東京大学環境安全本部
EHS Environment, Health and Safety, UTokyo

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RADIATION RE-EDUCATION MATERIALS
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1

Characteristics of Tritium and Its Effects on The Human Body and The Environment

Tritium, represented as ^{3}H or T, is a radioactive isotope of hydrogen consisting of one proton and two neutrons. Tritium disintegrates by beta-minus decay to helium-3 (^{3}He) with a half-life of 12.3 years. In nature, tritium is produced daily in the upper atmosphere through nuclear reactions between cosmic rays and atmospheric nitrogen and oxygen, and its amount is estimated to be about 200 g per year. The tritium produced in nature exists mainly as water in atmospheric vapor, rainwater, and seawater. On the other hand, some tritium can be artificially released into the environment. For example, large amounts of tritium were released from atmospheric nuclear tests in the 1950s and 1960s, and especially in 1963, tritium concentrations in precipitation in Tokyo were observed to be up to 100 times higher than natural levels. The tritium concentration in precipitation gradually decreased after the cessation of atmospheric nuclear tests, it has almost settled down to a steady-state level in nature. In addition, tritium is mainly produced by three-body fission of ^{235}U and ^{239}Pu in nuclear power plants and spent fuel reprocessing facilities for peaceful use. The tritium produced by nuclear facilities is slightly released to the environment during normal operation, but it is also released to the environment during accidents and other non-steady-state events. Although most radionuclides produced in nuclear facilities can be isolated, tritium is the only radionuclide that cannot be isolated. Furthermore, fusion reactors, which are expected to be the energy source of the future are expected to use tritium as fuel. The amount of tritium required for a fusion reactor is estimated to be equivalent to the amount of tritium present on Earth at steady state. Since a fusion reactor uses a large amount of tritium at a concentration never before experienced by humans, it is believed that it must be handled with the utmost care in the future.

Since tritium is an isotope of hydrogen, tritium is present in all hydrogen-containing materials in the environment. Therefore, the chemical forms of tritium in the environment include tritiated water, tritiated water vapor (HTO) in atmospheric water vapor, molecular tritium (HT) and hydrocarbon tritium (CH_3T) in the atmosphere, tissue free water in animal and plant bodies, tissue free water tritium (TFWT), and organically bound tritium (OBT), which exists in the organic matter that makes up the bodies of animals and plants. The tritium contained in each of these types of tritium must be considered separately because the chemical forms of tritium in each category are very different as is their behaviors in the environment. Since tritium is a beta-ray emitting radionuclide, ingestion is an important process when considering the effects on humans. The International Commission on Radiological Protection (ICRP) has proposed a dose coefficient (Sv/Bq) for each chemical form of tritium, i.e., the effective dose due to inhalation per unit of inhaled radioactivity. it is estimated that tritiated water vapor (HTO) is 10000 times more harmful than HT. When OBT is taken into the body, it is partly assimilated into the body through digestion and partly exhausted from the body. As a result, the dose coefficient of OBT is estimated to be about 2.3 times higher than that of tritiated water when assessing the dose due to the longer residence time in the body. Therefore, when assessing exposure due to tritium, it is important to take its chemical form into account in the analysis.

In general, tritium in water can be measured by a liquid scintillation counter, however, it needs to be distilled and purified to remove impurities as pretreatment. Liquid scintillation counter is a device that measures the light emitted when water containing tritium is mixed with a liquid (called a liquid scintillator) that fluoresces on interaction with radiation (beta particles in this case). To measure tritium in chemical forms other than water, such as HT, CH_3T, and OBT, it is common to oxidize these chemical substances to convert them to tritiated water and then measure them in the same way as water. The current tritium concentration in precipitation has temporarily increased as a result of the atmospheric nuclear tests, but as mentioned earlier, it has decayed to natural background levels, and its concentration is well below 1 Bq L^{-1} as an annual average. Even though liquid scintillation counters are highly sensitive measurement devices, their detection limits of 0.3 to 1 Bq L^{-1} are not sensitive enough to evaluate the current tritium concentration levels in precipitation in the general environment. Therefore, pre-concentration of tritium with electrolysis of water samples is indispensable for tritium analysis in water. On the other hand, a small amount of tritium is also produced from nuclear facilities and is supposed to be released after confirming the legal concentration limit, 60,000 Bq L^{-1} in Japan. According to the ICRP (publication 72), an adult male ingesting 2 L of 76,000 Bq L^{-1} water per day for 1 year can can accumulate an effective does of 1 mSv. At the Fukushima Daiichi Nuclear Power Plant, water stored in the reactor is treated by a radionuclide removal system (ALPS) to remove nuclides other than tritium. The government’s policy for the treated water is to release tritium under controlled conditions with a tritium concentration of 1500 Bq L^{-1} as the upper limit. this concentration is 1/40 of the concentration of the legal limit in Japan. The impact of the release of the treated water on the general public is not expected to exceed 1 mSv per year.

