PATIENT, WORKER AND PUBLIC RADIATION PROTECTION IN HOSPITAL

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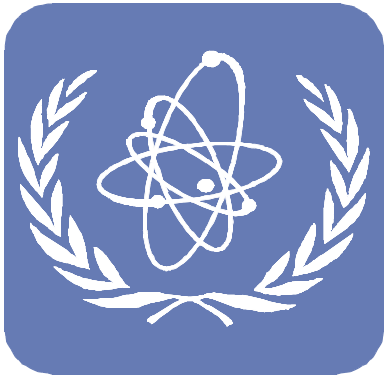
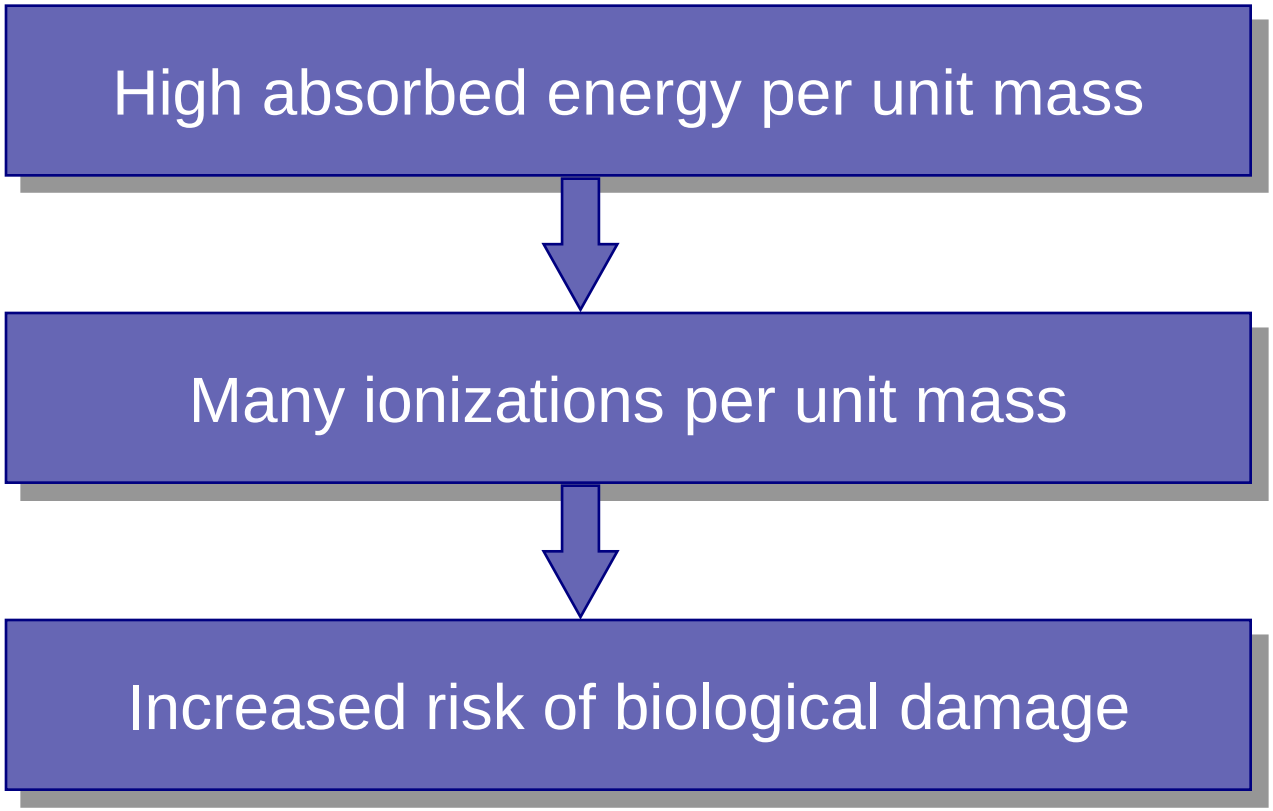
Part 2. Radiation Physics



Module 2.5. Radiation Quantities and Units

ENERGY ABSORPTION

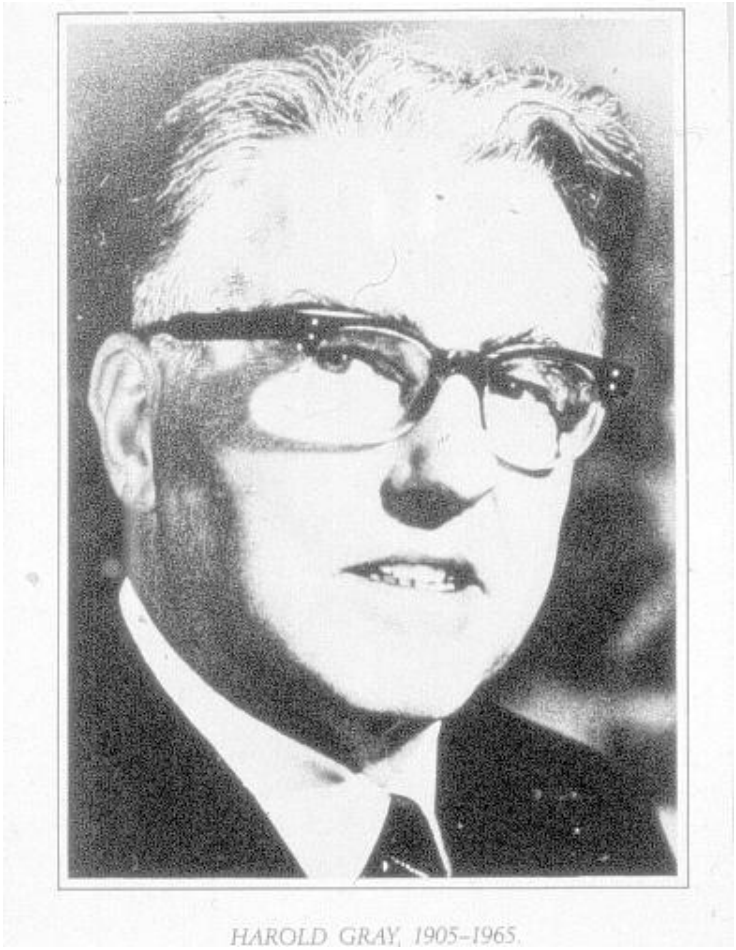


Absorbed Dose

Absorbed energy per mass unit

1 Gy (gray)=1 J/kg

Louis Harold Gray (1905-1965)



HAROLD GRAY, 1905–1965.

Absorbed Dose

absorbed dose, *D*

The fundamental dosimetric quantity D, defined as:

$$D = \frac{\mathrm{d}\bar{\varepsilon}}{\mathrm{d}m}$$

where $\mathrm{d}\bar{\varepsilon}$ is the mean energy imparted by ionizing radiation to matter in a volume element and $\mathrm{d}m$ is the mass of matter in the volume element.

- The SI unit for absorbed dose is joule per kilogram (J/kg), termed the gray (Gy).
- The energy can be averaged over any defined volume, the average dose being equal to the total energy imparted in the volume divided by the mass in the volume.
- Absorbed dose is defined at a point; the mean absorbed dose in a specified tissue or organ of the human body is termed the organ dose.

1 Gy is a relatively large quantity

- Radiotherapy doses > 1Gy
- Absorbed dose from nuclear medicine examination is typically 0.05-0.001Gy
- Annual background radiation due to natural radiation (terrestic, cosmic, due to internal radioactivity, radon,…) about 0.002-0.004 Gy

Equivalent & Effective Dose

$$H_e = w_r * D$$

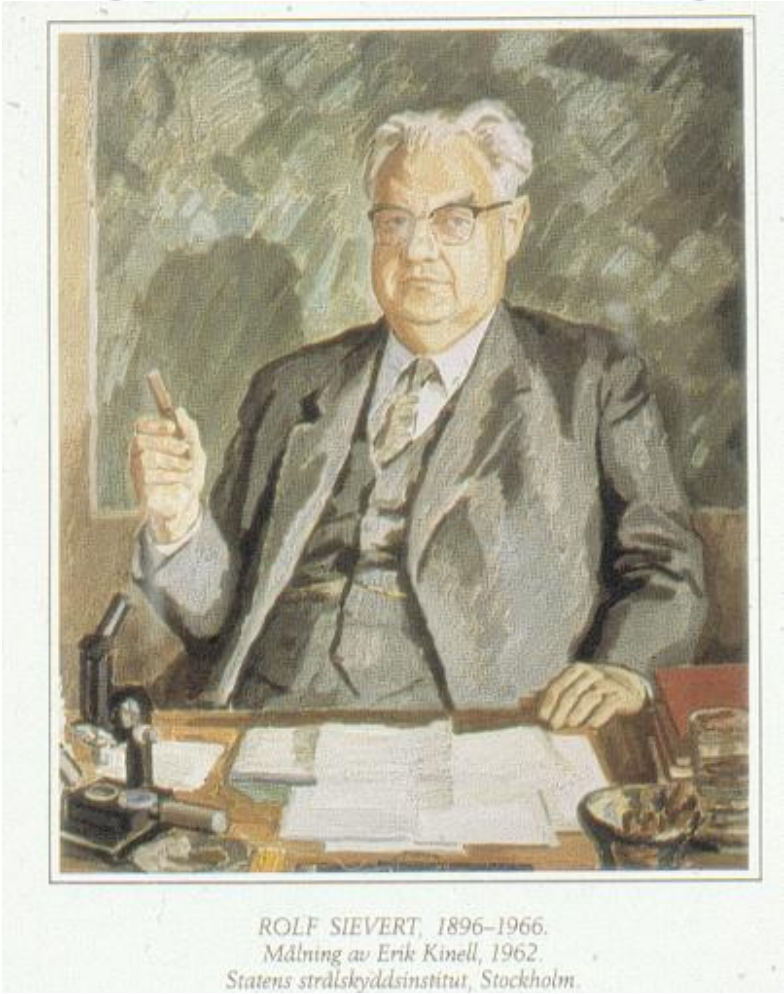
D: absorbed dose (Gy), w_r : radiation weighting factor (1-20)

$$H_{eff} = w_T * H_e$$

H_e: equivalent dose (Sv), w_T: tissue weighting factor (0.01-0.12)

Unit: 1 Sv (sievert)

Rolf Maksimilian Sievert (1896-1966)



ROLF SIEVERT, 1896–1966.
Målning av Erik Kinell, 1962.
Statens strålskyddsinstitut, Stockholm.

Equivalent Dose

equivalent dose, H_T

The quantity $H_{T,R}$, defined as:

$$H_{T,R} = w_R \cdot D_{T,R}$$

where $D_{T,R}$ is the absorbed dose delivered by radiation type R averaged over a tissue or organ T and w_R is the radiation weighting factor for radiation type R. When the radiation field is composed of different radiation types with different values of w_R, the equivalent dose is:

$$H_T = \sum_R w_R \cdot D_{T,R}$$

- The SI unit for equivalent dose is joule per kilogram (J/kg), termed the sievert (Sv). An explanation of the quantity is given in Annex B of International Commission on Radiological Protection Publication 103[2].
- Equivalent dose is a measure of the dose to a tissue or organ designed to reflect the amount of harm caused.
- Equivalent dose cannot be used to quantify higher doses or to make decisions on the need for any medical treatment relating to deterministic effects.
- Values of equivalent dose to a specified tissue or organ from any type(s) of radiation can be compared directly.

Equivalent Dose

radiation weighting factor, w_R

A number by which the absorbed dose in a tissue or organ is multiplied to reflect the relative biological effectiveness of the radiation in inducing stochastic effects at low doses, the result being the equivalent dose.

ⓘ Values are selected to be representative of the relevant relative biological effectiveness and are broadly compatible with the values previously recommended for quality factors in the definition of dose equivalent. The

Type of radiation	w_R
Photons	1
Electrons and muons	1
Protons and charged pions	2
Alpha particles, fission fragments, heavy ions	20
Neutrons	A continuous function of neutron energy:

$$w_R = \begin{cases} 2.5 + 18.2\, e^{-[\ln(E_n)]^2/6}, & E_n < 1\ MeV \\ 5.0 + 17.0\, e^{-[\ln(2E_n)]^2/6}, & 1\ MeV \leq E_n \leq 50\ MeV \\ 2.5 + 3.25\, e^{-[\ln(0.04E_n)]^2/6}, & E_n > 50\ MeV \end{cases}$$

Note: All values relate to radiation incident on the body or, for internal radiation sources, radiation emitted from the incorporated radionuclide(s).

