

# Study Guide for Radiation Safety



**October, 2022**

Radiation Science Center

High Energy Accelerator Research Organization (KEK)

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Radioisotopes (RI) and radiation-generating apparatus (installations producing ionizing radiation, such as accelerators) may have the potential to cause risks of hazardous radiation exposure to human bodies during handling and operation. KEK has a set of rules concerning the radiation protection system for radiation workers and the general public. This protection system satisfies the requirement that, during operation or handling, exposure of the staffs to radiation must be kept to a reasonably achievable minimum, while considering various factors.

From a radiation-safety point of view, this brochure aims to provide essential information concerning radiation protection. This information must be understood by staff members, students and users from other organizations. They have to follow certain regulations during their work involving radiation. The topics covered in the brochure include the radiation-safety control system, criteria for exposure control, various procedures that must be fulfilled by radiation workers, and fire emergency response procedures. For more details, please consult the Radiation-Control Office.

## 1 Basic Rules for Radiation Protection

There are seven radiation-controlled areas where accelerators and radioisotopes are handled. **Radiation work** implies all work conducted in these areas. The only workers allowed to perform work and experiments in these controlled areas are those who are registered as radiation workers, have received education and training on radiation safety, and have been health-checked by a doctor. Before working in a radiation-controlled area, it is advisable for everyone to get acquainted with the rules and standards concerning KEK radiation safety.

The risk of radiation exposure during radiation work greatly depends on the location in the radiation-controlled area. Radiation workers must know such information as admissible radiation level in their working area, which they need to understand to ensure radiation safety.

**They must try to avoid or keep as low as possible any undue radiation exposure.**

As a matter of fact, the achievement of radiation safety depends on individual personal comprehension of radiation safety. Every individual working with accelerators or radioisotopes must always be aware of the responsibility to protect both himself/ herself and other workers from any radiation exposure arising from his/her work.

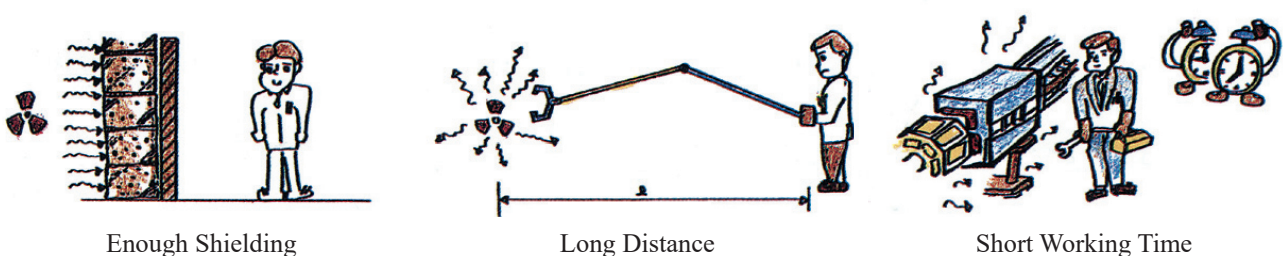


Figure 1-1: Three principles for protection against external exposure.

In order to reduce external exposure during radiation work, it is recommended to be properly shielded from radiation sources, to maintain sufficient distance from them as far as possible, and to complete all work within a short time.

## Radiation source at KEK

At KEK, the main radiation is coming from high-energy accelerators of electrons ( $e^-$ ) and positrons ( $e^+$ ): 7 GeV- $e^-$ /4 GeV- $e^+$  linear accelerator, 2.5 GeV- $e^-$  photon factory, SuperKEKB 4 GeV- $e^-$ /7 GeV- $e^-$  collider, 6.5 GeV- $e^-$  PF-AR ring. In the daily radiation work at KEK, the radiation environment is changing according to the operation conditions of the accelerator facilities. During the operation, radiation workers and beam users are working in the experimental areas with different radiation levels. In the electron facilities (photon factory, SuperKEKB), radiation level behind the shielding is quite negligible. After the operation stops, radiation workers can enter the beam-line tunnels for maintenance of the beam lines where **gamma-rays**, emitted from radioactive accelerator components, are responsible for most of the radiation.

## 2 Radiation-Safety System

- (1) The radiation-controlled area (Appendix 1) is divided into seven sections (Appendix 2). Each section has one appointed **regional radiation-safety officer** (belonging to the Radiation Science Center), and one or more appointed **regional radiation-safety liaison officers**, who belong to different institutes and facilities. They are representatives of each working area and facility. The regional radiation-safety officer, in cooperation with the radiation-safety liaison officer(s), carries out his duties to ensure radiation safety by monitoring the radiation and radioactivity levels in controlled areas in order to keep the safe working environment.
- (2) The Directors-General appoints a **radiation-generating installation supervisor** for each radiation-generating apparatus. Secondary beamlines, branching off from the main primary beam-lines, and systems, which emit X-rays, like klystrons, are also controlled as radiation-generating apparatus. While the Division or Group leaders are responsible for the maintenance and management of their assigned apparatus, the radiation-generating apparatus supervisor must operate the apparatus according to the license regarding the beam intensity and beam energy. He must regularly inspect the safety equipment, such as any interlock systems, in order to ensure safe operation. Naturally, any remodeling or renovation of the radiation-generating apparatus without the permission by the Directors-General is forbidden.
- (3) As shown in the scheme of the safety organization (Appendix 3), the KEK radiation-safety system is centralized. The **Radiation-Safety Supervisor** is in charge of observing the effectiveness of the radiation safety system. If any problem is found, it is his duty to inform the Directors-General to improve the system.
- (4) The **Radiation-Safety Committee** discusses important items, such as the basic rules, various criteria, and the installation or renovation of the facilities of the radiation-generating apparatus. Afterwards, it makes recommendations to the Directors-General.

- (5) The names and telephones of the regional radiation-safety officers, radiation-safety liaison officers and radiation-generating apparatus supervisors are listed on web page (<https://rcwww.kek.jp/user/top.html>). Daily or emergency contacts, requests, and inquiries should be reported to the **Radiation-Control Office (TEL:3500)**, which is located at the south part of the Radiation Science Center building.

Please feel free to send inquiries about any details concerning radiation safety to the Radiation-Control Office.

