IAEA
International Atomic Energy Agency

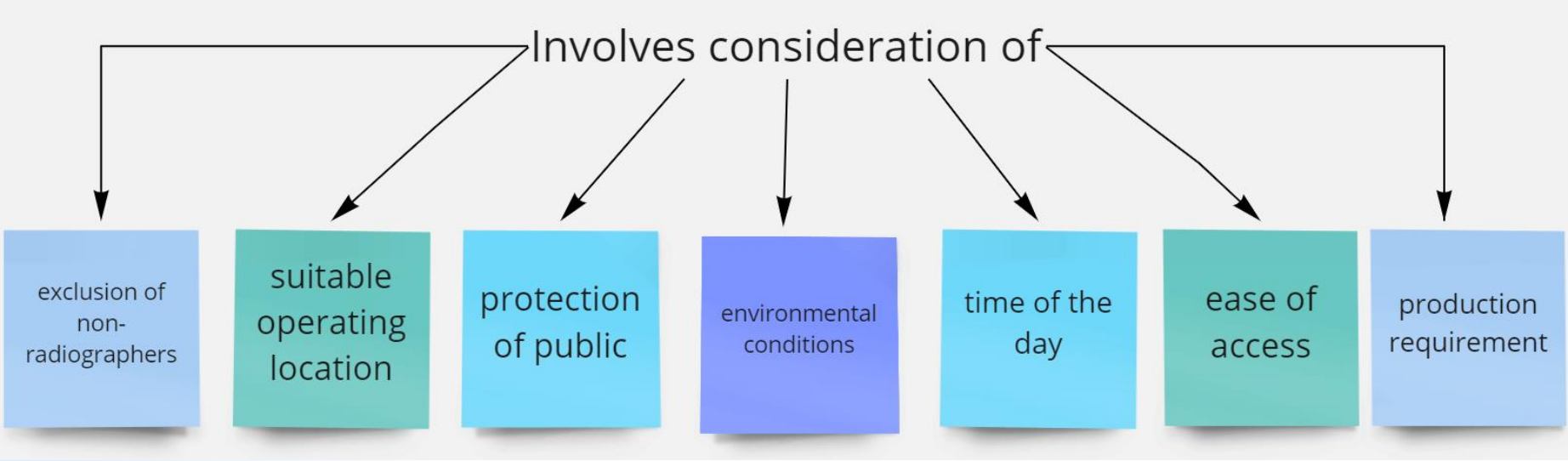
4.3 Optimization of occupational radiation protection in industrial radiography
Part 3

Site radiography gamma radiography

Site radiography with x-ray tubes

Requirements for site radiography

The radiography shall be confined to an area where the specific protective measures and safety provision can be rigidly enforced



Preparation for site radiography -1

Prior to commencing work under site radiography conditions, the Licensee shall:

1. obtain a Licence as required by the Regulatory Authority;
2. carry out a site-specific safety assessment;
3. establish a secure store that provides an adequate level of safety and security
4. exchange necessary information and co-operate with the site operator
5. evaluate the most appropriate radiation source to use

Boundary of controlled area

always, no exception

dose rate at boundary IAEA advises 7.5 to 20 μSv/h, test exposure

shall be physically demarcated

warning notices

warning signals

must be clearly visible

Typical warning notice

Defence in Depth

During site radiography, Licensees shall ensure that defence in depth is achieved by providing multiple layers of safety that include:

1. restriction of access to the Controlled Area;
2. patrolling the Controlled Area by the radiographers
3. use of survey meters before and after every exposure;
4. use of personal alarming dosemeters;
5. use of warning signals (pre-exposure and throughout exposure);
6. clear and well implemented operating procedures.

Shielding

use of natural boundaries around the work piece where this is possible (e.g. walls and other structures in the area).

use of localised shielding such as collimators, “beam stops”, flexible lead sheet, bags of lead shot, etc.

