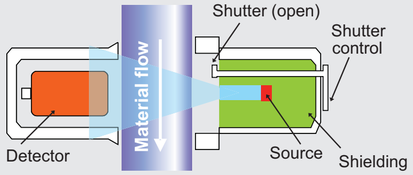
RADIATION PROTECTION OF WORKERS
Nuclear Gauges

IAEA

SEALED SOURCES IN GAUGES

Nuclear gauges are devices that use radioactive sources to measure parameters such as thickness, density, moisture or fill level.

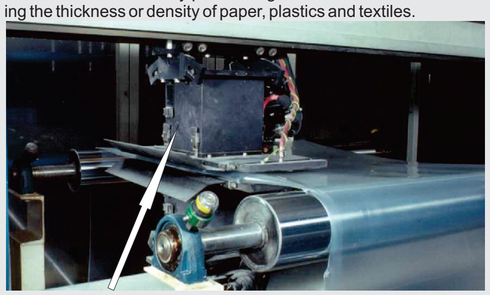
Nuclear gauges normally incorporate a nuclear source, a detector and a shutter. Although radiation is being emitted all the time, the shutter can be closed to shield the radiation beam.



Gamma, beta and neutron radiation sources can all be used in nuclear gauges, depending on the application.

Neutron radiation is very penetrating and is scattered by materials with a high hydrogen content, e.g. water. It is frequently used for measuring the moisture content in soil and asphalt.

Beta radiation is not very penetrating. It is often used for measuring the thickness or density of paper, plastics and textiles.



A thickness gauge incorporating a beta source. In the picture above, the source is contained in the housing above the product that is being measured and the detector is on the opposite side.

Gamma and neutron sources

The radioactive material is held within a tough metal casing. The casing prevents the radioactive material from escaping but does not shield the radiation completely.

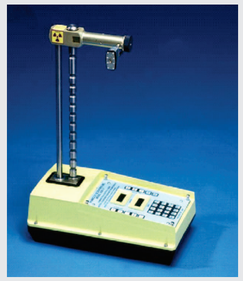
Beta sources

The walls of the capsule are thinner to allow the beta radiation to pass through. Beta sources are usually more fragile than gamma or neutron sources.

Gamma radiation is very penetrating and is scattered by dense materials. Gamma radiation is used for measuring the thickness of materials such as metals, detecting fill height or measuring density by detecting scattered radiation.

Routine tests are needed to check that the source capsule is intact, and that no radioactive material has leaked out.

The source housing of a level gauge incorporating a gamma source. The detector is on the opposite side of the vessel.



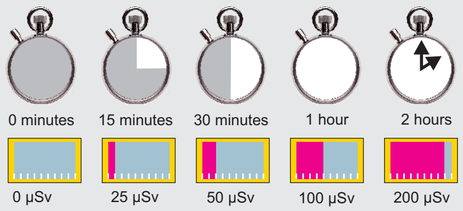
A portable gauge used to measure moisture and density, typically in soil and asphalt. These gauges incorporate gamma and neutron sources.

RADIATION PROTECTION

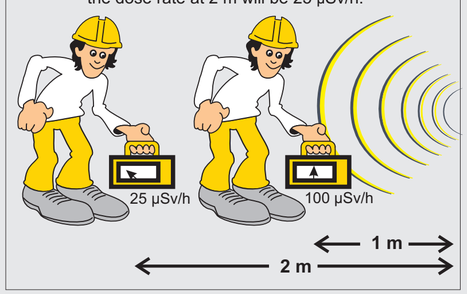
Time

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.

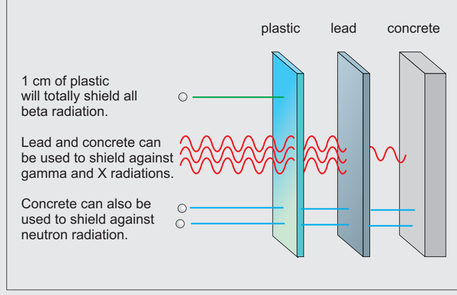
In an area where the dose rate is 100 µSv/h, the dose received will be:



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:



PORTABLE GAUGES

Portable gauges are used on-site, e.g. when laying road surfaces or well logging.

