HSE information sheet

# Industrial radiography – managing radiation risks

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## Introduction

This information sheet is for clients and principal contractors who engage specialist non-destructive testing (NDT) contractors to carry out a radiographic inspection. This includes inspection of products, operating plant, civil engineered structures or pipeline installations.

It will also be relevant to managers of these NDT companies, self-employed contractors and companies who carry out in-house industrial radiography. It does not give the full requirements of the Ionising Radiations Regulations 2017 (IRR17), as these can be obtained in the Approved Code of Practice and guidance supporting the Regulations.[1]

The information sheet focuses on the management of health and safety risks from industrial radiography work. It summarises precautions which, if followed, should help ensure compliance with IRR17's main health and safety requirements. Clients, principal contractors and contractors all have clear responsibilities under health and safety legislation. Contractors using sealed sources must also consider the requirements of the relevant environmental, transport and nuclear safeguarding legislation.

## What the problem is

Industrial radiography involves using intense radiation sources which have the potential to expose those at work, and other people, to significant doses of radiation. Over the years, several serious incidents have been caused by the failure to:

- maintain equipment
- correctly use active radiation monitoring instruments, or
- employ proper emergency procedures

HSE inspectors have also found a significant number of NDT contractors fail to adopt routine working practices capable of keeping radiation exposures of

employees, and other people, as low as reasonably practicable. This is the main requirement of IRR17.

Incidents generally occur because of:

- poor job planning (most notably with site radiography)
- failure to use adequate local source shielding
- poor maintenance of equipment, or
- inadequate systems of work

As a result, some people working in industrial radiography have received higher doses than those working in other sectors using ionising radiation, including nuclear power generation.

Too often, clients (or principal contractors) can cause difficulties for their NDT contractor by not allowing sufficient time, providing incomplete information or not ensuring effective communication to plan work properly.

There is rarely a valid reason for calling in an NDT contractor at the last minute unless it is an emergency situation. This work is normally a vital part of a quality assurance process or planned preventative maintenance and should be carried out in a carefully planned way.

## Consent for carrying out industrial radiography

Before any industrial radiography takes place, the company wishing to use ionising radiation for non-destructive testing purposes must apply for and obtain consent from HSE. The current HSE permissioning regime, RADAN, requires the NDT company to submit a safety assessment, as well as copies of their local rules and contingency plans, for review and is followed up by an inspection.

This allows HSE to determine if adequate safety arrangements are in place. The radiography company may still hold a valid consent under the previous system. When hiring a third-party contractor to carry out industrial radiography, the client should ensure the NDT company holds a valid consent certificate before allowing them to carry out any work.

## Enclosure radiography versus site (open-shop) radiography

The use of shielded enclosures and cabinets fitted with fully operational safety systems has a number of advantages over carrying out radiography under ‘site’ conditions, including:

- it can be far easier to restrict access and prevent accidental exposures (under Regulation 9 of IRR17)
- there will be more flexibility about the timing of the work (it does not need to be ‘out of hours’)

If the work involves routine radiography of readily moveable articles, it is nearly

always reasonably practicable to transport them to an enclosure or cabinet; this must always be the first choice for radiography work. In some cases, it may be practicable to build a temporary enclosure on site if the contract is of sufficient duration. Importantly, where any part of an enclosure safety system is faulty, it must be repaired before use – it is not acceptable to use the enclosure under site radiography conditions.

When site radiography is considered the only practicable option, risks must still be assessed and controlled. Exposure must be restricted so far as reasonably practicable, by using local shielding, warning devices, radiation controlled area designation, boundary patrols etc.

## Assessing the risks

All employers have to carry out a risk assessment to satisfy Regulation 3 of the Management of Health and Safety at Work Regulations 1999 and review it periodically to ensure it remains valid. When product or plant requires NDT, whether in-house or by contractors, the employers should assess how this can be done safely, as part of the general risk asessment. This cannot be ignored in the case of subcontracted NDT work. The responsibility for providing a safe working environment rests on clients as well as contractors (the following 'Planning for the job' section has more information on this).

In some cases, it may be appropriate to use NDT techniques that do not involve ionising radiation. It is advisable for clients to review their NDT requirements periodically with insurers and NDT contractors. This will help identify cases where ultrasonic or dye penetrant testing can be used, which would eliminate the risk from ionising radiation.

Before they start any new work activities involving radiation, radiography contractors must make sure their radiation risk assessment is suitable and sufficient for that work (under Regulation 8 of IRR17). They also have to consider the possibility of a radiation accident occurring and take reasonable steps to prevent this or mitigate its consequences by drawing up emergency procedures and training their staff in administering them.

