Protection Against Gamma Rays

Protection by awareness

Introduced by
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One day in Egypt

A ghost came to a small village

and caused the death of three and serious injuries to five from one family.

The villagers whispered to each other

"There is a ghost who visited that house."

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The cause of death and serious injuries was unknown.

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At the hospital, doctors noticed some burns and thought that these cases might have been exposed to a high dose of radiation.

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With research and investigation

it was found that there is a pipeline work site near the village, and that site uses a gamma ray to conduct radiography tests for pipe welds

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Upon further investigation, inspectors found that one of the gamma ray cameras had been **missing** from the site for several days.

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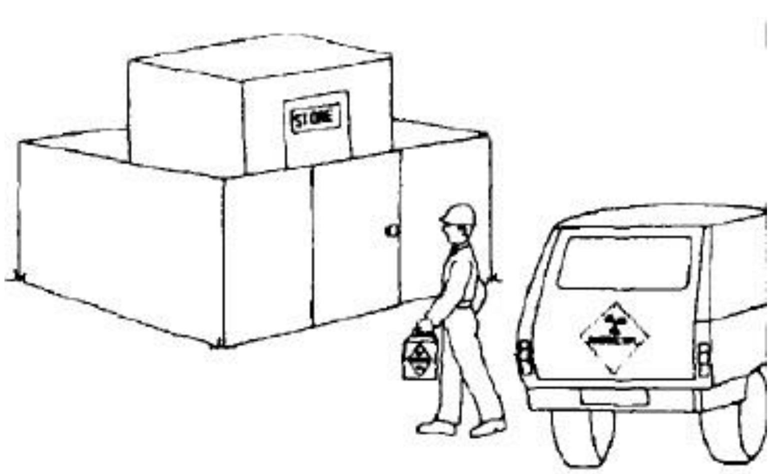
The scenario was as follows: After the end of the work day, the contractor's radiographers were supposed to **store** the gamma camera in a secure warehouse



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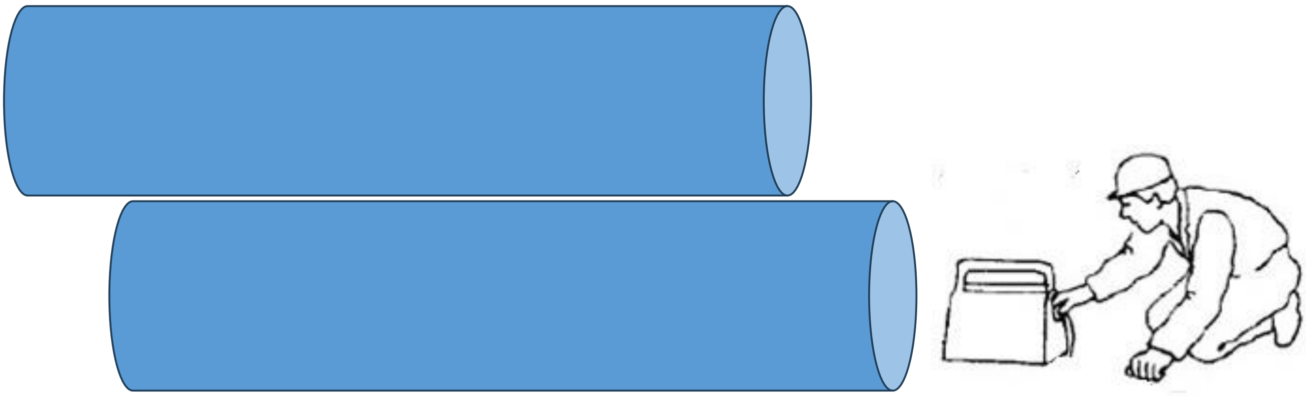
but they stored it **inside a pipe** on site for use it at the next day.



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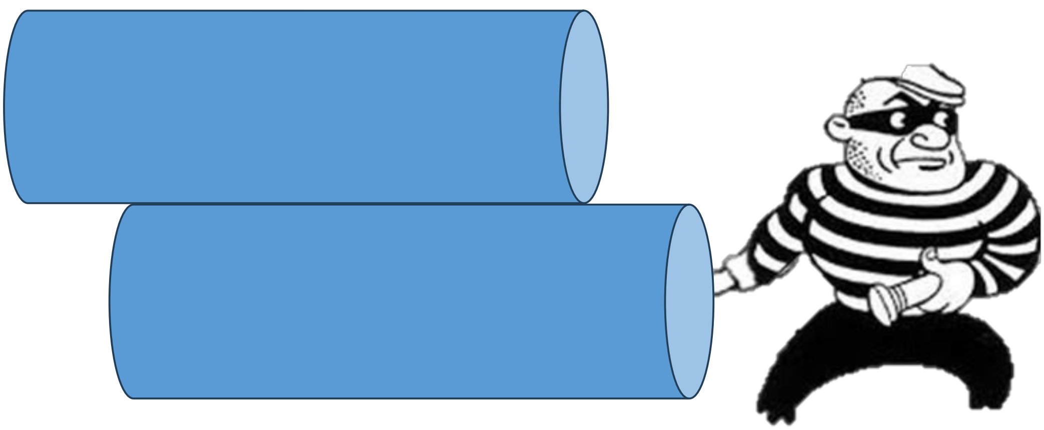
Someone saw the camera, **stole** it, took it to his house



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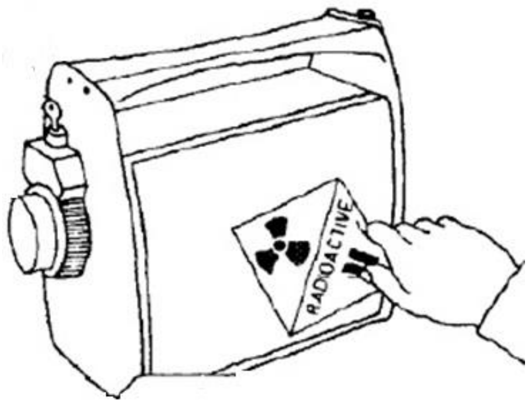
and tried to open it to find out what was inside it.



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This person and his family were exposed to high doses of radiation, which led to these deaths and serious injuries.

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There is great follow-up, interest and attention at the **highest level** in the country regarding the mystery of the incident.

الأخبار ● الصفحة الثالثة

مجلس الوزراء ناقش حادث «ميت حلفا»:

الإبرة المشعة بمنزل المصابين منذ عام واعتقدوا أنها معدن ثمين

مسح طبي للمواطنين والمنازل للتأكد من عدم وجود إصابات أو مصادر مشعة أخرى

الرئيس مبارك يتابع الحادث

صباح الخير

سعيد سنبل

«الأخبار» في «ميت حلفا»

الهدوء عاد إلي القرية بعد نقل الجسم المشع

تحقيقات مكثفة لمعرفة حقيقة

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This incident took place in the village of **Mit Halfa** in June 2000, and this scenario or something similar exists **worldwide**.

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Ionizing radiation are like a ghost because we cannot sense them with our five senses

But

With awareness and knowledge, we can avoid it's harm and obtain it's advantages.

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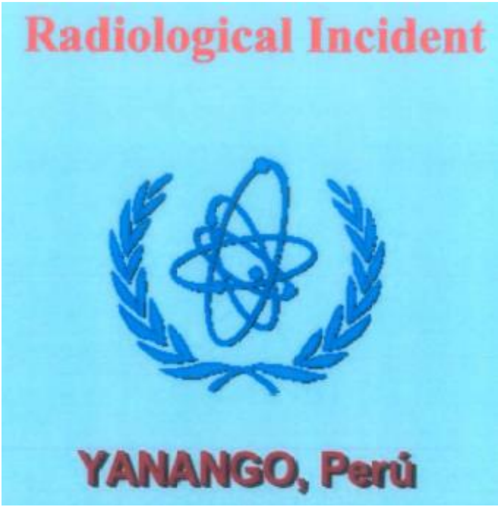
Another one



Radiological Accident

Yanango, Peru, Radiological Accident

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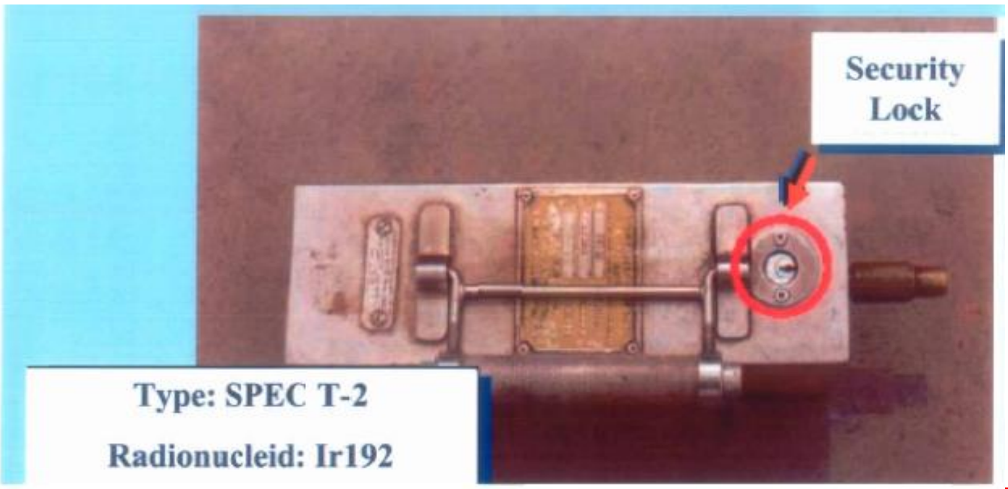
What Happened

A non-authorized person unscrewed the screws of the security lock to free the radioactive source of a Gamma camera.



