FANR
الهيئة الإتحادية للرقابة النووية
FEDERAL AUTHORITY FOR NUCLEAR REGULATION

Regulatory Guide

Radiation Safety in Industrial Radiography (FANR-RG-019)

Version 0

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Basic Principle of Regulatory Guides

Regulatory Guides are issued to describe methods and/or criteria acceptable to the Authority for meeting and implementing specific requirements in the Authority's regulations. Regulatory Guides are not substitutes for regulations, and compliance with them is not required. Methods of complying with the requirements in regulations different from the guidance set forth by the regulatory guide can be acceptable if the alternatives provide assurance that the requirements are met.

Introduction

Article (1)

This guide is for industrial radiography Licensees who use Radioactive Sources and/or X-ray radiation generators for the non-destructive testing of items of equipment. It adopts IAEA's Specific Safety Guide SSG-11, titled *Radiation Safety in Industrial Radiography* (Ref. 1) as providing acceptable methods and guidance for meeting the requirements of the Authority's regulation FANR-REG-24, *Basic Safety Standards for Facilities and Activities involving Ionizing Radiation other than in Nuclear Facilities* (Ref. 2) in the practice of industrial radiography. This guide is intended to help you understand and apply the guidance of SSG-11. In addition, you should refer to relevant guidance in the Authority's Regulatory Guide FANR-RG-007, Radiation Safety (Ref. 3).

This guide does not include a definitions section. Definitions of terms used in this guide can be found in the Authority's regulation FANR-REG-24 (Ref. 2) or RG-007 (Ref. 3) and are not repeated here.

The scope of this guide is limited to radiation safety. The Authority may provide additional guidance concerning security of radioactive sources.

Licensee Duties and Responsibilities

Article (2)

Senior Manager

1. You should ensure that a senior manager is made responsible for overseeing radiation Safety and verifying that work is carried out in accordance with regulatory requirements.

Radiation Protection Officer

2. You are required to appoint at least one of your employees to be a Radiation Protection Officer (RPO). You should give your RPO the authority, resources and time to do his or her job effectively. You should give your RPO the authority to stop unsafe work and to work with all staff, especially with senior managers, so decisions that may affect radiation Safety will have high level support.
3. Your RPO's responsibilities should include:
    a) Radiation Safety oversight of your industrial radiography activities;
    b) maintaining records of your Radioactive Sources and X-ray radiation generators;
    c) inspecting radiation Safety features and warning features and resolving problems;
    d) overseeing your controlled and supervised areas;

e) supervising personal dosimetry, including reviewing and maintaining occupational Dose records and making them available as required by FANR-REG-24;

f) supervising workplace monitoring arrangements;

g) ensuring that your radiographers receive radiation Safety training;

h) ensuring that your Emergency Plans are established and practised regularly;

i) establishing, issuing and reviewing local rules, that is, the procedures for carrying out radiography work (including work permits where appropriate); and

j) investigating incidents, including higher than usual exposures and overexposures, and accidents, and reporting them as appropriate.

4. The number of RPOs you need depends on the size of your business, the number of sources you have, the kinds of radiography your business does and how much radiography you do. If you appoint more than one RPO, you should define each RPO's duties and responsibilities, and identify one as the lead.

5. The specific qualifications and training of an industrial radiography RPO are discussed in Article (5), Training and Qualifications. A general discussion of RPOs is provided in FANR-RG-007 (Ref. 3).

Workers

6. Your workers should:

a) Follow the Authority's requirements and your local rules and procedures;

b) wear their dosimeters at all times when working with sources or generators (see Article (6));

c) use radiation monitors and radiation survey meters properly (see Article (6));

d) cooperate with your RPO on all radiation Safety issues;

e) tell your RPO about any Doses they have received while working for others over the past five years, and provide the RPO with any Dose records they may have;

f) participate in all assigned radiation Safety training; and

g) promptly tell your RPO of radiation Safety problems, such as problems with Safety equipment; problems with procedures; or workers who behave unsafely.

7. The specific qualifications and training of an industrial radiography worker are discussed in Article (5).

Short-Term Workers

8. If you hire any radiographers on a short term basis, you should make sure they have the same level of protection and Safety as your full time radiographers. In particular, you should learn of any Doses received by a short term worker within the past five years and make sure that his or her total Dose does not exceed the worker Dose limits of an average of 20 mSv per year averaged over a period of five years and 50 mSv in any one year, as required by the Authority's Regulation FANR-REG-24, Article (10) (Ref. 2).

9. You should verify that short-term workers have all necessary qualifications and training in both radiation Safety and industrial radiography techniques. You should also be sure to give them documents, especially procedures, in a language they understand and make sure they read and understand them. You should test their understanding by asking them questions or having them complete a short written exam.

Clients

10. You should not let clients, that is, organizations or persons who hire your organization to perform industrial radiography, set conditions that might keep your workers from doing radiography safely. You should require clients to provide a safe working environment for your radiographers, to inform you and your radiographers about any site-specific workplace Safety issues, and to provide any necessary workplace Safety training.

Safety Assessment

Article (3)

1. You should conduct a Safety Assessment that takes into account each type of Radiation Source that you use. Your Safety Assessment should include equipment, procedures and Operations. It should identify the sources of routine and potential exposures; it should provide a realistic estimate of the resulting Doses; and it should identify the resulting radiological protection measures that you need for routine operations and to prevent and respond to incidents.
2. You should conduct the Safety Assessment before you receive a source at your site or before you use it for the first time.
3. If you are already performing radiography and no Safety Assessment has been made, you should conduct a retrospective Safety Assessment, to either confirm that all needed protective measures are in place or to identify any additional ones that you should put in place.
4. You should also reconsider your Safety Assessment when you make significant changes to your operations that might affect radiation safety, such as making a significant change in the types of radioactive sources you use or the type of radiography you perform.
5. Annex 1 of this guide provides an example of an industrial radiography Safety Assessment (taken from IAEA's SSG-11).