Transport

Portable gauges must be carried in transport packages that comply with national and international regulations.

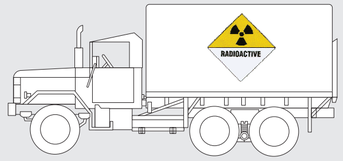
These could be:

- ☑ Excepted packages.
- ☑ Type A packages.
- ☑ Type B packages.

Type A and Type B packages must be labelled to indicate the dose rate on the surface, and at 1 m from the package:

For excepted packages, the dose rate around the outside of the package must be less than 5 µSv/h. Dose rates are not required to be indicated on the package labelling.

The driver must carry transport documents, including the Consignor's Note. Placards must be displayed on vehicles carrying gauges, unless they are excepted packages.



Note: Placard not to scale

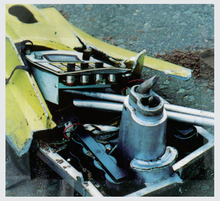
Cooperation and exchange of information

When a gauge is used at another employer's site, there must be discussion and exchange of information in advance. Many aspects will need to be agreed, including:

- ☑ Temporary secure storage arrangements.
- ☑ When the gauge will be used.
- ☑ Where the gauge will be used.
- ☑ Whether it will be necessary to restrict access to the area around the work.
- ☑ What warning will be used when the source is, or is about to be, exposed.
- ☑ Who is responsible for the gauge on-site.
- ☑ Emergency procedures.

WHEN THINGS GO WRONG

This nuclear density gauge was left for a few moments. A road roller struck the gauge and, as a result, it was badly damaged.



CARE AND SECURITY

Supervision

- ☑ The employer will nominate a Radiation Protection Officer to supervise work with radioactive sources.
- ☑ An inventory must be kept of the radioactive sources on a site.
- ☑ Regular checks should be made to ensure that the sources are present, source containers are not damaged and no radioactive material is outside the container.

Storage

When a gauge is not in use, it should be made safe and secure or, if it is portable, it must be properly stored. A good storage location will be:

- ☑ Secure.
- ☑ Fireproof.
- ☑ Weatherproof.
- ☑ Shielded.
- ☑ Labelled.

The storage location should only be used to store the gauge and related equipment.

Marking and labelling

Gauges containing radioactive sources should be clearly marked as "Radioactive". Details of the source, such as the radioisotope and its activity, should also be displayed.

This radioactive source should have been disposed of as radioactive waste. However, it was found in a scrap yard. Appropriate labelling and proper supervision of the source would have prevented this.

PRACTICAL PROTECTION

Physical controls

Where shutters are used, lights can be used to show whether the shutter is open or closed.

Physical barriers can be used to stop people getting close to a gauge where dose rates may be high.

Procedures

The employer must set out written procedures for undertaking the work. If operators follow the procedures, their doses will be 'as low as reasonably achievable' (ALARA).

This operator must follow clear procedures for loading a well logging source. The procedures might state that he/she must prevent access to the area while he/she carries out this work, use remote handling tools and complete the task as quickly as possible.

☑ DO

- ☑ Make sure the source is always kept safe and secure.
- ☑ Close the shutter when the gauge is not in use (if necessary, check this using a radiation survey meter).
- ☑ Observe any warning lights and obey the instructions given on signs and notices.
- ☑ Follow the procedures set out by your employer.
- ☑ Report any safety concerns to the Radiation Protection Officer.
- ☑ Wear your personal dosimeter.

☐ DO NOT

- ☑ Leave a portable gauge unsecured or unattended.
- ☑ Handle an unshielded radiation source.
- ☑ Attempt to repair a damaged gauge or its safety features unless you have been formally trained.

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 an 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 nuclear gauges 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)