Hideki KAKIUCHI
Institute for Environmental Sciences
Re-Education Theme: Laws and ordinances; Human body effects

2

Characteristics of Various Accelerators and Notes for Using Them

Radiation is used in various fields such as medicine (diagnosis, treatment, etc.), manufacturing (semiconductors, tires, etc.), and agriculture (mutation breeding, food irradiation, etc.), while radiation exposure can cause various disorders. In order to prevent radiation hazards, a law (Act on the Regulation of Radioisotopes, etc.) has been enacted to regulate the handling of "radiation generators" and radioisotopes. In this law, "radiation generator" is defined as "an equipment which generates radiation by accelerating charged particles such as cyclotrons, synchrotrons, etc., which is prescribed in Cabinet Order." In short, "radiation generators" are accelerators, although there are some exclusions based on the maximum dose equivalent rate at a position 10 cm away from the surface, acceleration energy, etc.

Accelerator is a general term for equipment that accelerates charged particles in an electric field and is broadly classified into electrostatic accelerators and radio frequency (RF) accelerators. The former, such as the Cockcroft-Walton and Van de Graaf accelerators, accelerate charged particles using an electrostatic field, which does not change with time. Since a high voltage is constantly applied, discharges are likely to occur, and the upper limit of the acceleration voltage is around 20 MV. On the other hand, the latter, such as linacs, cyclotrons, and synchrotrons, utilize a periodically varying high-frequency electric field, enabling higher acceleration energies while minimizing the risk of electrical discharges. For further information on the types of accelerators and their characteristics, please refer to the text of the High Energy Accelerator Seminar, OHO [1].

When using a charged particle beam provided by an accelerator, it is essential that the users are never directly exposed not only to this beam, except in exceptional cases such as cancer treatment, but also to the secondary radiations generated by the interaction of charged particles with air, sample, or other materials, i.e., bremsstrahlung and radiation from radioactivated materials. Samples and beam dumps near the beam window are easily activated and must be carefully surveyed when entering the room after a prolonged or high-dose irradiation.

In addition, the law requires that automatic signaling devices and interlocks be provided. The former automatically indicates the use of a radiation generator at a room entrance/exit, and the user must confirm its location in advance. The latter is a mechanism that prevents entry into a room when the radiation generator is in use, such as a limit switch that ensures that the door to the room entrance is securely closed. Interlocks may also be used to prevent users from being accidentally locked in. In such cases, the interlocks are designed so that each user carries a personal key when entering the room, and the interlocks are not released until all users have left the room. Although not a direct risk, it should be noted that if a user from a distant location accidentally takes his/her personal key home, it may interfere with the operation of the accelerator.

In addition to the direct influence of radiation, other risks, such as charging and heating, must also be taken into consideration. When an insulator material (acrylate, etc.) is irradiated with an electron beam whose range is shorter than the thickness of the plate, electric charges in the beam accumulate, causing dielectric breakdown at a certain point and forming Lichtenberg diagrams[1] associated with branching discharges. If the jig or stand holding the sample is not properly grounded, the same discharge may cause damage to peripheral equipment or even cause a fire, depending on the situation.