Protection and Safety Programme

Article (4)

1. You are required by FANR-REG-24 to have a protection and Safety programme. It should include:
   a) Your Safety Assessment;
   b) your management structure as it relates to radiation Safety. It should document the duties and responsibilities discussed in Article (2) above;
   c) your policies on radiation Safety, including a commitment to keep radiation Doses as low as reasonably achievable;

d) a process for your employees to interact with the client, if your employees perform radiography at a client's site;

e) your local rules that describe the procedures for carrying out radiography, written in all languages appropriate for your workers;

f) your procedure to use controlled areas to restrict human exposure;

g) your policies and procedures to provide Radiation Protection, including:

   i. Your use of Dose constraints. As discussed in FANR-RG-007 (Ref. 3) Article (6), the Authority recommends that industrial radiography Licensees use a worker Dose constraint of 6 mSv per year and considers that a Dose Constraint for Public Exposure below 0.1 mSv per year is generally acceptable;

   ii. Your arrangements for monitoring your workers and the workplace and for worker Dose Assessments, including your arrangements for dosimetry services;

h) your training programme for all employees involved in radiography activities and Emergency operations, especially for your RPO;

i) your Emergency Preparedness and Response plans. Guidance on Emergency Preparedness is provided in Article (12);

j) your Quality Assurance programme to ensure that your equipment and your radiation Safety systems are regularly checked and that any problems are corrected; and

k) a plan to review your radiation Safety performance, including the performance of the protection and Safety programme itself.

2. A detailed description of an industrial radiography protection and Safety programme is provided in Section 4 of IAEA's Specific Safety Guide SSG-11, titled *Radiation Safety in Industrial Radiography* (Ref. 1).

Training and Qualification

Article (5)

1. You should be sure that radiography is only done by workers who are qualified and trained. Three categories of workers should receive special training; the RPO, radiographers and assistant radiographers.

   a) The RPO should have the qualifications, experience and training to be able to supervise setting up barriers around controlled areas; to supervise provision of personal dosimetry services; to monitor Dose rates; to supervise transport and Storage of sources; and to implement your Emergency Response plans.

   b) A radiographer should be able to perform and direct industrial radiography according to your procedures, and while ensuring radiation safety; to be responsible for the radiographic method or technique to be used; and to assess radiographs.

   c) An assistant radiographer should be able to carry out industrial radiography under the direction of a level 2 radiographer, and while ensuring radiation safety, but would not be responsible for the radiographic method or technique to be used, nor for assessing radiographs.

2. The Authority has provided detailed training suggestions for these workers in Annex 2.
3. You should give all of your workers refresher training, including general refresher training once per year, with the exception of Emergency Response training which you should provide twice annually.
4. You should also be sure to give your workers documents, especially procedures, in a language they understand and make sure they read and understand them. You should test their understanding by asking them questions or having them complete a short written exam.

Dosimetry and Radiation Monitoring

Article (6)

Dosimetry

1. Each of your radiographers and any other worker who regularly enters controlled areas should use equipment that provides personal alarm monitoring and two kinds of dosimetry:
   a) Personal Alarm Monitors – These give a warning when a preset Dose or Dose rate is exceeded. They are very useful in alerting workers to unexpected high exposures.
   b) Occupational Dosimetry – This dosimetry is used to create a formal record of an employee's exposure. They are usually thermoluminescent dosimeters or film badges. Industrial radiography workers' dosimeters should be read monthly in normal conditions.
   c) Direct Reading Dosimeters – These give an instantaneous Dose reading. Workers should check them during the day to monitor their Doses. These dosimeters include quartz fibre electroscopes and electronic direct reading dosimeters.
2. Some electronic direct reading dosimeters may have alarms so they can be used as personal alarm monitors, and may have recording capabilities so they can be used instead of thermoluminescent dosimeters or film badges as the record-keeping dosimeter.
3. So that you can get an accurate record of worker exposure, the Authority recommends:
   a) Workers should wear dosimeters at all times when working near Radiation Sources.
   b) Workers should wear dosimetry in the way the dosimetry provider recommends.
   c) Workers should be careful with dosimeters because they can be damaged by being dropped.
   d) Each worker should only wear the dosimeter specifically assigned to him or her.
   e) Dosimeters should be rated for the conditions in which they are used, particularly temperatures.
   f) Dosimeters should be stored away from Radiation Sources when not being worn.
   g) Occupational dosimeters should be read promptly after the end of their monthly cycle.

h) You should tell your dosimetry service if you think a dosimeter has been damaged or has been exposed to radiation while not being worn.

4. Note that most dose rate meters are unsuitable for measuring Dose rates near flash X-ray units, owing to the extremely short pulse time of the units and the relatively slow response time of the meters. Instead, use suitable integrating dosimeters.

Monitoring

5. You should monitor radiation levels in the workplace. Your monitoring programme should say where and how often you will monitor, and the records you will keep. You should use radiation survey meters that measure gamma radiation from 0.1 micro Sv per hour through 10 mSv per hour, and that will not saturate and read incorrectly.

6. You should monitor radiation levels at the following locations:

   a) For radiography in shielded enclosures

      i. Around the walls and openings of the enclosure to ensure adequate shielding;

      ii. At the entrance to the enclosure after each exposure, to confirm that the gamma source is back in the projector or that X-ray emission has stopped;

      iii. Around your gamma source Storage facility, to ensure shielding is adequate.

   b) For site radiography work:

      i. Around the barriers during a test exposure (or first exposure) to confirm that the barriers are located properly;

      ii. At the Operator location during wind-out of a gamma source or when an X-ray generator is energized, to confirm that radiation levels are acceptable;

      iii. Around the barriers during routine exposures, to confirm that Dose rates remain below specified values;

      iv. Around the projector after each exposure, to confirm that the source has returned to the shielded position;

      v. Around any source store used on-site, to ensure that shielding is adequate;

      vi. Around the site at the end of radiography work, to confirm that no gamma sources have been left on the site;

      vii. Around vehicles used to transport gamma sources before departure to and from the site.

