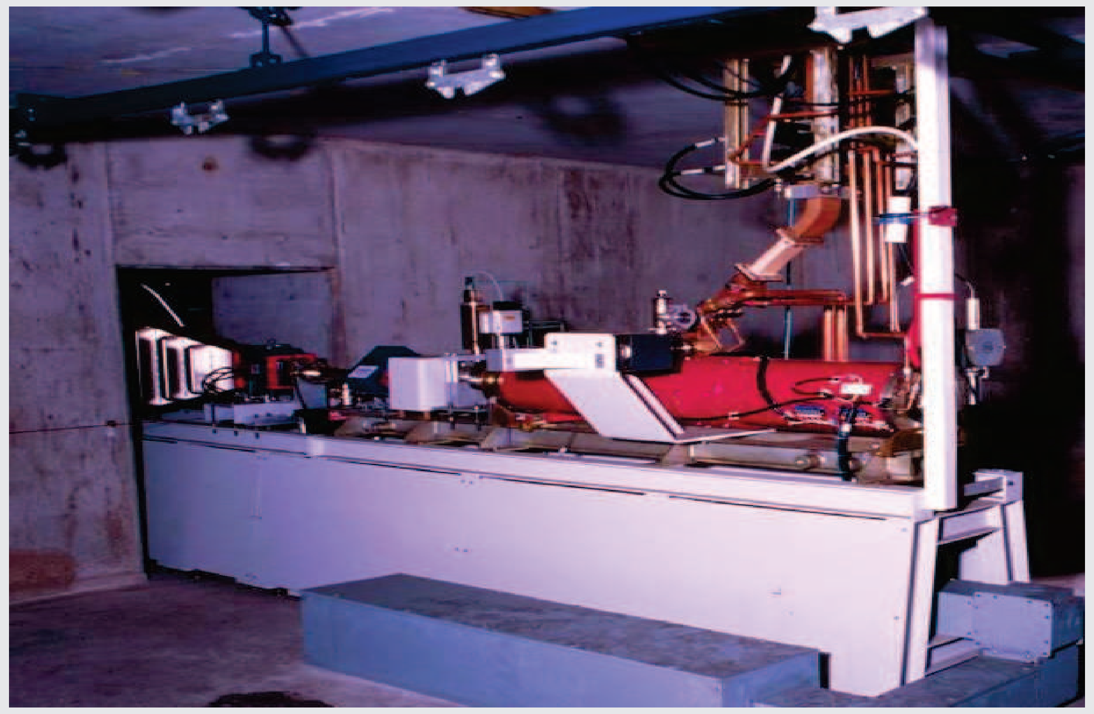
# RADIATION PROTECTION OF WORKERS
# Industrial Irradiators

IAEA

Industrial irradiators use sources that emit very high levels of penetrating ionizing radiation in a range of applications, e.g. to sterilize medical products, for food preservation and in the curing of resins and surface coatings. As the radiation levels inside the irradiation area are very high, it is important that no one is present in this area unless the sources are in the fully shielded position, or for accelerator systems, the high voltage has been disabled.



An example of an accelerator based industrial irradiator. Note the thick (approx. 2 m) concrete walls which are required to shield against the high doses inside the irradiator.

## DEFENCE IN DEPTH

**Radiation safety must be considered in the design of an industrial irradiator. If the safety features are correctly designed and safe working procedures followed, doses will be As Low As Reasonably Achievable (ALARA) and accidents will not occur.**

**The safety features should include:**

- ☑ Warning lights at the entrance and a lock on the door. Both must be actuated by a monitor inside the cell.
- ☑ An interlock for terminating irradiation automatically if the door is opened during an exposure.
- ☑ A fixed radiation monitor with alarms that provide independent verification of radiation levels in the irradiation area.
- ☑ In gamma irradiators, monitors at the product exit points that stop the conveyor if high dose rates are detected and automatically return the source to the fully shielded position.
- ☑ An alarm that sounds if a door is opened when the source is exposed. This alarm must alert another trained person on-site.

**These must be maintained and checked regularly**

**Safe working procedures include:**

- ☑ Observing the control panel for indications that the source has retracted safely or the accelerator high voltage has been disabled.
- ☑ A 'search and lock-up' procedure forces the operator to check that there is nobody in the irradiation area when irradiation begins.
- ☑ Observing the warning lights above the entrance to the irradiation area.
- ☑ Using a survey meter to check radiation dose rates when entering the irradiation area.
- ☑ Checking the function of your survey meter, before entering the cell, using a small check source.
- ☑ Never entering the cell through the product entrance/exit.
- ☑ Never disabling any safety system.
- ☑ Never entering the cell unless you are sure it is safe to do so.

**SAFE WORKING PROCEDURES SHOULD BE REGULARLY REVIEWED**

## PRINCIPLES OF RADIATION PROTECTION FROM AN EXTERNAL EXPOSURE

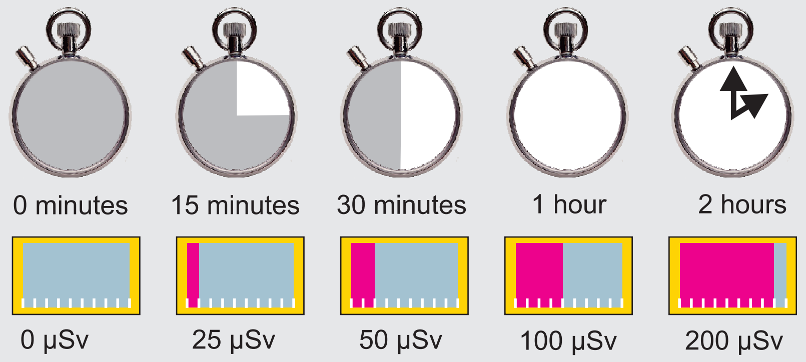
During normal use, you can only receive a radiation dose from exposure to industrial irradiator sources from outside the body.

