STUK

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RADIATION SAFETY IN INDUSTRIAL RADIOGRAPHY

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Authorization

The Radiation Act stipulates that the party running a radiation practice is responsible for the safety of the operations. The responsible party is obliged to ensure that the level of safety specified in the ST Guides is attained and maintained.

Under section 70, paragraph 2, of the Radiation Act (592/1991), STUK – Radiation and Nuclear Safety Authority (Finland) issues general instructions, known as Radiation Safety Guides (ST Guides), concerning the use of radiation and operations involving radiation.

Translation. In the event of any differences in interpretation of this guide, the Finnish and Swedish versions shall take precedence over this translation.

1 General

In industrial radiography, the conditions essential for safety include the presence of an appropriate management system, a radiation user's organization and devices that meet all relevant safety standards. Practical instructions and appropriate working methods are necessary in order to keep the radiation doses of the workers and other individuals as low as possible. Owing to the risk of accidents involved in industrial radiography, it is essential to anticipate abnormal events, to prevent safety-threatening events as effectively as possible, and to provide instructions for the case that any such should occur.

This Guide presents the requirements concerning industrial radiography practices. Where applicable, these requirements shall also concern scanning and imaging practices not covered by any other ST Guide, undertaken in conditions and with devices similar to those in industrial radiography. Such practices include, for example, scanning of objects using pulsed X-ray devices or particle accelerators.

The definitions of the terms used in the Guide are presented in Appendix.

2 General requirements

2.1 Safety licence and user's organization

Radiography practices require safety licences that can be granted by STUK upon written application. The safety licence application shall include a description of the operations, the radiation safety arrangements and the radiation user's organization. The name of the radiation safety officer shall be given in the safety licence application.

Provisions concerning the safety licence, the organization description and the radiation safety officer are laid down in sections 16 and 18 of the Radiation Act (592/1991). Provisions concerning information to be included in the safety licence application are laid down in section 14 of the Radiation Decree (1512/1991). The general requirements concerning the use of radiation are discussed in more detail in Guide ST 1.6. More detailed information concerning the organization description is given in Guide ST 1.4.

2.2 Persons in charge of the use of devices

Radiography devices may only be used by persons trained in the use of the particular devices. The party running a radiation practice (hereafter the responsible party) shall take care of the training of radiographers in safe working practices. All persons engaging in radiography are required to have training in operating radiography devices and in radiation safety as is appropriate for their duties.

If, owing to the nature of the work, such as field work, the radiation safety officer is not able to actively supervise the safety of the operations, an on-site radiation safety person shall be appointed for each place where radiation is used. Such on-site radiation safety persons shall be responsible for radiation safety during radiography. The on-site radiation safety person is required to be present during radiography procedures. The radiation safety officer and the on-site radiation safety person are required to be qualified as specified for industrial radiography in Guide ST 1.8.

The requirements concerning the training and qualifications of radiation safety officers and other individuals working in radiation user's organizations are presented in Guide ST 1.8.

2.3 Instructions

Workers shall have access to the user guides of the relevant devices as well as to the radiation safety guides drawn up for the operations. All relevant instructions shall be accessible also while workers perform their duties outside their regular places of work. The instructions shall detail, in particular, the procedures in the case of abnormal events (see chapter 8).

2.4 Monitoring of radiation exposure and medical surveillance

In industrial radiography, workers shall be classified as radiation workers of category A; their radiation exposures shall be monitored and medical surveillance shall be arranged for them. The required individual monitoring of workers' radiation exposures shall be implemented with personal dosemeters with measurements in one-month measuring cycles.

However, in cases of enclosed installation,

workers may be classified as radiation workers of category B, and their individual monitoring may be implemented with measurings in three-month measuring cycles.

Provisions concerning worker classification, individual monitoring and medical surveillance are laid down in chapter 3 of the Radiation Decree. Monitoring of radiation exposure is treated more fully in Guide ST 7.1 and workers' medical surveillance in Guide ST 7.5.

2.5 Radiation meters

The number of radiation meters available shall suffice for the intended radiography procedures.

Each radiography team shall have access to a dose rate meter suitable for the purpose. All workers engaged in radiography must have personal dosemeters and in addition, personal radiation alarm devices that warn of increases in dose rates. It is necessary to ensure that alarms are easily noticeable in noisy work environments as well. STUK assesses the acceptability of radiation meters and alarms for the proposed uses when issuing safety licences or inspecting practices.