7. Selection, testing, calibration and Maintenance of radiation survey meters are discussed in FANR-RG-007 (Ref 3).

Dose Management

8. You are required by FANR-REG-24 (Ref. 2) to limit your workers occupational Doses to 50 mSv in any one year and an average of 20 mSv per year over five years. This includes any Doses your workers may receive while working for others or may have received while working for others over the past five years.

9. Therefore, you should require your workers, particularly your short-term workers, to tell you of other jobs where they may have been exposed and to give you their Dose records from those jobs. If they do not have official Dose records, you should contact their other employers and get their Dose information. You should include the name of the employer and the Dose received in each worker's Dose record, and manage workers' assignments so their Doses stay within the Authority's limits.
10. The Authority recommends that you give your workers a copy of their exposure records when they leave your employment. The Authority also notes that FANR-REG-24, Article (26) (40 (c) requires you to 'facilitate the provision of copies of Workers' exposure records to new employers when Workers change employment;'

Safety of Gamma Sources & Devices

Article (7)

1. You should only buy radiography equipment from manufacturers that meet international or equivalent national standards.
2. You should make sure that your source assemblies, projectors, control cables, guide tubes, collimators and so on are all compatible.
3. You should not use older types of exposure systems such as compressed air system until you do a Safety Assessment to learn whether you need additional workplace or radiation Safety precautions.
4. You should not use the 'torch' system. This was a system in which the source was mounted on the end of a short rod that was stored inside an exposure device, and manually removed to make exposures. This was very dangerous because it caused radiographers to get unacceptably high radiation Doses.
5. You should label each exposure device permanently and clearly with the following:
   a) The radiation symbol (trefoil);
   b) The word "RADIOACTIVE" in letters not less than 10 mm in height, together with a brief warning in the languages understood by your workers;
   c) The chemical symbol(s) and mass number of the radionuclide(s) for which the exposure device is suitable (e.g. "Ir-192" or "Co-60");
   d) The maximum source activity permitted in the exposure device, quoted for each radionuclide for which the device is suitable;
   e) The name of the manufacturer, the model number and the serial number of the device;
   f) The mass of the depleted uranium shielding, where relevant, or the indication "Contains depleted uranium";
   g) Your Company's name, address and Emergency telephone number.
6. In addition, the exposure device should display a durable fireproof label or tag with information about the Radioactive Source that it currently contains, including:
   a) The chemical symbol and mass number of the radionuclide;

b) the activity of the source and the date on which this activity was measured;

c) the identification number of the source; and

d) the identity of the source manufacturer.

7. Some devices use depleted uranium shielding, which the Authority regulates through FANR-REG-10, Regulation for the System of Accounting for and Control of Nuclear Material and Application of Additional Protocol. If you have any devices that use depleted uranium shielding you must formally declare them to the Authority and control them as you would control Radioactive Sources, even when they are empty.

8. You should use control cables and guide tubes that maximize the distance between the radiographer and the source, without being longer than the manufacturer's recommendations. Typical lengths are 7–15 m for control cables and 2–6.5 m for guide tubes.

9. You should use collimators whenever possible to reduce radiation levels.

10. You should use source changers to exchange sources between your projectors and shipping or Storage containers. Source changers should include a system for ensuring that the source is not accidentally withdrawn when connecting or disconnecting. They should be able to be locked to prevent removing the source from its shielded position, and should be kept locked with the key removed when they contain sealed sources, unless they are under the direct surveillance of an authorized worker. Sources should only be exchanged by qualified workers.

11. Storage containers should allow for the safe Storage of sealed sources when not in use, and should be able to be locked to prevent removing the source.

12. Your Storage facility should be a lockable room or a purpose-built unit that provides protection and Safety. It should be designated as a controlled area or supervised area, where appropriate, and should be:

    a) Resistant to fire;

    b) away from any fire, explosion or corrosion hazards; and

    c) kept locked with the keys held only by authorized personnel. A warning notice including the radiation symbol (trefoil) should be displayed on the door.

13. You should check all radiography equipment routinely and have it periodically inspected by its manufacturer or a qualified expert, following a schedule recommended by the manufacturer or expert (Qualified experts are discussed in FANR-REG-24).

    a) Maintenance should be done only by the manufacturer or by specially trained personnel in accordance with the manufacturer's instructions.

    b) Maintenance should take into account any use in severe environments, such as heat, sand, dirt or water.

    c) Any modifications should be approved by the manufacturer.

    d) Records should be kept of all Maintenance, including replacement of parts.

14. Equipment should be kept clean so that it functions properly. Mud and dirt should be cleaned off after using the source, because it could hinder the movement of the source.
15. Your radiographers should inspect their equipment before starting radiography. Checks should include:
    a) Radiation levels are normal;
    b) locking mechanisms work properly;
    c) connections between the projector, guide tube and control cable are secure;
    d) fittings and fasteners are tight;
    e) the drive cable can move freely; and
    f) there are no indications of crushing, kinks or dents.
16. If any faults are found, the equipment should not be used until a replacement is provided or a repair is made and the equipment is recalibrated as appropriate.

Safety of X-Ray Radiation Generators

Article (8)

1. You should use only generators that comply with the following.
    a) X-ray radiation generators should conform to national and international electrical Safety requirements.
    b) Where radiography cannot be carried out in a shielded enclosure, cable lengths should not be less than 20 m for X-ray radiation generators up to 300 kilovolts (kV) and longer for higher energy equipment.
    c) X-ray radiation generators used for directional radiography should be fitted with collimators and beam filters where practical.
    d) The control panel should include:
        i. A label in languages understood by your workers that includes the radiation symbol (trefoil), a statement that X-rays are emitted when the equipment is operating and a warning prohibiting unauthorized use;
        ii. a key switch to prevent unauthorized use, made so the key can be removed only when the switch is in the ‘off’ or ‘standby’ position;
        iii. a warning light that indicates when the equipment is energized and able to emit X-rays;
        iv. a separate warning light that indicates when the equipment is actually emitting X-rays;
        v. a timer that controls the exposure duration, or an ‘on’ switch that requires continuous pressure by the radiographer to maintain the generation of X-rays;
        vi. indicators that show the kilovolts (kV) and the current in milliamperes (mA) when the X-ray beam is ‘on’; and
        vii. a clearly labelled Emergency shut off switch or device.

e) The X-ray tube head should be supported in a suitable stand or clamped into position, to prevent inadvertent movement. Leakage radiation should be restricted by good Design and Construction.