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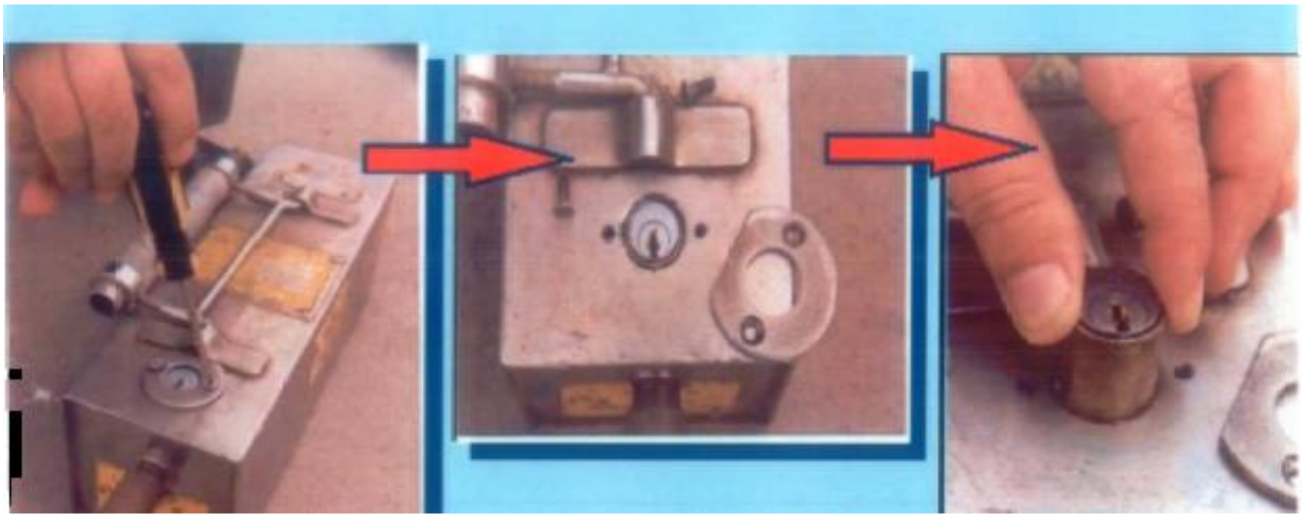
No key is needed to remove the source, it can be done with a screwdriver.



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Consequences:

A welder working with a radiographer at a hydroelectric plant picked up a lost iridium-192 industrial radiography source on 20 February 1999 and put it in his pocket for several hours.

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Consequences:

After about six hours the worker began experiencing pain in the back of the right thigh. He went home with the source, causing minor exposures to family members.

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The radiographer, having discovered the source was missing about midnight, came to the welder's home at 1:00 AM on 21 February and helped discover the source.

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The welder received an estimated whole body dose of 150 rem, although localized doses were much higher--up to 10,000 rad to one buttock--requiring amputation of one leg.

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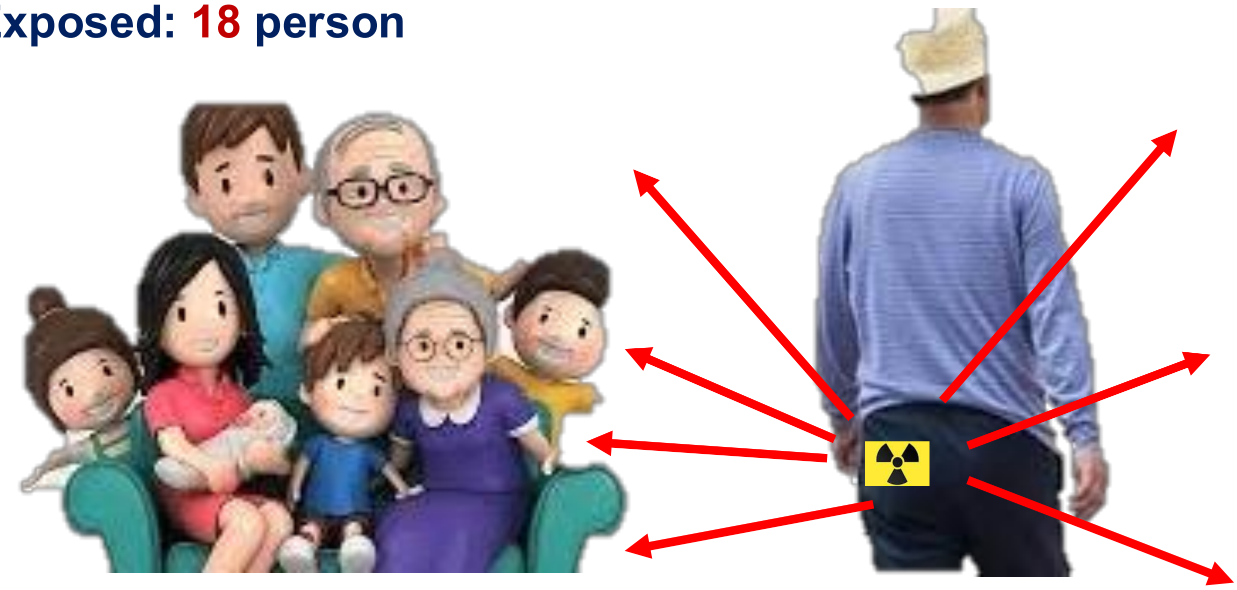
The result was

Over-radiation: 1 person
Exposed: 18 person



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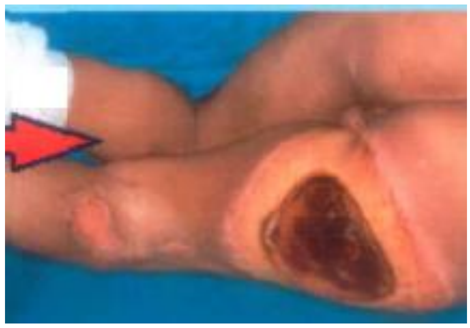
Effect on the leg the next day at 1:00 noon on February 21, 1999.

Impact on the leg 16 days after the accident 03-08-1999



Impact on the leg 70 days after the accident 1-5-1999

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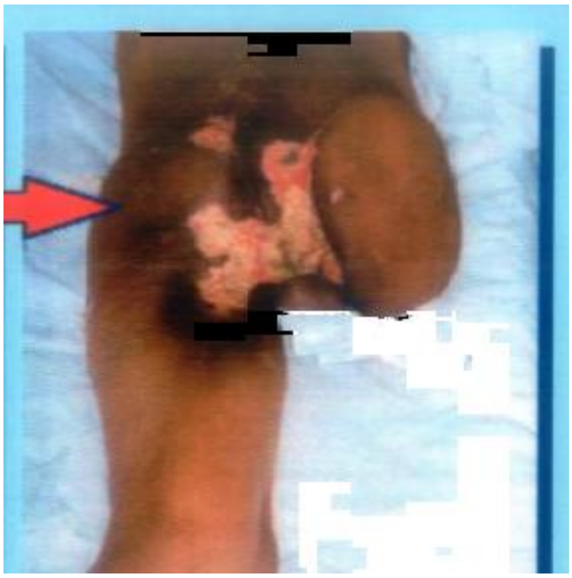

10-18-1999
Amputation of the leg

14-12-1999
Serious infection and contamination

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Common causes of accidents

Lack of awareness.

Procedures were not implemented.

Lack of regular oversight or inappropriate oversight

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Common causes of accidents

Lack of training or inappropriate training

Lack of a safety and security program

Absence of Safety Culture.

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Common causes of accidents

Failure to follow safety and security procedures

Source inspection and measures were inadequate.

Failure to use the radiation survey meter

Equipment or device malfunction

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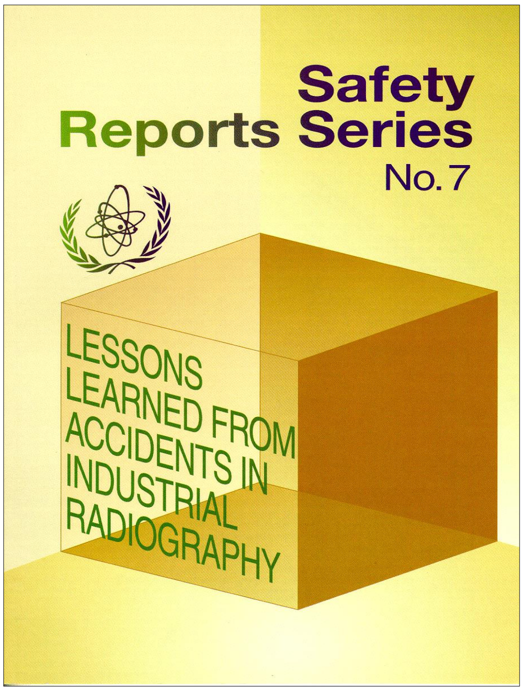

43 accidents, including 9 accidents involving the general public or non-radiology workers.

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We mention these incidents to spread awareness and take lessons learned to avoid the recurrence of such incidents

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Aside from what is complex or academic, there is a role for specialists to raise awareness for the community, customers, contacts, and those close to danger areas.

Let’s ask ourself some questions

Is there a radiation emergency plan?

Let's ask ourself some questions

Is the emergency plan being reviewed?

According to pre-determined periodic timings.