### 3 Personal Exposure Control

- (1) The criteria concerning the annual dose limit for radiation workers and other persons have been determined as listed in Table 1 (each year, beginning from the 1st of April; every three months, starting from the 1st day of April, July, October, and January).
- (2) According to the philosophy of the law regarding radiation exposure, the latter must be kept to a reasonably achievable minimum; also considering the international tendency for decreasing of the dose limit, working levels of radiation doses are employed in order to be controlled daily and weekly (Table 2). In order to avoid over-exposure inside of the area of high radiation, such as beam lines of accelerator facilities, it is recommended that each radiation worker must keep the working level per day in mind.
- (3) Personal dosimetry for radiation workers is performed as follows:
  - Personal monitoring of radiation doses is conducted at KEK using a personal dosimeter, and the radiation dose is measured monthly. It is required that workers keep these assigned dosimeters with them in any controlled area. Other personal dosimeters, such as a direct-reading **alarm meter** and a **DIS dosimeter**, must be carried in addition to the assigned personal dosimeters, when working in a high-radiation area, such as the beam-line tunnels of the proton synchrotron facilities, some high-dose areas in the Linac, and the SKEKB tunnel.
  - Users are required to exchange monthly their personal dosimeters. Any used personal dosimeter should be returned immediately after the end of the month period to the Radiation-Control Office through the group offices. If there is a delay in returning a dosimeter, personal monitoring cannot be performed promptly, and evaluating the dose becomes difficult.
  - The results of personal monitoring are sent to individuals by the Radiation-Control Office through the leaders of the divisions, groups, and facilities. Please consider carefully these results of personal monitoring to keep the exposure during radiation work as low as possible.

Table 1: Exposure Control

| Category                                    | Item                        | Dose Limit                     |
|---|-----------------------------|--------------------------------|
| Radiation Worker                            | Effective Dose:             |                                |
|   | Man                         | 20 mSv/year                    |
|   | Woman <sup>[1]</sup>        | 6 mSv/year<br>2 mSv/3month     |
|   | Internal Exposure           | 1 mSv/gestation <sup>[2]</sup> |
|   | Equivalent Dose:            |                                |
|   | Female Abdomen              | 2 mSv/gestation <sup>[2]</sup> |
|   | Eye Lenses                  | 50 mSv/year, 100 mSv/5years    |
|   | Skin                        | 300 mSv/year                   |
| General Public<br>(Non Radiation<br>Worker) | Emergency:                  |                                |
|   | Male only, once in his life | 100 mSv                        |
|   |                             | 100 µSv/work                   |

[1] This is not applicable if workers did not report on intention of pregnancy to the Radiation-Safety Supervisor.

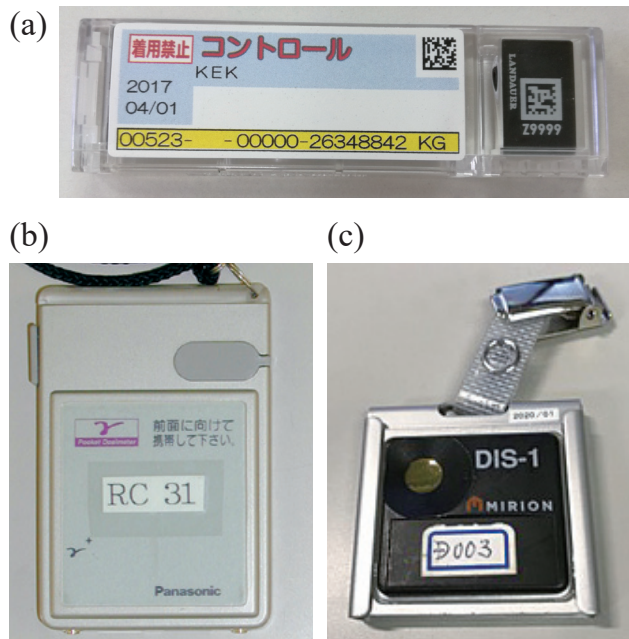
[2] During the gestation after declaring pregnancy.

Table 2: Working Level for Exposure Control

|                |          |       |         |
|----------------|----------|-------|---------|
| Effective Dose | per day  | Man   | 0.5 mSv |
|                |          | Woman | 0.3 mSv |
|                | per week | Man   | 1.0 mSv |
|                |          | Woman | 0.5 mSv |
| Effective Dose | per year | Man   | 7 mSv   |
|                |          | Woman | 2 mSv   |

Figure 3-1: Dosimeters at KEK

- (a) Personal dosimeter,
- (b) Alarm meter, (c) DIS dosimeter



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### Note on the Handling of Dosimeters

Personal dosimeters would be installed in their cases so as to display the name of the carrying person and should be worn on the chest for a man or on the abdomen for a woman, with the name side facing outward. If these dosimeters are worn at some distance from the body, the dose is underestimated. An alarm dosimeter sounds an alarm when the integral dose exceeds the preset value, thus urging the bearer to leave promptly the area. Since the battery power is consumed and falls off after an alarm, this produces an unstable operation. Therefore, it is thus advisable to use it only after charging the battery.

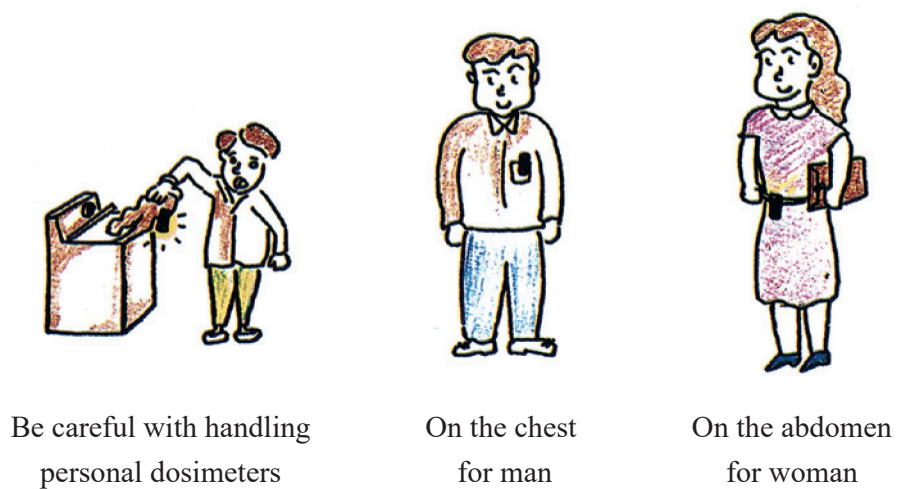


Figure 3-2: Handling personnel dosimeters

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Table 3: Criteria for Radiation-Controlled Areas

| Area                      | Name                   | External Dose Rate and Radioactive Contamination and Concentration |  |
|---------------------------|------------------------|--|--|
| Radiation Controlled Area | General Radiation Area | Dose Rate  | 1.5 ~ 20 $\mu\text{Sv}/\text{hour}$<br>Air Concentration $\leq \text{DAC}_a^{*1} \times 0.1 \text{ Bq}/\text{cm}^3$  |
|                           | Restricted Area        | Dose Rate  | 20 $\mu\text{Sv}/\text{hour}$ ~ 100 $\text{mSv}/\text{hour}$<br>Air Concentration $> \text{DAC}_a^{*1} \times 0.1 \text{ Bq}/\text{cm}^3$<br>(Contamination Area)<br>Surface Contamination ( $\alpha$ ) $> 0.4 \text{ Bq}/\text{cm}^2$<br>( $\beta, \gamma$ ) $> 4 \text{ Bq}/\text{cm}^2$ |
|                           | Forbidden Area         | Dose Rate  | $> 100 \text{ mSv}/\text{h}$   |
| Warning Area              |                        | Dose Rate  | 0.2 ~ 1.5 $\mu\text{Sv}/\text{hour}$   |
| Non-designated Area       |                        | Dose Rate  | $\leq 0.2 \mu\text{Sv}/\text{hour}$  |
| Site Boundary             |                        | Dose Rate  | $\leq 50 \mu\text{Sv}/\text{year}^{*2}$  |
|                           |                        |  | Concentration of Air and Water<br>$\leq \text{DAC}_p^{*3} \times 0.05 \text{ Bq}/\text{cm}^3$  |