2. Data on the maximum Dose rates due to leakage radiation at the surface of the device and at 1 m from the X-ray target should be documented by the manufacturer. Typical maximum Dose rate values for leakage radiation from commercial X-ray tubes are up to 100 µSv/hr at 1 m from the target.

3. Some X-ray radiation generators emit very short pulses of X-ray radiation, and the exposure duration is set in terms of the number of pulses required for the exposure. The same precautions that are used for regular X-ray equipment should be used, together with any additional Safety precautions as determined by your Safety Assessment.

   a) Most radiation survey meters are unsuitable for measuring Dose rates near flash X-ray units, due to the extremely short pulse time of the units and the relatively slow response time of the meters. Instead, suitable integrating dosimeters should be used.

4. You should check all radiography equipment routinely and have it periodically inspected by its manufacturer or a qualified expert following a schedule recommended by the manufacturer or expert.

   a) Maintenance should be performed only by the manufacturer or by specially trained personnel in accordance with the manufacturer's instructions.

   b) Maintenance should take into account any use of equipment in severe environments, such as heat, sand, dirt or water.

   c) Any modifications should be subject to approval by the manufacturer.

   d) Records should be kept of all Maintenance, including the replacement of parts.

5. Your radiographers should inspect their equipment before starting radiography. Routine checks should include:

   a) There is no visible equipment damage;

   b) electrical grounding and cable insulation are in order;

   c) liquid cooling systems are not leaking and their filters are in good condition;

   d) X-ray leakage from the tube is normal;

   e) all cables are in good condition;

   f) all interlocks and Emergency cut-out switches are working properly

   g) warning indicators and lights are working properly; and

   h) fasteners are tight, and threaded connections are secure.

6. If any faults are found, the equipment should not be used until a replacement is provided or a repair is made and the equipment is recalibrated as appropriate.

Radiography in Shielded Enclosures

Article (9)

1. You should perform radiography in shielded enclosures whenever practical.

2. You should design enclosures so that you don't need a controlled area outside them. Before using an enclosure, you should test it to confirm that it meets its Design criteria. The Design should take into account the following.

    a) Your enclosure should be consistent with the Radiation Sources that you will use and the work that you will do.

    b) Your Design should include a drawing of the enclosure and its surroundings, including any adjacent offices or buildings. The drawing should include dimensions, as well as the thicknesses, densities and types of shielding materials on all sides of, above and below the exposure area. You will probably need a qualified expert to Design the shielding. You should show entrances and distances to potentially occupied areas adjacent to, above and below the enclosure, including information on occupancy factors (See FANR-RG-007, Ref. 3).

    c) Preferably, your enclosure will have a shielded roof. If it does not, you will need to pay special attention to scattering of radiation by air and by outside objects such as higher ceilings or walls near the enclosure.

    d) You should design doors and any openings for cables, pipes or ventilation very carefully to avoid or at least minimize their penetration by radiation.

    e) Persons inside the enclosure should be able to leave rapidly.

    f) You should keep all documents relating to the enclosure's Design for future reference.

3. Because Dose rates are very high inside the enclosure during radiography, you should designate it as a controlled area. However, you may not need to designate it as a controlled area when it is not in use.

4. Your enclosures should use Safety systems so people cannot enter while a source is exposed. With some manually operated exposure devices, it may not be possible to install such interlocks. In this case, you should have written procedures that require your radiographers to close and lock the door before exposing the source. Door locks and interlocks should not keep people who may be inside from leaving in an Emergency.

5. You should have an installed radiation monitoring system that includes fail safe features, that is, features that will cause no harm if they fail. Ideally, your system should be integrated with the door interlocks to prevent entry when the radiation monitor detects a preset level of radiation. This may not be possible with some manually operated gamma exposure devices.

    a) Your monitor system should trigger visible and audible signals when the source is exposed. However, even when automatic systems are used, your workers entering the enclosure should always use a radiation survey meter to confirm that the source is shielded.

    b) There should be a visible or audible pre-warning signal immediately before exposing a source. It should be clear to anyone inside or near any entrance to the enclosure, and provide enough time for Persons inside to leave.

    c) There should be a second visible or audible warning signal given while the source is in the exposed position. The pre-warning signal and the 'source exposed' warning

signal should be clearly different. Both should be visible and/or audible from inside the enclosure.

d) Preferably, both signals should operate automatically.

e) If there is more than one Radiation Source, the exposure controls and warning signals should be clearly different for each source.

f) You should post notices that clearly explain these signals. They should be written in all languages appropriate for your workers.

6. You should have Emergency stop buttons or pull-cords so that any Persons inside the enclosure can trigger an alarm and can stop or prevent radiation exposure. These stop buttons should be so located that they can be reached without passing through the primary radiation beam, and should be labelled with clear instructions. The radiographer should be able to terminate the exposure immediately in an Emergency.

7. X-ray radiation generators should be integrated into the Safety systems and warning systems of an enclosure so that it is not possible to operate the X-ray generator without the Safety systems being in operation.

   a) Shielded enclosures should use interlocks on access doors so that no one can enter while an X-ray radiation generator is generating radiation. The interlock should prevent the generation of X-rays until the door is closed, and it should immediately stop the production of X-rays if the door is opened. Subsequent closing of the door should not automatically re-energize the X-ray radiation generator. Door interlocks should not keep people who may be inside from leaving in an Emergency.

   g) A visible or audible pre-warning signal should be given immediately prior to generating X-rays. A second visible or audible warning signal should be given while X-rays are being generated. The warning signal system should prevent X-rays from being generated in the event of the failure of any component of the system (e.g. failure of a light bulb). You should post notices that clearly explain these signals. They should be written in all appropriate languages.