&

When new developments arise in operations, equipment, procedures,

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Let's ask ourself some questions

Is the emergency plan being reviewed?

When an accident or emergency occurs in the work area or affects the work area.

&

When an accident or emergency occurs outside the work area, it can be used to develop the plan.

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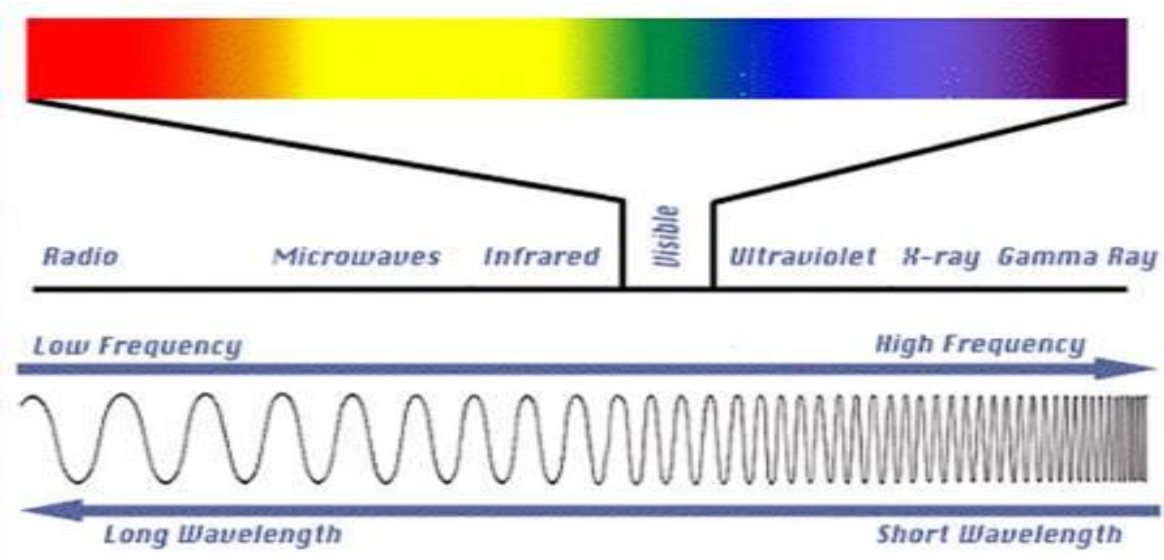
Let's protect ourselves against gamma rays

By

awareness & knowledge

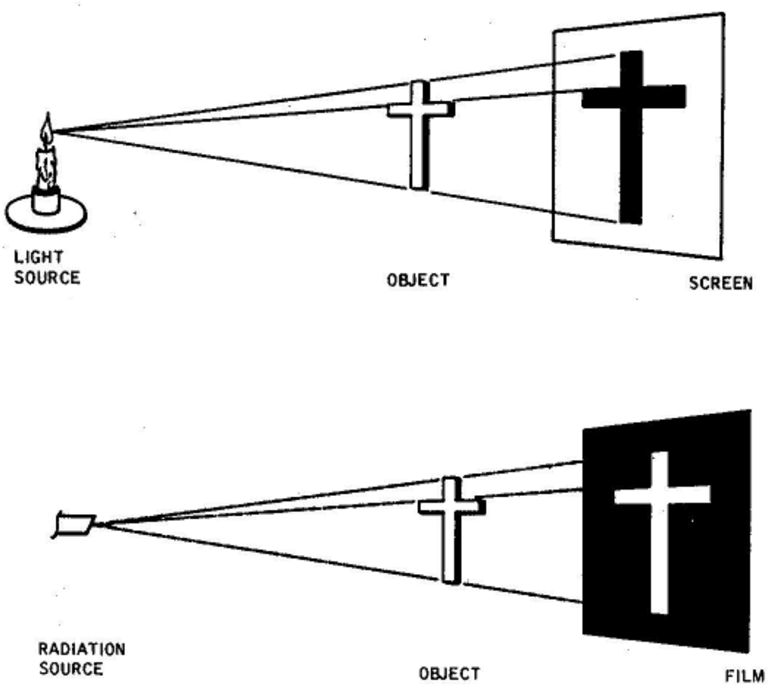
Ionizing radiation

It is part of the electromagnetic spectrum, which includes light, X-rays and gamma rays



Ionizing radiation

Gamma rays have the same properties as light, in addition to the property of penetrating materials, but light does not penetrate through opaque objects.



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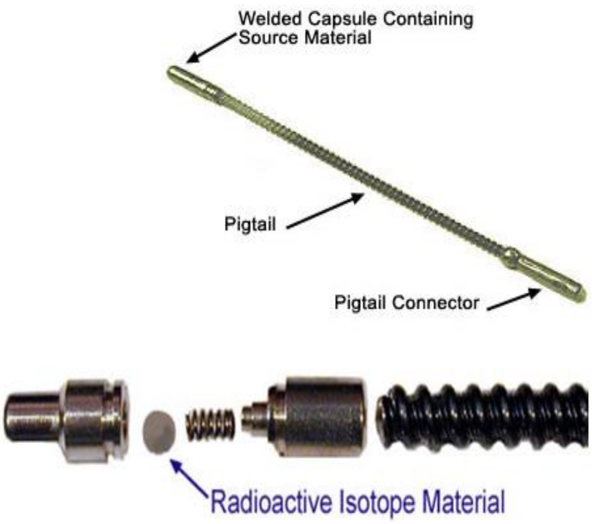
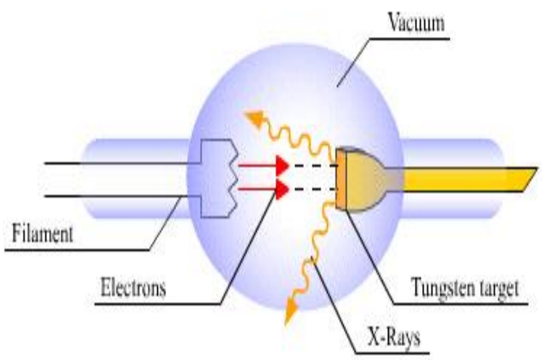
Gamma rays and X-rays





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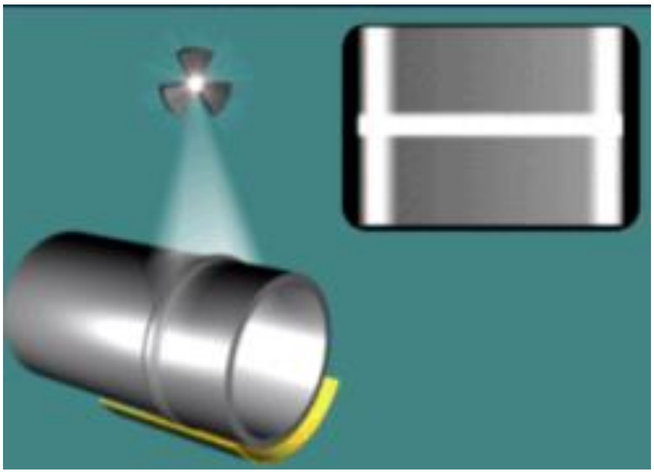
Radiography

The rays penetrate the materials and reach a sensitive film that is exposed to the penetrating rays. It is then processed and exposed to a screen to see and interpret internal defects.



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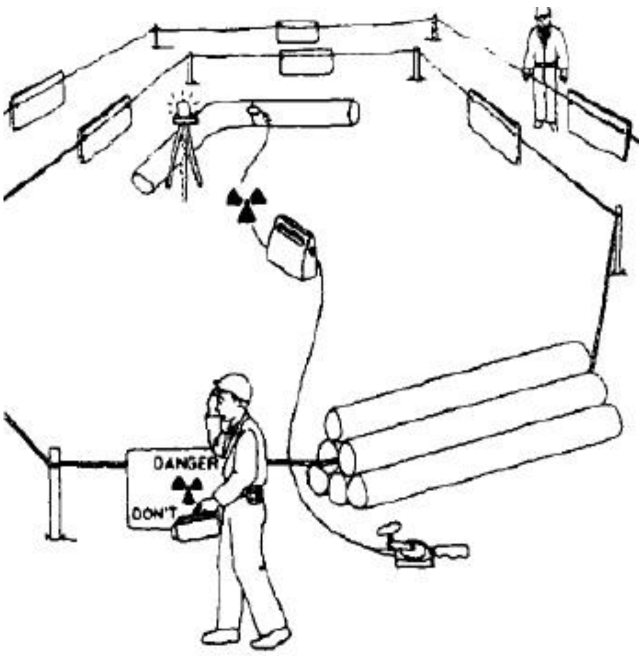
Radiography is used to test many products such as welds, castings, and forgings.