Effective Dose

effective dose, E

The quantity E, defined as a summation of the tissue or organ equivalent doses, each multiplied by the appropriate tissue weighting factor:

$$E = \sum_{\mathrm{T}} w_{\mathrm{T}} \cdot H_{\mathrm{T}}$$

where H_{T} is the equivalent dose in tissue or organ T and w_{T} is the tissue weighting factor for tissue or organ T. From the definition of equivalent dose, it follows that:

$$E = \sum_{\mathrm{T}} w_{\mathrm{T}} \cdot \sum_{\mathrm{R}} w_{\mathrm{R}} \cdot D_{\mathrm{T,R}}$$

where w_{R} is the radiation weighting factor for radiation type R and $D_{\mathrm{T,R}}$ is the average absorbed dose in the tissue or organ T delivered by radiation type R.

ⓘ The SI unit for effective dose is joule per kilogram (J/kg), termed the sievert (Sv). An explanation of the quantity is given in Annex B of International Commission on Radiological Protection Publication 103[1].

Effective Dose

tissue weighting factor, w_T

Multiplier of the equivalent dose to a tissue or organ used for purposes of radiation protection to account for the different sensitivities of different tissues or organs to the induction of stochastic effects of radiation.

ⓘ Tissue weighting factors used for calculating effective dose are as follows.

Tissue or organ	w_T	$\sum w_T$
Bone marrow (red), colon, lung, stomach, breast, remainder tissues[a]	0.12	0.72
Gonads	0.08	0.08
Bladder, oesophagus, liver, thyroid	0.04	0.16
Bone surface, brain, salivary glands, skin	0.01	0.04
	Total	1.00

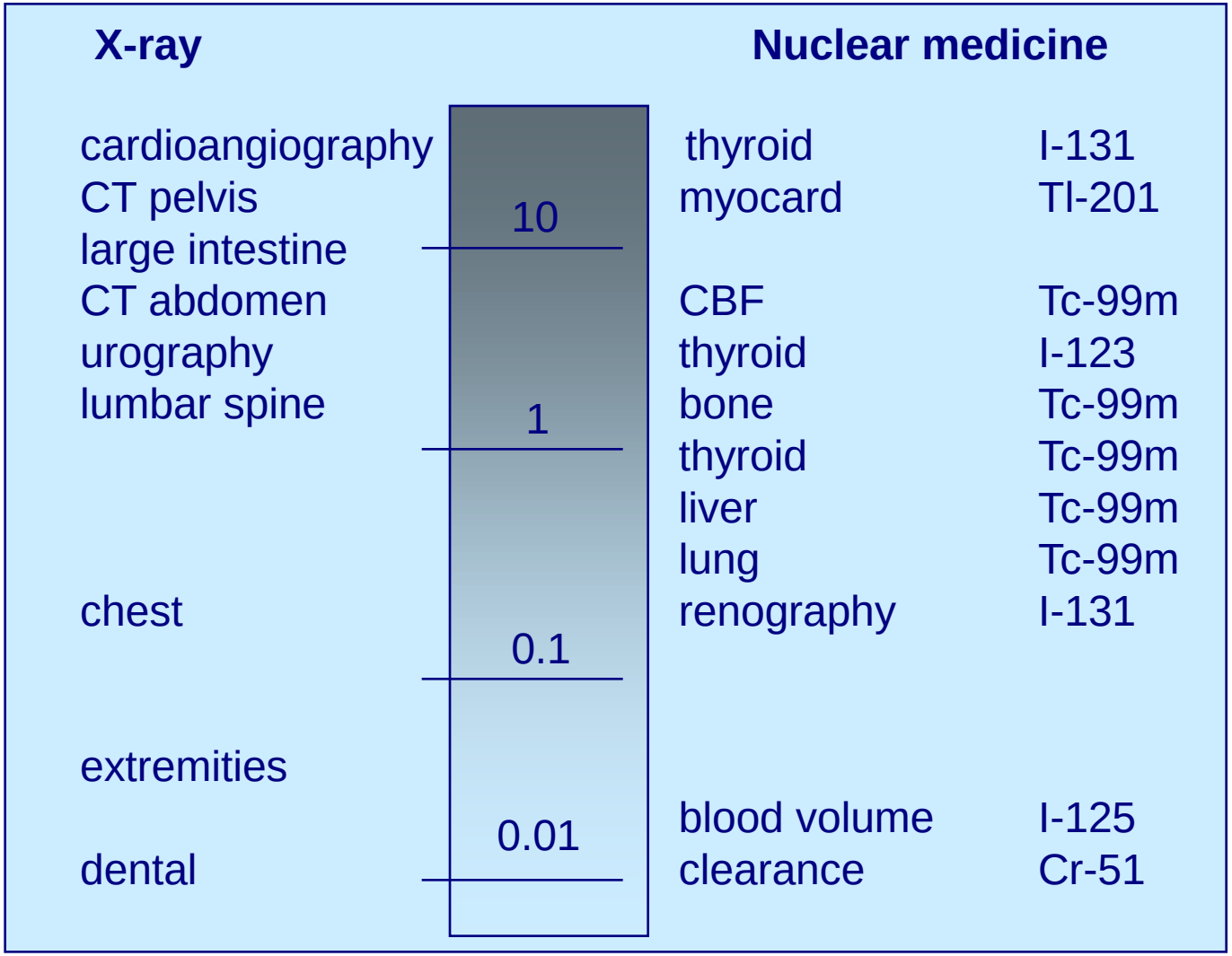
[a] The w_T for remainder tissues (0.12) applies to the arithmetic mean dose to these 13 tissues and organs for each sex: adrenals, extrathoracic region, gall bladder, heart, kidneys, lymphatic nodes, muscle, oral mucosa, pancreas, prostate (male), small intestine, spleen, thymus, uterus/cervix (female).

Effective Dose

$$E = \sum_T w_T \cdot H_T$$

Tissue or organ	*Tissue Weighting factor*
Gonads	0.20 / 0.08
Bone marrow (red)	0.12
Colon	0.12
Lung	0.12
Stomach	0.12
Bladder	0.05 / 0.04
Breast	0.05
Liver	0.05 / 0.04
Oesophagus	0.05 / 0.04
Thyroid	0.01 / 0.04
Bone surface	0.01
Remainder (adrenals, kidney, muscle, upper large intestine, small intestine, pancreas, spleen, thymus, uterus, brain 0.01)	0.05 / 0.12

Effective Dose (mSv)



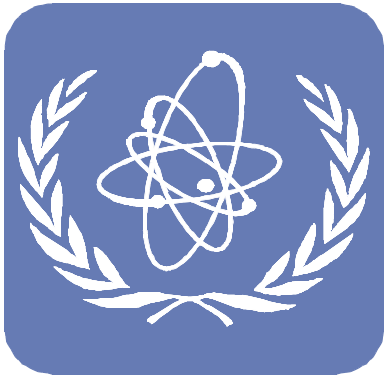
Effective Dose (mSv)

TABLE 1. TYPICAL ACQUISITION TECHNIQUES USED FOR WHOLE-BODY FDG-PET-CT IMAGING		
Study	**Injected Activity**	**Effective Dose Estimate**
PET[6, 7]	[5-15] mCi ^{18}F-FDG Injected (185-555 MBq)	3.5-10.5 mSv
CT for diagnostic purposes[8]	[110-200] mAs[1] $CTDI_{vol}$ = [8-14] mGy	11-20 mSv
CT for anatomic localization[8]	[30-60] mAs[3] $CTDI_{vol}$ = [2-4] mGy	3-6 mSv
CT for attenuation correction only[8]	[5-10] mAs[4] $CTDI_{vol}$ = [0.3-1.0] mGy	0.5-1.0 mSv

For ease of comparison, all CT studies presented are performed with 120 kVp, pitch 1.375, 40 mm collimation, 900 mm scan range, average tube current-time product.

http://www.imagewisely.org/imaging-modalities/nuclear-medicine/articles/ct-protocol-selection

Part 6



Medical Exposure
Protection of the Patient

Protection from what?

- Unnecessary examination or treatment (justification)
- Unnecessary exposure (optimization)
- Inadequate examination or treatment, which can lead to incorrect or incomplete diagnosis or therapy (optimization)

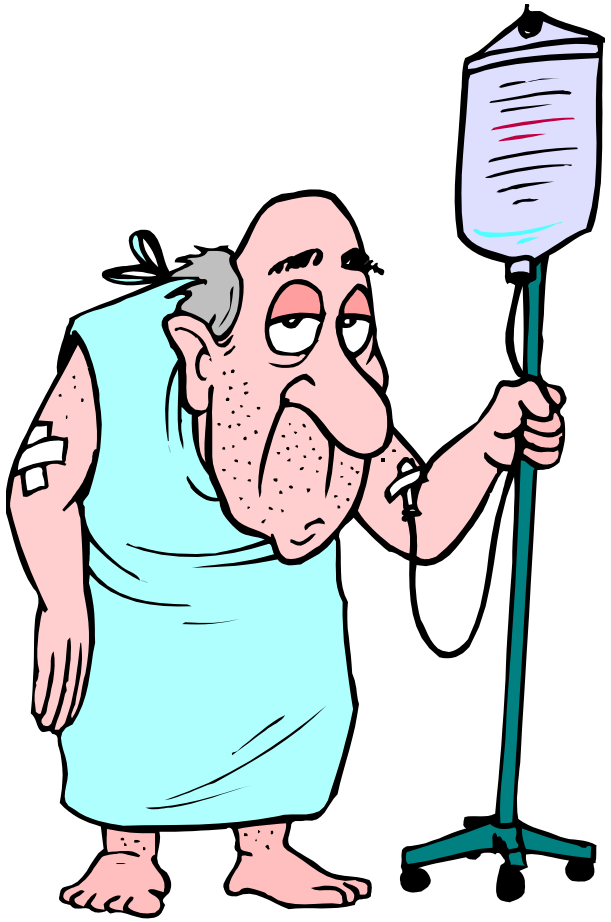
MEDICAL EXPOSURE DEFINITION

medical exposure

Exposure incurred by patients for the purposes of medical or dental diagnosis or treatment; by carers and comforters; and by volunteers subject to exposure as part of a programme of biomedical research.

ⓘ A patient is an individual who is a recipient of services of health care professionals and/or their agents that are directed at (a) promotion of health; (b) prevention of illness and injury; (c) monitoring of health; (d) maintaining health; and (e) medical treatment of diseases, disorders and injuries in order to achieve a cure or, failing that, optimum comfort and function. Some asymptomatic individuals are included. For the purpose of the requirements on medical exposure in the IAEA safety standards, the term 'patient' refers only to those individuals undergoing radiological procedures.

Protection of the patient



MEDICAL EXPOSURE DEFINITION

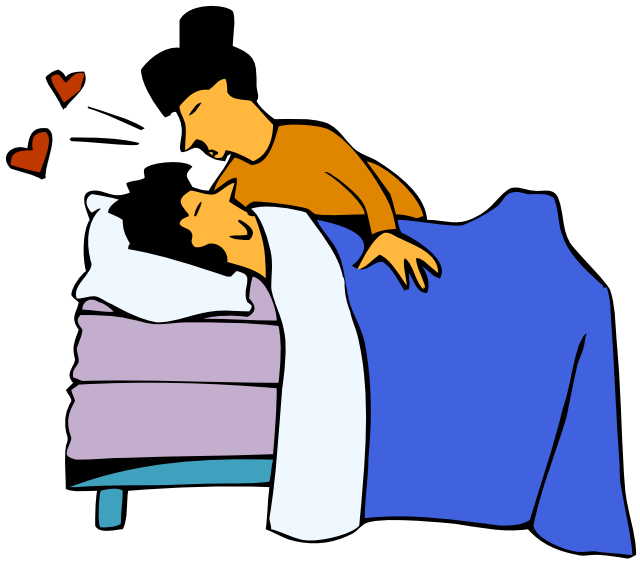
medical exposure

Exposure incurred by patients for the purposes of medical or dental diagnosis or treatment; by carers and comforters; and by volunteers subject to exposure as part of a programme of biomedical research.

carers and comforters

Persons who willingly and voluntarily help (other than in their occupation) in the care, support and comfort of patients undergoing radiological procedures for medical diagnosis or medical treatment.

Protection of carers and comforters



MEDICAL EXPOSURE

Dose limits do not apply to medical exposures.