Radiation measurements, meters and their calibration are treated in more detail in Guide ST 1.9.

3 Requirements for X-ray radiography devices

The X-ray devices and all other equipment used in radiography shall be suited for their purposes so that imaging can take place safely.

3.1 Leakage radiation

The protective housing of the tube unit must minimize leakage radiation so that leakage radiation does not exceed the following values at a distance of one meter from the tube:

Tube voltage	Leakage radiation
less than 150 kV	1 mSv/h
150–200 kV	2.5 mSv/h
more than 200 kV	5 mSv/h

3.2 Filtration

The total filtration of primary radiation shall at least equal the following values:

Tube voltage	Total filtration
less than 50 kV	no requirement
50–100 kV	2 mm aluminium
100–200 kV	3 mm aluminium
200–300 kV	4 mm aluminium
more than 300 kV	0.5 mm copper

If the filtration of the tube unit is lower than the above values, an extra filter that is easy to install shall be made available. The total filtration shall then equal the above values. The extra filter shall be used unless the imaging technique requires lower filtration than normal.

3.3 Shutter and diaphragms

For preheating the X-ray tube, the radiation window shall be provided with a shutter that attenuates the primary beam so that the leakage radiation values given in 3.1 are not exceeded. The shutter must operate reliably and be easy to install. Panoramic X-ray devices are required to have corresponding belt shutters.

Diaphragms for achieving different primary beam field sizes (collimators) must be available. Panoramic X-ray devices are required to have diaphragms enabling directional beam exposure. This is not required for X-ray crawlers.

3.4 Cable and control panel

The length of the cable between the tube unit and the control panel shall be at least 20 metres. The cable may be shorter if the control device is used on the outside of the shielded enclosure or in a comparable place that is protected from radiation.

The control panel shall include:

- a key switch without which the device is inoperable
- two functionally independent exposure indicators; one of these must be a red signal lamp

- a connector for the door switch to the shielded enclosure; the connector must be set to cut off exposure when the door is opened, and the device can only be restarted from the control panel after the door has been closed again
- facility for connecting a separate signal lamp
- a text warning of a radiation hazard, stating that the device may only be used by persons specifically authorized to do so.

3.5 Markings on the tube unit

The tube unit shall have the following markings:

- maximum tube voltage (kV)
- maximum tube current (mA)
- primary beam angle
- tube unit filtration.

The cylindrical window of a panoramic X-ray device must be clearly marked.

4 Requirements for gamma radiography devices

4.1 General requirements

A gamma radiography device shall be of such a design that faultless operation is ensured as effectively as possible. Attention must be paid, for example, to the following:

- durability and corrosion resistance
- prevention of the passage of water, sand and other foreign materials into the exposure container
- tolerance of abnormal temperatures
- radiation resistance of the rubber, plastics and other corresponding components.

In addition to what is presented in this Guide, gamma radiography devices shall comply with the requirements in standard ISO 3999.

4.2 Radiation source

The radiation source shall comply with at least classification C 43515 in standard ISO 2919. The classification of the radiation source is indicated on the manufacturer's certificate.

More detailed requirements concerning sealed sources in gamma radiography devices are presented in Guide ST 5.1. More provisions concerning high-activity sealed sources are laid down in chapter 8 A of the Radiation Act and in chapter 5 A of the Radiation Decree.

4.3 Exposure container and remote control

The exposure container shall have the following markings:

- a sign warning of a radiation hazard (see Guide ST 1.3)
- the radionuclide and maximum activity for which the container is intended
- the radionuclide in use, its activity and the date when the activity was determined
- type of exposure container
- date of the latest inspection of the device.

The exposure container shall have a locking device; it shall be possible to lock the container without a key and to open it with a key only. Locking must be prevented if the radiation source is not in the storage position. The locking device shall be clearly marked to show whether the exposure container is locked or not.

The exposure container shall be of such a design that the radiation source can be moved from the storage position only by remote control. When the radiation source is in the storage position, the dose rate of leakage radiation must not exceed 2 mSv/h on the surface of the container, and 0.02 mSv/h at a distance of one metre from the container surface.

The remote control shall clearly show whether the radiation source is in the storage position or in the working position.

Under chapter 17 of the Nuclear Energy Decree (161/1988), notifications shall be submitted to STUK concerning all exposure containers containing depleted uranium.