Since an accelerator gives high kinetic energy to charged particles, the samples and beam dumps continue to receive them and get heated. Generally, a system with sufficient heat dissipation is used, but localized heating can occur under certain conditions. If the acceleration energy or beam current (dose rate) is high, heat is supplied quickly, and the samples or other materials are easily heated. If the range of the charged particles is short, energy is deposited densely over a shallow region, and localized heating is likely to occur. As a result, there is a risk of melting or evaporation if the melting or boiling point of the samples is low. Careful confirmation is necessary, especially when irradiating high-density samples or beam dumps at high dose rates or at high repetition rates.

The higher the acceleration energy, the more likely that activation by nuclear reaction occurs, which is generally vital above the average binding energy of nucleons (about 8 MeV). More precisely, the cross-section of the nuclear reaction depends on the combination of the charged particles (type and energy) to be accelerated and the target materials, and in some cases, multi-step complex reactions can occur. In addition to the sample and supporting jigs, the activation of the beam window, beam dump, and even the surrounding air must be grasped in advance. In addition, spallation reactions (fragmentation) are unneglectable for the beams of GeV-class heavy ion accelerators used for cancer therapy. Spallation reactions don't affect the velocity of the particles in the beam much but reduce the masses and charges of the particles. For example, the spallation of carbon ions produces many protons (hydrogen ions) of similar velocity. The range of a proton is longer than that of a carbon ion with the same velocity. Thus, spallation affects the dose distribution in the depth direction. Recently, versatile simulation tools such as PHITS and Geant4 have become widely available to perform such calculations.

An example of the case with activation and heating is the radioactive material leakage accident at the J-PARC Hadron Experimental Facility in 2013. At that time, a proton beam provided by a 50-GeV synchrotron was irradiated onto a gold target to generate a secondary beam of elementary particles (K- and π mesons, etc.). The target was monitored by thermocouples and cooled as a countermeasure against target heating. However, an unexpected instantaneous irradiation melted a part of the target. The melted target would be released into the atmosphere, causing the leakage of the radioactive materials that had accumulated from irradiation until the accident. Please refer to the press release for the detailed background and subsequent countermeasures [2].

Radiation can be generated not only during beam use but also during maintenance work. The inside of the accelerator tube of an RF accelerator is usually kept under an ultrahigh vacuum. When an RF electric field is applied to the tube, a small amount of electrons are generated from the inner surface of the tube by field emission or by ionization of residual gas. If the RF electric field is high, some of the electrons are accelerated in the acceleration phase, which is called "dark current." Therefore, although the dose is much lower than the operation in normal use, the possibility that X-rays are generated by bremsstrahlung due to collisions with the wall surface cannot be denied. Proper shielding and personal dosimetry should be performed even during maintenance work.

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[1] Visualization of the trajectory of electrical discharge along an insulator surface when high voltage is applied to that surface, which is a finely branched pattern like the spreading branches of a tree or lightning bolt.

Attention should also be paid to accelerators with an acceleration voltage of less than 1 MeV (generally around 200 keV), such as portable X-ray generators used for concrete inspection. These accelerators are not classified as “radiation generators” as defined in the law but are regulated by another law, the Industrial Safety and Health Act. Such accelerators are generally used in areas that are not designated as radiation-controlled areas, including outdoors. It is crucial to set up radiation-controlled areas and thoroughly inform the public so that exposure does not occur near the areas.

Radiation generators need permissions and licenses for their use, and care must be taken to avoid unintended modifications. As research progresses, the requirements for beam utilization change, often raising the necessity for their modifications. In such cases, appropriate procedures must be followed before the modifications. The doses (air dose rates) at the boundary of the radiation-controlled area and the site boundary of the business site, etc., must meet requirements to get permissions and licenses. For this purpose, shielding calculations are performed not only for the main beam supplied by the accelerator but also for the secondary radiations produced by bremsstrahlung and nuclear reactions. Even for research purposes, careful confirmation is required before, for example, modifying any part of the irradiation port.