[43] The diagnostic or therapeutic benefit that medical exposures are expected to yield may not necessarily be to the person exposed. For patients, this is clearly the case, but for exposures in biomedical research the benefit is expected to be for biomedical sciences and for future health care. Similarly, the benefit for carers and comforters might be, for example, the successful performance of a diagnostic procedure on a child.

For medical exposure, the dose constraint is a source related value used in optimizing the protection of carers and comforters of patients undergoing radiological procedures, and the protection of volunteers subject to exposure as part of a programme of biomedical research.

PLANNED MEDICAL EXPOSURE SITUATIONS

PLANNED MEDICAL EXPOSURE SITUATIONS

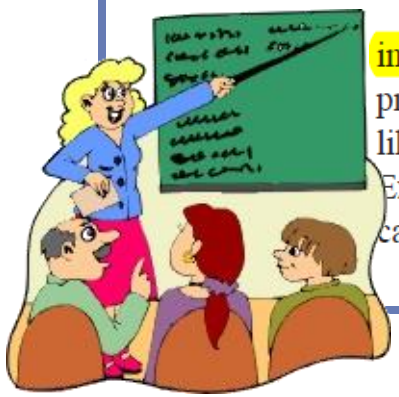
Requirement 35: Responsibilities of the regulatory body specific to medical exposure

The regulatory body shall require that health professionals with responsibilities for medical exposure are specialized in the appropriate area and that they fulfil the requirements for education, training and competence in the relevant specialty.

personnel (radiological medical practitioners, medical physicists, medical radiation technologists and any other health professionals with specific duties in relation to the radiation protection of patients)

[41] 'Specialized' means specialized as acknowledged by the relevant professional body, health authority or appropriate organization.

[42] 'The appropriate area' means, in the first instance, diagnostic radiology, image guided interventional procedures, or radiation therapy or nuclear medicine (diagnostic radiological procedures, therapeutic radiological procedures or both). The area of specialization is often likely to be narrower, however, in particular with regard to the radiological medical practitioner. Examples are dental, chiropractic or podiatric specialists in the case of diagnostic radiology, and cardiologists, urologists or neurologists in the case of image guided interventional procedures.



PLANNED MEDICAL EXPOSURE SITUATIONS

Requirement 37: Justification of medical exposures

Relevant parties shall ensure that medical exposures are justified.

Requirement 38: Optimization of protection and safety

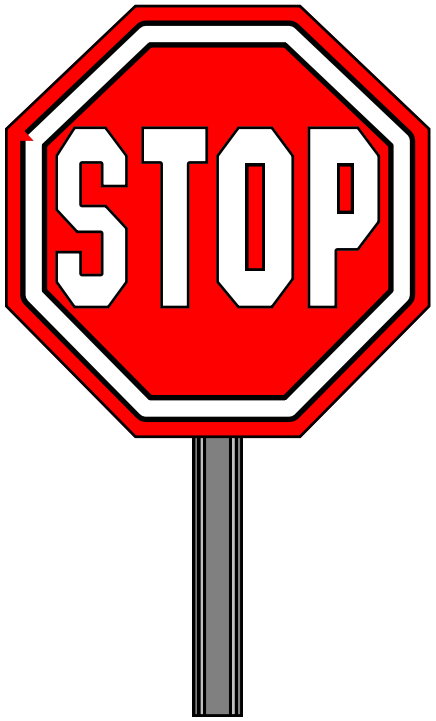
Registrants and licensees and radiological medical practitioners shall ensure that protection and safety is optimized for each medical exposure.

Medical objective Medical exposure

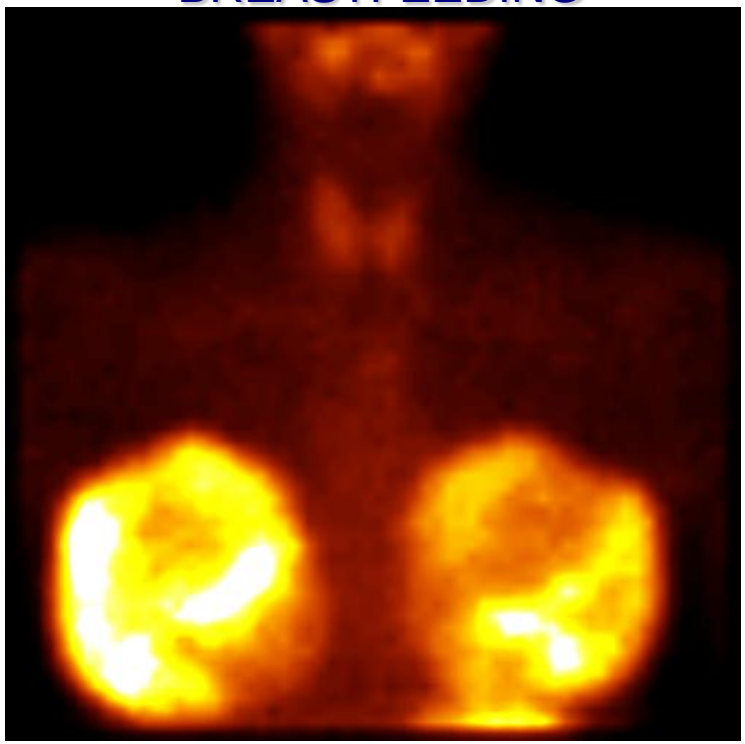
PLANNED MEDICAL EXPOSURE SITUATIONS

Requirement 39: Pregnant or breast-feeding female patients

Registrants and licensees shall ensure that there are arrangements in place for appropriate radiation protection in cases where a female patient is or might be pregnant or is breast-feeding.



BREASTFEEDING



PREGNANCY AFTER THERAPY

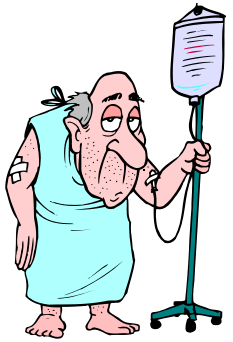
Radiopharmaceutical	All activities up to (MBq)	Avoid pregnancy (months)
Au-198 colloid	10000	2
I-131 iodide (thyroid ca)	5000	4
I-131 iodide (thyrotoxicosis)	800	4
I-131 MIBG	5000	4
P-32 phosphate	200	3
Sr-89 chloride	150	24
Y-90 colloid (arthritic joints)	400	0
Y-90 colloid (malignancy)	4000	1

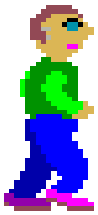
PLANNED MEDICAL EXPOSURE SITUATIONS

Requirement 40: Release of patients after radionuclide therapy

Registrants and licensees shall ensure that there are arrangements in place to ensure appropriate radiation protection for members of the public and for family members before a patient is released following radionuclide therapy.

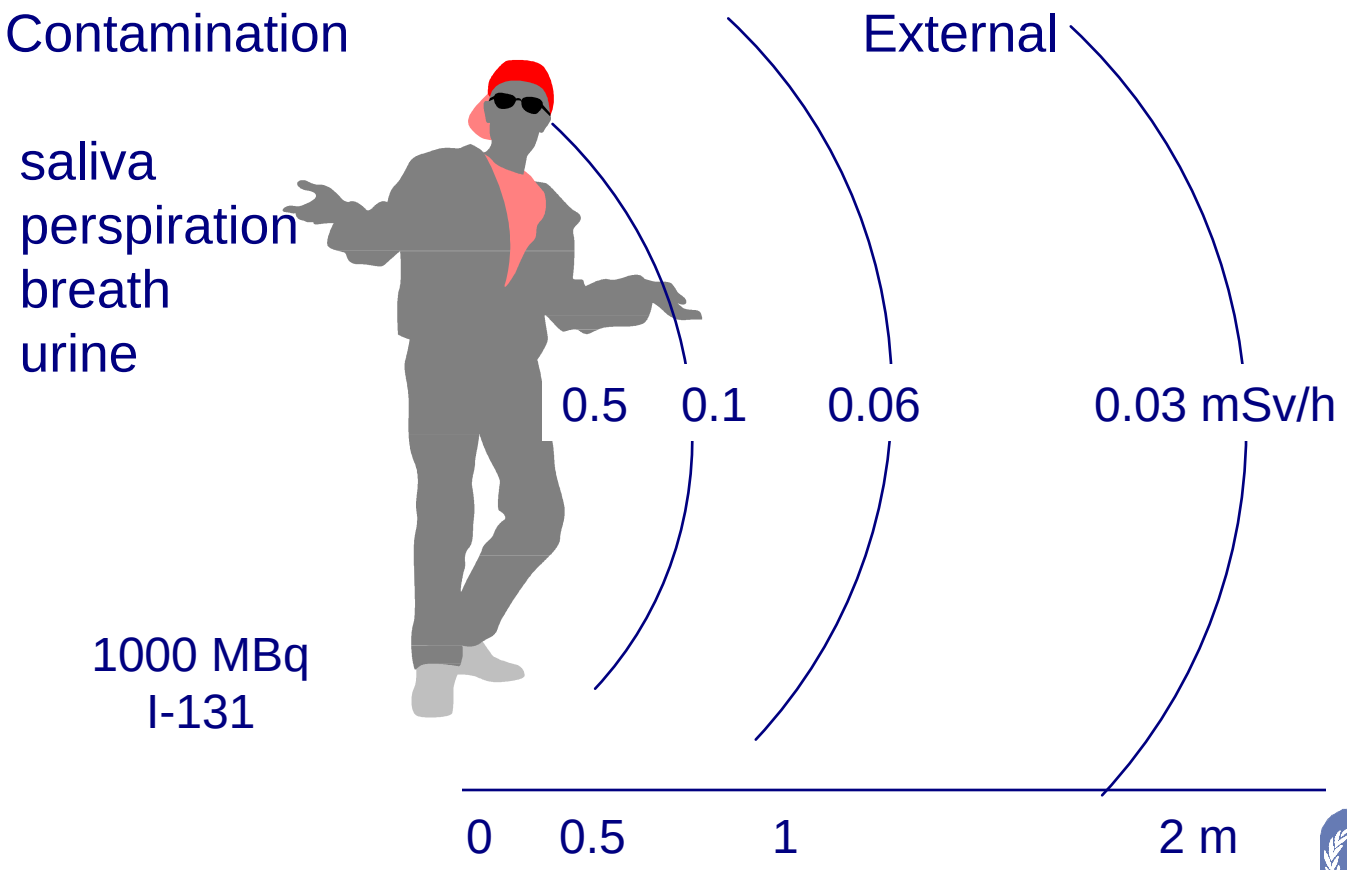
Shall the patient be hospitalized?



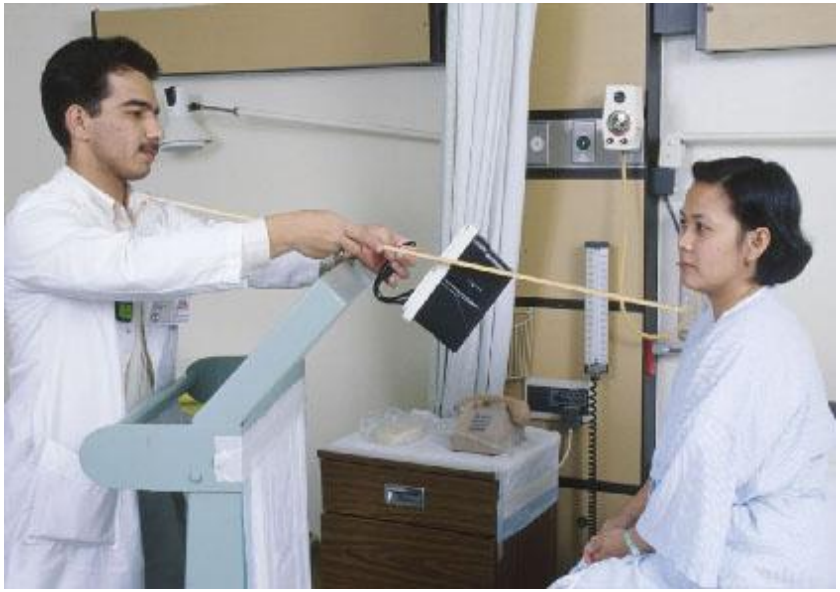


Can the patient leave? Any restrictions?