4.4 Projection sheath and control cable

The projection sheath and the control cable shall be capable of withstanding the stresses caused during the use of the device. The connections between the control cable and the radiation source, and between the projection sheath and the exposure container, shall be of such a design that the radiation source can move only when the connections are properly made. The radiation source must not become loose or be jammed in the projection sheath.

The remote control shall be of such a design that the control cable cannot be accidentally disengaged from its drive.

The control cable sheath shall be of such a length that the remote control can be placed at a distance of at least 15 metres from the exposure container. Shorter control cables and sheaths may be used in enclosed installations.

The control cable and projection sheaths and the openings in the exposure container shall be provided with covers that prevent dust from entering the device.

4.5 Collimators

A sufficient number of collimators shall be provided for radiography. The collimators shall provide an attenuation corresponding to at least 2 TVT (tenth value thickness).

5 Procedures on the radiography site

5.1 General

The meaning of safety precautions such as barrier tapes, warning signs and lights, necessitated by the use of radiation, as well as the potential risk of a radiation hazard shall be explained to individuals near the radiography site.

Before starting work, radiographers must ensure that the radiography devices are in proper condition and that the persons engaged in radiography are provided with a functioning dose rate meter and personal dosemeters and radiation alarm devices. During the work, unauthorized persons must be prevented from handling the radiography device. When authorized personnel leave for their breaks, the radiography device must be locked in such a way that it can not be used. Furthermore it must be ensured that its unauthorized seizure is effectively prevented.

The primary beam must be limited with collimators to make it as small as possible with respect to the radiography procedures in question. If part of the radiation beam bypasses the object that is being radiographed, a separate shield shall be placed behind the object. Guiding rods may be used to aid the directing of the radiation beam.

The radiation window must be covered with a shutter during the preheating of the X-ray device.

All radiography shall be performed in enclosed installations whenever reasonably practicable.

As a rule, the radiographer must have at least one assistant. However, the radiographer may work alone in an enclosed installation. In an open installation, the radiography team may only use one device at a time. If more radiography teams than one are working in the same area, special arrangements shall be made to ensure safety and the mutual awareness of the teams of one another's operations.

After imaging, the control panel of the X-ray device must be checked to make sure that exposure has been terminated. When a gamma radiography device is used, it must always be checked with a radiation meter that the radiation source has returned to the storage position.

After radiography, all radiography devices shall be kept in a safe storage that unauthorized persons cannot access.

5.2 Open installation

Open installation means that radiography is performed in an isolated and guarded area without shielded enclosure.

When planning radiography, for example when selecting the radiography device and technique as well as the location and time for the procedures, special attention shall be paid to the following factors that affect radiation safety:

The dose rates in the vicinity of the radiography site must be checked with a radiation meter when imaging is first begun.

The area around the radiography site where the dose rate exceeds 60 μSv/h shall be isolated and designated as a controlled area. Warning signs, barrier tapes or other blocks to access shall be used for indicating isolation. If individuals not engaged in radiography are expected to move around in the areas near the radiography site, a separate flashing signal lamp mounted on the X-ray device shall be used. The controlled area and access to it shall be controlled for the entire duration of the radiography work. If radiography work takes place in an open field and it can be effectively controlled, the area does not need to be isolated. Nobody is allowed to remain inside a

controlled area during exposure.

In addition to the controlled area, those areas shall be supervised where the dose rate is higher than 7.5 μSv/h (supervised area). Only members of the radiography team may stay or work in this area during radiography work. However, brief visits such as transit are allowed.

If any work or lounge facilities exist near the shielded enclosure for persons other than those engaged in radiography, it shall be ensured that their annual doses remain as low as reasonably practicable and do not exceed 0.3 mSv/year. In normal operation, this usually is the case when the dose rate is less than 7.5 μSv/h.

The control panel and the remote control must be placed so that the radiographers can control the area to a sufficient extent. One radiographer must remain near the control panel or the remote control so that exposure can be quickly interrupted should an emergency occur.

The dose rate shall be restricted to as low a level as reasonably practicable in the area where radiographers work.

5.3 Enclosed installation

Enclosed installation means that the radiography device and the subject of the procedure are placed in a shielded enclosure that only authorized personnel can enter. The radiography device is controlled from outside the enclosure. The shielded enclosure is a controlled area.