For site radiography work, there must be a clear and thorough co-operation agreement between all employers present on site (the client, principal contractor, security contractor and radiography company). This should identify the responsibilities of each employer and establish which one is in control of the radiography area (usually the radiography company). The risk assessment should consider any special features of the site such as:

- problems of access or lighting
- manual handling or lifting equipment difficulties, or
- the need to isolate vessels or pipelines carrying dangerous materials or atmospheres

## Planning for the job

All clients and principal contractors have general duties under the Health and Safety at Work etc Act 1974 to make sure, so far as reasonably practicable, that the site is safe and without risks to health. Clients also have responsibilities under the Management of Health and Safety at Work Regulations to co-operate with the contractor. They must provide information about risks on site and the precautions for dealing with these (including information on appointed people responsible for emergency procedures). This information will help the contractor to ensure the work is properly planned and carried out.

For engineering construction and maintenance work, the client and principal contractor will have explicit duties under the Construction (Design and Management) Regulations 2015[2] for the management of the entire project. Where the project includes radiographic inspection of plant, they should develop safe procedures, with the co-operation of the NDT contractor, at the planning stage. These details should be incorporated into the pre-construction information by the principal designer and subsequently by the principal contractor for the construction phase health and safety plan.

On a nuclear licensed site, the licensee will generally oversee all work with ionising radiation, including radiography done by a specialist contractor (Regulation 4(3) of IRR17). The licensee should check that companies carrying out radiography on their site are suitably qualified and experienced (the British Institute of Non-Destructive Testing[3] holds details of suitable certification schemes). They will also ensure people carrying out radiography:

- follow the site's general health and safety rules and access arrangements
- receive sufficient information, instruction and training to enable them to carry out their work safely

Remember, site radiography contractors should receive written notification of the radiography work from their client at least 7 days in advance of the work taking place. This is a condition of the radiography contractor's consent (as required by Regulation 7 of IRR17). This period of time is deemed necessary to:

- enable consultations between client and contractor to take place (including a visit to the client's site, where practicable)
- prepare site-specific risk assessments
- allow any necessary variations to be incorporated into the local rules

These processes must be built into the planning of the job. If the client is unable to provide 7 days' notice, for example due to an emergency or because the nature of their client's work means they cannot be specific about the date and time the site radiography will be required, the site radiography company will need to apply to HSE for a waiver. In this case, a radiation specialist inspector will review the situation and could grant a waiver removing the need for 7 days' prior notice. Waivers can also be granted if a radiography company is embedded long-term within a client's site.[4]

## Enclosure radiography

During large-scale construction or refurbishment projects, such as those typically carried out in the chemical and offshore sectors, a significant amount of radiography will often be needed for loose pipework before it is installed. If pipework is prefabricated at another location, it should normally be possible for this to be radiographed before its arrival on site. When the fabrication is being done on the construction site and no permanent enclosure is available, it may be possible to provide a temporary enclosure or additional local shielding for examining material fabricated there.

Manufacturers who need radiographic inspections of their products will often find that it is cost-effective to provide an enclosure for the work, whether they do the work themselves or engage contractors. For example, at major petrochemical plants ongoing radiography is likely to be needed during the entire working life of the plant, so it is sensible for the client to construct a permanent radiography enclosure. This will then be available for continuing use during all subsequent maintenance and refurbishment operations. Some employers in the general engineering and fabrication sector have also achieved significant improvements in their productivity by using purpose-built enclosures (or shielded radiography cabinets for small items).

A well designed and constructed enclosure or cabinet for routine radiography will generally have walls (and roof and floor, if appropriate) sufficient to restrict the dose rates outside below 7.5 micro-sieverts per hour. However, it is common practice in enclosure and cabinet design to aim for dose rates around 1 micro-sievert per hour outside the enclosure. HSE inspectors have found badly designed enclosures with inadequate shielding, for example:

- shipping containers
- with no roof, causing shine paths, or
- where lead sheeting has slipped out of place

When assessing shielding requirements, the 3-dimensional space surrounding the radiation source needs to be considered, as people working near, above or below the enclosure may also be at risk. Scattered radiation (sky-shine) outside large open-top enclosures can often be controlled by adequate collimation. During typical radiographic set-ups, it is very important to monitor levels of radiation around the enclosure to ensure they are as low as reasonably practicable (and below 7.5 micro-sieverts per hour). Monitoring should also include measurements at greater distances from the enclosure walls to detect the presence of sky shine around the full perimeter and potentially outside the building.