Exposures from patient

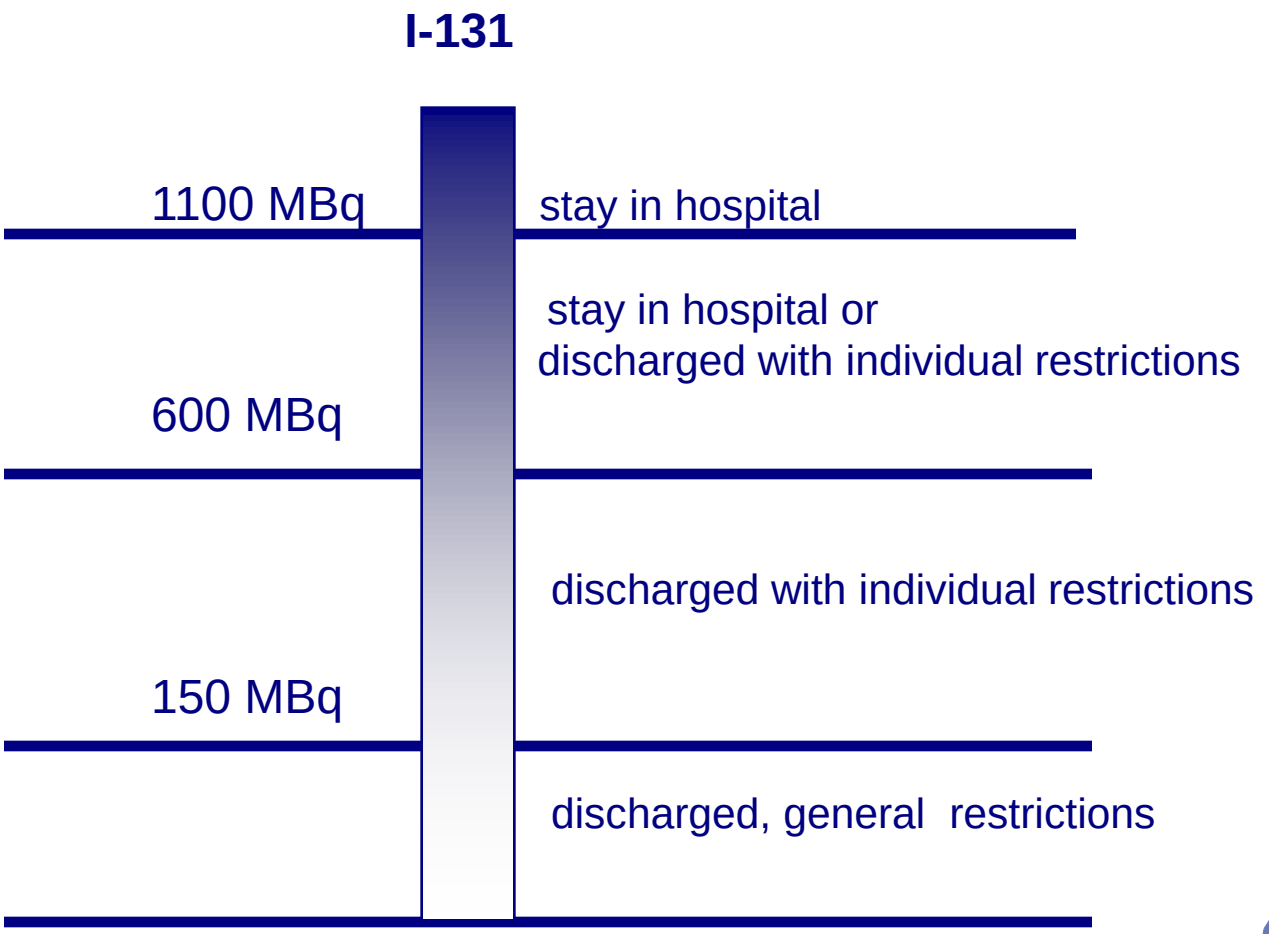


Therapy Patient
I-131

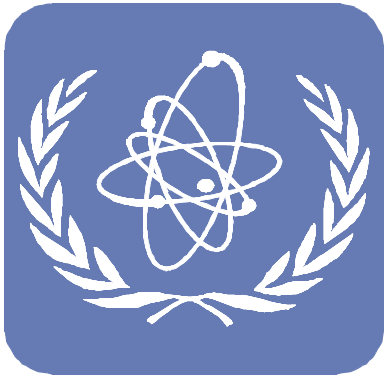


The patient should be kept at least 2h, and if possible one day in the hospital.
In the case of cancer treatment, the patient should generally be hospitalized for several days.
In all cases, the dose rate at 1 m from the patient should be down to an acceptable level established by the RPC.

HOSPITALIZATION OR NOT



Part 5



Occupational Exposure Protection of the Worker

OCCUPATIONAL EXPOSURE DEFINITION

occupational exposure

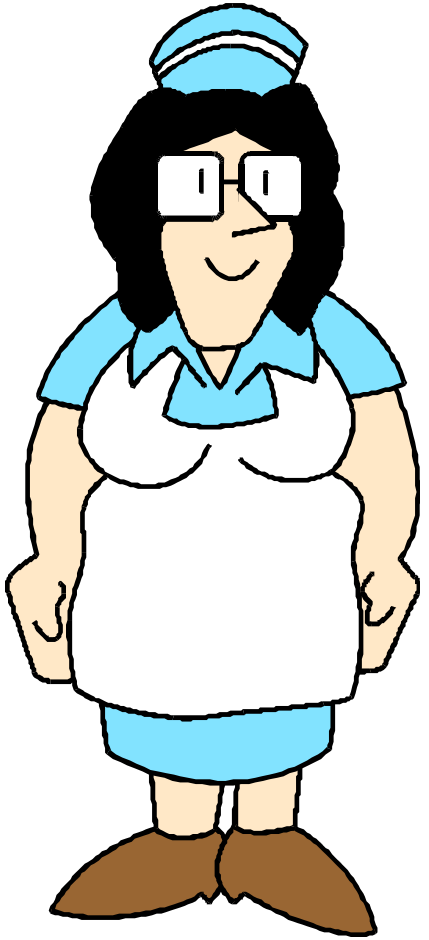
Exposure of workers incurred in the course of their work.

worker

Any person who works, whether full time, part time or temporarily, for an employer and who has recognized rights and duties in relation to occupational radiation protection.

ⓘ A self-employed person is regarded as having the duties of both an employer and a worker.

Protection of the worker



PLANNED OCCUPATIONAL EXPOSURE SITUATIONS

PLANNED OCCUPATIONAL EXPOSURE SITUATIONS

Requirement 19: Responsibilities of the regulatory body specific to occupational exposure

The government or the regulatory body shall establish and enforce requirements to ensure that protection and safety is optimized, and the regulatory body shall enforce compliance with dose limits for occupational exposure.

Requirement 21: Responsibilities of employers, registrants and licensees for the protection of workers

Employers, registrants and licensees shall be responsible for the protection of workers against occupational exposure. Employers, registrants and licensees shall ensure that protection and safety is optimized and that the dose limits for occupational exposure are not exceeded.

PLANNED OCCUPATIONAL EXPOSURE SITUATIONS

III.1. For occupational exposure of workers over the age of 18 years, the dose limits are:

(a) An effective dose of 20 mSv per year averaged over five consecutive years[66] (100 mSv in 5 years) and of 50 mSv in any single year;

(b) An equivalent dose to the lens of the eye of 20 mSv per year averaged over five consecutive years (100 mSv in 5 years) and of 50 mSv in any single year;

(c) An equivalent dose to the extremities (hands and feet) or to the skin[67] of 500 mSv in a year.

Additional restrictions apply to occupational exposure for a female worker who has notified pregnancy or is breast-feeding (para. 3.114).

[66] The start of the averaging period shall be coincident with the first day of the relevant annual period after the date of entry into force of these Standards, with no retrospective averaging.

[67] The equivalent dose limits for the skin apply to the average dose over 1 cm^2 of the most highly irradiated area of the skin. The dose to the skin also contributes to the effective dose, this contribution being the average dose to the entire skin multiplied by the tissue weighting factor for the skin.

PLANNED OCCUPATIONAL EXPOSURE SITUATIONS

III.2. For occupational exposure of apprentices of 16 to 18 years of age who are being trained for employment involving radiation and for exposure of students of age 16 to 18 who use sources in the course of their studies, the dose limits are:

(a) An effective dose of 6 mSv in a year;
(b) An equivalent dose to the lens of the eye of 20 mSv in a year;
(c) An equivalent dose to the extremities (hands and feet) or to the skin[67] of 150 mSv in a year.

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[66] The start of the averaging period shall be coincident with the first day of the relevant annual period after the date of entry into force of these Standards, with no retrospective averaging.

[67] The equivalent dose limits for the skin apply to the average dose over 1 cm^2 of the most highly irradiated area of the skin. The dose to the skin also contributes to the effective dose, this contribution being the average dose to the entire skin multiplied by the tissue weighting factor for the skin.

PLANNED EXPOSURE SITUATIONS

III.4. The effective dose limits specified in this schedule apply to the sum of the relevant doses from external exposure in the specified period and the relevant committed doses from intakes in the same period; the period for calculating the committed dose shall normally be 50 years for intakes by adults and shall be up to age 70 years for intakes by children.

PLANNED OCCUPATIONAL EXPOSURE SITUATIONS

Requirement 20: Requirements for monitoring and recording of occupational exposures

The regulatory body shall establish and enforce requirements for the monitoring and recording of occupational exposures in planned exposure situations.

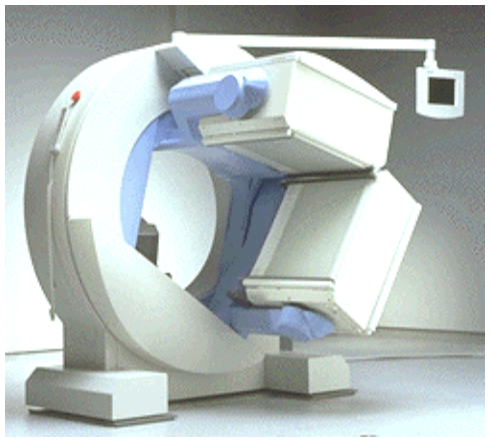
MONITORING

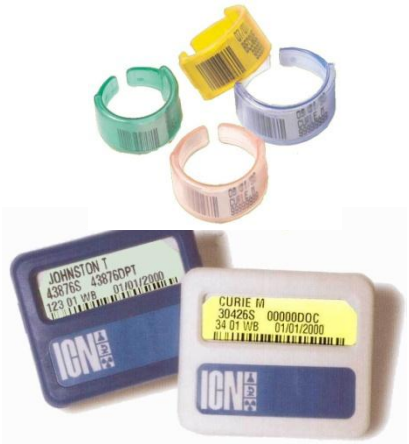
Personal

(effective dose, extremity dose & contamination)

Workplace

(external dose rate & contamination)





Individual monitoring

- control of radiation exposure
- assessment of optimization principle
- identifies high doses
- assessment of working practices

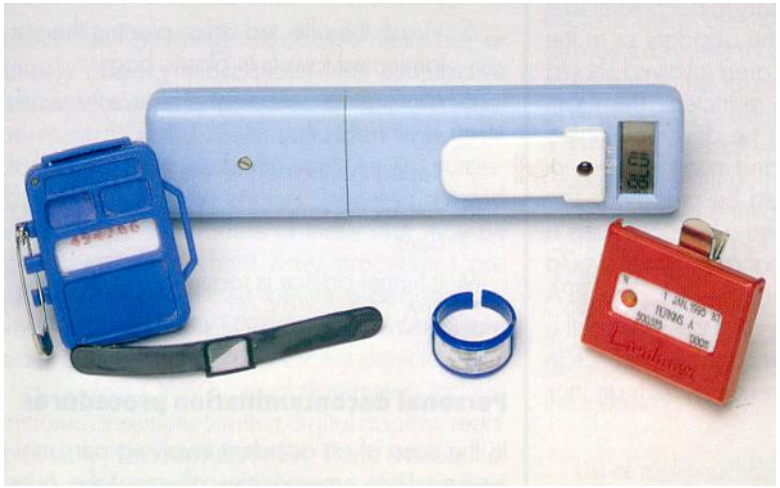
WHO SHOULD BE MONITORED?

Those who are working with preparation and administration of radiopharmaceuticals and those who are performing patient examinations and quality control of the equipment such as:

Nuclear medicine specialist
Nuclear medicine technicians
Medical physicist
…and more?