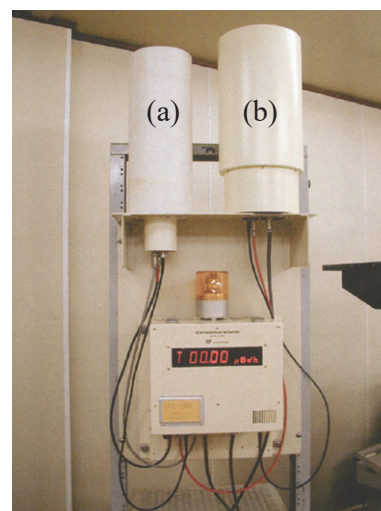
- 1) Radioisotope concentrations are listed in Table 1 and 2 in the Legal Notification of quantities of radioisotopes.
- 2) This is determined by the Directors-General.
- 3) Radioisotope concentrations for the general public are listed in a public notice mentioned in (1) above.

## 4 Radiation-Controlled Areas

- (1) Radiation-controlled areas on the KEK campus are shown in Appendix 1. The classification of the areas are listed in Table 3.
- (2) The radiation-controlled areas are normally surrounded by fences; a sign with a radiation symbol and instructions for entering the areas are posted on the gates of the main entrances. Many monitors measuring radiation and radioactivity are installed inside the radiation-controlled areas to control the level of radiation so that it would not exceed the criteria, designated to each controlled area.

Figure 4-1: Radiation monitor

- (a)  $^3\text{He}$  tube of 1 inch diameter with polyethylene moderator for neutron measurement
- (b) 10 liter ionization chamber for  $x/\gamma$  -ray



## 5 Entering a Radiation-Controlled Area

In general, only radiation workers are allowed to work inside a radiation-controlled areas. The general rules for entering radiation-controlled areas are explained as follows:

### (1) **Forbidden Area**

Entering this area is strictly forbidden, except for emergency cases, which must be determined by the Directors-General.

### (2) **Restricted Area**

Access to this area is only allowed to radiation workers who obtain permission in advance from the regional radiation-safety officers. When somebody is registered as a radiation worker, the officer can assign the person's name to the restricted radiation-controlled area, if he is scheduled to enter the area daily. The group leader specifies the person's name in the application form. According to the registration, KEK-ID cards of radiation workers are registered with information regarding the restricted areas. While radiation workers with the permission in advance are allowed to enter the restricted area with their KEK-ID cards, other radiation workers must submit a **Radiation-Work Form (No.2)** to the guard at the gate to borrow access cards for entering the area. The restricted radiation-controlled areas, such as the beam-line tunnels of accelerators are strictly controlled by an access-control system. Please follow strictly all procedures when you enter such areas.

### (3) **Contamination Area** (PS accelerator, NML beamline, EP1 tunnel, EP2 room, Positron-Electron Injector room, Shiryo Sokuteitoh Radiochemistry Laboratory, PF Radiochemistry Laboratory (BL 27))

This area has been classified as one of the restricted areas, since the surface contamination by radioisotopes may possibly exceed the criteria. When you enter this area, it is required to obtain advance permission from the regional radiation-safety office using the same procedure as for the restricted area. Radiation workers who have been assigned to work in the area can enter using their cards; other radiation workers must submit a **Radiation-Work Form (No.2)** to the guard at the gate of the area in order to borrow access cards.

Generally, **gate monitors** (Fig.5-1) or **hand-foot-clothes-monitors** are installed at the entrance to check any contamination of clothes, hands, and feet. Please remember that eating, drinking and smoking are prohibited in this area.

### (4) **General Radiation Area**

Although the entrance procedure depends on the type of radiation-controlled area, KEK-ID and access cards are always used for entrance control. Although radiation workers can freely enter this area because of the low radiation level, only radiation workers who are supposed to work in the area are registered from a general safety point of view. Radiation workers, who are not registered in this area, can enter by submitting a **Radiation-Work Form (No.2)** to the guard in order to borrow an access card.

(5) **Warning Area** (PS accelerator circumference, PF LINAC circumference SuperKEKB, PF-AR and DR Dengen-toh)

In order to exclude general public and non-radiation workers, this area is surrounded by a fence with locked entrances. A radiation worker may freely enter the area by borrowing a key. General public or non-radiation workers may enter after reporting to the regional radiation-safety office.

(6) **Personal Key**

In order to ensure safety, a personal-key system is employed in special areas, such as the beam-line tunnels of PS, cERL, LINAC, DR, BT, PF-AR, ATF, STF and SuperKEKB, where entering during operation is strictly prohibited. This is because of the lethal dose rate in the accelerator rooms. In the case of entering the area, a KEK-ID or access card must be placed on the card reader, after which a personal key can be pulled out. **Every individual must carry one personal key** to enter the area. This key must be returned to the key box when leaving the area.

Figure 5-1: Gate monitor



Radioactive air duct



Radioactive water pipe



Signs indicating **Radiation-Controlled Area**  
(These signs are specified by law.)



Signs established by KEK  
(not specified by law.)

Figure 5-2: Signs for radiation control

## Key Points Concerning Radiation-Safety Control

Radiation-safety control can be classified into the following three major items, listed in the order of importance: (1) radiation-source control; (2) environment control; (3) personal control.

To ensure radiation safety, it is important that radiation sources, such as radio- isotopes and radiation-generating apparatus, are always maintained in normal conditions: i.e., it is a fundamental rule of radiation-safety control that these sources must be kept and controlled safely using a safety system and shielding.

The second item above indicates the confirmation of radiation-control in each radiation-controlled area by measuring the radiation or radioactivity around any radiation sources to check that the level is below the criteria of the controlled area.

The third item is the final confirmation of the personal radiation exposure by the exposure control using the results of personal monitoring; hence, it is unavoidable to take time to obtain a confirmation.