For X-ray sets, it should always be reasonably practicable to install effective engineering controls and safety features. Examples of these are:

- reliable electrical or mechanical interlocks, which prevent or terminate an exposure if the door of the enclosure is opened
- 3-stage warning lights indicating when the tube is ready to emit radiation, when X-rays are imminent and when an X-ray exposure is underway

Emergency stop buttons or pull chords should be fitted if a person could possibly be inside the enclosure when an exposure is initiated. These devices should all be automatic and fail-to-safe. It may not always be reasonably practicable to achieve this level of protection for sealed sources, for example when using manual wind-out systems, though other robust safety systems such as capture key systems should be considered in this case.

It is considered reasonably practicable for all new facilities utilising gamma radiography to install automatic wind-out systems. The advantage of these systems is being able to link them directly to door interlocks, warning lights and safety systems so a source is automatically retracted into its shielding if a safety system is breached.

Regardless of the type of engineering controls installed, they should be tested during a critical examination of the facility and subsequent period checks to ensure they have not deteriorated over time (Regulations 9 and 11 of IRR17).

An enclosure designed for one type of radiation source (for example X-rays) may not be suitable for another type (such as sources) without upgrading the shielding and safety system.

## Managing site radiography

Site radiography is only acceptable when it is not reasonably practicable to provide a shielded enclosure for radiographing articles (as covered in the Approved Code of Practice to Regulation 9 of IRR17), for example on in-situ pipework which is an integral part of process plant. Careful planning is critical for complex site radiography work.

Any contractors (including temporary workers and the self-employed) need to be given sufficient information on the specific location and work to be done as far in advance as possible. The contractor will often need to inspect the plant to plan for any challenging circumstances such as difficult access (for example if a weld is inside a vessel or the pipework is in a rack at height). Consideration needs to be given to site lighting, areas with multiple levels or access routes, a safe location from which to control the exposure, whether the person changing films is clearly visible from the control position and the potential for multiple radiography teams working simultaneously. An effective communication system between the radiographers and assistants will be necessary.

The size of the controlled area can be a major decision for both the client and contractor (Regulations 17 and 19 of IRR17). It should be under the control of the radiography company (Regulation 17(2) of IRR17) and not so large that it is difficult to manage. Boundaries to the controlled area must be continuous but can include physical structures, for example walls. Access to the controlled area must be restricted to ensure that only authorised people enter.

Bespoke localised shielding around exposed radiation sources can be used to significantly reduce the size of the controlled area. Collimation, moveable panels,

pre-formed shields, lead mats, bags of lead shot and even earth mounds or a careful array of large drums filled with water can be effective.

Suitable and sufficient warning devices must be used for all types of site radiography to indicate the status of the radiation source, for example gamma-alarms for gamma radiography and fail-safe warning lights for X-radiography.

Suitable warning signs are required for each controlled area and may be appropriate for some designated supervised areas. All warning signs must comply with the Health and Safety (Safety Signs and Signals) Regulations 1996,[5] be suitably positioned and give sufficient information to alert people to the risks arising from the radiation source.

Routine monitoring must be carried out around the extent of the controlled area to confirm barriers are in the correct place and dose rates are less than 7.5 micro-sieverts per hour. Monitoring should be carried out throughout the duration of the work and results must be recorded.

A radiation protection supervisor (RPS) must be present for site radiography.

## Use, maintenance and safety checks of equipment for radiography

The use of torch-type radioactive source containers in the past has caused serious overexposures and has not been acceptable in Great Britain for many years. It should always be reasonably practicable to use sealed source exposure containers that at least conform to ISO 3999:2004 – Apparatus for industrial gamma radiography.[6]

If critical components of radiography equipment such as the control cable, pigtail connector and guide tube of projection type containers fail, this is likely to leave the source exposed. Therefore, it is essential that NDT contractors have a suitable programme of inspection (including go/no-go checks) and maintenance of their radiography equipment and keep adequate records (Regulation 11 of IRR17).

Source exchanges should be carried out by specialist contractors unless the NDT company has the correct equipment, trained staff capable of carrying out this work safely and it is suitably risk assessed. Where a source exchange is carried out at a radiography company's site, this should only be done within the company's radiography enclosure. The transport container must be connected to the enclosure's safety systems before the transfer can begin.

X-radiography equipment, especially that used for site radiography (for example tube heads and fail-to-safe warning lights), must be inspected on a regular basis to check for damage and to ensure correct functionality. Maintenance of the tube heads and the associated warning devices should be carried out in line with the manufacturer's recommendations (typically annually) and adequate records kept.

Thorough examination and test of controls and safety features associated with radiography enclosures, X-ray equipment and projectors should be carried out at suitable intervals and records maintained.