8. If you use a shielded enclosure for radiography outside its Design specification, such as radiographing unusually long vessels by keeping the door open, or using a gamma exposure device in an X-ray radiography shielded enclosure, then your radiographers should use site radiography procedures.

Radiography on Site

Article (10)

1. You should do site radiography only when it is not practical to do it in a shielded enclosure. Your planning should include consideration of the location, nearby members of the public, including any employees other than radiographers and their assistants, weather conditions, the time of day, and whether work will be under difficult conditions.

2. You should have at least two radiographers, of whom at least one should be a level 2 radiographer, for each source of radiation being used. You should also have an RPO for each source of radiation being used. The level 2 radiographer may serve as the RPO if that radiographer is qualified as an RPO.

3. If you do radiography at a client site, you should consult the client as a part of planning. You should discuss selecting a suitable location and time to do the work, and the warning signals and alarms you will use, to avoid possible confusion on the site.

    a) You should learn of any site specific hazards and any work permit systems the client may use. You should give the client copies of your local rules and Emergency Plans as appropriate.

    b) You and your client should agree on the timescale of the work. You should plan enough time for the work to be done safely.

    c) You should tell the client about the type of Radiation Source(s) you plan to use, and ensure that proper Storage is available for any Radioactive Sources you may intend to store on the site overnight.

    d) You should also learn whether the client has planned any other industrial radiography work at about the same time and location as your work, to avoid confusion.

4. You should designate a controlled area surrounding your radiography work, and not permit any other work in this area until your work is done and you have shut down the controlled area. You should set the boundary of the controlled area so that possible Doses to people outside it are below your reference Dose levels. Your reference Dose levels should depend on how your radiography work will be done and how the areas just outside your controlled area boundary will be occupied. In FANR-RG-007, Radiation Safety, Article (27) (6) the Authority recommends reference Dose levels in the range of 2.5–20 μSv/hour, depending on the occupancy factor (Ref. 3).

    a) You should use collimators whenever practical to limit the extent of the controlled area. You should also consider using local shielding such as lead sheets as appropriate.

    b) You should set out the boundaries of your controlled area by physical means such as walls, temporary barriers or tape. You should consider establishing controlled areas on floors above or below your work area and at other nearby locations such as scaffolding as needed.

    c) Your radiographers should locate the radiation generator control panel or the gamma wind-out to minimize Doses to themselves when initiating and ending an exposure.

    d) You should arrange to give a warning signal immediately before an exposure and to give a second warning signal when radiation is being generated or a gamma source is exposed. In general, your pre-warning signals should be audible (a siren, whistle or bell) while ‘exposure in progress’ signals should be visible (e.g. flashing lights). These signals can be operated manually when using gamma sources, but should operate automatically with X-ray equipment. Your signals should be clearly audible and/or visible from all points around the barrier of the controlled area.

    e) You should post signs at control area boundaries that include the radiation symbol (trefoil), warnings and appropriate instructions in all appropriate languages. The signs should also explain the meaning of the warning signals.

    f) When your radiographers begin, they should clear the area of all other Persons, and before initiating an exposure, they should confirm that there is no one in the area.

g) The boundary of your controlled area should be clearly visible and well lit. Your radiographers should patrol it constantly during radiography work to be sure no one enters. You may need more than one Person to patrol the boundaries of some areas.

h) Your radiographers should measure Dose rates around the barriers during a test exposure and adjust the controlled area boundary if necessary. A single test exposure at the beginning of the work may be enough. However, if the source location or the collimator direction is significantly changed, additional test exposures may be appropriate.

5. You should have at least one radiation survey meter for each radiography source. Before your radiographers start work, they should test it as directed by the operating manual. They should also test to confirm that the gamma source is in the shielded position. If they find any faults with either the survey meter or the exposure device, they should not use the faulty equipment until it is repaired. If equipment cannot be repaired it should be replaced.

6. Your radiographers should always approach radiography devices using a survey meter to confirm that the source is in its shielded position or that X-ray emission has stopped.

7. If you have several gamma sources, your choice of which radionuclide to use will usually depend on the object you will radiograph. Generally, you should use the lowest activity source consistent with obtaining your desired radiograph.

8. Dose rates outside the controlled area can be much higher during wind-out and wind-in operations than during the exposure itself, when the source is in its collimator. Therefore your radiographers should take special care during this part of the operation, especially to be sure no one is standing at the controlled area boundary.

9. Radioactive Sources should not be left unattended. If an emergency requires that you must leave a Radioactive Source unattended, lock the projector and secure it in a way that provides the same level of protection as your permanent Storage facilities.

10. If you store Radioactive Sources in remote locations temporarily, store them in facilities that provide the same level of protection as your permanent Storage facilities.

11. When your radiographers have finished their work, they should use a radiation survey meter to be sure that all sources have been fully retracted into the exposure device and that no sources have been left in an exposed position or have become detached. Before leaving the site, they should visually inspect the equipment to be sure it has not been damaged.

12. Your choice of X-ray tube voltage should be linked to your requirements for the quality of your radiograph. You should choose your exposure technique based on both good image quality and minimization of Doses to Persons in the vicinity.

13. Accelerators generate very high energy X-rays. The Dose rate in the main beam of an accelerator can range from 50 mGy/min (3 Gy/h) from a portable accelerator to 4 Gy/min (240 Gy/h) from a mobile accelerator. The Dose rate around the apparatus is much higher than for conventional X-ray radiography. You should take more comprehensive control measures to restrict the exposure to radiation of your radiographers and others in

the vicinity. In addition, survey meters should be used that respond accurately to the pulsed nature of the radiation field.