A risk of a somewhat unique case is ozone formation when irradiating samples cooled with liquid nitrogen [3,4]. Since the boiling point of nitrogen (-196°C) is lower than that of oxygen (-183°C), oxygen is liquefied and dissolved in liquid nitrogen placed in air. When radiation strikes here, radiation-induced decomposition (radiolysis) occurs with the energy of the radiation, forming highly reactive intermediate species, which may eventually produce ozone. The higher the dose rate, the higher the efficiency of ozone production. Although ozone is corrosive, it is generally not explosive. However, in liquid nitrogen, ozone is frozen and concentrated, and if it is irradiated with charged particles, there is a risk of electrical discharge. As a result, some accidents have been reported, and the possibility of an explosion was pointed out [5].

References

[1] The High Energy Accelerator Seminar, OHO, http://accwww2.kek.jp/oho/index.html.

[2] J-PARC Center Press Release “Information on the Accidental Leakage of Radioactive Materials at the J-PARC Hadron Experimental Facility” https://j-parc.jp/HDAccident/HDAccident-j.html.

[3] A. Matsumoto, R. Yugeta, H. Karasawa, S. Sato, “The G-Values of Nitrogen Atoms Produced in the γ-Radiolysis of Liquid Nitrogen and the Ozone Formation in the γ-Irradiated Liquid Nitrogen Solution of Oxygen”, Bulletin of the Chemical Society of Japan 51(10) 2838-2840, 1978.

[4] J.D. Gault, K.W. Logan, H.R. Danner, “Ozone Formation by the Radiolysis of Liquid Nitrogen: Calculation and Measurement”, Nuclear Safety 14(5) 446-451, 1973.

[5] H. Watanabe, K. Watanuki, and E. Kikuchi, “Disaster Case Analysis: Explosion Hazard of Ozone in Irradiated Liquid Nitrogen,” Safety Engineering 15(5), 338-347, 1976. [Article in Japanese]

Shinichi YAMASHITA and Kazuyuki SAKAUE
Nuclear Professional School, School of Engineering

Re-Education Theme: Safety handling; Laws and ordinances

3

Characteristics of Nuclear Fuel Materials and Their Legal Status

We often hear the term “radioactive material,” but how is it treated legally? Materials that contain radioactive nuclides are generally called radioactive materials. Legal regulations refer to materials that have radioactivity or radioactivity concentrations above a certain value. The “Act on the Regulation of Nuclear Source Material, Nuclear Fuel Material, and Nuclear Reactors,” which we will discuss today, and the “Radioisotope Regulation Act,” which is the core of radiation safety management, do not use this term, but use the terms “nuclear source material, nuclear fuel material, and radioisotopes.” The “nuclear fuel material” that I would like to talk about today refers to relating materials that release high energy during the process of atomic fission, such as uranium, plutonium, and thorium, and that undergo nuclear fission in a nuclear reactor. One term that is often misunderstood is “nuclear source material,” but nuclear source material refers to the ore that is the raw material for uranium and thorium, which are nuclear fuel materials, and is defined in the Atomic Energy Basic Act as “uranium ore, thorium ore, and other materials that are the raw materials for nuclear fuel material, as specified by government ordinance.” The Cabinet Order stipulates that any material that contains uranium or thorium or their compounds is excluding nuclear fuel material. The Atomic Energy Basic Act was enacted in 1955 when Japan began to fully utilize peaceful nuclear energy, and it stipulates that the aforementioned nuclear fuel material is to be regulated in accordance with another law, the “Law Concerning the Regulation of Nuclear Source Material, Nuclear Fuel Material, and Nuclear Reactors.” In response to this, the Cabinet Order on the Definitions of Nuclear Fuel Material, Nuclear Source Material, Nuclear Reactors, and Radiation was enacted, which, although a bit technical, defines the following materials as “nuclear fuel material” under the law.

1. Uranium and its compounds with a natural ratio of uranium 235 to uranium 238
2. Uranium and its compounds with a ratio of uranium 235 to uranium 238 that does not reach the natural ratio
3. Thorium and its compounds
4. Substances containing one or more of the above substances 1 to 3 that can be used as fuel in nuclear reactors
5. Uranium and its compounds with a ratio of uranium 235 to uranium 238 that exceeds the natural ratio
6. Plutonium and its compounds
7. Uranium 233 and its compounds
8. Substances containing one or more of the above substances 5 to 7