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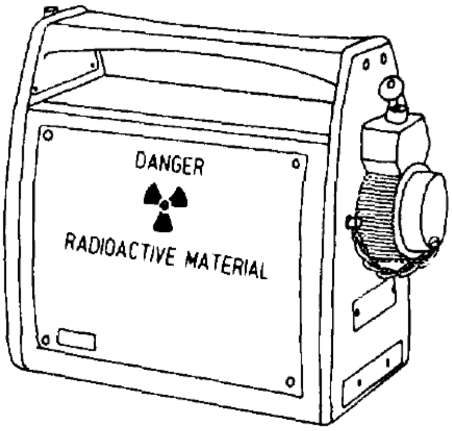
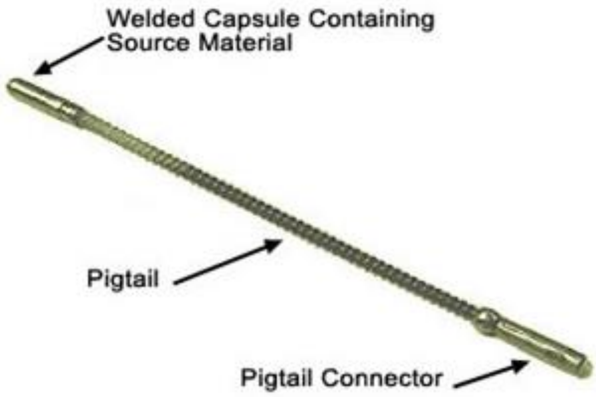
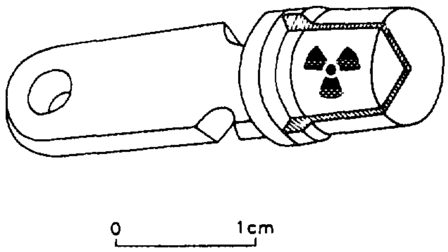
Radiography camera and radioactive source







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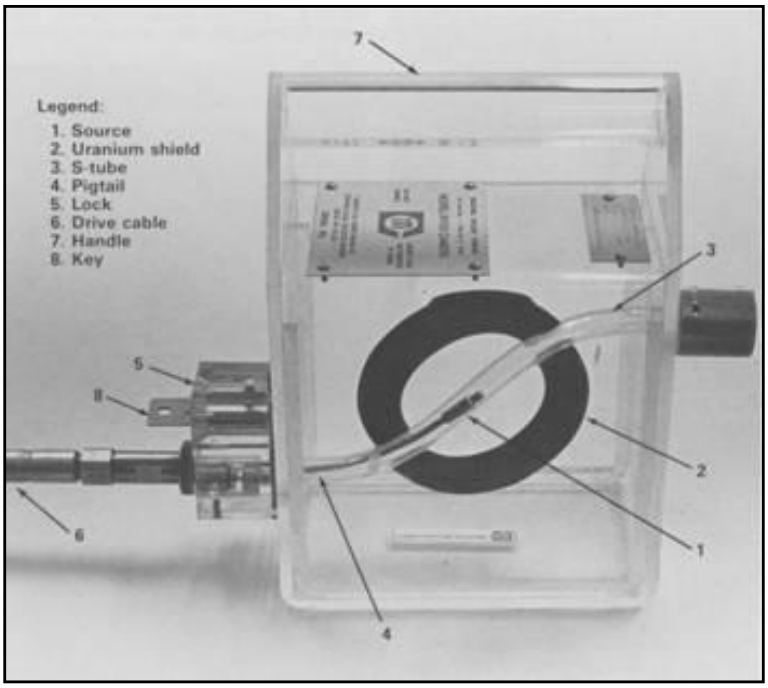
Radiography camera



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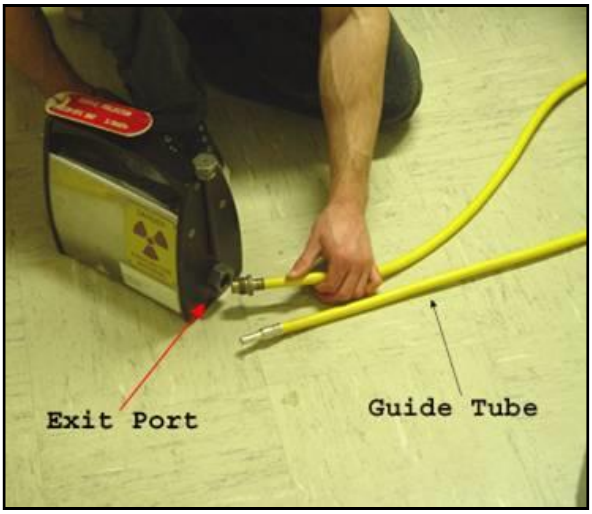
Radiography camera



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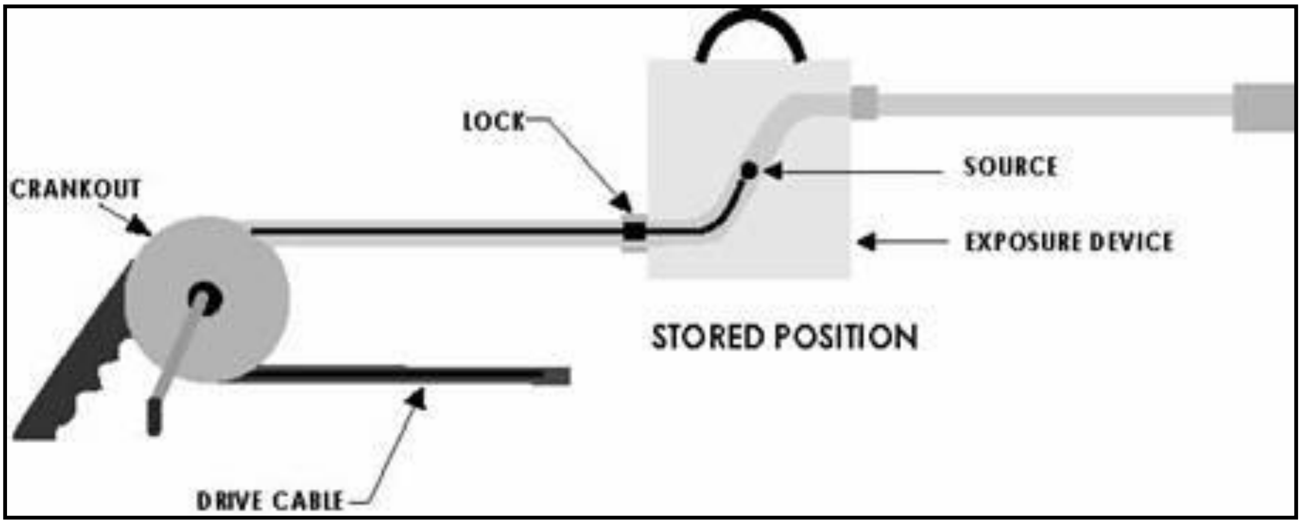
Radiography camera and its accessories



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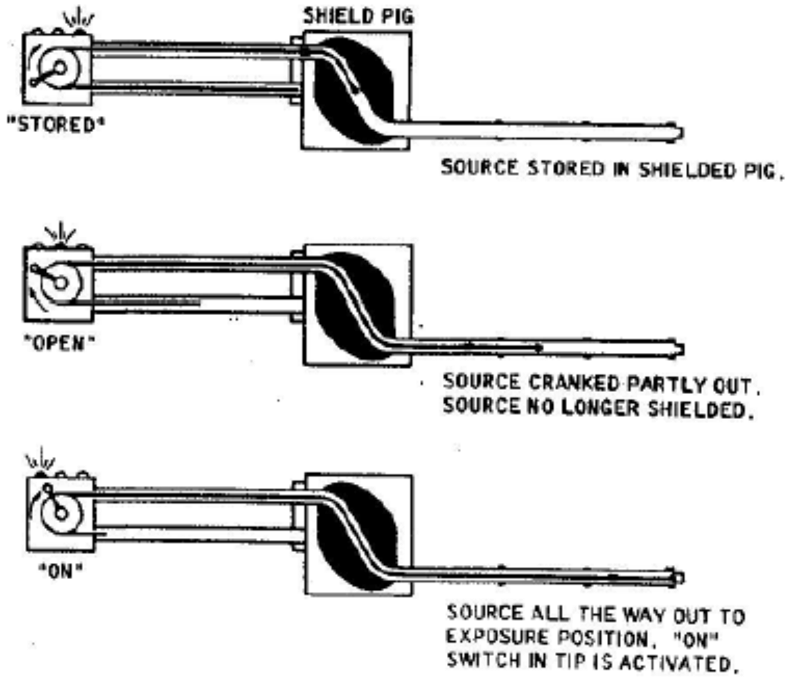
Movement of the source from inside the gamma camera to the external cable



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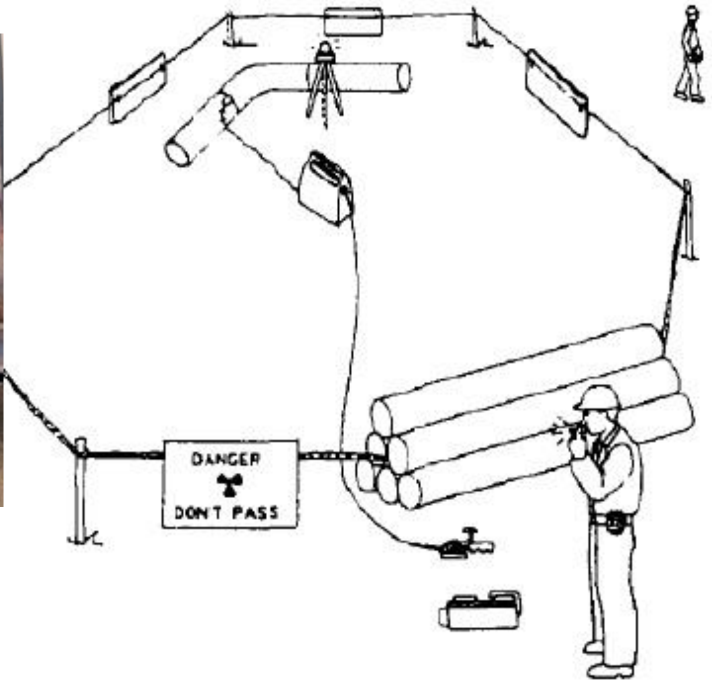
Radiography site