Safety and warning systems

The use of safety and warning systems has prevented many accidents. The lack of such systems, or the fact that people have ignored them has resulted in serious health consequences to the exposed persons.

Warning Notices

Warning notices shall be displayed at suitable positions around the controlled area boundary

The notices shall bear the international radiation trefoil symbol, warnings and appropriate instructions in the local language

The meaning of the warning signals shall be clearly stated

The notice should also include a phone number for use in case of emergencies.

Warning Signal

Automated Warning Signals

Radiation generators

These shall operate automatically and be designed to fail-to-safe

Sealed sources

Preferably, the warnings be arranged to operate automatically

Take care of the following when using Warning Signals

Do they have other local significance ? (e.g. could they be confused with fire alarms ?);

In some situations, such as environments with high ambient noise levels, the use of an audible warning may not be appropriate;

Does any of this equipment present an ignition hazard (e.g. where flammable liquids or vapours may be present).

Patrolling and monitoring the controlled area

Before the start of radiographic work, the area shall cleared of all people except for authorized personnel.

The boundary shall be clearly visible, well illuminated and continuously patrolled to ensure that unauthorized people do not enter the controlled area.

Prior to carrying out the first exposure the radiographers shall perform a test exposure to ensure that dose rates at the boundary do not exceed any authorized limits. Dose rates at representative points at the boundary shall be checked during operations to ensure that the barriers are correctly positioned, particularly if the position of the equipment or direction of the radiation beam is changed.

Specific procedures for site radiography -1

Licensees shall ensure that the following procedures are included in the local rules:

- site radiography shall not be undertaken unless at least two trained radiography staff (one of who may be an assistant radiographer) are in attendance for each radiation source in use;
- radiographic techniques shall be chosen with a view to minimizing doses received by radiography staff and other persons;
- physical control should be exercised over the radiation beam in so far as this will assist in restricting the size of the controlled area;
- the boundary of the controlled area shall be delineated (utilising natural boundaries whenever possible);

Specific procedures for site radiography -2

warning notices and warning signals shall be clearly visible at the boundary of the controlled area;

only the RPO, radiographers and trained radiography assistants shall be permitted inside the controlled area.;

dose rates at the boundary of the controlled area shall be checked during the first exposure and re-checked whenever exposure conditions are materially altered. The results should be recorded;

the boundary of the controlled area shall be kept under continual surveillance throughout all exposures. This may require additional personnel if the area is large and/or complex;

a survey meter shall be used after every exposure to confirm that the exposure has ceased and, in the case of the use of a sealed source, that the source is fully shielded;

Specific procedures for site radiography -3

any person who enters the controlled area shall wear a personal dosemeter and a functioning personal alarm monitor;

the wind-out crank or radiation generator control panel shall normally be outside the controlled area. Where this is not possible it should be positioned such that the authorized radiographer who enters the Controlled Area in order to initiate or terminate an exposure shall not be exposed to a dose rate in excess of 2 mSv/h;

Specific procedures for site radiography-4

on completion of an exposure using a sealed source, the operator shall ensure that the source is secured in the container or that the container is securely closed, as appropriate to the type of container in use (with newer containers this should be automatic);

on completion of an exposure using a radiation generator, the operator shall remove the key from the console and take it with him when entering the controlled area;

the controlled area shall be de-designated.

De-designating the controlled area

On completion of site radiography work (or at the end of a working period if the work is long-term) the controlled area shall be de-designated and the following steps shall be taken:

- confirmation that all radioactive sources are fully shielded and in their exposure container;
- after all exposure containers have been removed a final check shall be made with a survey meter to ensure that no radioactive sources have been inadvertently left behind;
- check that all warning notices have been removed.