The radiographer must take into account the restrictions on working that apply, for example, to the maximum operating voltage of the X-ray device or the direction of the primary beam. If these requirements cannot be met, radiography must be performed in accordance with requirements for open installations in item 5.2.

The dose rate outside the shielded enclosure must be lower than 7.5 μSv/h when the X-ray device is operated at its maximum allowable parameters, or when the highest allowable activity is used in the gamma radiography device. If any work or lounge facilities exist near the shielded enclosure for persons other than those engaged in radiography, it shall be ensured that the annual doses of these individuals remain as low as reasonably practicable and do not exceed 0.3 mSv/year. In normal operation in shielded enclosures, this usually is the case when the dose rate outside the enclosure is less than 7.5 μSv/h.

Doors to the shielded enclosure must have locks. At least one door must be of such a design that it can always be opened from the inside of the enclosure.

The control panel and remote control of the radiography device must be placed so that the door of the shielded enclosure can be seen easily. If there are other doors to the shielded enclosure they must be locked for the time of exposure so that they cannot be opened from the outside. Prior to exposure, it must be ensured that the shielded enclosure is cleared of all persons.

Before entering the shielded enclosure after exposure, the radiographer must make certain that exposure has been terminated. When radiography is carried out with a gamma radiography device, this check must always be done with a radiation meter.

When the shielded enclosure is not in use, the operators are required to ensure that unauthorized persons have no access to the radiography devices. The exposure container of the gamma radiography device must be locked.

Doors to a shielded X-ray enclosure shall be provided with switches connected to the control panel (see item 3.4). The switches shall be connected so that the device is prevented from starting and working in the event of switch failure.

The shielded enclosure shall be marked with a sign warning of a radiation hazard. On the outside, a clearly visible warning light shall be on during exposure. The light must be accompanied with an explanatory text, e.g. “During exposure red light is illuminated”.

The shielded enclosure shall contain information about restrictions on the use of radiation, such as the maximum allowable operating parameters for the X-ray device, direction of the primary beam, and the highest allowable activity for the gamma radiography device.

If a gamma radiography device is used in the shielded enclosure, it is required that inside the enclosure there is a separate warning light or buzzer connected to a radiation meter clearly indicating an increase in the dose rate.

When radiation shielding is being planned for

new enclosures, STUK will, upon request, provide an advance statement concerning the adequacy of the shields. An advance statement should be requested when the intention is to use a particle accelerator or a high-activity sealed source in the radiography site.

Warning signs for radiation sources are presented in Guide ST 1.3.

6 Device inspections by the user

6.1 X-ray devices

X-ray devices shall be inspected at least once a year. During the inspection, it shall be ensured that the warning lights, shutter, diaphragms, guiding rod, warning signs, barrier tapes and all other safety devices are operable and that the electrical cables are undamaged.

In addition to the annual inspections, the operating condition of X-ray devices shall be checked and the required service actions carried out in accordance with the manufacturer's operating and service instructions. All faults and deficiencies shall be repaired before use. All inspections and service actions shall be documented in the maintenance log or other service records of the device. The general condition of all devices shall always be checked before they are introduced in use.

6.2 Gamma radiography devices

Gamma radiography devices shall be inspected and serviced at least once a year. During the inspection, it shall be ensured that the device conforms to requirements and is in good operating condition. Inspections shall be carried out as specified in items 6.2.1–6.2.6 in this Guide. Inspections shall be recorded with appropriate markings on the exposure container (see item 4.3).

In addition to the annual inspections, the operating condition of gamma radiography devices shall be checked and the required service actions shall be carried out in accordance with the manufacturer's operating and service instructions. All faults and deficiencies shall be repaired before use. All inspections and service actions shall be documented in the maintenance log or other service records of the device. The general condition of all devices shall always be checked before they are introduced in use.

6.2.1 Projection sheath

It shall be checked that:

- the projection sheath is not worn or damaged, it has no fractures, and it has not become brittle
- the fixing joint is not damaged and it operates faultlessly
- the inside of the projection sheath is clean and undamaged.

6.2.2 Control cable and fixing joint

It shall be checked that:

- the cable is not corroded and no strands are damaged; damage often occurs near the fixing joint of the radiation source
- the cable is not bent; the cable must be replaced if it cannot be straightened without tools
- the fixing joint between the cable and the radiation source holder is not worn or damaged; the tensile strength of the joint must be tested by subjecting it to a force of 400 N.