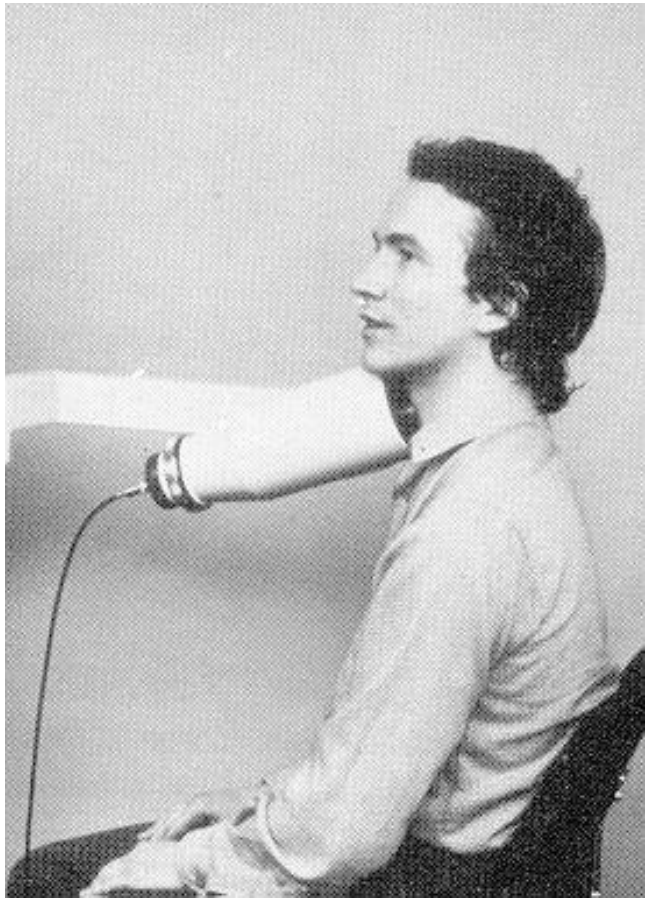
Category A & B workers? Who should decide?

Different types of personal dosemeters for monitoring external exposure

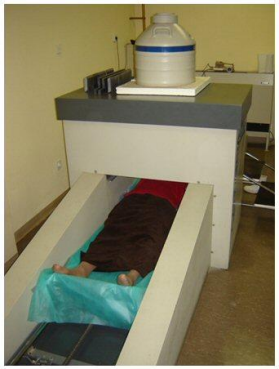


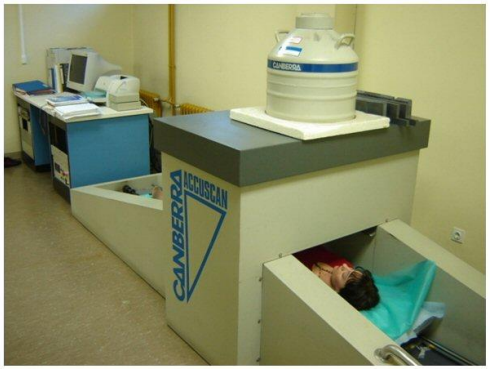
- film
- termoluminescence dosemeters (TLD)
- electronic" dosemeters

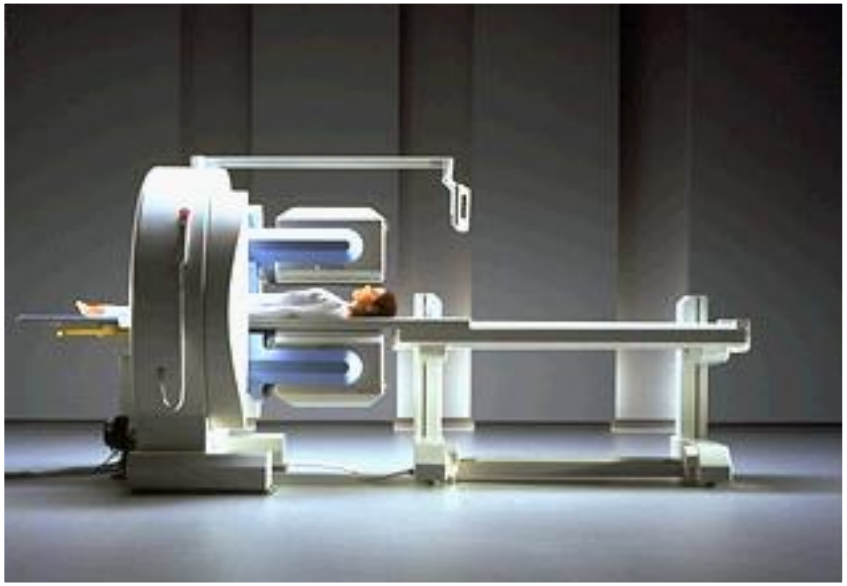
MONITORING OF THYROID (internal contamination)



WHOLE BODY MONITORING (contamination)







Whole-body counter or gamma camera without collimator can be used

EXPOSURE OF THE WORKER

The monitored effective dose for workers in a nuclear medicine department is about 3-5 mSv per year. The extremity dose (fingers) is about 10 times higher.

PLANNED OCCUPATIONAL EXPOSURE SITUATIONS

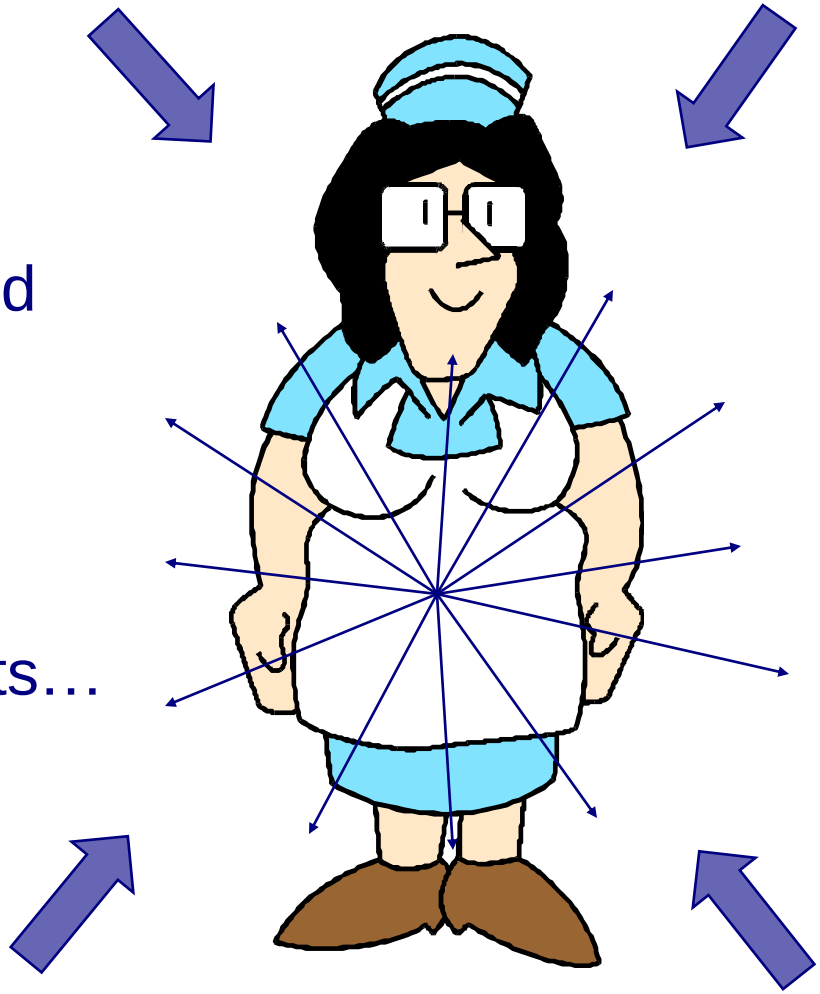
Requirement 22: Compliance by workers

Workers shall fulfil their obligations and carry out their duties for protection and safety.

EXPOSURES IN NUCLEAR MEDICINE

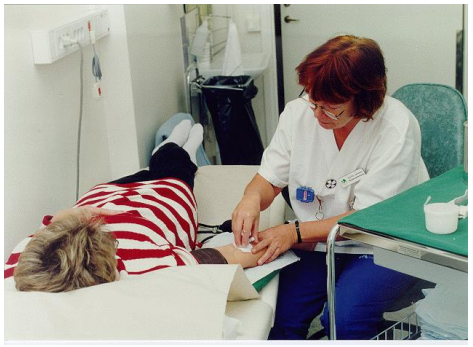
Internal
Ingested and/or inhaled radionuclides

External
Vials, syringes, patients…



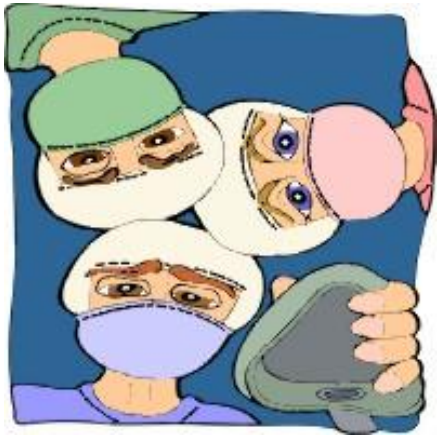
Exposure of the worker

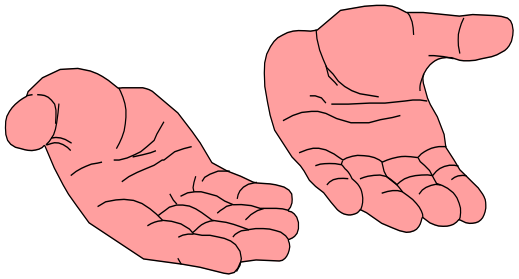
Unpacking radioactive material
Activity measurements
Storage of sources
Internal transports of sources
Preparation of radiopharmaceuticals
Administration
Examination of the patient
Care of the radioactive patient
Handling of radioactive waste
Accidents



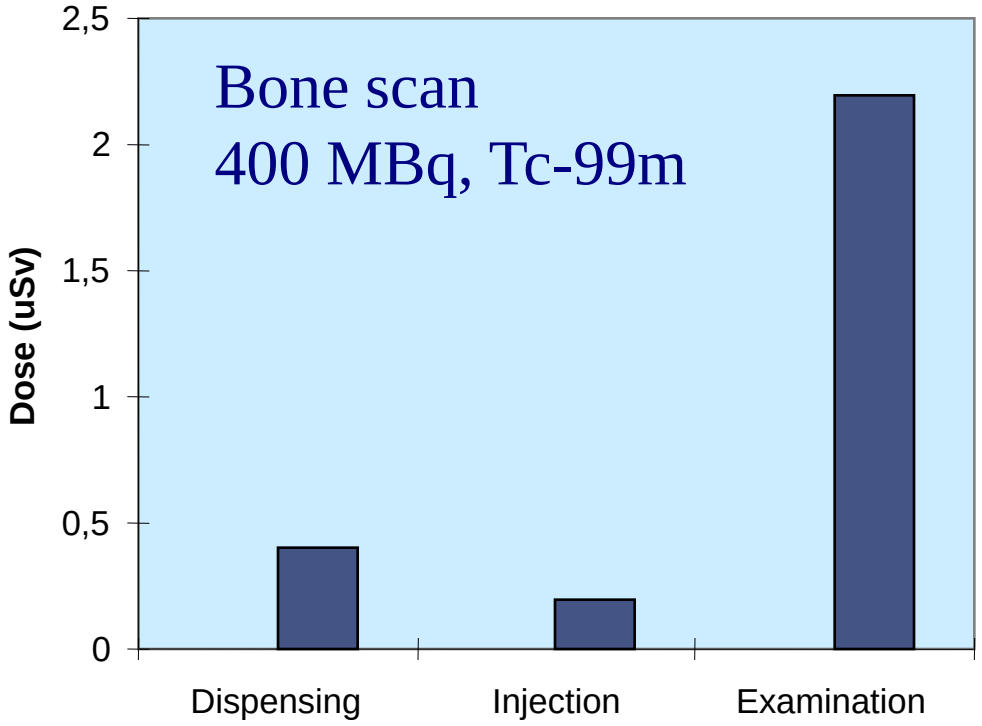
Contamination of the worker

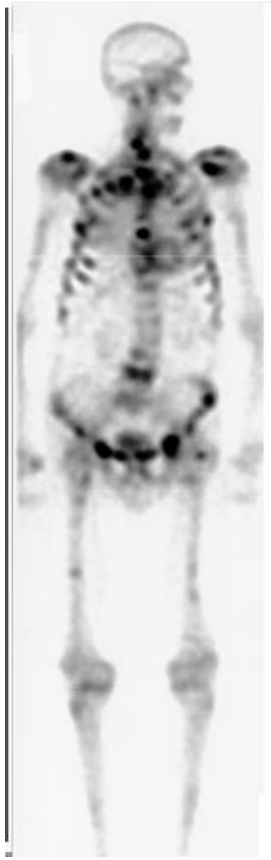
- spills
- improper administration
- experimental work with animals
- emergency surgery of a therapy patient
- autopsy of a therapy patient