This law, enacted in 1957, aims to prevent disasters and ensure public safety by ensuring the peaceful and planned use of nuclear source materials, nuclear fuel materials, and nuclear reactors, preventing disasters, and protecting nuclear fuel materials (preventing use for terrorism, etc.). Usually abbreviated as “Nuclear Reactor Regulation Act,” this is one of three major laws that regulate the use and safety of nuclear power and radiation:

the Atomic Energy Basic Act, the Nuclear Reactor Regulation Act, and the Radioisotope Regulation Act. The specific objects of regulation are refining, processing, storage, reprocessing, and disposal businesses, as well as the installation and operation of nuclear reactors, and the use of internationally controlled materials. Internationally controlled materials, which are managed at various locations at our university, refer to the small amounts of nuclear fuel material that are natural uranium or depleted uranium of 300g or less, or thorium of 900g or less. In order to ensure that nuclear fuel material is used only for peaceful purposes and is not diverted to nuclear weapons, etc., even if only a few grams of nuclear fuel material is stored, a place to handle it must be designated, and the increase or decrease in the amount of nuclear fuel material brought in and taken out of the area over a certain period of time, as well as the current amount of stock, must be accurately managed and reported to the Nuclear Regulation Authority, and the government must also report this information to the International Atomic Energy Agency (IAEA). Therefore, even if a small amount of nuclear fuel material is used, it is necessary to obtain permission to use internationally controlled materials and submit a nuclear fuel material management report twice a year.

The competent authorities for nuclear fuel materials are the Nuclear Power Plant Site and Nuclear Fuel Cycle Industry Division, Electricity and Gas Business Department, Agency for Natural Resources and Energy, an external bureau of the Ministry of Economy, Trade and Industry, and the Nuclear Regulation Planning Division, Nuclear Regulation Department, Nuclear Regulation Agency, an external bureau of the Ministry of the Environment (formerly 、the Nuclear Fuel Management and Regulation Division, Nuclear Safety and Security Agency), which work in cooperation with the Nuclear Regulation Authority and the Nuclear Energy Division, Research and Development Bureau, Ministry of Education, Culture, Sports, Science and Technology, and it is important to check the trends of these competent authorities when managing nuclear fuel materials.

Finally, some definitions of terms are provided.

“Refining” refers to the chemical processing of nuclear source material or nuclear fuel material in order to increase the ratio of uranium or thorium contained in the nuclear source material or nuclear fuel material.

“Processing” refers to the physical or chemical processing of nuclear fuel material to give it a shape or composition that can be used as fuel in a nuclear reactor.

“Reprocessing” refers to the treatment of nuclear fuel material used as fuel in a nuclear reactor or other nuclear fuel material that has undergone atomic fission (hereinafter referred to as “spent fuel”) by chemical means in order to separate nuclear fuel material and other useful materials from it.

It is expected that various changes will be made to the Nuclear Reactor Regulation Act, related laws and regulations, and related organizations in the future, but we ask that all workers involved in radiation work reaffirm the importance of following the law to the bare minimum, and engage in safe radiation handling work.

Hiroyuki IIZUKA
School of Engineering, Environment, Health and Safety Office
Re-Education Theme: Nuclear fuel materials; Safety handling; Laws and ordinances

4

Category and Mechanism of X-ray Equipment for Research

X-ray (also called Roentgen ray named after the discoverer) is widely used for research, industry, medical, and so on. It is a type of electromagnetic wave, same as gamma ray, and has strong permeability. While wave length of gamma ray is distributed under 10^{-2} nm, wave length of X-ray is distributed from 10^{-3} to 10 nm. The shorter the wave length, the higher the resolution, so X-ray is extremely useful as a way of analyzing the structure of the material.

X-ray tube consist of the filament as a cathode and the target as an anode (also an anticathode), and they are sealed in a vacuum tube made of glass or ceramic. Filament material is usually tungsten, and target material is tungsten, molybdenum, copper, rhodium, silver, etc. Some X-ray tubes have X-ray transparent windows made of metal beryllium (harmful), so we have to remove that tube from X-ray equipment when disposing of the equipment and suitably dispose of the beryllium separately from the main X-ray body.