6.2.3 Remote control

The remote control must be opened to check for worn parts that may endanger the faultless operation of the device.

6.2.4 Exposure container

The exposure container shall be inspected at least once a year, and always when the radiation source is replaced. The exposure container can be inspected either loaded or empty. Locking devices and radiation shields must not be dismantled for the sake of carrying out an inspection. The inspection shall ensure that:

- the exposure container has been marked properly (see item 4.3); the plate indicating the radionuclide shall be in its place only when the container is loaded
- the container shows no visible signs of damage that can affect its shielding properties, and the radiation source has not caused any wear to the internal parts of the container

- the connections to the projection sheath and control cable sheath are clean and undamaged
- the shutter and locking mechanism function faultlessly and show no visible signs of damage
- the markings on the shutter and on the locking mechanism that indicate the readiness of the radiation source for operation can be seen clearly.

6.2.5 Radiation source and source holder

When the radiation source is replaced, the exposure container shall be marked appropriately (see item 4.3). The container shall be checked for leakage radiation. Manufacturer's instructions shall be obeyed when replacing the source.

The radiation source holder shall be replaced with a new one when the source is replaced.

6.2.6 Leak test of the radiation source

High-activity sealed sources shall undergo leak tests in accordance with standard SFS 5111 part 7; these tests shall take place regularly and at least once a year. Leak tests are not required if the source is replaced at intervals of less than one year. The leak test wipe sample shall not be taken directly from the surface of the radiation source capsule. The wipe sample is taken from a surface that has been in contact with the source, e.g. from the inside surface of the projection sheath.

The dates of leak tests must be included in the records of the respective high-activity sealed sources, and copies of these records must be sent to STUK annually.

If a leak is detected in a sealed source, it must be ensured that no hazard is caused by the leaking source. STUK shall be notified promptly of a leaking source.

6.3 Radiation meters

Dose rate meters used in monitoring working conditions shall be calibrated in a measurement standard laboratory or a calibration laboratory at intervals of no less than five years. In addition, the operating conditions of dose rate meters and radiation alarm devices shall be checked at regular intervals, and these inspections shall be documented in the maintenance logs or other service records of the respective devices. The general condition of dose rate meters shall be checked before exposures are started.

Requirements concerning the calibration and inspection of meters are treated in more detail in Guide ST 1.9.

7 Storage and transport of gamma radiography devices

After use, a gamma radiography device shall be locked and kept in a fire-proof and safe place, e.g. in a locked cabinet or storage room marked with a sign warning of a radiation hazard. Outside the storage, the dose rate shall not exceed 7.5 μSv/h. If any work or lounge facilities exist near the storage room, it shall be ensured that the annual doses of individuals working or moving about in these facilities remain as low as reasonably practicable and do not exceed 0.3 mSv/year.

Regulations concerning transportation of dangerous goods shall be complied with when gamma radiography devices are transported. During transportation, it shall be ensured that:

- the transport package and its labels are appropriate
- the driver carries the required consignment documentation (freight declaration, safety instructions for the consignment)
- the vehicle displays the appropriate placards to indicate transport of radioactive material
- the driver is qualified to transport dangerous goods
- the vehicle is equipped as required for the transport of dangerous goods
- radiation sources are placed in the vehicle in a manner that minimizes the radiation dose to the driver and passengers during transportation
- damage to, loss and unauthorized seizure of the radiation source are effectively prevented for the duration of transportation.

When the exposure container of a gamma radiography device functions as the transport package, it must fulfil the requirements set upon transport packages of type B(U). A package shall not be used for transportation

if its certificate has expired. A special form certificate concerning the radiation source shall be included in the consignment, or the freight declaration shall indicate the identification mark of the special form certificate. In addition, an approval certificate for package design shall be included, or the freight declaration shall indicate the identification mark of the certificate.

Provisions concerning the transportation of radioactive materials are laid down in the Act on Transport of Dangerous Goods (719/1994) and the Decree on the Transport of Dangerous Goods by Road by the Ministry of Transport and Communications (369/2011).