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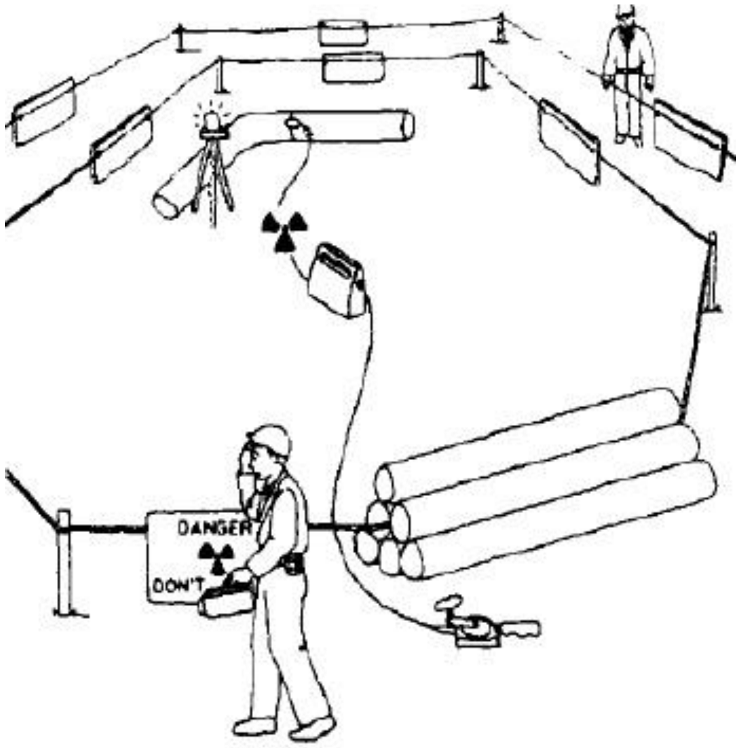
If the radiographer cannot return the source to the gamma camera for any reason,
What should he do?
He should remain calm and withdraw to the barriers location, measure the dose rate, expand the barriers circle, if necessary, prevent entry to this area, and inform the site management to begin emergency procedures.



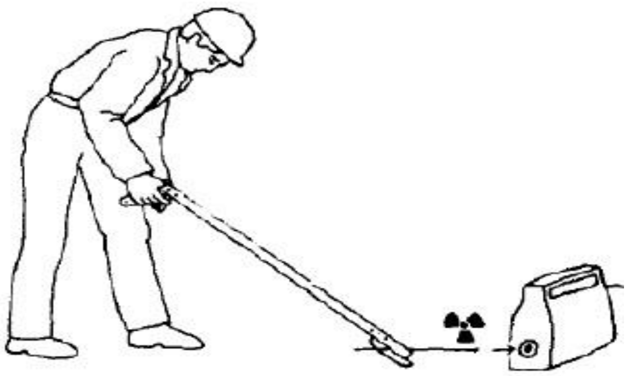
The radiographer should to put in his mind:

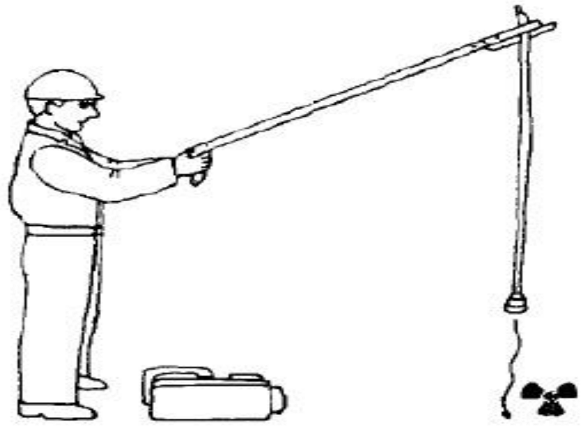
1- Move away from the source at once and keep other people away.

2- Calm down and think.

3- Establish a restricted area, and make sure no one approaches the source.

4- Call for help. Don’t try to do anything yourself that you are not trained to do. A common requirement of emergency procedures is that you should contact your employer’s Radiation Safety Officer (RSO) for help.





If the source comes out, the radiographer must use tweezers to pick up the radioactive source capsule from a distance and make the greatest possible distance between him and the source and do not let the source touch any part of his body under any circumstances when returning it to the device.

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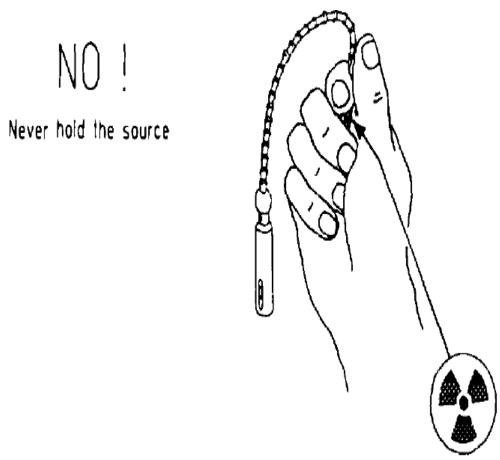

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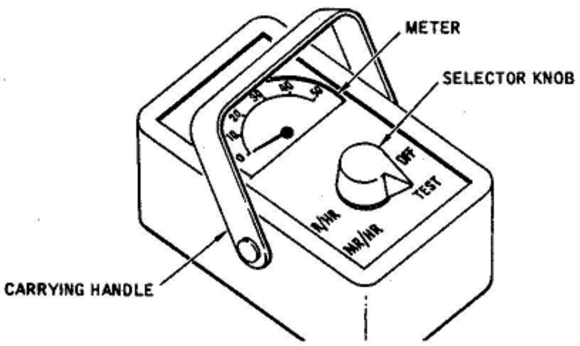
Radiation detection and measurement instruments

Since our senses cannot detect radiation, several devices are Commonly used in the field of radiography.

These devices are classified according to use and are called "survey meters" and "personnel monitoring devices."

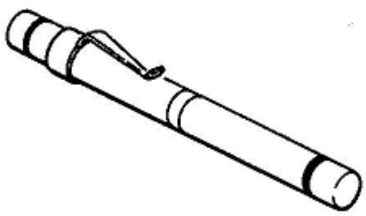
Radiation detection and measurement instruments

Survey meters are portable instruments used to monitor radiation areas.
The survey meter is designed to give radiation exposure rate.

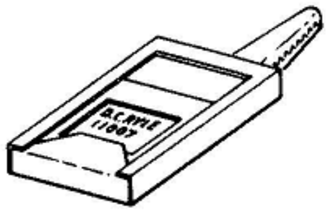


Radiation detection and measurement instruments

Personnel monitoring devices are attached to the clothing of the radiation worker.
These devices are designed to give cumulative readings of exposure



POCKET DOSIMETER



FILM BADGE

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Protection against radiation

There are three basic means of providing protection from radiation:

1. **Time — controlling the length of time a person is exposed to radiation.**

2. **Distance — controlling the distance between personnel and the source.**

3. **Shielding — placing absorbing materials between personnel and source.**

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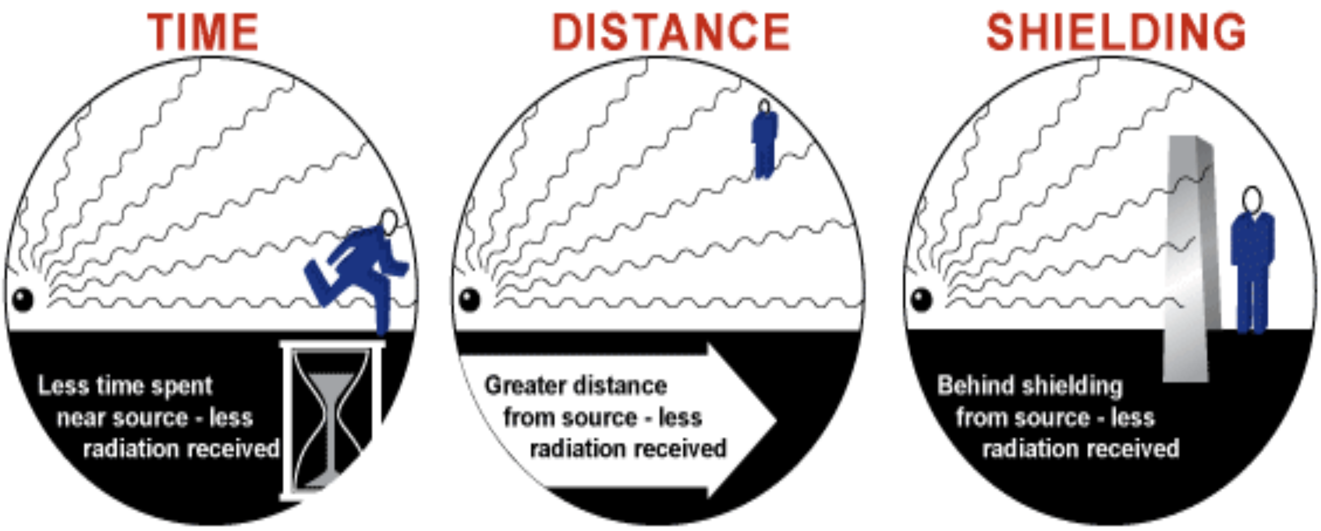

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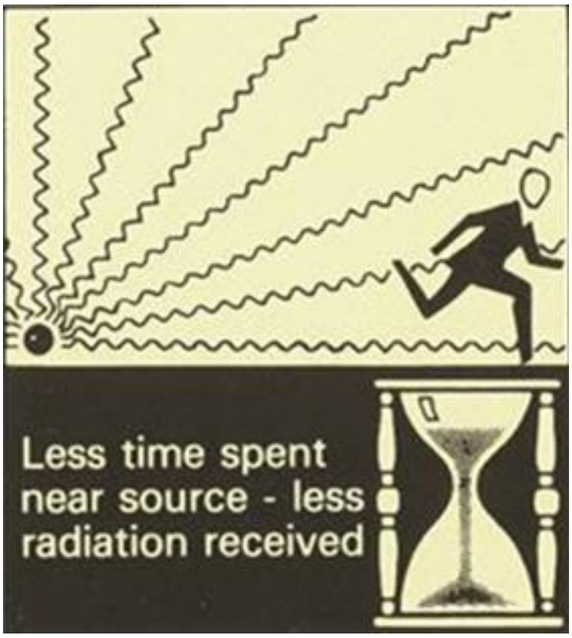
Time

Do not stay near a radiography source or camera any longer than you have. The less time you spend at the radiation field, the fewer doses you will receive.