Transportation

Article (11)

1. Before you move a source, disconnect any ancillary equipment from your exposure device, and install any required plugs and caps. You should move sources only in exposure devices or shipping containers and these should be locked and the keys should be removed. If you use a vehicle or trolley, fasten the device to it securely. Keep the device under surveillance as long as it is being moved.
2. If you move a source to another worksite, be sure to comply with the Authority's Regulation FANR-REG-13, Regulation for the Safe Transport of Radioactive Materials (Ref. 4). Guidance on how to comply with this regulation is provided in the Authority's Regulatory Guide FANR-RG-006, Transportation Safety Guide (Ref. 5).

Emergency Preparedness and Response

Article (12)

1. You should develop your Emergency Preparedness arrangements in several steps, as follows:
   a) Identify potential incidents and their associated risks;
   b) develop an Emergency Plan and procedures for dealing with these incidents;
   c) obtain all needed Emergency equipment;
   d) train your staff to implement the Emergency Plan and procedures, including how to use the Emergency equipment;
   e) hold exercises twice a year to test and evaluate the Emergency Plan; and
   f) review and update your Emergency Plan as needed.
2. Annex 3 to this guide discusses the incidents that industrial radiography Emergency Plans should address; the scope of an Emergency Plan, Emergency equipment, and Emergency procedures.
3. Your Emergency Plan may include response by external organisations and specialist consultants. Your plan should include details of any external response, and you should make sure that responders understand and accept their responsibilities. In particular, you should have a system to communicate immediately with everyone involved. You are required to submit your Emergency Plan to the Authority for approval.
4. If your source might have been damaged, your radiographers should take extra care, as Radioactive Material could leak out and there could be a risk of contamination. Detecting and measuring radioactive contamination needs specialized monitoring equipment and expertise, which you may not have. If the source has been ruptured, you should promptly seek advice from a qualified expert.

5. You should train all Persons who will be involved in Emergency Response. This should include training in the plans, source recovery procedures, and how to use Emergency equipment.
   a) You should provide refresher training twice each year.
   b) You should hold Emergency exercises twice each year and you should address any lessons learned.
6. You should review your Emergency Plan annually to be sure the named Persons and their contact information are up to date. You should inspect your Emergency equipment annually and maintain it as needed.
7. You are required to notify the Authority within specific time limits for certain kinds of Incidents. The time limits may be as little as 4 hours or a long as a week, depending on the Incident. Specific requirements for what must be reported and when it must be reported are given in the Authority's Regulation FANR-REG-24 (Ref. 2) which is posted on the Authority's web site, located at http://fanr.gov.ae/en. They are also discussed in the Authority's Regulated Materials Licence Guide, which is provided with each licence.

IF YOU ARE UNCERTAIN ABOUT REPORTING, CALL THE AUTHORITY (FANR) PROMPTLY AND ASK WHAT NOTIFICATION IS REQUIRED. You can reach FANR during business hours at 02-651-6666 and outside business hours at 050-641-6533.

References

Article (13)

1. Radiation Safety in Industrial Radiography, IAEA Specific Safety Guide SSG-11, 2011
2. Basic Safety Standards for Facilities and Activities Involving Ionising Radiation other than in Nuclear Facilities, FANR-REG-24, October 2010
3. Radiation Safety, FANR-RG-007, January 24, 2012
4. Regulation for the Safe Transport of Radioactive Materials, FANR Regulation 13, April 2010
5. Transportation Safety Guide, FANR-RG-006, August 1, 2011

Annex 1

Example of a Safety Assessment[1]

Introduction

I-1 The operating organization carries out a Safety Assessment for any source of radiation under its control, to determine what steps are necessary to restrict the exposure of its employees. Both normal working conditions and the potential for accidents are considered in the Safety Assessment.

I-2 The following Safety Assessment example covers the use of X-rays and gamma rays in a purpose-built shielded enclosure for a hypothetical company performing non-destructive testing. The following are considered in the Assessment:

a) Normal Operations for the purposes of radiography work within the enclosure.

b) Possible accident situations and steps to prevent accidents and to limit their consequences.

c) Control measures to restrict exposures.

d) Potential exposures and possible Doses during normal radiography operations.

Radiography sources

I-3 The operating organization is authorized to use X-ray and gamma ray radiography sources in a shielded enclosure. Authorized sources include:

a) One X ray generator (directional) operated at 250 kV and 4 mA, with a radiation output at 1 m of 4 Sv/hr

b) One Co-60 source up to a maximum of 925 GBq.

c) One Ir-192 source up to a maximum of 3.7 TBq.

Persons at risk

I-4 Persons at risk include radiographers and other employees working nearby.

Existing measures to control exposures

I-5 The shielded enclosure is fitted with high quality Safety systems so that opening the enclosure door during an exposure automatically terminates the X-ray exposure or retracts the gamma source to the shielded position. An exposure cannot commence if the enclosure door is open.

I-6 Safety systems and procedures ensure that only one Radiation Source can be used at any one time. Radiation symbols (trefoils) are displayed on all doors to indicate a possible radiation hazard. The shielded enclosure is fitted with a fixed area radiation monitor plus warning lights and signals to indicate when the exposure is due to commence and when exposure is under way.

I-7 Emergency stop switches are provided in the shielded enclosure. These switches can be operated by anyone inside the radiography enclosure and will stop the X-ray generator and retract the gamma source to the shielded position.

I-8 The enclosure is shielded so that maximum Dose rates outside the enclosure at ground level are less than 1 micro Sv/hr.[2] This means that the maximum annual Dose to a Person outside the enclosure will be less than 0.25 mSv, assuming a maximum

[1] This example is taken directly from Annex I, EXAMPLE OF A SAFETY ASSESSMENT, in IAEA's SSG-11.

[2] Here the Authority recommends providing the basis for estimating this dose rate.

occupancy in the area of 250 hours per year. This estimated Dose is considered to be acceptable.

I-9 Safety systems and procedures are in place to prevent access to the roof during radiography work.

Possible Doses Due to Accidents

I-10 The following are considered to be foreseeable accident scenarios:

a) A gamma source failing to retract correctly to its shielded position;

b) A dropped or detached source (location known);

c) A missing or stolen source;

d) Failure of a warning system or Safety system, leading to entry to the enclosure during an exposure;

e) Fire or mechanical damage impairing the shielding of an exposure device or breaching the integrity of a sealed source.

