.

Engineering controls are the preferred means for limiting exposures to microwave radiation. Typical engineering controls involve either completely enclosing the source or shielding personnel from the source.

2. Microwave Ovens

"The microwave ovens cooks food on the inside and outside simultaneously by means of microwave radiation. Most general-use ovens operate at a frequency of 2,450 megahertz.

The hazards commonly involved are leakage of microwave energy by warped or misaligned doors or through defective seals around the door or viewing window or failure of door interlocks to shut off the oven when the door is opened. Although present ovens are built to prevent leakage, faulty interlocks could expose personnel near the oven to microwave radiation a hundredfold above safe levels.

The following precautions must be taken to reduce the possibility of injury from microwave radiation:

Do not operate the oven when empty

Do not use metallic containers

Do not leave food residue in oven

Do not tamper with oven

Keep door gaskets clean