When voltage is applied to a tungsten filament, it heats up and electrons are produced by the thermionic effect from the filament surface. The electrons are accelerated by the high voltage potential between the cathode (filament) and the anode (target), and hit the anode, and X-rays are generated. About 1 % of the applied electrical energy is used for X-ray generation, the remaining 99 % of the electrical energy converts to heat. The tungsten filament becomes hotter than 2000°C by the heat and the tungsten gradually evaporates from the surface of filament and ruptures at the end (called burnout). The time until burnout is the lifetime of the filament i.e. X-ray tube, and the higher the temperature of the filament, the shorter its lifetime. There is a tendency that the greater the current applied to the tube, the shorter its lifetime. Therefore, all X-ray equipment needs a cooling mechanism: equipment with small output (around 2 kV or below) uses an air cooling mechanism, while cooling mechanism for equipment with large output (over 2 kV) involves circulating a cooling liquid such as a cooling water or an insulation oil. Also, the lifetime of the filament can be shortened by rapidly applying a large current to the cold state, as such recent X-ray equipment use a start-up program for softly increasing current when starting the device.

X-ray is used for many types for analysis and examination in combination with measuring instruments by taking advantage of its interaction with material. In the research field, it is used for crystal structure analysis by diffraction, for elemental identification

Table 1 Requirements for extremely low-risk X-ray equipment at the University of Tokyo

Equipment using photoelectron spectroscopy
Using MgKα, AlKα, or ZrLα X-ray
The inside of the housing will be in an ultra-high vacuum state during measurement.

In order to be certified as very safe X-ray equipment and exempt from radiation control, the equipment must register after receiving confirmation from the X-ray WG of the Radiation Control Office in central EHS office of the University of Tokyo. If you would like to receive certification of your XPS equipment, please first consult your department's radiation control section.

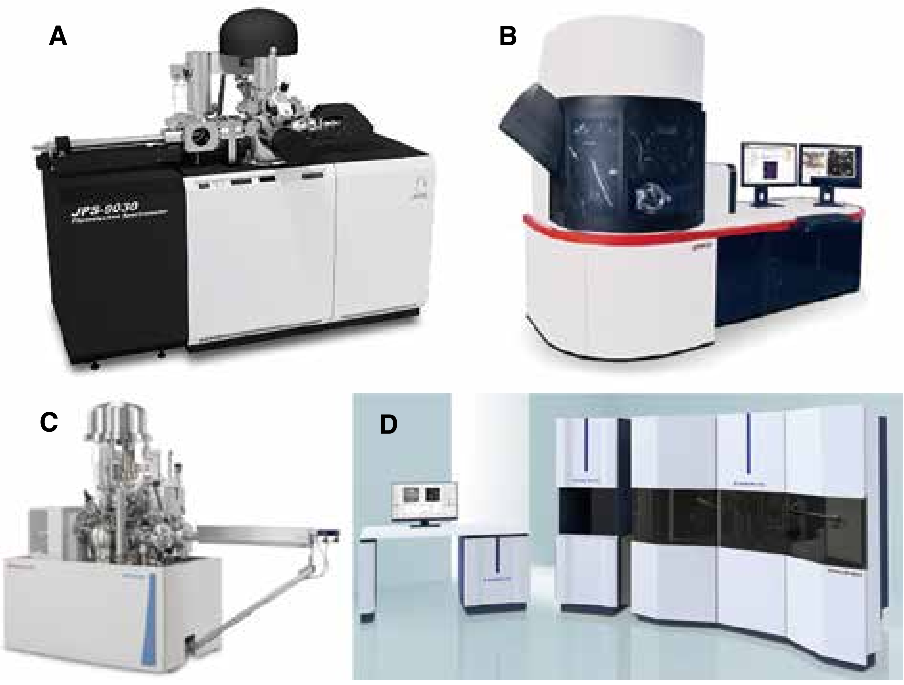

Figure 1 Example of XPS equipment

A. JEOL:JPS-9030 (https://www.jeol.co.jp/products/scientific/xps_esca/JPS-9030.html)

B. Shimadzu corp.:KRATOS ULTRA2 (https://www.an.shimadzu.co.jp/products/surface-analysis/x-ray-photoelectron-spectrometer/axis-supra/index.html)