### KEK-ID and access cards

KEK-ID and access cards are applied to control the access to radiation-controlled areas. The information, which is registered in the database, determines the areas which can be entered. It is advisable to follow the instructions below when handling the cards:

(1) The cards should not be bent, cut or stained on the surface. A crooked card cannot be read correctly by card readers. Cuts or stains on the surface cause reading of incorrect information by card readers.

(2) It must be noted that the magnetic data in the card are often erased due to exposure to any magnetic field while working near magnets.

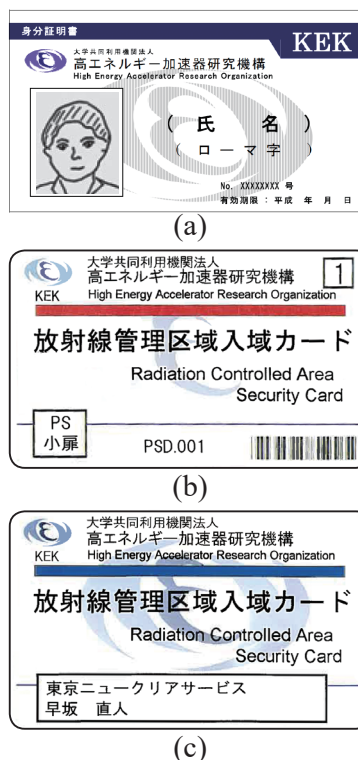
Figure 5-3: KEK-ID and access cards

Personal information is stored in the IC-chip and magnetic tape on the back side:

- (a) KEK-ID for staff,
- (b) access card for contractors,
- (c) access card for users.



Please be careful; the card is fragile.



## 6 Radiation-Generating Apparatus and Instructions concerning Radiation Work

### (1) Radiation-Generating Apparatus

- Characteristics of the major radiation-generating apparatus are listed on the web page (<https://rcwww.kek.jp/user/top.html>).
- Except for the radiation-generating apparatus defined by law, other radiation-generating installations, such as secondary-beam lines attached to the apparatus, X-ray generators, DC separators, and klystrons are controlled according to the KEK rules applied to the radiation-generating apparatus. Hence, it is necessary to report to the radiation-safety supervisor, and to obtain permission from the Directors-General before using these installations. They must be operated only after the inspection of the safety system and obtaining approval by the radiation-safety supervisor.

### (2) Instruction for Radiation Works

Although instructions for radiation workers during their radiation work differ slightly depending on each radiation-controlled area, the major points are given below. The instructions for handling radioisotopes are summarized in Chapter 8.

- Several kinds of flashing lamps are employed to indicate the operation of the apparatus.  
**Yellow flashing lamps** installed at the gate of a radiation-controlled area indicate the operation of radiation-generating apparatus, such as accelerators.  
**Red flashing lamps** indicate the operation of apparatus with high voltage on (magnets, X-ray generators, DC separators, klystrons, etc.).  
**Green flashing lamps** indicate the operation of apparatus with high pressure gases, such as cryostat using liquid He (super conducting magnet) and production facilities of high pressure gas and liquid He.
- When the radiation level exceeds the allowed level of the radiation-controlled area, radiation monitors sound an alarm. If the alarm rings continuously or frequently, you must promptly leave the area and inform the regional radiation-safety liaison officers and the Radiation-Control Office (TEL:3500).
- Beam lines in the experimental area are usually surrounded by fences and hatches with interlock doors. When entering such an area, the instructions for entering must be followed.
- If you are working in a restricted area, such as accelerator tunnels, and you hear an announcement that accelerators will start operation, you must stop the accelerator operation by pushing emergency buttons.
- If the radiation level exceeds the controlled level during accelerator operation or the handling of radioisotopes, the area is temporarily fenced off even inside the general radiation area, to control it as a restricted radiation area. Permission to access the area must be obtained from the regional radiation-safety officer.

- The entrance into a restricted area, where surface contamination may occur due to radiation work, is strictly controlled. Radiation monitors, such as gate monitors and hand-foot-cloth monitors, are installed at the gate to check the contamination of any human body and goods (equipment, tools, etc.) carried from the outside.
- When activated materials are carried out from radiation-controlled areas, it is necessary to obtain permission from the regional radiation-safety officers. Hence, goods carried outside must be checked by an article-monitor at the gate whether or not they are activated. If it is difficult to check the goods by the monitor because of its size, individuals must inform the Radiation-Control Office (TEL:3500) and the items must be checked. Even one tiny bolt should not be brought out carelessly without permission.



Figure 6-1:  
Flashing yellow pilot lamp indicates the operation of accelerators.



Figure 6-2:  
Emergency button: in the case of an emergency, accelerator operation can be terminated.



Figure 6-3:  
Three-color pilot lamp;  
**Red:** high voltage, high magnetic field;  
**Green:** high pressure gas (Liquid He) ;  
**Yellow:** radiation (accelerator operation).



Figure 6-4:  
If the alarm sounds continuously or frequently, evacuate the area immediately.



### (3) Radiation Work Accompanying Internal Exposure

- If entering a beam-line tunnel immediately after operation, the concentration of radioactive air in the tunnel must be measured in order to ensure that the level is below the standard ( $DAC_a \times 0.1$ ). Please obey the instructions for entering the beam-line tunnel if the waiting time is specified by the radiation-control center. In the case of an emergency, these rules are not applicable.
- Any cutting, welding or machining of radioactive materials may result in internal exposure. Therefore, before undertaking such radiation work, it is compulsory to inform the radiation-control office and to follow the instructions.

### (4) Instructions for Radiation Workers

- In order to conduct safely radiation work, it is advisable for radiation workers to understand well the rules and to follow the work procedures and instructions, which are specified in each facility. At each facility, education and training about the safety systems, such as the interlock, are given to operators and maintenance workers for radiation-generating apparatus by the division leader and radiation-generating apparatus supervisor. Especially, if radiation workers who work on the maintenance of the safety system ignore the rules and procedures, serious radiation exposure may be induced. To ensure radiation safety, it is important for radiation workers to work under the control of a radiation-generating apparatus supervisor and with their clear instructions about their duties and assignments.