Dose to worker



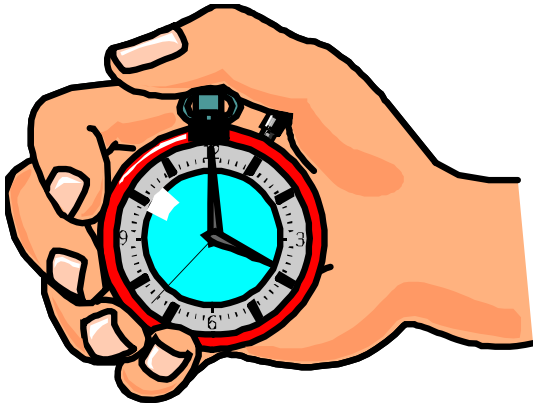


Radiation Protection Measures

- **Time**
- **Distance**
- **Shielding**

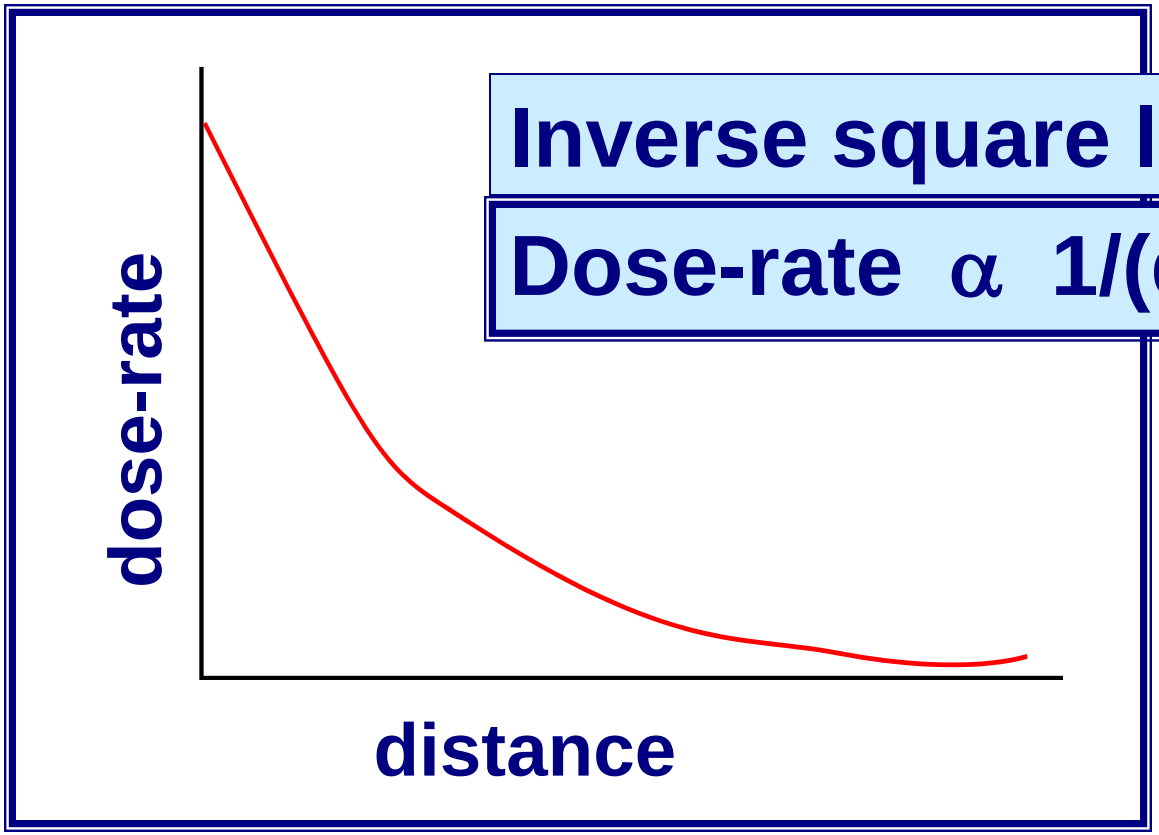
Time

Dose is proportional to the time exposed



Dose = Dose-rate x Time

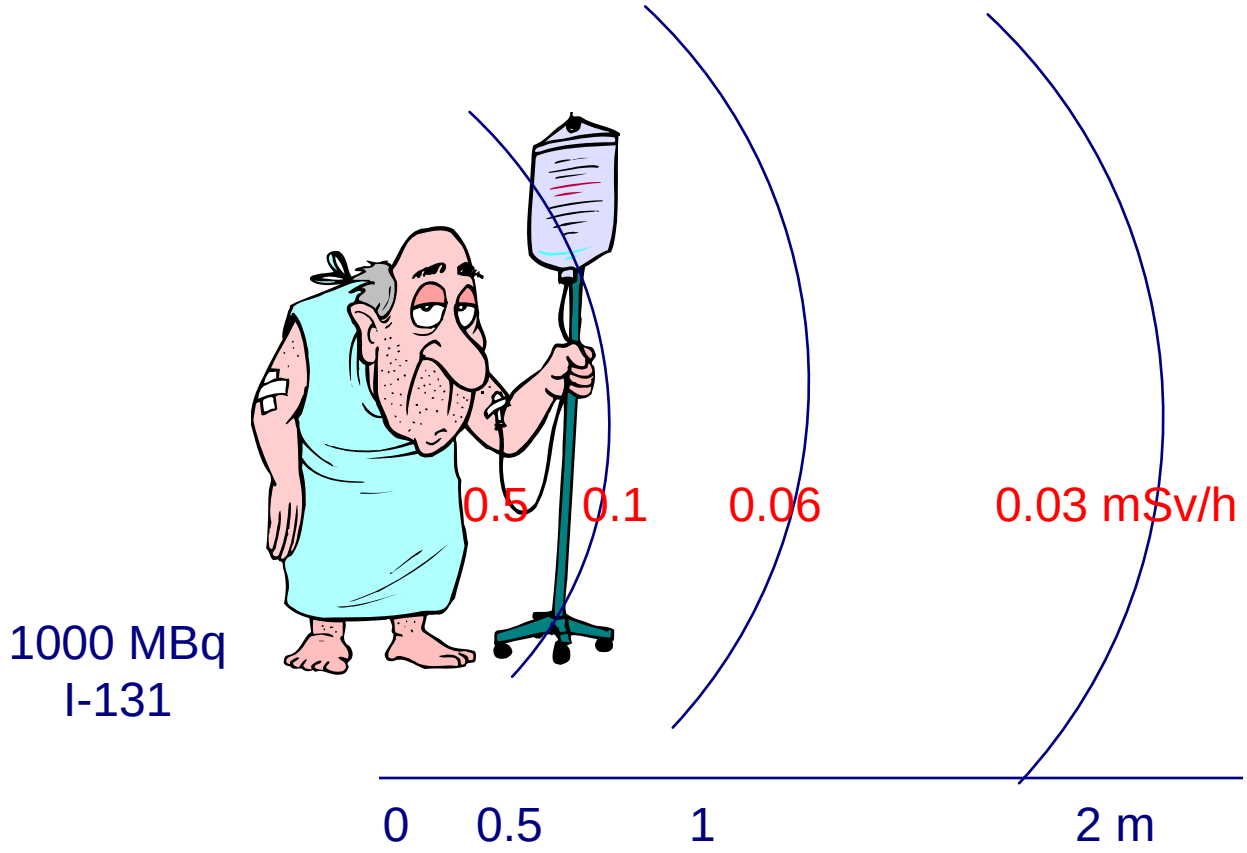
Distance



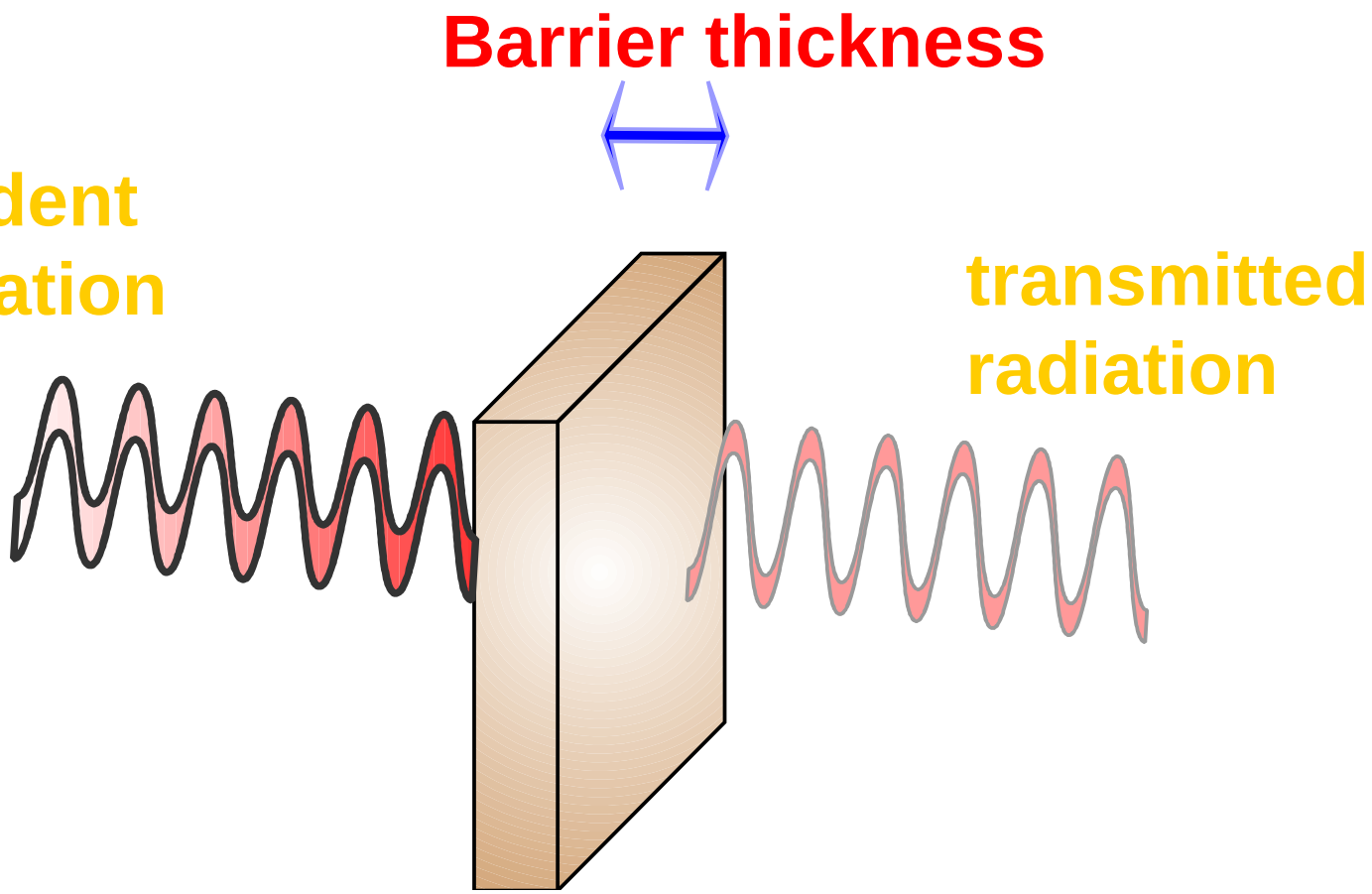
Inverse square law (ISL):