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Time

The relationship of time to exposure is directly proportional.

The longer you stay in a radiation area, the more radiation exposure you receive.

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Time

Dose = dose rate X time

This means if your survey meter reads 10 mrem per hour (100 µSv / hr) you will receive 10 mrem in one hour, 5 mrem in ½ hour, and 2.5 mrem in ¼ hour and so on, on the other hand you will receive 20 mrem in 2 hours, 30 mrem in 3 hours.

Radiation dose		Time (hour)
mrem	µSv	
2.5	25	¼
5	50	½
10	100	1
20	200	2
30	300	3
40	400	4

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Time

(A person receiving 10 mr in one hour would receive 5 in 8 hours.)

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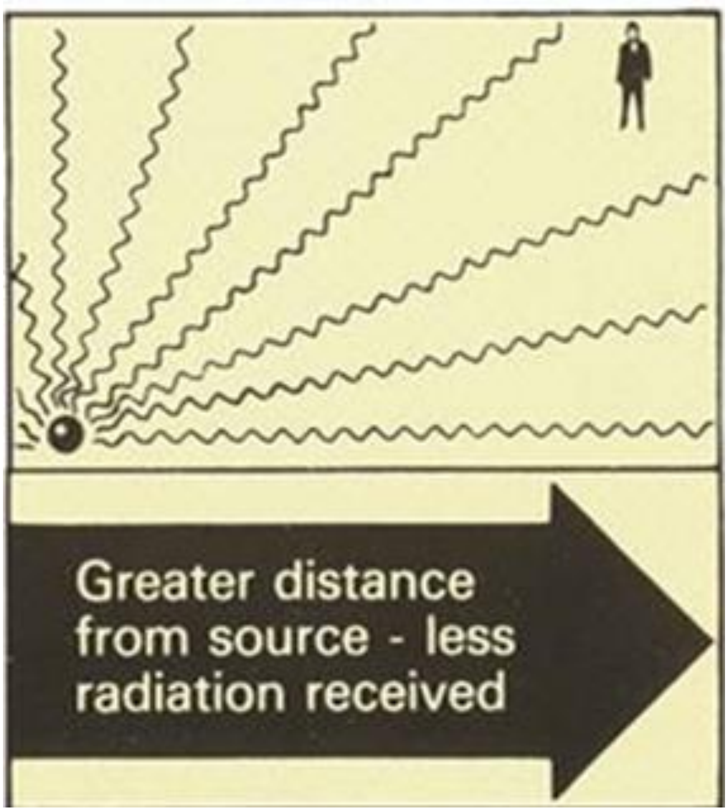
Distance

Stay as far away from the source as you can



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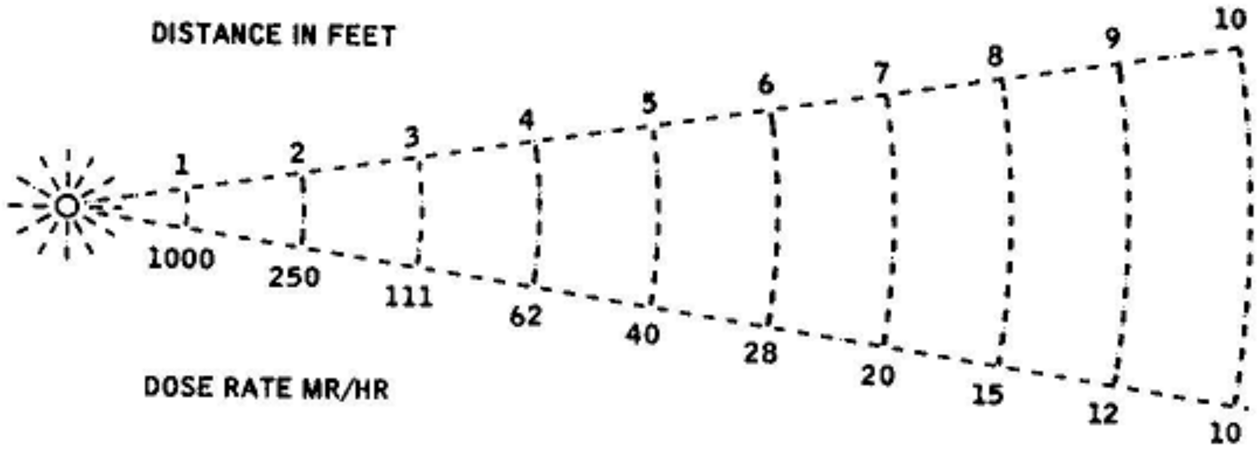
Distance

Radiation exposure decreases drastically as the distance from the source increases.



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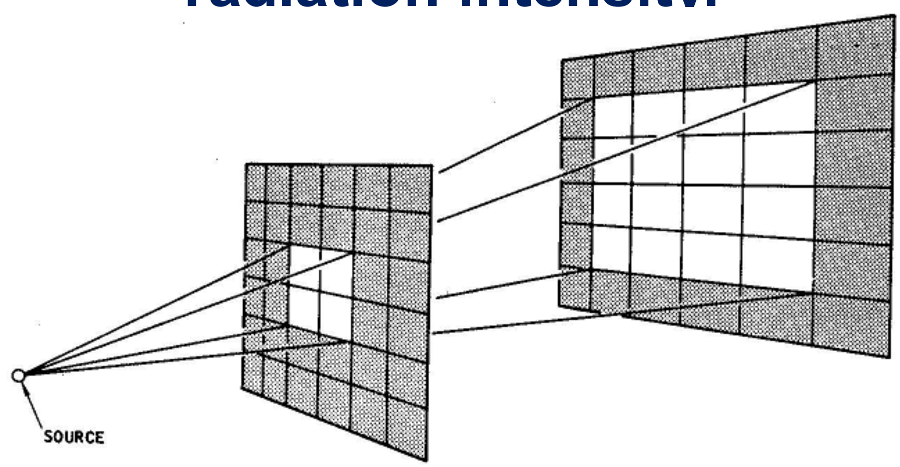
Distance

The mathematical law known as the "inverse square law" states the relationship of distance to varying radiation intensitv.



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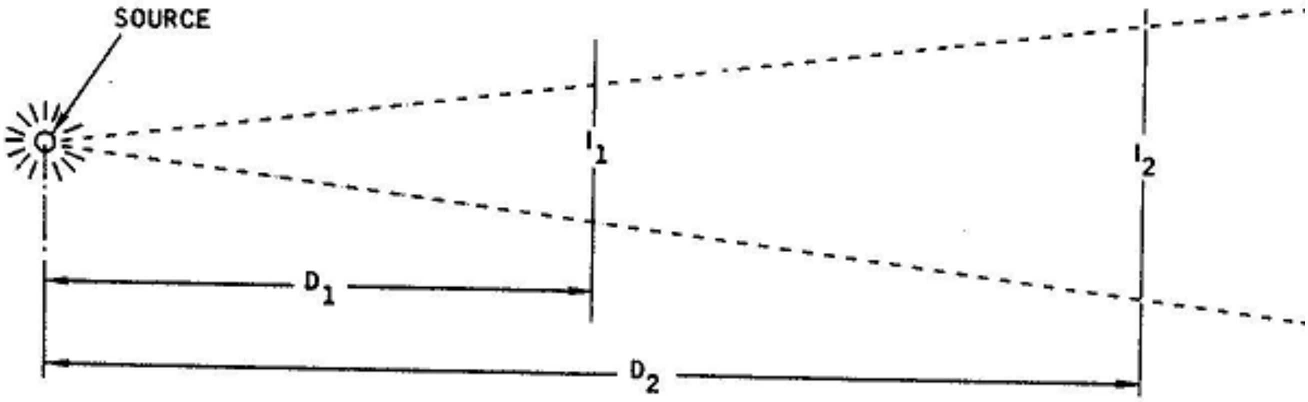
Distance

The law states that radiation **intensity** varies **inversely** as the **square** of the **distance** from the source.

$$\frac{I_1}{I_2} = \frac{(D_2)^2}{(D_1)^2}$$



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Distance

The inverse square relationship means that if you double the distance, you will receive only

5

the amount of radiation.