## 7 Radiation Work for Outside Workers

- (1) In principle, even outside workers must be registered as radiation workers at KEK, if they are to work in the radiation-controlled area. The procedure to register outside workers as radiation workers is shown in detail in appendices on the web page (<https://rcwww.kek.jp/user/top.html>). Information can be obtained from the Radiation-Controlled Office. The procedure is different from that of staff members, because, **at their companies, they must be registered as radiation workers, take education and training, health examination and dosimetry control**. After submitting the required forms (No.10), it is compulsory for outside workers to take the original KEK education course for radiation safety before starting their radiation work. The procedures for radiation work in any radiation-controlled area are listed as follows:

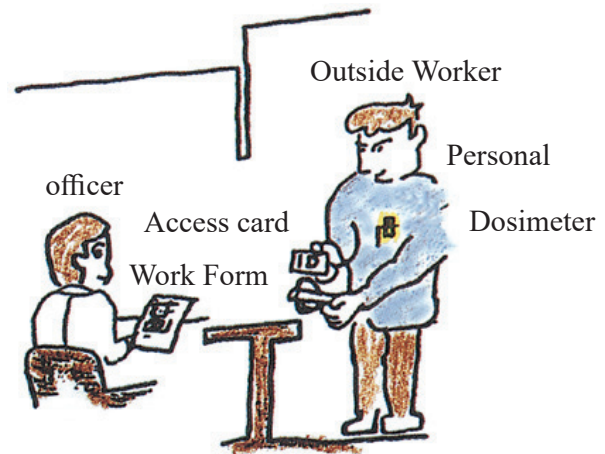
- a. Preparation of the Radiation-Work Form (No.2)

A staff member (radiation-work supervisor), who orders outside workers to carry out radiation work, must give them thorough instructions concerning their work as follows: wearing personal dosimeters issued by their organization and safety instructions concerning radiation and general safety in their work area. Also, the person must complete a Radiation-Work Form (No.2).

- b. After submitting the form to the Radiation Reception Desk, access cards for the gate control and personal dosimeters are issued.
- c. Using the access card, they can enter the area and conduct their radiation work.
- d. The access card must be returned every day, even if the radiation work is to continue for a few days.

Figure 7-1:

Outside worker is visiting the radiation control guard office and submitting a Radiation-Work Form (No.2) to borrow an access card.



- (2) At some radiation-controlled areas, it is necessary to obtain a signature on the **Radiation-Work Form (No .2) for general safety** from the responsible person. Areas, where the signature is required, and the responsible persons are determined in advance. Please refer to the web page (<https://rcwww.kek.jp/user/top.html>).
- (3) In the case that the entrance procedure is altered by regional radiation-safety officers because of a low radiation level, the procedures mentioned above are not always necessary.
- (4) Radiation works (such as cutting or welding of radioactive materials) which may induce internal exposure require a permission from an officer in charge in addition to the Radiation-Work Form.

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## Visiting a Radiation-Controlled Area

- 1. Staff members registered as radiation workers can guide visitors just for showing facilities in radiation-controlled areas. A form (No.3) for **Visiting Radiation-Controlled Area and Warning Area** must be filled out and submitted to the guard in charge of the controlled area in order to borrow access cards and personal dosimeters. Furthermore, **a signature of the general safety supervisor is required for visiting areas of SuperKEKB, PF-AR DR and BT.**
- 2. In general, a visit can only last for 30 minutes. If it is necessary to visit for more than 30 minutes because of special circumstances, it is compulsory to obtain permission from the regional radiation-safety officer when submitting the form to the guard.
- 3. In general, it is forbidden to visit any restricted areas in the PS facilities on a Saturday or Sunday.



## 8 Handling of Radioactive Materials

Radioactive materials are listed as follows:

- a. Legal radioisotopes (RI);
- b. Weak radioisotopes (checking sources), which are not controlled by law;
- c. Nuclear fuel materials (U, Th, and Pu), and nuclear raw materials;
- d. Materials contaminated by radioisotopes.

Request for these radioactive materials (to use, purchase, carry from one place to another, bring in, take out, receive, transfer, and produce) must be made to the chief of the Radiation-Control Office or radiation-safety officers in charge; after completing the required procedures and obtaining permission, these materials can be handled. Generally, only a radiation worker registered at KEK can deal with these radioactive materials. It must be noted that the production of radionuclides using a beam from accelerators can be allowed only after obtaining an approval from the Ministry of Education, Culture, Sports, Science and Technology.

### 8.1 Handling and Loan of Sealed Radioisotopes

- (1) All radioisotopes at KEK are to be controlled by the Radiation-Control Office and lent out to users upon request. All details about handling must be obtained from the Radiation Reception (TEL:3500), since the activities and kinds of sources, places and conditions for usage are limited.
- (2) If you need radioisotopes, which are not prepared at the Radiation-Control Office, a purchase request must be submitted to the Radiation-Control Office person in charge. The details should be coordinated with the person.
- (3) Inquiries and the loan of radioisotopes are accepted at any time. As of the handling, the items listed below must be strictly followed:
  - In the case of the Fuji and Tsukuba experimental halls, you must borrow storages located in each safety guard office. Users who use isotopes in the other places must arrange storage facilities (which must be locked) and ask for conformation from the regional radiation-safety officers.
  - In the case of radioisotopes emitting gamma rays, RI storage facilities with sufficient shielding must be prepared, and the radiation level outside of the storage facilities must be measured and confirmed to be below the level of the controlled area.
  - Loaned sources must be handled carefully and should not be lost or stolen, they should not be used at other places where their use is not specified.
  - A term of loan must be strictly observed. Once the term is ignored, a subsequent loan may not be possible. In the case of a long-term loan, renewal must be regularly carried out (every March and September for checking sources).

- Any user who rents a source must not loan it to other users.
- Every source is placed inside a case with a tag which specifies the name of the source, user's name and the term of the loan. Do not remove the tag while in use.
- If you use a source in a special way (installing it inside an apparatus or removing a tag from it), a request must be made to the Radiation-Control Office in advance. You need the approval from the heads of your division, group or center.
- If you find out that a source is missing, broken or contaminated, please immediately inform the Radiation-Control Office about it (TEL:3500).



Figure 8-1: Various checking sources.



Figure 8-2: RI storage



Figure 8-3: Radioactive sources with a tag; white and yellow tags are connected to checking sources and RI, respectively.



Figure 8-4: Handling of non-sealed RI.

In handling of a non-sealed RI or machining activated materials, internal exposure may possibly be induced. Since your contaminated body may likely induce internal exposure, it is necessary to wear gloves, mask and clothes in order to avoid body contamination.

## 8.2 Handling of Radioactive Materials, such as Non-sealed Radioisotopes

- (1) Non-sealed radioisotopes can be used only at RI laboratories inside Shiryō-Sokutei-Toh (Building for the Measurements of Radioactive Samples), and RI laboratories inside PF. The machining of activated equipment is forbidden, except in the machining room inside Hoshakabutu-Kako-Toh. A request to use or handle these non-sealed radioactive materials must be made to a regional radiation-safety officer of the 7-th section in order to obtain his advice. If you need to handle any non-sealed materials at different places from the laboratories listed above, permission of the Radiation-Safety Supervisor is required. (The handling of non-sealed radioactive materials is not allowed under certain circumstances, and special training and education are often required.)
- (2) When samples containing nuclear-fuel materials are used for an experiment, the places for the experiment, the quantities and the way of handling are strictly limited. Hence, the request must be confirmed in advance by the Radiation-Safety Supervisor. Regardless of the quantity of the samples, any use of them is forbidden without permission.