C. ThermoFisher SCIENTIFIC:ESCALAB Xi+(https://www.thermofisher.com/jp/ja/home/electron-microscopy/products/xps-instruments/escalab.html)

D. PHYSICAL ELECTRONICS:PHI VersaProbe 4 (https://www.phi.com/products/versaprobe.html).

by fluorescence, for photography and nondestructive inspection by permeability, etc. Some modern X-ray diffraction analyzers (XRD) and X-ray fluorescence analyzers (XRF) have low power and, as such, come as small tabletop devices. In the field of microstructure analysis, monochromatic X-rays are required. Many X-ray equipment obtain monochromatic X-rays of required wavelength with a combination of X-ray tube and suitable filter, while large-scale synchrotron radiation facility can obtain high brightness monochromic X-ray beam.

X-ray photoelectron spectroscopy (XPS, also ESCA) use the photoelectric effect and measure the photoelectrons from sample surface by irradiating the sample with soft X-rays (i.e. MgKα or AlKα, etc.) which energy is several tens of eV to several kilo-eV. Beamline of XPS needs to be housed in an ultra-high vacuum environment. X-ray will stop when the XPS housing is no longer under vacuum, and X-ray never go outside of housing, so XPS is certified as very safe X-ray equipment in the University of Tokyo (Table 1, Figure 1). Users of XPS only do not need to register as a radiation handler.

In the medical field, X-ray is widely used by permeability for diagnosis in the way of photography, X-ray CT, angiography, etc. High doses of X-ray irradiation are used to treat cancer as radiotherapy.

In X-ray equipment, there is a possibility of exposure when human body enters between X-ray generator (X-ray tube) and measuring instruments or enters in X-ray irradiation area. Radiation damage by X-ray is mainly skin injury as deterministic impact (hair removal, erythema, blisters, ulcer, depending on the exposure dose). Because the lens of the eye is highly sensitive to radiation, exposure to X-rays may increase the risk of cataracts. In the field of microstructure analysis, X-ray beam is narrow and radiation exposure spot will be small. But large X-ray equipment almost outputs high-energy X-ray, so users must be very careful not to get their hands, fingers, or head into x-ray beamline when adjusting.

In examinations using medical X-ray equipment, the patient exposure is about 0.06 mGy X-ray in every chest X-ray imaging (diagnosis), about 3.0 mGy in every stomach X-ray imaging, about at most 30 mGy in every X-ray CT scan (depends on the part of body). No one other than the patient normally will be exposed to X-ray, but the worker who enters the X-ray irradiation field to fix the patient or the animal under treatment with them may be exposed. The hands, fingers, and eyes of the operator on interventional radiology equipment (IVR, also called vascular imaging) are exposed to X-ray, so it is necessary to control exposure dose by using a dedicated dosimeter such as ring dosimeter or eye dosimeter.

In the University of Tokyo, X-ray equipment are classified into five categories from A to E depending on the safety of the equipment, not depending on their output. Type-A and type-B X-ray equipment are certified as a safe X-ray equipment, and users of Type X-A or Type-B equipment only have to take radiation education and don't have to take radiation medical examination. (The aforementioned XPS is safer than Type X-A equipment) Type X-A equipment has a sensor in the X-ray cover, when the X-ray cover is open, the X-ray power supply is turned off. Type X-B equipment has interlock system for safety and when the X-ray cover is open, the X-ray shutter closes and X-ray beam stops. Type X-C,D,E equipment don't have interlock system or stop the system, so the user need to be as safe as preventing the human body from entering the X-ray irradiation area or X-ray beamline when measuring (Type X-C), as avoiding entering the radiation controlled area during X-ray irradiation (Type X-D), and as prohibiting people from entering the direction of X-ray radiation (Type X-E), etc.

Some Type X-B equipment can stop interlock system by key during inspection and beam line adjustment. In this state, this equipment will be equivalent to Type X-C and if a human body enters the X-ray beamline, there is a risk of exposure. In 2021, an accident occurred at Nippon Steel's X-ray facility in which workers were exposed to more than 100 mGy. The cause of this accident was that safety procedures were not thoroughly followed while interlock of the X-ray equipment was turned off and the shutter was open, and the worker worked in the irradiation area without realizing that X-ray was being irradiated. When generating X-ray while the interlock system is stopped, it is necessary to follow the work procedure manual and great care must be taken to ensure that no human body enters the beam line.