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Distance

if the survey meter reads 10 mrem/hr (100 µSv/hr) at 100 feet (30.48 m) for example: the dose rate at 50 feet will be [10(100/50)2=40] 40 mrem per hour, and the dose at 200 feet will be

5

mrem per hour

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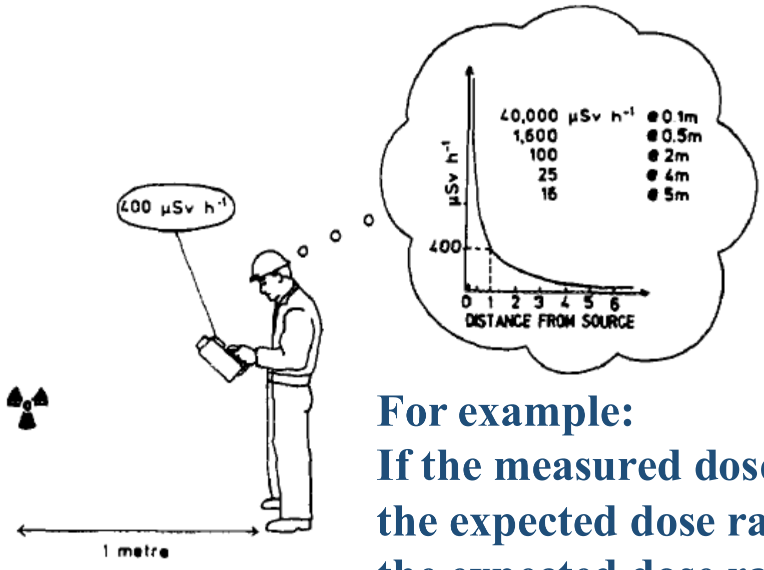
After measuring the dose rate, estimates can be made of the dose rates at different distances from the source.



For example:

If the measured dose rate at 1 m is 400 µSv/h

the expected dose rate at 2 m is

the expected dose rate at 10 m i

the expected dose rate at 20 m i

5

Distance

Radiation dose		distance	
mrem/hr	µSv	ft	m
40	400	50	15.24
10	100	100	30.48
2.5	25	200	60.96
0.625	6.25	400	121.92

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In spite of, the dose rate is best determined using a reliable survey meter, it is so important to know how to estimate the dose if the survey meter is not immediately available or there is a problem to read with it or others, so in these instances we should assume that the source is in open area and use the gamma factor for this source to estimate the dose rate

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(gamma factor for certain source indicates the absorbed dose rate at a distance unit from an activity unit of a gamma source) for example Ir-192 has a gamma factor 0.55 which is the absorbed dose rate in r/hr at 1 m from 1 Ci of gamma source equivalent to (5.9 r/hr /Ci/Feet or 0.13 msv/hr/GBq/m), here we can use the following relationship:

$$\text{Dose rate} = \frac{\text{(gamma factor X source activity)}}{\text{(distance square)}}$$

(1 Ci = 37 GBq)

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Approximate distance required to reduce radiation level to 2 mrem/hr (20 µSv/hr) for Ir-192. Ir-192 has a gamma factor 0.55 which is the absorbed dose rate in r/hr at 1 m from 1 Ci of radionuclide this equivalent to (5.9 r/hr /Ci/Feet or 0.13 msv/hr/GBq/m)

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Dose rate = (gamma factor X source activity) / (distance square).

Source activity		Distance from the source	
Ci	GBq	ft	m
100	3700	509	155
50	1850	360	110
40	1480	322	98
30	1110	279	85
20	740	228	70
10	370	161	49
5	185	114	35
2	74	72	22
1	37	51	15.5
1/2	18.5	36	11

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Shielding

Shielding is the third means of providing personnel safety.

The shielding material absorbs the radiation energy when the rays collide with electrons in the material.

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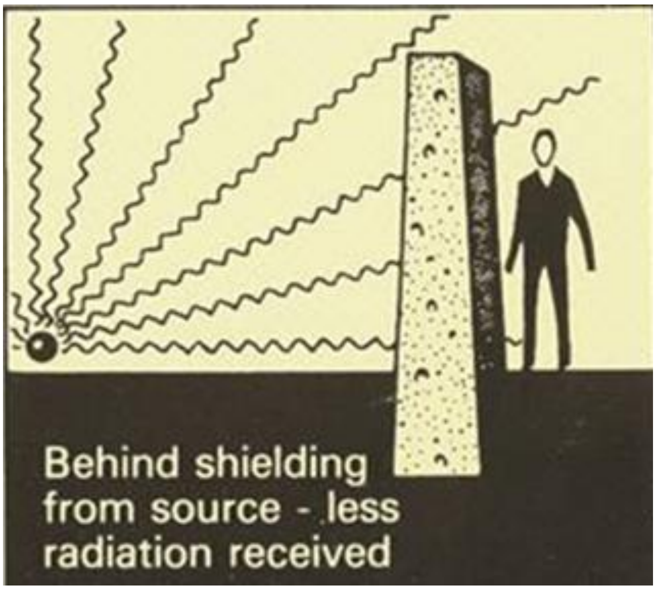
Shielding

In practical applications, lead and concrete (or combinations) are the most common shielding materials.



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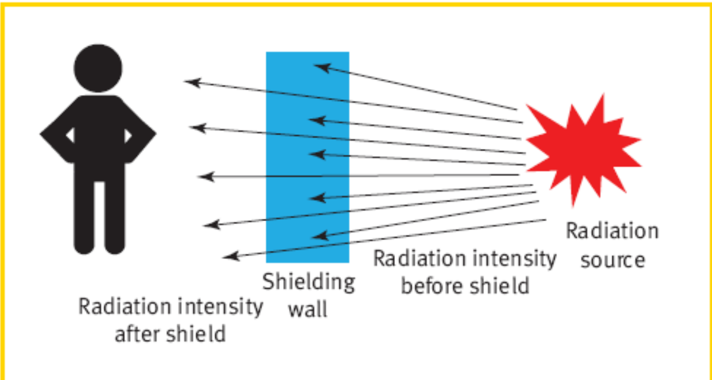
Shielding



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Shielding

The Half-value layer is a thickness of material that will reduce radiation to one-half the original intensity.

The tenth-value layer is another standard that will reduce the radiation passing through that material to one-tenth the original intensity.

Isotope	Half Value Layer (cms)			Tenth Value Layer (cms)		
	Lead	Iron	Concrete	Lead	Iron	Concrete
^{192}Ir	0.6	1.3	4.6	2.0	4.3	14.7
^{60}Co	1.2	2.0	6.6	4.0	6.9	20.6

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Shielding

% Radiation Reduction of certain material thickness

= Number of HVL X HVL(thickness)

Or = Number of TVL X TVL(thickness)

Isotope	Half Value Layer (cms)			Tenth Value Layer (cms)		
	Lead	Iron	Concrete	Lead	Iron	Concrete
^{192}Ir	0.6	1.3	4.6	2.0	4.3	14.7
^{60}Co	1.2	2.0	6.6	4.0	6.9	20.6

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HVL for concrete = 4.6 cm

To reduce the radiation from 100 µSv / hr to 50 µSv / hr use concrete shield with thickness 4.6 cm
&
to reduce it to 25 µSv / hr use concrete shield with thickness 9.2 cm

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HVL for concrete = 4.6 cm

& to reduce it to 12.5 µSv / hr use concrete shield with thickness 5

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TVL for concrete = 14.7 cm

To reduce the radiation from 100 µSv / hr to 10 µSv / hr use concrete shield with thickness 14.7 cm

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TVL for concrete = 14.7 cm

& to reduce it to 1 µSv / hr use concrete shield with thickness 5

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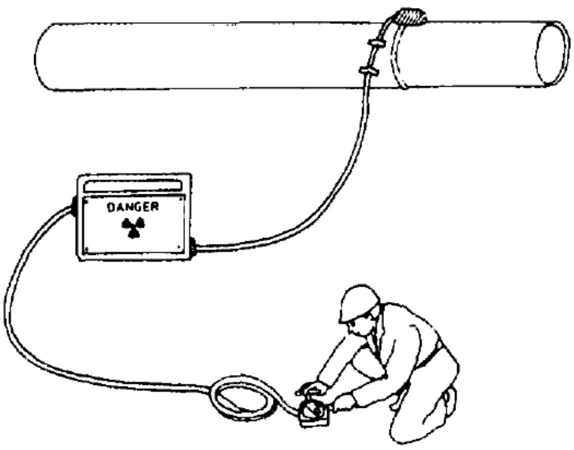
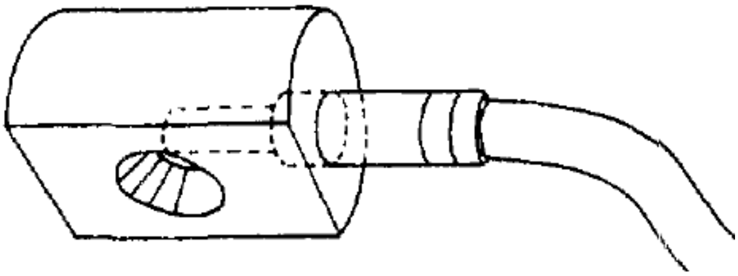
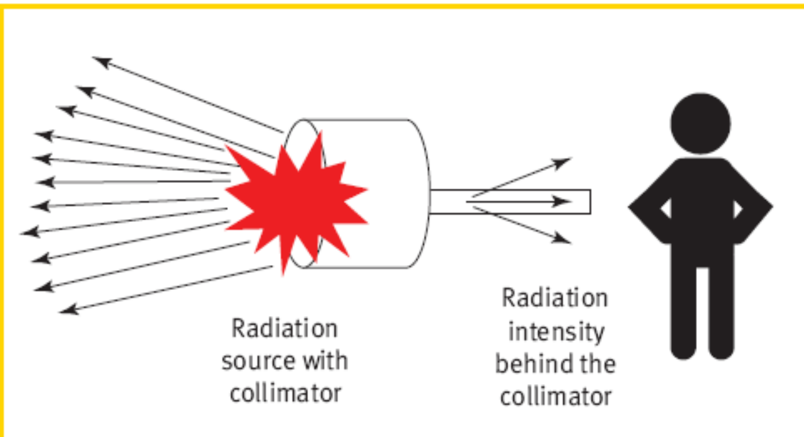
Collimators

One of the most effective means that you can use to reduce the radiation dose to yourself and others is by using collimators.