I-11 In each of the above scenarios, the worst foreseeable case is that an individual is exposed close to an unshielded source or an energized X-ray generator. Table I–1 gives an indication of the whole body Doses that could result.

I-12 Dose rates very close to the Radiation Sources will be very high:

a) For the gamma source, the Dose to the hands if they were placed at a distance of 5 cm from the source for 5 min would be approximately 11 Gy (for the Co-60 source) or 16 Gy (for the IR-192 source). This level of Dose would result in severe deterministic effects to the hands.

b) For the X-ray generator, the Dose to the hands if they were held close to the window of the X-ray generator for 5 min would be approximately 8 Gy (assuming a focus–skin distance of 20 cm). This would result in severe deterministic effects to the hands (radiation burns).

I-13 The operating organization has put in place a number of measures to reduce the likelihood of accidents occurring and to mitigate the consequences if an accident does occur. These measures include:

a) Periodic training in radiation Safety for all relevant staff;

b) provision of written procedures to minimize the risk of human error;

c) regular Maintenance of the X ray generator, exposure device and wind-out equipment;

d) frequent checks to confirm the location of Radioactive Sources;

e) regular Maintenance of all Safety and warning systems, as well as routine checks on their Operation;

f) provision of permanently installed radiation detectors in the shielded enclosure;

g) provision of portable radiation monitoring equipment;

h) fire prevention measures; and

i) provision of detailed Emergency Plans, regular Emergency training and Emergency exercises.

Table I–1

Dose rate at 1 m, Time for Exposure at 1 m to exceed a whole body Dose of 20 mSv for three different sources

Source (activity)	Dose rate at 1 m (mSv/hr)	Time for exposure at 1 m to exceed a whole body Dose of 20 mSv
Co-60(925 GBq)	325	3.7 min
Ir-192(3.7 TBq)	480	2.5 min
X ray generator operating at 250 kV and 4 mA	4000	18 s

Control Measures

I-14 The Safety Assessment described here (based on I-10) shows that measures for protection (described in I-13) are necessary to restrict exposures. The provision of shielding, the use of Safety systems and warning systems, and the following of written procedures are necessary measures for protection in a controlled area. The interior of the enclosure is designated as a controlled area.

I-15 The measures specified in the following will ensure that radiation Doses to the radiographers and other Persons in the area of the radiography facility will be satisfactorily controlled.

Designated Areas

Controlled Areas

I-16 The inside of the shielded facility is designated as a controlled area on the basis that special procedures are necessary for controlling exposures and for preventing or limiting the extent of potential exposures. Entry into the controlled area is restricted to authorized Persons wearing personal dosimeters.

Supervised Areas

I-17 The area immediately outside the enclosure and the corridors are designated as supervised areas. This designation is made on the basis that, although the potential for exposures in these areas is minimal, this situation could change (e.g. in the event of changes in working practices or degradation of the shielding). It is therefore appropriate to keep the situation in these areas under review.

Provisions necessary to restrict exposures

I-18 Detailed local rules are available that specify the procedures to be followed to restrict exposures when carrying out radiography work. Restriction of exposures is also achieved by the use of radiography equipment with fail-to-safe warning systems. Provided that the local rules are adhered to, exposure will be restricted as far as is reasonably achievable.

Arrangements for female employees

I-19 If there is a female employee in the operating organization, she would be advised of the necessity and importance of informing her manager if she were to become

pregnant, and appropriate arrangements would be made for the Radiation Protection of the foetus.

Dose investigation level

I-20 A Dose investigation level of 2 mSv per year has been set by management. Provided that all Safety systems function properly and all procedures are adhered to, the potential for exposure is small, and this investigation level will not be exceeded. This value serves as a useful management tool and is included in the local rules.

Training and qualifications

I-21 All staff are trained to a level appropriate to understand the nature of the radiation hazards and the importance of following specified procedures. All staff are informed that this is essential to minimize radiation Doses and to prevent incidents from occurring or to mitigate the consequences of incidents. All staff are also informed to an appropriate level about national regulatory requirements. The need for refresher training is kept under review by the Radiation Protection Officer. Records are kept of all training conducted. All radiographers have nationally recognized qualifications in industrial radiography techniques and are trained in radiation Safety.

Individual Dose Assessment

I-22 There is a potential for radiography staff to receive high Doses in the event of a breach of procedures or an accident. Consequently, all radiography staff are subject to individual radiation monitoring and are issued with thermoluminescent dosimeters, which are changed every two weeks. Dosimeters are worn during all periods of work and are stored away from radiation.[3]

Health surveillance

I-23 Radiographers undergo annual health reviews with a doctor approved by the regulatory body. Radiographers are entitled to see the results of their health reviews.

Workplace monitoring

I-24 Routine workplace monitoring is carried out to verify the extent of the controlled areas and to monitor the effectiveness of engineered Safety systems. Routine monitoring is carried out around controlled areas and supervised areas once per week and on each occasion that a Radioactive Source is renewed. Special monitoring is carried out if there are any changes in radiography techniques or beam direction. Records of all monitoring are kept in accordance with regulatory requirements.

I-25 In addition, a continuous indication of Dose rate is provided by radiation meters installed in the shielded enclosure.

I-26 The Dose rate meters are tested annually by a test laboratory. Instrument test certificates are retained by the Radiation Protection Officer.

Accounting for Radioactive Sources

I-27 All Radioactive Sources are uniquely identifiable, and their locations are checked and recorded every working day. Records are also kept of all changes of Radioactive Sources, and all spent sources are returned to their original supplier.

Safety system evaluations

[3] Here the Authority recommends including personal alarm monitors as discussed in Article (6) of this regulatory guide, above.

I-28 Restriction of exposures relies heavily on engineered Safety systems as control measures. The correct functioning of the Safety systems is checked at the start of each shift by the radiographers. Records are kept of these checks.