## 9 Radiation Detectors

- (1) Radiation workers can borrow radiation detectors from the Radiation-Control Office to measure the radiation field at their workplace. If needed, please contact the Radiation-Control Office (TEL:3500). Since radiation detectors should be chosen depending on the radiation field any inquiry should be made through the regional radiation-safety officers.
- (2) The borrowing of detectors is limited to only a short term. If detectors are necessary to be used continuously for a long term, the users should purchase their own detectors.
- (3) Radiation detectors bought by institutes or divisions should be inspected regularly and corrected by the Radiation-Control Office more than once a year. When obtaining a new detector, please register it at the Radiation-Control Office (TEL:3500).

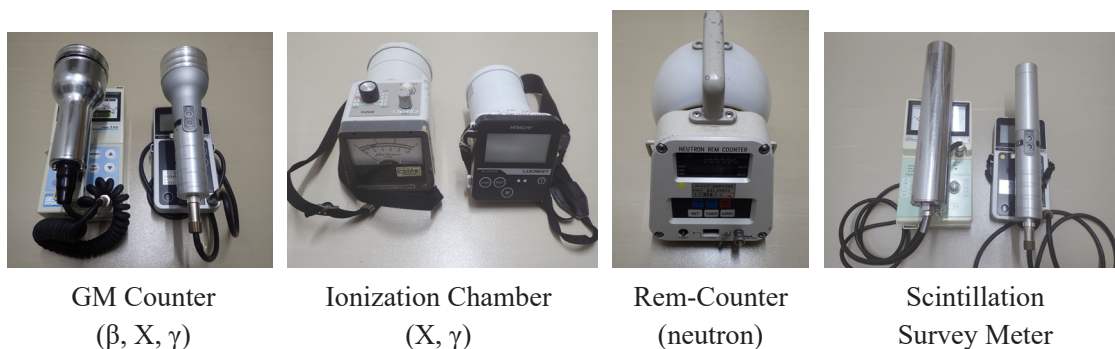


Figure 9-1: Radiation detectors

## 10 Suspension, Return, and Termination of Radiation Work, and Radiation Work outside KEK

- (1) If radiation workers suspend their radiation work temporarily due to an official trip or other reasons, a form (No.7) of **Suspension or Return for Radiation Work** should be submitted to the Radiation-Control Office.  
When radiation workers resume their radiation work after suspending, a form (No.7) should also be submitted. According to these forms, the Radiation-Control Office prepares personal dosimeters for each radiation worker. Hence, you should not forget to submit these forms in such cases.
- (2) If you do not need to be a radiation worker at KEK due to a change of work, a form (No.8) for **Termination of Radiation Work** should be submitted.
- (3) In the case of radiation work outside of KEK for experiments or other purposes, permission of the Directors-General is required. A form (No.6) for **Radiation Work Outside of KEK** should be submitted; you can perform radiation work after obtaining permission. Your own personal dosimeter issued at KEK should be brought with you.
- (4) The forms mentioned above are prepared at the business offices of the Institutes, Facilities, Divisions, and the Radiation-Control Office. You can download the latest version from the web page (<https://rcwww.kek.jp/user/yousiki.htm>).

## 11 Fire Emergency Response Procedures in the Radiation-Controlled Areas

### 11.1 Fire Emergency Response Procedures

The fire emergency response procedures in the radiation-controlled areas of KEK are as follows:

1. In the case of a fire emergency, the safety of human life is the most important factor. In the case of a life-threatening fire, ensure your own safety, notify the information center immediately (TEL:3399) and ask them to summon the fire department.
2. If you discover a fire, alert all persons in the nearby area, and notify both the information center and the Radiation-Reception (TEL:3500) immediately or ask somebody around you to notify them. If you discover a minor fire at an early stage, extinguish it very carefully.
3. When you discover a fire or when you are engaged in extinguishing a minor fire during an early stage, ask a guard who has come to your aid or the information center to summon the fire department, in a case that the fire might spread dangerously.

4. The information center, when asked to summon the fire department, must do that immediately, alert the chief of the account section (head of the self-defense fire division) of the general-affairs department about the situation, and make an emergency announcement.
5. In the case of a fire emergency, the Shift Leader of the Accelerator Operation in the area must stop the accelerator immediately and turn off any electric power that is connected to the equipment in the area.
6. As soon as the fire department has been summoned, the operation of all accelerators at KEK must stop. Do not begin operation of the accelerators until the Radiation-Safety Supervisor has given an all-clear signal.
7. The response procedures to fire-fighters are as follows:
  - (I) In the case of a fire in a radiation-controlled area, the guard at the gate should provide dosimeters to the chief of the fire brigade. These dosimeters must be kept in the Guard's Office.
  - (II) When the fire-fighters come to the area, the KEK staff members must instruct them, or act as follows:
    - a. In those areas designated as a **general area**, ask the fire-fighters to start extinguishing the fire as soon as possible because the fire-fighters are not restricted anywhere in respect to radiation control due to low radiation level.
    - b. In those areas designated as a **Fire extinguishing restricted area**, KEK staff members who are familiar with the area, must accompany the fire-fighters in order to extinguish the fire promptly. If high radiation levels are expected, or if radioisotopes are in use in the area, enter the area with a survey meter in order to identify any radiation source.
    - c. In the radiation control areas, the fire-fighters may enter the area freely having received permission to enter the control area in advance by the Radiation-Safety Supervisor.
    - d. The KEK staff should accompany the fire-fighters and provide any necessary information about extinguishing the fire.
8. A manual of **Fire Emergency Response Procedures** must be prepared in each radiation-control area. Those who engage in fighting minor fires during an early stage must act according to the manual.

## 11.2 Fire extinguishing restricted area

Fire extinguishing restricted area and General area are defined as follows:

### 1. Fire extinguishing restricted area:

- (1) In this type of fire zone, it is unlikely that the fire-fighters would receive a dose larger than 0.1 mSv during the work of extinguishing a fire. However, because in this area higher radiation levels are expected from the accelerator system at some points, or radioisotopes may be used, KEK staff members who are familiar with the area must accompany the fire-fighters.
- (2) In this type of fire zone, although no radiation dose is expected during the work of extinguishing a fire, other dangers such as high-pressure gas or high voltages may be encountered. Hence, KEK staff members who are familiar with the area must accompany the fire-fighters.
- (3) In this type of fire zone, no radiation dose is expected during the work of extinguishing a fire, but the building has tunnels of a labyrinth structure. Hence, KEK staff members who are familiar with the area must accompany the fire-fighters.

2. **General area:** Radiation-controlled areas other than Special or Fire extinguishing restricted area.