Restriction of dose rate

01

Use a source not significantly greater than required to produce radiograph

02

Use natural boundaries where possible

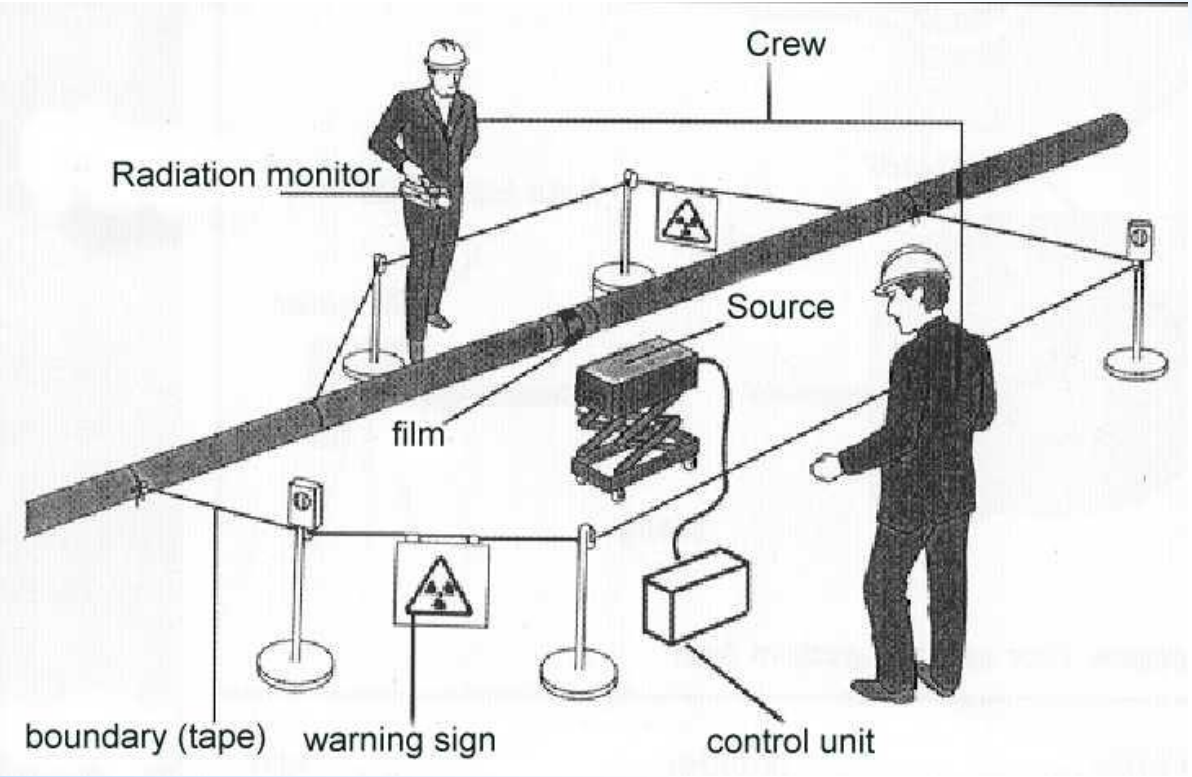
03

Use shielding: collimators, lead sheets, bags of lead shot etc.

04

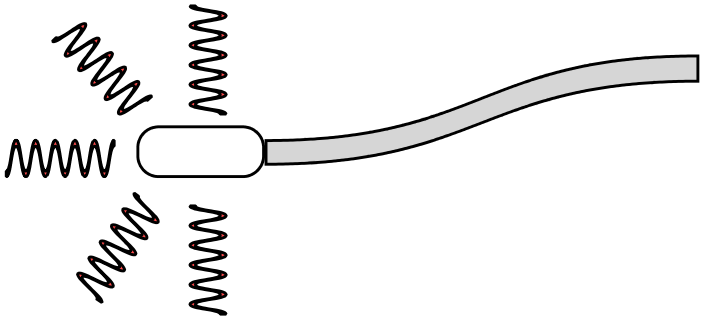
minimise scatter by controlling beam direction (preferably downwards)