Dose-rate α 1/(distance)^2

Patient with iodine-131



Shielding


Barrier thickness
incident radiation
transmitted radiation

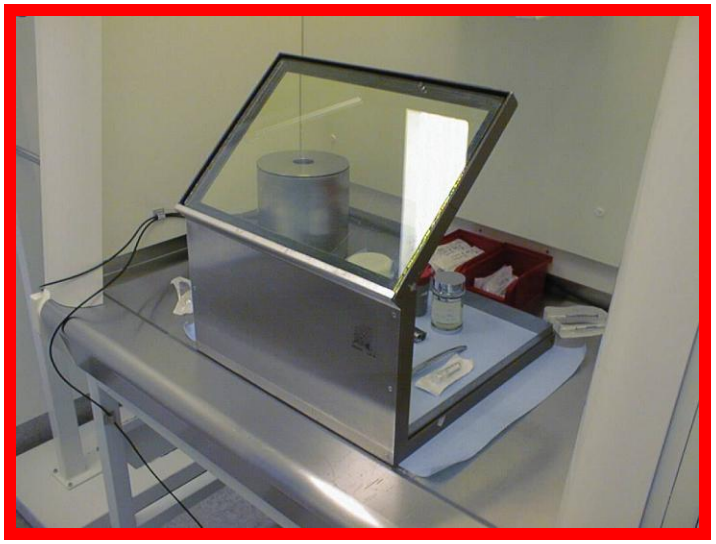
Shielding

Bench top shield
Vial shields
Syringe shields

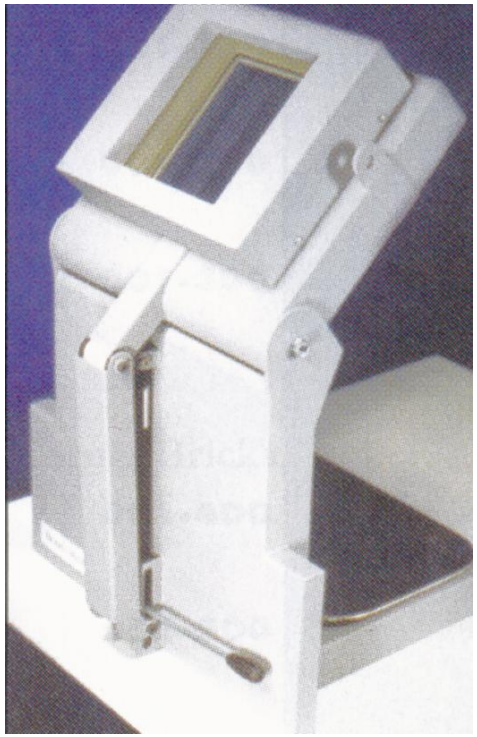
SHIELDING OF SOURCES

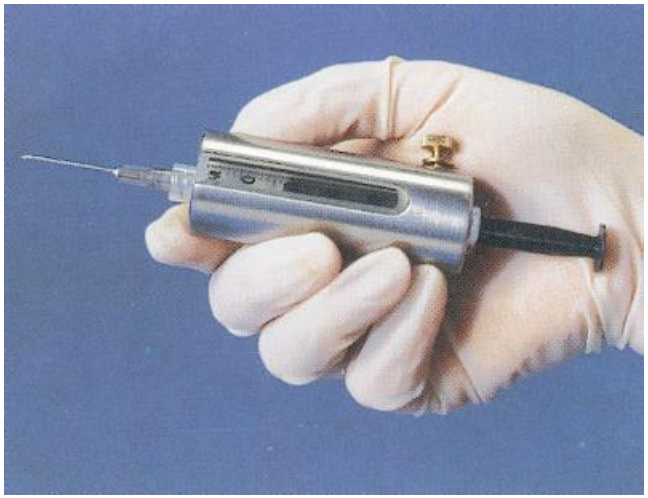
Factors affecting the design:

- radionuclide
- activity
- shielding material



SHIELDING IN PET





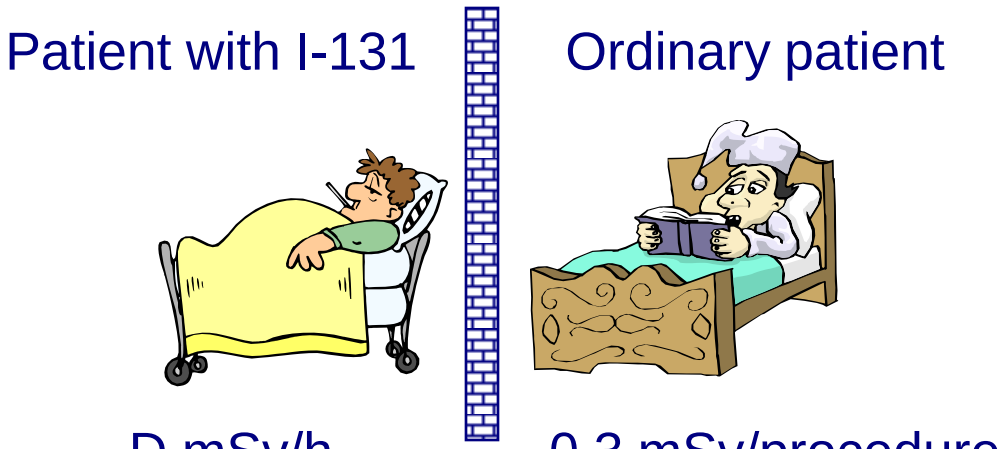
Protection against high energy photons requires lead shield of significant thickness (cm)

Biodex Medical

STRUCTURAL SHIELDING

The absorbed dose is determined by factors such as:

- source strength;
- length of exposure;
- distance from the source;
- transmission through the protective barrier.



PROTECTIVE CLOTHING

Appropriate clothing should as a minimum include lab coat and gloves.National regulations may require more.

Safety equipment needed depends on the type of work

Example unpacking:

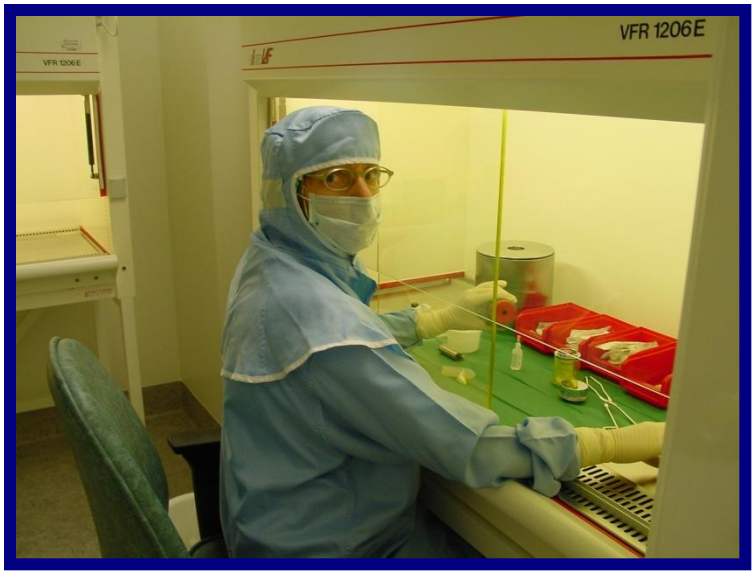
- check for damage
- check for contamination
- check the content
- check the activity

Safety equipment:

- protective clothing
- contamination monitor
- shields
- forceps, tongs

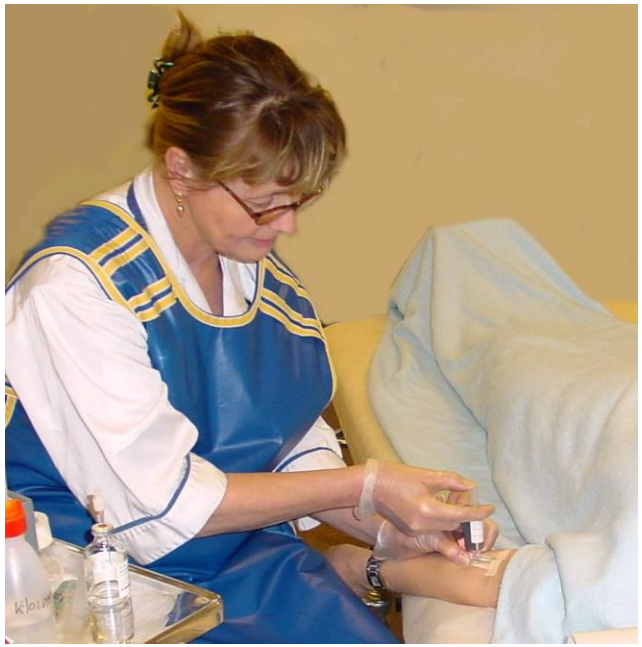
SAFETY EQUIPMENT

PREPARATION OF RADIOPHARMACEUTICALS



- Shields
- Protective clothing
- Tools for remote handling of radioactive material
- Containers for radioactive waste
- Dose rate monitor with alarm
- Contamination monitor
- Decontamination kit
- Signs, labels and records

ADMINISTRATION

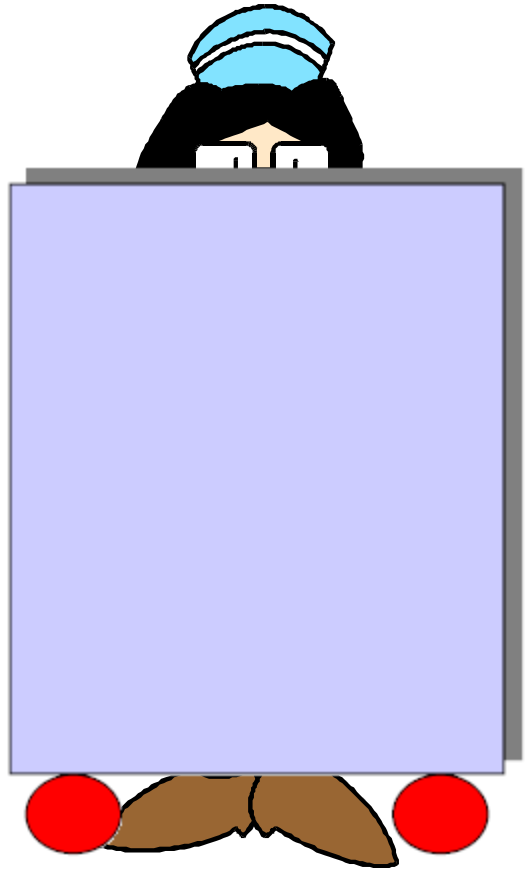


Syringe shield
Gloves
Lead apron?
Absorbing pads

Vial Shield

PATIENT EXAMINATION

Movable shield
Lead apron



To minimize contamination risks

- adopt clean operating conditions
- adopt good laboratory practices
- do not eat, smoke etc…
- use protective gloves and clothing

PLANNED OCCUPATIONAL EXPOSURE SITUATIONS

Requirement 24: Arrangements under the radiation protection programme

Employers, registrants and licensees shall establish and maintain organizational, procedural and technical arrangements for the designation of controlled areas and supervised areas, for local rules and for monitoring of the workplace, in a radiation protection programme for occupational exposure.

CLASSIFICATION OF AREAS

- Controlled area
- Supervised area

…..display a warning symbol

……appropriate instructions at access points

Monitoring instruments

EXAMPLE: MONITORING THERAPY WARD

Area or item	Initial (Bq/cm^2)	After cleaning (Bq/cm^2)
Toilet		
Washroom floor		
Sink and Faucets		
Shower		
Bed		
Armchair		
Bedroom floor		
TV/Telephone		
Bedside table		
Doorknobs		
Lamp switches		

Derived limit: 3 Bq/cm^2

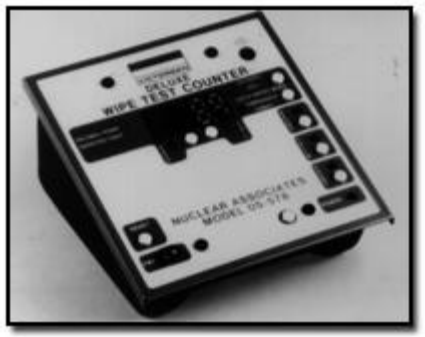
METHODS
- wipe test
- area monitor

WIPE TEST

Wipe a known surface area with an absorbent material moistened with water or alcohol. Put the sample in a tube and measure the activity in a well counter or a liquid scintillation counter.

$(cps-BG)/(E_c*E_w*A) = contamination\ (Bq/cm^2)$

cps: counts per second for sample
BG: instrument background
E_c: counter efficiency (cps/Bq)
E_w: swipe efficiency (assumed to be 0.1)
A: area swiped (cm^2)



PLANNED OCCUPATIONAL EXPOSURE SITUATIONS

Requirement 25: Assessment of occupational exposure and workers' health surveillance

Employers, registrants and licensees shall be responsible for making arrangements for assessment and recording of occupational exposures and for workers' health surveillance.

3.104. Records of occupational exposure for each worker shall be maintained during and after the worker's working life, at least until the former worker attains or would have attained the age of 75 years, and for not less than 30 years after cessation of the work in which the worker was subject to occupational exposure.