### 11.3 Facilities and Rooms Assigned as Special and Fire extinguishing restricted area

The radiation-controlled areas classified as Fire extinguishing restricted area are listed in Table 4.

Table 4: The radiation-controlled areas classified as Fire extinguishing restricted area

| Facilities               | Fire extinguishing restricted area |
|--------------------------|------------------------------------|
| Proton Synchrotron       | Main Ring                          |
| Facility                 |                                    |
| Neutron and Meson        | NML beam line                      |
| Science Laboratory       |                                    |
| Counter Hall (CH)        | EP2 room                           |
| (PS Experimental Hall)   | EP1 beam line                      |
| PF Facility              | BL-27                              |
| Radiation Chemistry Lab. | Non-sealed source laboratory       |
| RI Experimental Lab.     | Storage room of RI                 |
| Irradiation Facility     | Storage Container of RI            |
| Target storage building  | Storage room                       |

<https://stw.kek.jp/stpg/hso/files/2014/11/kasaitaiou.pdf>



## 11.4 Signs Indicating Fire extinguishing restricted area

### 1. Signs indicating Fire extinguishing restricted area.

Zones inside the Radiation-Controlled Areas

Fire-fighters may not receive a dose larger than 0.1 mSv but higher radiation level may be found at some points, or RI may be in use, so the KEK staff members must accompany the fire-fighters.



(横型)



(縦型)

### 2. Signs indicating Fire extinguishing restricted area other than radiation:



(横型)



(縦型)



(横型)



(縦型)



(横型)

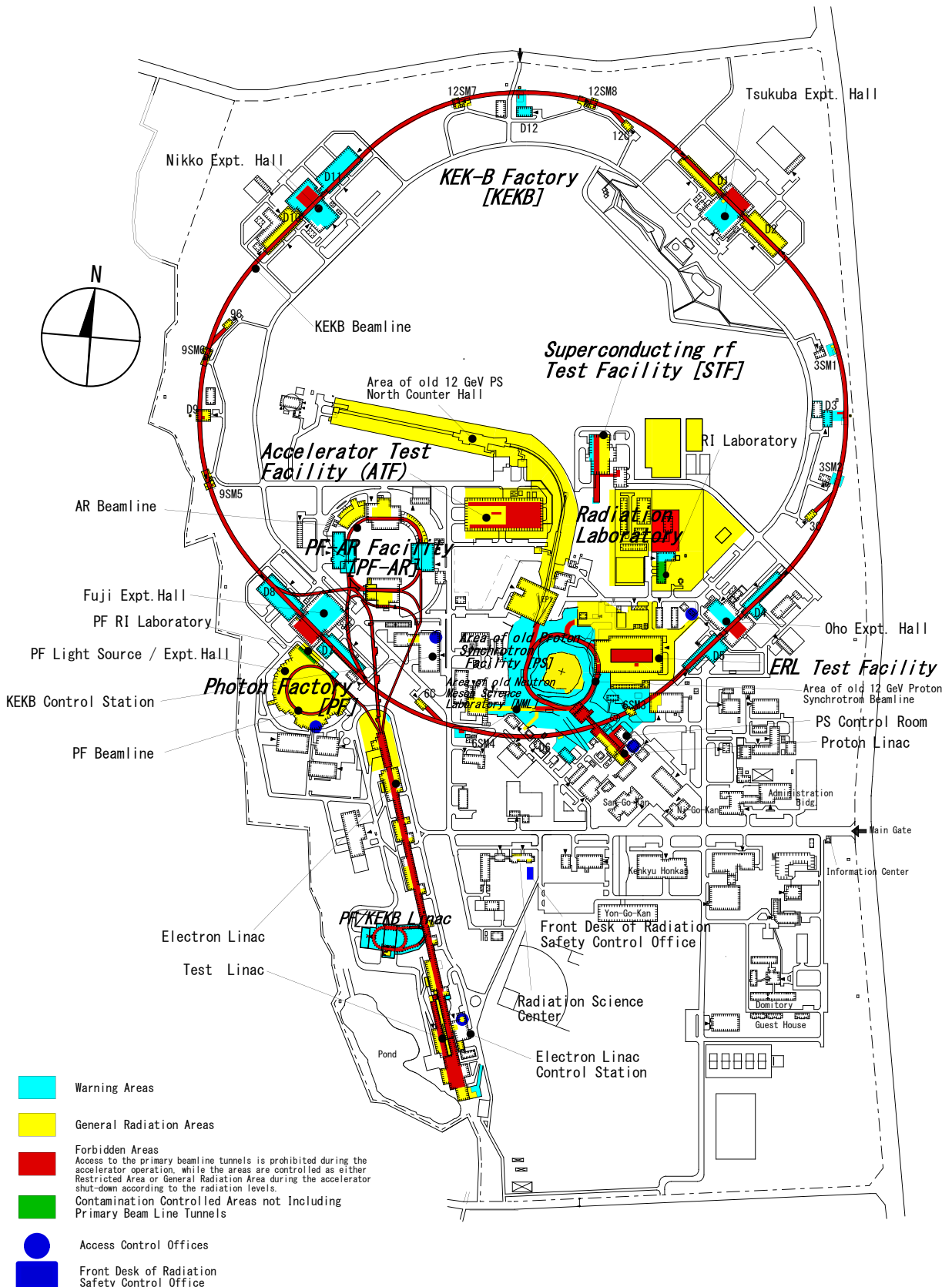


(縦型)