External exposures can be controlled by consideration of time, distance and shielding:

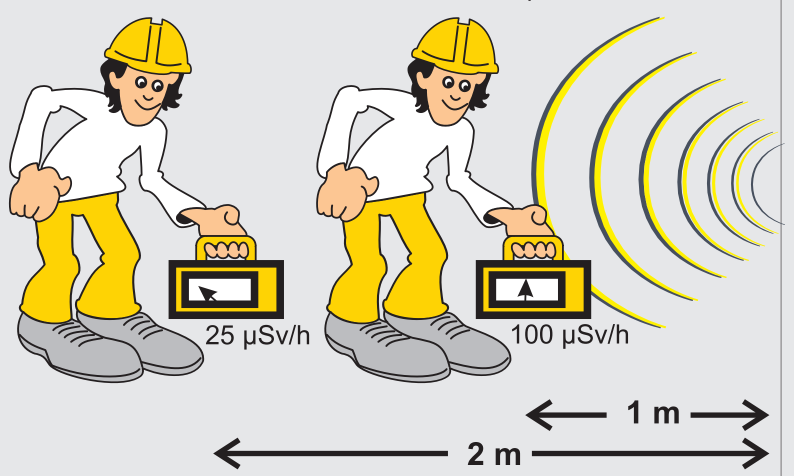
**Time**

To reduce radiation doses, the time spent in radiation areas must be kept as short as possible. The longer the time spent in an area, the higher the dose received.

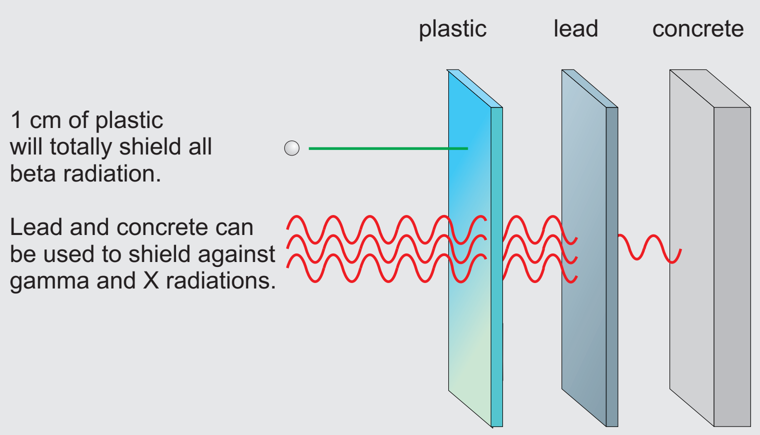
In an area where the dose rate is 100 μSv/h, the dose received will be:




**Distance** If the dose rate at 1 m from a source is 100 μSv/h, the dose rate at 2 m will be 25 μSv/h.




**Shielding** Shielding material must be appropriate for the type of radiation. For example:




## THE SAN SALVADOR ACCIDENT

1. The accident happened when the source rack became stuck in the exposed position.
2. The operator bypassed the irradiator's already degraded safety systems and entered the irradiation area with two other workers to free the source rack manually.
3. The doses were so high that radiation sickness occurred within an hour of the exposure, although the skin burns did not appear until many days later.

## THE CONSEQUENCES OF NOT FOLLOWING SAFETY PROCEDURES

| | | | |
|---|---|---|---|
| Worker A | Died | Body dose:<br>Dose to feet: | 8 Gy<br>100 Gy |
| Worker B | Survived, but leg amputated | Body dose:<br>Dose to feet: | 4 Gy<br>100 Gy |
| Worker C | Survived | Body dose:<br>Dose to feet: | 4 Gy<br>10 Gy |

The IAEA published a detailed report of its investigation into the accident. The report identified a range of serious errors and many lessons have been learnt.

- ☑ The safety features were disconnected, or in very poor condition.
- ☑ The control panel lights were dim and unlabelled.
- ☑ The door could be unlocked with a knife.
- ☑ The monitor based interlocks had been removed.
- ☑ There had been no training and instruction manuals were not in the local language.

## DOSE AND EFFECTS

**Units of dose**

The unit of absorbed dose is the gray (Gy).

The unit used to quantify the dose in radiation protection is the sievert (Sv).

One millisievert (mSv) is 1/1000 of a sievert.

- ▶ Annual doses from natural background radiation vary on average between 1 mSv and 5 mSv worldwide.

One microsievert (μSv) is 1/1000 of a millisievert.

- ▶ The typical dose from a chest X ray is 20 μSv.

**Dose rate**

Dose rate is the dose received in a given time.
The unit used is microsieverts per hour (μSv/h).

- ▶ If a person spends two hours in an area where the dose rate is 10 μSv/h, then they will receive a dose of 20 μSv.

**Health effects of radiation exposure**

If radiation doses are very high, the effect on the body will appear relatively soon after the exposure. These acute injuries will occur if the absorbed dose is higher than a threshold value; the sources and equipment used in industrial irradiators are capable of delivering such doses. It is therefore essential that procedures for work are followed.

Even if the dose is not high enough to cause serious injury, there is still the possibility of incurring other health effects. These effects, e.g. radiation induced cancer, are risk based, i.e. the higher the dose received, the greater the chance of developing the effect. To reduce the possibility of developing late effects, radiation doses must be kept:

**AS LOW AS REASONABLY ACHIEVABLE (ALARA)**