Site Radiography



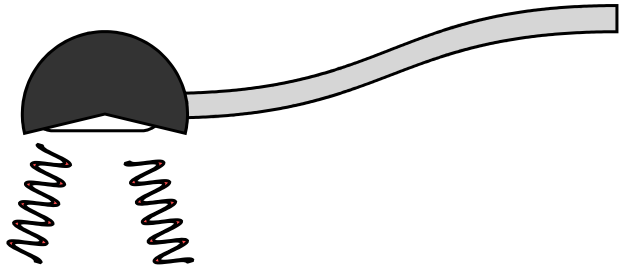
Collimation Gamma Radiography

uncollimated



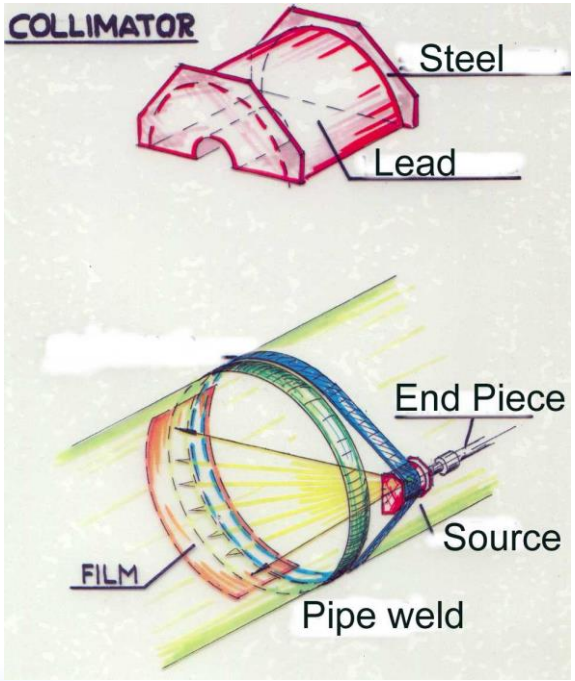
(panoramic)

collimated



(directional)

Collimators



Are collimators available and then well installed ?

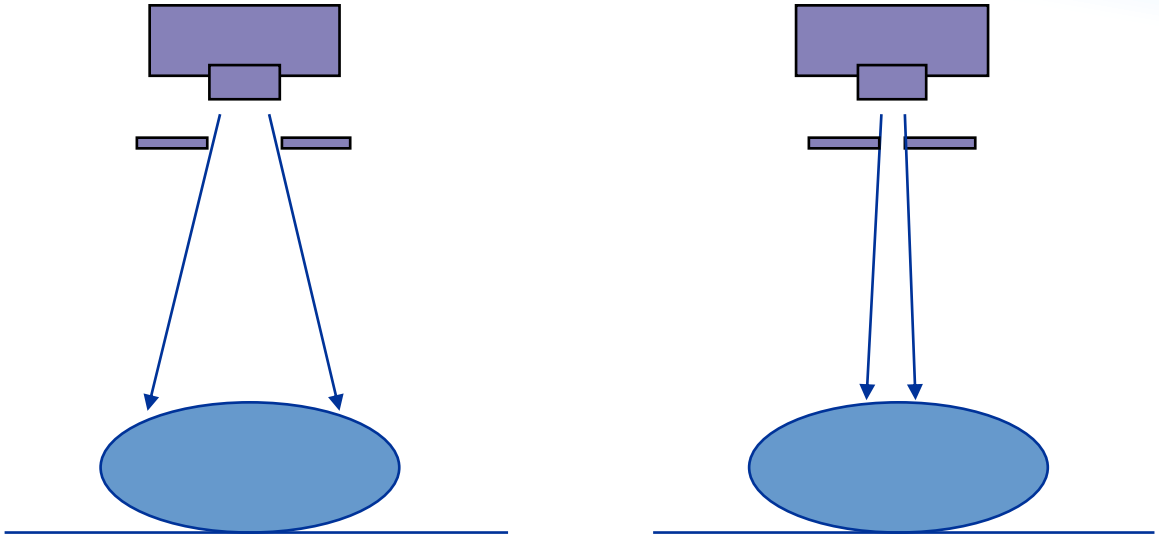
The spherical source radiates in all directions : a collimator must be used to reduce the radiation of a beam.
Nowadays collimators are preferably made out of tungsten. There should be a collimator for various angles. Lack of application of the right collimator must be considered an infringement