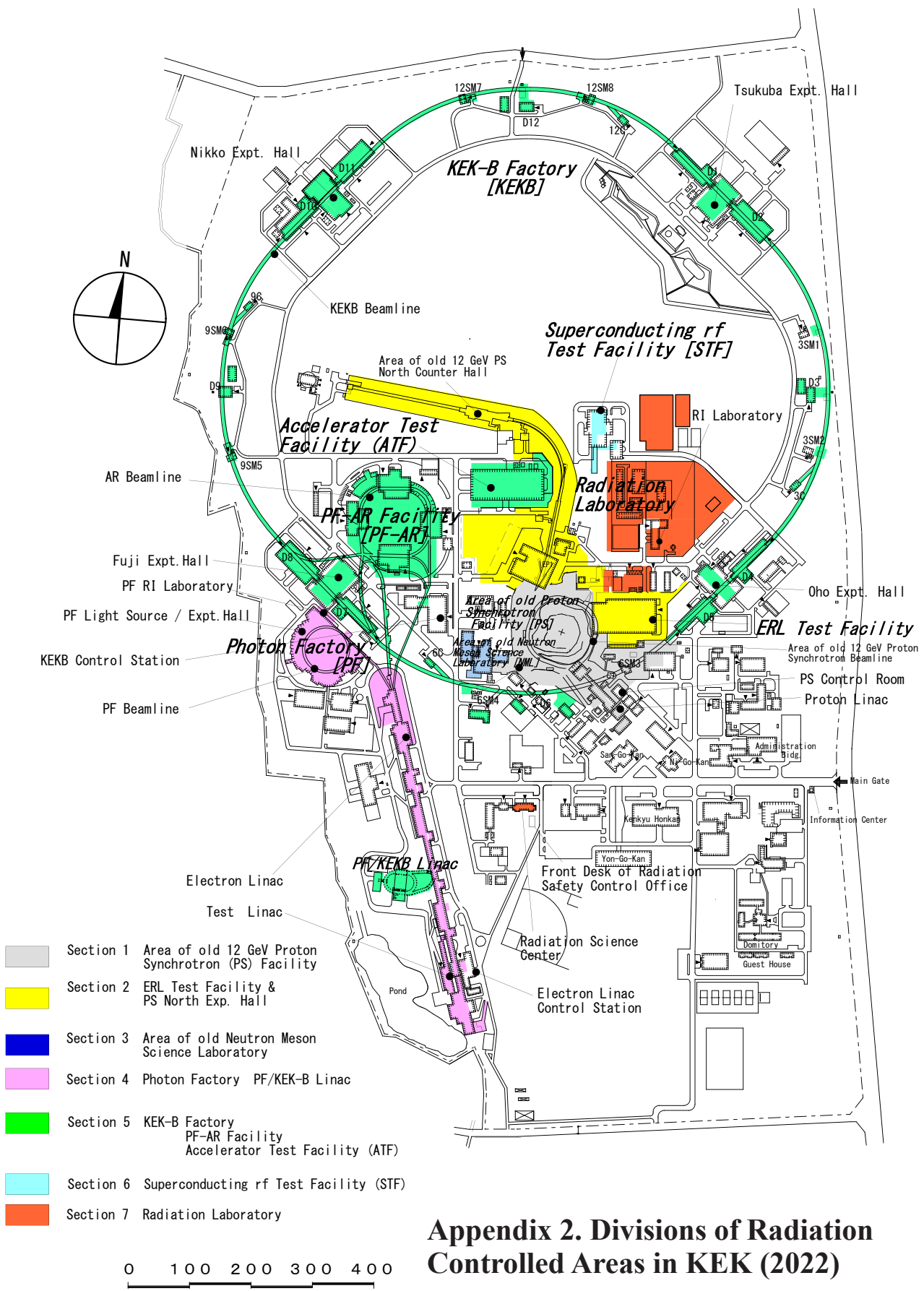
## Reference

- This article is translated from “Radiation Safety Textbook” in Japanese (Houshasen No Anzen No Tebiki), published by Radiation Science Center, KEK, 2021.



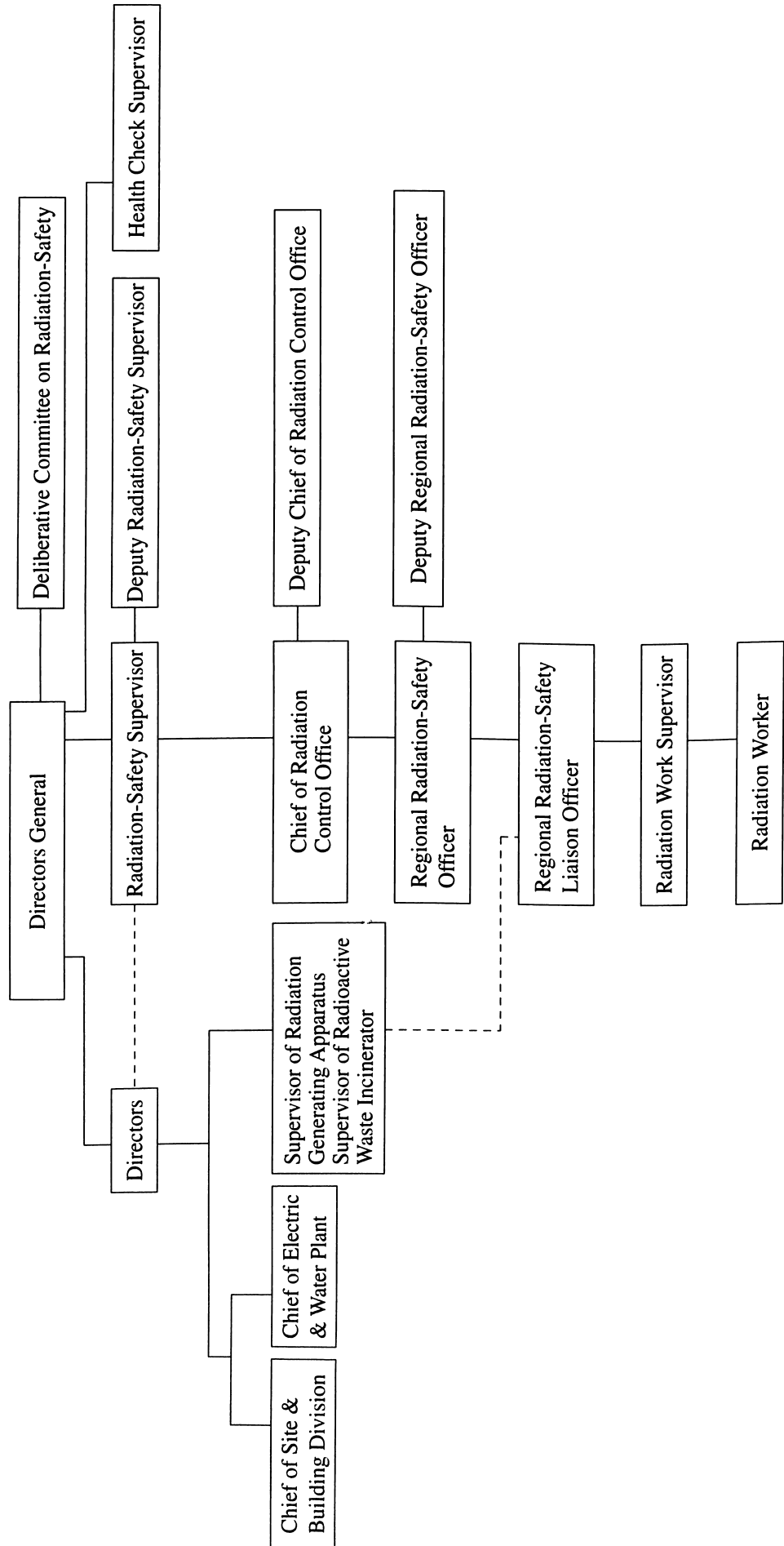


**Appendix 1. Radiation Controlled Areas in KEK (2022)**



**Appendix 2. Divisions of Radiation Controlled Areas in KEK (2022)**

### Appendix 3, Radiation Safety System at KEK





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