## Local rules and contingency plans

The radiography contractor (or main employer if in-house) will need site-specific written local rules outlining the systems of work required for radiography and other key information such as the size of the controlled area. It is advisable for the client to check that these cover the planned work. These local rules must be available to employees doing the work and should reflect any special arrangements for the particular job – a suitable radiation protection supervisor must be appointed to ensure the local rules are followed (Regulation 18 of IRR17). HSE has relevant guidance on radiation protection supervisors.[7]

The local rules must summarise, or refer to, key aspects of the contractor's contingency plans which detail the procedures to deal with reasonably foreseeable accidents such as a stuck or detached radiography source, or an X-ray tube or betatron failing to terminate (Regulation 13 of IRR17).

The contingency plan may require some flexibility for specific situations but should contain sufficient detail on action to be taken at that site to restrict exposure. A typical 'emergency' kit to be taken to the site and used as part of the plan would normally include at least:

- bags of lead shot
- a shielded pot
- cutting equipment for the guidetube
- long-handled tools

It is a regulatory requirement to rehearse the operation of the contingency plans periodically (Regulation 13(2) of IRR17). The rehearsal should include the whole process, from identifying the accident, the initial planning stage (calculating how long people can remain close to the source, identifying personnel roles etc), to the physical recovery of the source. It is good practice to use dummy sources during these rehearsals and practise cutting an old guidetube.

## Dose assessment

Normally, those involved in radiography will be designated as 'classified persons' (Regulation 21 of IRR17). The contractor (or main employer if in-house) will need to arrange for health surveillance (Regulation 25 of IRR17) and an approved dosimetry service to make routine dose assessments (1 month wear period for personal dosimetry) and keep dose records (Regulation 22 of IRR17). The HSE website has further advice on the assessment and recording of doses.[8]

Dose rate monitoring instruments are essential for radiographers to check that sealed sources have fully retracted into containers, or emission from X-ray sets has terminated. Many radiographers have received inadvertent exposures to radiation because they failed, or were unable, to make these checks with correctly functioning and appropriate monitoring equipment. Instruments must:

- be suitable for the radiation type in use
- have been type tested
- have a valid test certificate, and
- be in fully working order

During routine work, the use of real time monitoring such as bleepers or personal electronic alarming dosemeters (PEDs), may be particularly useful to radiographers. Bleepers give the wearer immediate warning of the presence of high dose rates and PEDs additionally provide information about the dose received. However, wearing such devices should not replace the use of portable dose rate monitors.

HSE expects radiographers involved in site radiography work (gamma and X-ray) or during any gamma source recovery, to use PEDs. Bleepers are not suitable in these circumstances because they cannot be set to alarm once a specified dose has been received. The ‘bleep’ also tends to saturate at dose rates above 1 mSv/h, meaning the radiographer cannot be sure of the dose rate they are working in. This means they cannot determine the length of time they can remain in that area before exceeding their agreed dose limit.

## Radiation protection advisers

Contractors (or the main employer if in-house) will need to appoint a suitable radiation protection adviser (RPA) with up-to-date knowledge of the requirements of IRR17 and radiation protection for industrial radiography (Regulation 14 and Schedule 4 of IRR17). The individual or organisation appointed as the RPA must satisfy HSE’s criteria of competence.

## References

1 Work with ionising radiation: Ionising Radiations Regulations 2017: Approved Code of Practice and guidance L121 (second edition) HSE www.hse.gov.uk/pubns/books/l121.htm

2 Managing health and safety in construction: Construction (Design and Management) Regulations 2015: Guidance on Regulations HSE www.hse.gov.uk/pubns/books/l153.htm

3 PCN Verification Form. BINDT: www.bindt.org/certification/pcn-certificate-verification/

4 HSE guidance on site radiography waivers HSE www.hse.gov.uk/radiation/assets/docs/site-radiography-waiver.pdf

5 Safety signs and signals. The Health and Safety Regulations 1996. Guidance on Regulations HSE www.hse.gov.uk/pubns/books/l64.htm

6 ISO 3999:2004 Radiation protection - Apparatus for industrial gamma radiography - Specifications for performance, design and tests: https://www.iso.org/standard/40447.html

7 Radiation protection supervisors IRP6 HSE www.hse.gov.uk/pubns/irp6.pdf

8 Dose monitoring, assessment and recording HSE www.hse.gov.uk/radiation/ionising/doses/index.htm

## Further information

For information about health and safety, or to report inconsistencies or inaccuracies in this guidance, visit www.hse.gov.uk. You can view HSE guidance online and order priced publications from the website. HSE priced publications are also available from bookshops.

This guidance is issued by the Health and Safety Executive. Following the guidance is not compulsory, unless specifically stated, and you are free to take other action. But if you do follow the guidance you will normally be doing enough to comply with the law. Health and safety inspectors seek to secure compliance with the law and may refer to this guidance.

This information sheet is available at www.hse.gov.uk/radiation/links.htm.



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