Collimator may reduced exposure by up to 250

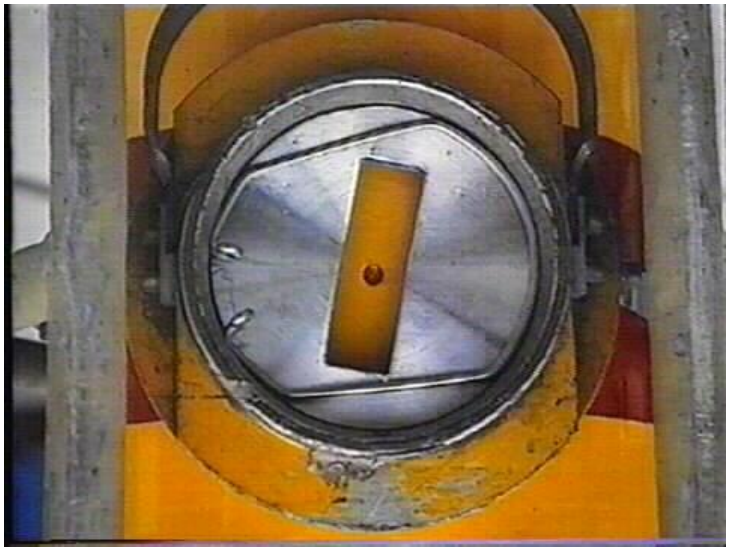
Its cost is a few hundred of € (3, 4)

This should also be absolutely "reasonable"

Collimation X-ray Tube



Diaphragm



What shielded screens and where to install them?

Some radiation of the direct beam remains after attenuation by the object and the film.

Some radiation passes besides the object and/or the film.

Indirect radiation is scattered by the object and the surrounding air.

Screens of lead may be used for the absorption of these radiation.

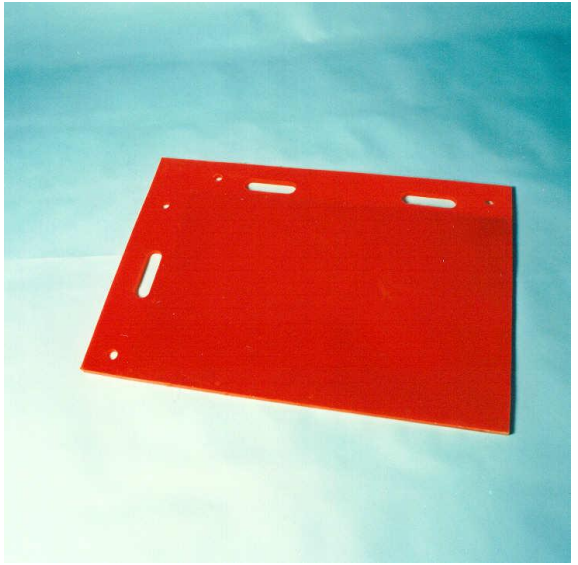
The dose rate from an Ir-192 source will be reduced by half with a 4mm lead shield.

Its cost will be 200 € per blanket, and when 2 are used it costs 400 €; this is “reasonable” when dose savings exceed 0,5 man-mSv a year, which we can be considered as often being the case.

A plastic covered variety of 6-mm lead exists with handles to carry these.

The best positions have to be established, often near the source.

Lead slabs



Lead sheet for pipe