Because X-ray may leak due to malfunction of the X-ray equipment, X-ray leakage inspection is required once a year by the law. In the University of Tokyo, the radiation control office in each department mainly conduct X-ray leakage inspections using survey meters.

Satoshi IIO
School of Engineering, Environment, Health and Safety Office
Re-Education Theme: X-ray; Safety handling

5

Overview and Notes on Using the University of Tokyo Radiation Worker Management System (UTRadMS)

At the University of Tokyo, all the radiation workers are managed through the University of Tokyo Radiation Worker Management System (UTRadMS). This system is unique to the university, and all the university members who handle radioisotopes and/or X-ray apparatus, whether on or off campus, must register their information as radiation workers with this system. Currently, approximately 4,500 workers are registered. This chapter outlines key points for using UTRadMS, but for detailed instructions, please refer to the various manuals available on the Environmental Health and Safety (EHS) portal site.

On the UTRadMS user page, you can submit various applications necessary for your lab experiments as radiation workers, such as online medical questionnaires for radiation workers and requests for the initial training courses for radiation workers. UTRadMS is linked to the UTokyo Account, and you will need your personal ID and password to log in to the user page. If you do not have one, please contact your departmental radiation safety office.

ログインユーザ：東 大 花 子

希望する内容を選択してください。

Figure 1. Top page of the UTRadMS user page

Application for Registration: This button is for submitting new or re-registration applications. If you are already registered but the button is still clickable, it may indicate a duplicate registration. Please contact your departmental radiation safety office.

Application for handling radioisotopes and/or X-ray apparatus in other departments: If you want to work in multiple departments, you can submit a registration application to each department. After registering with your primary department and completing the required initial training for radiation workers, initial department workshop, and medical examinations for radiation workers, you can proceed with the application for use by other departments. Be sure to consult your laboratory staff or your departmental radiation safety office before submitting this application.

Application for Modifying Registration Details: This button will become clickable after you have completed the required initial training courses for radiation workers, the initial department workshop, and the initial medical examination for radiation workers. If you need to modify your registration information before this button is available, please contact your departmental radiation safety office.

Application for suspending your certification as a radiation worker: If you want to discontinue your lab. experiment using radioisotopes and /or X-ray apparatus, please promptly submit the cessation application. Even if your certification is suspended, your medical examination history and radiation exposure records will remain accessible on your My page in UTRadMS.

Medical Questionnaire on the Web: Before undergoing the initial medical examination for radiation workers or the regular medical examination for radiation workers conducted twice a year, you must complete the online questionnaire from this section. If you receive a follow-up email for medical examination for radiation workers after the initial evaluation, promptly undergo the examination, including hematologic tests. The first assessment is valid for six months. You can also check the date of your initial evaluation and the progress of your medical examinations through the “Radiation Medical Examination History” section on your My Page in UTRadMS.

Medical Examination Sheet: When attending a radiation medical examination, please download the medical examination sheet, print it on A4 paper, and submit it to the reception on the day of your examination. Ensure that the printout is correctly formatted, as incomplete printouts may not be accepted.

My Page: If any of your applications or medical questionnaires are returned by an administrator, you will need to resubmit them through your My Page. Make sure to check My Page for any notifications when you log in to the user page.

In addition to submitting applications and completing medical questionnaires, UTRadMS allows users to check the results of mandatory medical examinations and radiation exposure records as required by law. To ensure the safe and compliant handling of radiation, please complete the necessary training and medical exams and regularly log in to the user page to check your medical examination history and radiation exposure results.

Reference

UTokyo Portal | UTRadMS
https://univtokyo.sharepoint.com/sites/EHS_portal/SitePages/d/UTRadMS.aspx [in Japanese]

Satori KUKITA
Division for Environment, Health and Safety
Re-education theme: Safety handling; Laws and ordinancesnancses