8 Abnormal events

8.1 Preparedness for abnormal events

Relating to the use of radiation appliances, the responsible party shall identify in advance the abnormal events that might pose a hazard. All operations must be planned and implemented so that the likelihood of any abnormal event is minimized. Abnormal events shall be anticipated by, for example, providing the workers with written instructions for the case that any such should occur. The instructions shall cover at least the following:

- immediate actions for restricting the radiation exposure as effectively as possible
- warning the personnel and outsiders
- notifying the radiation safety officer and STUK
- reporting a theft of a radiation source and any other unlawful acts to the police.

Preparedness for abnormal events shall be maintained through regular assessments of all respective instructions and arrangements. Drills shall be arranged in the handling of hazards relating to gamma radiation sources.

8.2 High-activity sealed sources

The responsible party shall protect all sources against unlawful actions, loss and damage. Protective actions include the following:

- locking (shield/device, place of use, storage)
- regular inspections of devices
- access control on relevant premises
- alarms on relevant premises to indicate unauthorized access.

These actions shall be defined in writing and all respective inspections shall be documented.

The selected procedures shall be proportionate to the risks identified and the type of practice. Actions implemented for other reasons (such as economical values or occupational safety) are often sufficient to protect sources against unlawful actions. All documents relating to safety arrangements of radiation sources and their places of use shall be kept so that they cannot be acquired by unauthorized persons and that they do not endanger the safety arrangements.

8.3 Notifications concerning abnormal events

STUK shall be promptly notified of the following:

- any abnormal event pertaining to the use of radiation that is substantially detrimental to safety at the place where radiation is used or in its environs
- any disappearance, theft or other loss of a radiation source such that it ceases to be in the possession of the licensee
- any other abnormal observation or information of essential significance for the radiation safety of workers or the environment.

When STUK is first notified of an abnormal event, usually by telephone, the following matters shall be stated:

- the responsible party (holder of the safety licence) and the radiation safety officer
- the name and contact details of the person reporting
- the time and place of the event
- description of the event
- information of the endangered individuals and the radiation exposure to which they may have been subjected
- immediate measures.

The first notification shall be confirmed in writing later. In addition to the information listed above, the written report shall include the reasons for and the consequences of the event (particularly any potential exposures to radiation) and the

actions taken to prevent similar events in the future.

Provisions concerning notifications of abnormal events are laid down in section 17 of the Radiation Decree. Preparedness for abnormal events, procedures in the case of abnormal events and notifications to STUK are treated in more detail in Guide ST 1.6.

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10. Valtioneuvoston asetus vaarallisten aineiden kuljetuksesta tiellä (Government Decree on the Transport of Dangerous Goods by Road) (194/2002).

APPENDIX

Definitions

Gamma radiography device
A radiography device containing a gamma radiation source, comprising the radiation source (sealed source), the exposure container, remote control, projection sheath, remote control cable and sheath, and the necessary accessories, such as collimators and tripods. Gamma radiography devices are also called gamma cameras.

Worker engaged in radiography
A worker who performs radiography, assists in radiography or acts as the area supervisor for open installations.

Remote control
A device that remotely controls the radiation source in a gamma radiography device.

On-site radiation safety person
A key person appointed for a place of use of radiation by the responsible party, tasked with supporting the radiation safety officer in the supervision of activities in this place of use in order to ensure the safety of operations and compliance with relevant radiation safety guides.

Control panel
An operating and control device of an X-ray device, containing controllers for current and voltage, a timer, radiation signal lights and the main switch with its key.

Panoramic X-ray device
An X-ray device with a radiation window of 360º. Panoramic X-ray devices are used e.g. inside pipelines for radiographing the joints.

Radiography device
A device for X-ray radiography or gamma radiography.

X-ray crawler
An X-ray tube unit mounted on a mobile platform equipped with wheels and a power unit. The device is used for radiographing pipelines; it is guided to the appropriate spot from outside of the pipeline using a radiation source or some other tracking mechanism.

X-ray device
An X-ray -emitting radiography device containing the X-ray tube unit, transformers, mains and high-voltage cables, the control panel and the necessary accessories such as collimators, filters and tripods.

Tube unit
The X-ray tube and its protective housing. Depending on the device type, the tube unit may also contain a high-voltage transformer, filament current transformer and cooling devices.

Exposure container
A radiation shield for a gamma radiography device; used for storing and transporting the radiation source.

Leakage radiation
The portion of radiation that penetrates the protective housing of an X-ray tube unit or the exposure container wall of a gamma radiography device.