PLANNED OCCUPATIONAL EXPOSURE SITUATIONS

Requirement 26: Information, instruction and training

Employers, registrants and licensees shall provide workers with adequate information, instruction and training for protection and safety.

PLANNED OCCUPATIONAL EXPOSURE SITUATIONS

Requirement 27: Conditions of service

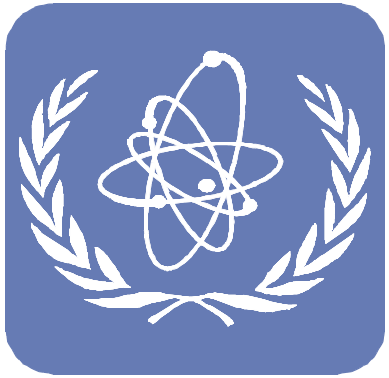
Employers, registrants and licensees shall not offer benefits as substitutes for measures for protection and safety.

PLANNED OCCUPATIONAL EXPOSURE SITUATIONS

Requirement 28: Special arrangements for protection and safety for female workers and for persons under 18 years of age undergoing training

Employers, registrants and licensees shall make special arrangements for female workers, as necessary, for protection of the embryo or fetus and breastfed infants. Employers, registrants and licensees shall make special arrangements for protection and safety for persons under 18 years of age who are undergoing training.

Part 12



Public Exposure
Protection of the General Public

PUBLIC EXPOSURE DEFINITION

public exposure

Exposure incurred by members of the public due to sources in planned exposure situations, emergency exposure situations and existing exposure situations, excluding any occupational exposure or medical exposure.

member of the public

For purposes of protection and safety, in a general sense, any individual in the population except when subject to occupational exposure or medical exposure. For the purpose of verifying compliance with the annual dose limit for public exposure, this is the representative person.

Exposure of the general public

- Contamination in/out-side department
- Lost sources
- Nuclear medicine patient
- Visitors
- Radioactive waste
- Transportation of sources

PLANNED PUBLIC EXPOSURE SITUATIONS

PLANNED PUBLIC EXPOSURE SITUATIONS

Requirement 29: Responsibilities of the government and the regulatory body specific to public exposure

The government or the regulatory body shall establish the responsibilities of relevant parties that are specific to public exposure, shall establish and enforce requirements for optimization, and shall establish, and the regulatory body shall enforce compliance with, dose limits for public exposure.

PLANNED PUBLIC EXPOSURE SITUATIONS

III.3. For public exposure, the dose limits are:

(a) An effective dose of 1 mSv in a year;
(b) In special circumstances[68], a higher value of effective dose in a single year could apply, provided that the average effective dose over five consecutive years does not exceed 1 mSv per year;
(c) An equivalent dose to the lens of the eye of 15 mSv in a year;
(d) An equivalent dose to the skin of 50 mSv in a year.

[68] For example, in authorized, justified and planned operational conditions that lead to transitory increases in exposures.

PLANNED EXPOSURE SITUATIONS

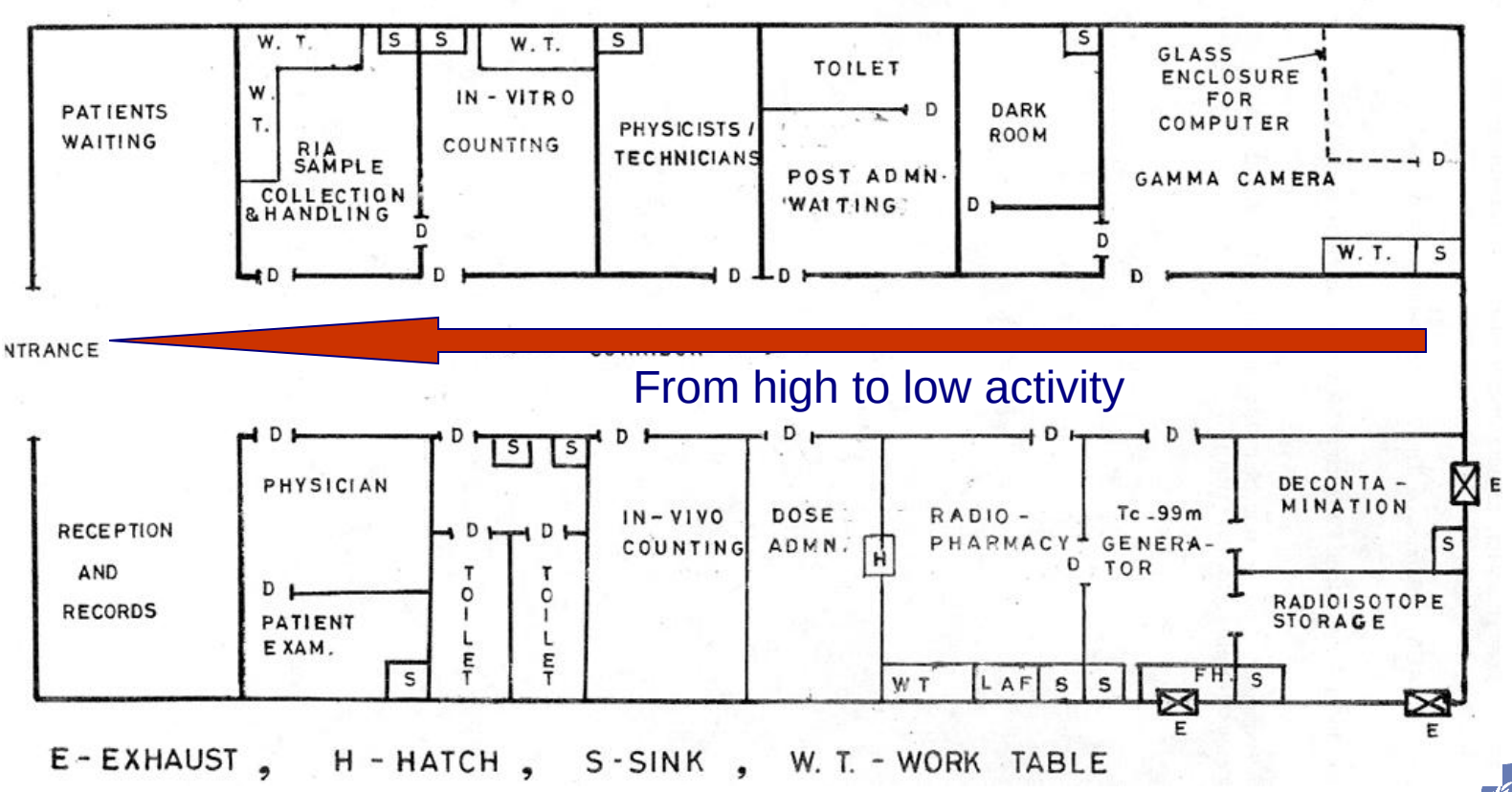
III.4. The effective dose limits specified in this schedule apply to the sum of the relevant doses from external exposure in the specified period and the relevant committed doses from intakes in the same period; the period for calculating the committed dose shall normally be 50 years for intakes by adults and shall be up to age 70 years for intakes by children.

PLANNED PUBLIC EXPOSURE SITUATIONS

Requirement 30: Responsibilities of relevant parties specific to public exposure

Relevant parties shall apply the system of protection and safety to protect members of the public against exposure.

Layout of a nuclear medicine department



CLASSIFICATION OF AREAS

- Controlled area
- Supervised area

Patient areas

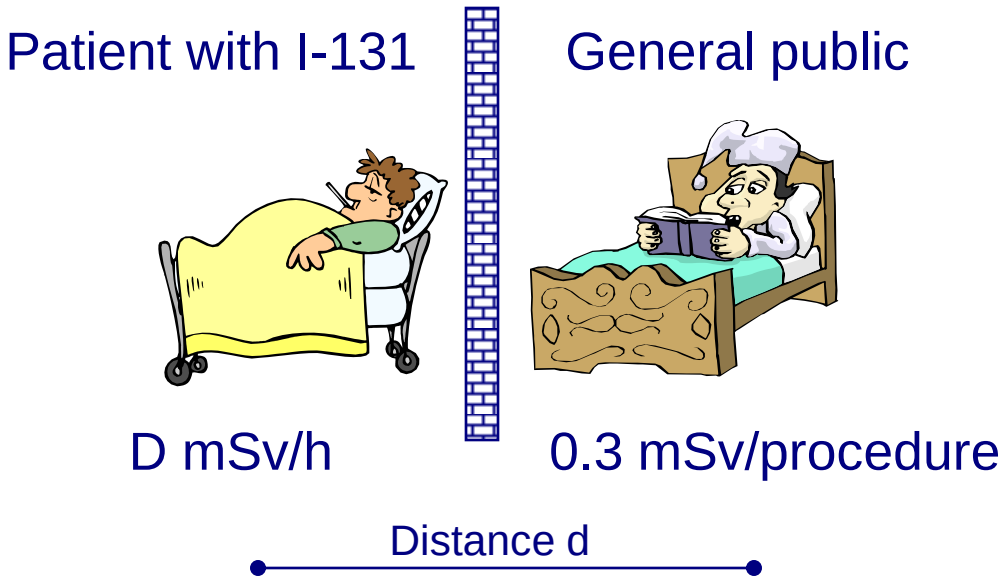
- Separation of radioactive patients and other patients waiting is an example of good practice, especially in a busy department.

- Separate toilet room for the exclusive use of injected patients should always be considered. This patient washroom should not be used by general public or hospital staff as it is likely that the floor, toilet seat and sink faucet handles will be contaminated frequently.

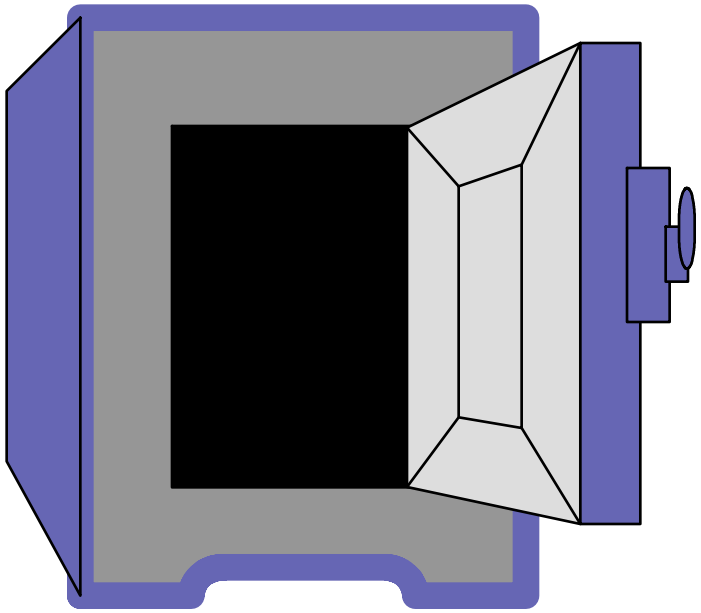
STRUCTURAL SHIELDING

The absorbed dose is determined by factors such as:

- source strength;
- length of exposure;
- distance from the source;
- transmission through the protective barrier.



STORAGE OF SOURCES



- locked to prevent unauthorized use and theft
- warning sign
- shielded to <2 uSv/h at 1m (permanently occupied areas) alternatively <20 uSv/h at 1 m (temporarily occupied areas)
- inventory record

The radioactive patient

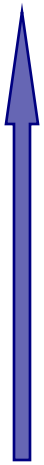
Uncontrolled unsealed radioactive source that causes external exposure and contamination of the general public?

YES!

(after leaving the hospital)

The radioactive patient

Exposure of general public



Release the patient without any restrictions

Release the patient with restrictions

Keep the patient in the hospital

Transport Container

White-I Label

- **< 5.0 μSv/h @ surface**
- **< 0.05 μSv/h @ 1.0 m**
- **TI = 0**

Yellow-II Label

- **< 500 μSv/h, > 5 μSv/h @ surface**
- **< 10 μSv/h @ 1.0 m**
- **0 < TI < 1.0**

Vehicle Placards

3 placards on vehicle

PLANNED PUBLIC EXPOSURE SITUATIONS

Requirement 31: Radioactive waste and discharges

Relevant parties shall ensure that radioactive waste and discharges of radioactive material to the environment are managed in accordance with the authorization.

PLANNED PUBLIC EXPOSURE SITUATIONS

Requirement 32: Monitoring and reporting

The regulatory body and relevant parties shall ensure that programmes for source monitoring and environmental monitoring are in place and that the results from the monitoring are recorded and are made available.