Collimators are small pieces of lead, uranium, or tungsten that surrounds the source to absorb radiation not directed toward the object being radiographed. Collimators can achieve dose reductions of about 20 to 10,000 times for Iridium-192 for example.



Conclusion

First of all always treat gamma radiation with respect. Do not touch your source during test process, it will cause radiation burns in second if held in hand. Never point your source at yourself or at anyone else when the shutter is open. Don't be hero, follow the procedures, restrict and post the area down to the 2 mrem/hr (20 µSv/hr) level, attempt to determine the actual exposure by calculation if beyond the survey meter range.

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Lower your dose using time, distance, and shielding factors. Bear in your mind that any time radiation exposure is received unnecessarily, this exposure is considered to be excessive whether or not it exceeds the allowable limits. It should be recommended that the limits given in this presentation are subject to change at any time based on studies and researches.

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Refer to the regulations in force for radiation protection in the **country** (or **state**) in which it is to be used. Remember that radioactive sources are **regulated** substances, it means that their **import**, **export**, **providing**, **transport**, handling and elimination are managed by **legislative** texts, so allows **refer to local laws** (ex. United States Nuclear regulatory Commission (USNRC)).

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Radiation hazard warning signs

Hazardous levels of ionizing radiation are signified by the **trefoil** sign on a **yellow** background. These are usually posted at the **boundary** of a radiation **controlled** area or in any place where radiation levels are significantly **above background** due to human intervention.

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Suitable Sign for General Awareness of Radiation Area (New version starting from Feb. 2007)

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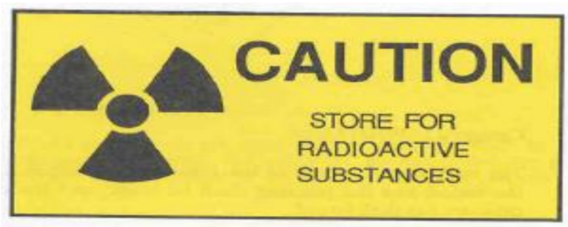
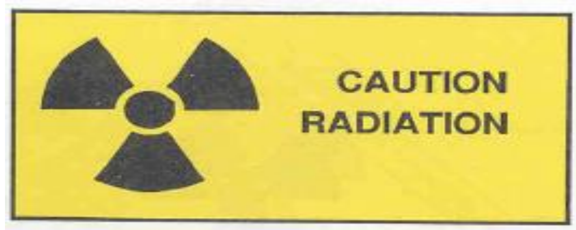


Suitable Sign for Store



Suitable Sign to be post around operating area of radioactive source

Placard for vehicles and should post around all 3 direction of the vehicle

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PACKAGE LABELS

All shipments of radioactive material must bear two identifying warning labels affixed to opposite sides of the outer package. Three different labels (White-I, Yellow-II, or Yellow-III) are used for packages of radioactive material. The United Nations hazard class "7" appears on all radioactive material labels. The standard label size is approximately 4 x 4 inches

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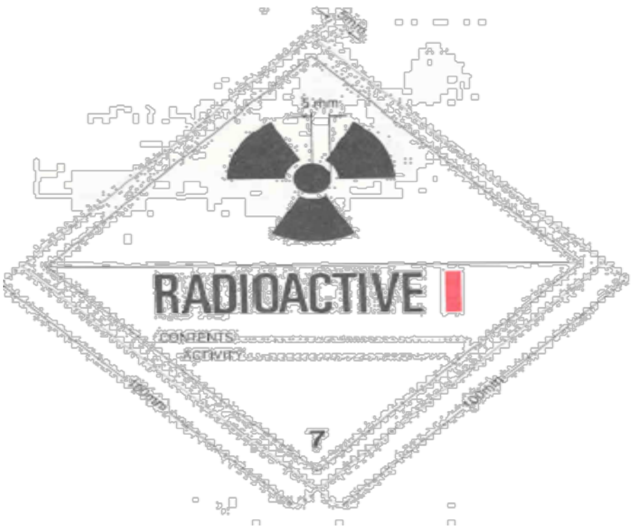

Radioactive White-I
Almost no radiation
0.5 mR/hr (0.005 mSv/h) maximum on surface
Transport Index: 0

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Radioactive Yellow-II

Low radiation levels

50 mR/hr (0.5 mSv/h) maximum on surface

1 mR/hr maximum at one meter

Transport Index: 0 – 1

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Radioactive Yellow-III

Higher radiation levels

200 mR/hr (2 mSv/h) maximum on surface

10 mR/hr maximum at one meter

Transport Index: 1 - 10

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Overview of new and old units

	SI -units		Formerly used		Conversion
Designation of quantity	Name	Unit Designation	Name	Unit Designation	Old to SI
Activity (A)	Becquerel (Bq)	1/s*	Curie	Ci	1 Ci = 37 GBq
Ionization dose rate	Coulomb (C)	C/kg	Röntgen	R	1 R=2.58 x 10^{-4} C/kg
Ionization dose	Coulomb (C) Ampère (A)	C/kg.s or A/kg		R/s	
Absorbed energy dose (D)	Gray (Gy)	J/kg	Rad	Rad	1 Rad = 0.01 Gy
Equivalent dose (H) H=D x RBE**	Sievert (Sv)	J/kg	Rem	Rem	1 Rem = 0.01 Sv

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(1.0 rem =1000 mrem and 1.0 Sv =1000 mSv = 100 rem)

1 nCi	1 µCi	1 mCi	1 Ci	10 Ci
37 Bq	37 kBq	37 MBq	37 GBq	37 TBq

(1Gy =100 rad =100 cGy)

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- **Law No. 7 of 2010**

•It is not permissible to grant a personal license to practice any activity that results in exposure to ionizing radiation unless appropriate qualifications and training are obtained.

•The law also requires the licensee to notify the Nuclear and Radiological Regulatory Authority in writing immediately upon becoming aware of the loss or theft of any shipment containing radioactive materials.

القانون رقم 7 لسنة 2010

ولا يجوز منح ترخيص شخصى لمزاولة اى نشاط يترتب عليه التعرض للاشعاعات المؤينة الابعد الحصول على التاهيل والتدريب المناسبين.

كما يلزم القانون المرخص له بابلاغ هيئة الرقابة النووية والاشعاعية كتابة فور علمه بفقد او سرقة اية شحنة تحتوى على مواد مشعة.

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- **Law No. 7 of 2010**

•According to Article 38, Clause 16, one of the obligations of the person licensed to practice nuclear or radiological activity is to spread the culture of nuclear security and safety among the facility's employees in all fields.

•There are penalties in the law for violators of up to life imprisonment if the crime is committed or attempted for a terrorist purpose or through coercion or the threat of using weapons..... (Article 97).

القانون رقم 7 لسنة 2010

وطبقا للمادة 38 بند 16 فانه من التزامات المرخص له بممارسة نشاط نووى او اشعاعى نشر ثقافتى الامن والامان النوويين بين العاملين بالمنشاة فى كافة المجالات.

وهناك عقوبات فى القانون للمخالفين تصل الى السجن المؤبد اذا ارتكبت الجريمة او الشروع فيها لغرض ارهابى او بالاكراه او بالتهديد باستخدام السلاح .....(مادة 97).

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Activate your mind & Strengthen your memory

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We can detect Ionizing radiation by

A – survey meters
B – our five senses
C – touch it
D – Gamma camera

5

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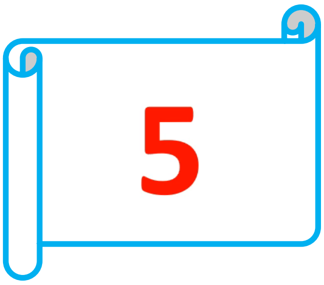
Common cause/causes of accidents is/are



A - Lack of awareness
B - Procedures were not implemented
C - Lack of training
D – all of the above

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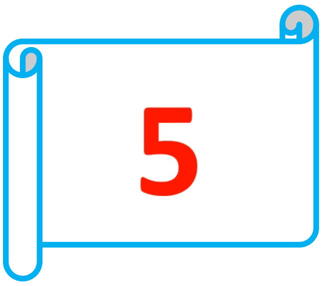
The difference between Ionizing radiation and light is



A – they have the same properties

B – the Ionizing radiation has the property of penetrating materials

C - the Ionizing radiation has not penetrate materials

D – the Ionizing radiation does not penetrate through opaque objects.

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If the radiographer cannot return the source to the gamma camera for any reason, and the source comes out the camera, What should he do?

5

A - Move away from the source at once and keep other people away.

B - Call employer's Radiation Safety Officer (RSO) for help

C - Pick up the radioactive source capsule with hand gloves and request help from his colleagues

D – A and B above

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Thank you

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