I-29 All Safety systems are also maintained annually by a service contractor, and records are kept.

Annex 2

Industrial Radiography Training Syllabus

This syllabus is for radiation Safety training for industrial radiography Licensees who use Radioactive Sources. It identifies radiation Safety training subjects for radiographers and assistant radiographers and for Radiation Protection Officers.

Radiation Safety training for level 1 and level 2 radiographers is expected to take 1-2 days, depending on their previous experience.

Radiation Safety training for Radiation Protection Officers is expected to take 2-3 days, depending on their previous experience.

A radiation Safety training syllabus for Licensees using X-ray radiation generators will be provided separately.

Syllabus

Topic	Assistant Radiographers	Radiographers	Radiation Protection Officers
Fundamental concepts and measurements:			
General	History and use of penetrating radiation Advantages and disadvantages of industrial radiography	History and use of penetrating radiation Advantages and disadvantages of industrial radiography	History and use of penetrating radiation Advantages and disadvantages of industrial radiography
Basic radiation concepts;	Description of gamma radiation & its interaction with matter Concept of radioactive decay Isotopes Half lives	Description of gamma radiation & its interaction with matter Concept of radioactive decay Isotopes Half lives	Alpha, beta and gamma radiation & their interactions with matter The electromagnetic radiation spectrum Contamination Concept of radioactive decay Activity and specific activity Isotopes Half lives
Radiation quantities and units;	Curie, Becquerel, Sievert	Curie, Becquerel, Sievert	Curie, Becquerel, Sievert
Radiation detecting instruments;	Purposes of radiation detection instruments How to properly use and perform daily checks on	Purposes of radiation detection instruments How to properly use and perform daily checks on	Purposes of radiation detection instruments and their principles of operation How to select, inspect, calibrate, maintain, operate

Topic	Assistant Radiographers	Radiographers	Radiation Protection Officers
	Occupational Dosimeters Personal alarm Dosimeters Direct Reading Dosimeters Survey Meters	Occupational Dosimeters Personal alarm Dosimeters Direct Reading Dosimeters Survey Meters	and perform daily checks on Occupational Dosimeters Personal alarm Dosimeters Direct Reading Dosimeters Survey Meters
Biological effects of radiation.	Effects of radiation at the gross physical level. Deterministic effects. Stochastic somatic effects	Effects of radiation at the cellular and gross physical levels. Deterministic effects. Stochastic somatic effects	Effects of radiation at the molecular, cellular and gross physical levels. Equivalent Dose and effective Dose Deterministic effects. Stochastic somatic effects. Stochastic hereditary effects. Effects on the embryo and foetus.
Principles of Radiation Protection:			
System of Radiation Protection (justification, optimization and Dose limitation);	ALARA	ALARA	Concepts of justification, optimization and Dose Constraints ALARA The above should reflect FANR-REG-24 Articles (8), (9), (20) & (29) and FANR RG-007 Articles (4), (5) & (6)
Regulatory requirements;	Key requirements of Licence and FANR-REG-24. Worker Dose limits in FANR-REG-24 compared to background and deterministic effects	All requirements of licence, key requirements of FANR-REG-24. General content of Industrial Radiography RG and RG-007 Worker Dose limits in FANR-REG-24 compared to background and deterministic effects	All requirements of Licence and all applicable requirements in FANR-REG-24. Content of this RG, FANR-RG-007, & FANR--RG-006
Designation of controlled areas and of supervised areas;	Safety basis for controlled areas Procedure used to establish controlled areas Warning signals, notices and monitoring of controlled areas Importance of	Safety basis for controlled areas Procedure used to establish controlled areas Warning signals, notices and monitoring of controlled areas	Technical basis needed to write procedure to establish controlled and supervised areas Importance of protecting the public Necessary techniques to establish controlled areas Basis for warning signals,

Topic	Assistant Radiographers	Radiographers	Radiation Protection Officers
	protecting the public	Importance of protecting the public	notices and monitoring of controlled areas
Dose limits and investigation levels.	What constitutes high dosimetry or survey meter readings and what to do if they occur	What constitutes high dosimetry or survey meter readings and what to do if they occur	How to select performance measures, how to establish investigation levels for them, and how to establish actions to take if they are exceeded The above should reflect FANR-RG-007 Articles (7), (21) & (22)
Safety Culture	Worker's role in Licensee's Safety culture	Worker's role in Licensee's Safety culture	How to establish and maintain a strong Safety culture The above should reflect FANR-Reg-24, Article (13) (3) and recommendations in FANR-RG-007 Article (16)
Practical Radiation Protection:			
Source outputs;	Sources used by Licensee Isotope Activity Unshielded Dose rate at 1 meter	Sources used by Licensee Isotope Activity Unshielded Dose rate at 1 meter	How to confirm source isotope and activity Physics and mathematics used to calculate Dose rates at various distances based on isotope and activity
Effects of time, distance and shielding;	Relationship between time, distance and deterministic effects for Licensees sources Shielding half-value layers and tenth-value layers Effects of shielding materials and shielding thickness on Licensee's sources Collimators	Relationship between time, distance and deterministic effects for Licensees sources Shielding half-value layers and tenth-value layers Effects of shielding materials and shielding thickness on Licensee's sources Collimators Inverse square law	Relationship between time, distance and deterministic effects for Licensees sources Technical basis for the interaction of alpha, beta and gamma radiation with shielding materials Shielding formulae: half-value layers; tenth-value layers Effects of shielding materials and shielding thickness on Licensee's sources Collimators Inverse square law
Individual monitoring and survey meters;	Procedures for using Occupational Dosimeters Personal alarm Dosimeters Direct Reading Dosimeters	Procedures for using Occupational Dosimeters Personal alarm Dosimeters Direct Reading Dosimeters	FANR dosimetry and monitoring recommendations in this Reg Guide, Article (5) How to write local rules for using Occupational

Topic	Assistant Radiographers	Radiographers	Radiation Protection Officers
	Survey Meters Laboratory practice in using the above instruments	Survey Meters Laboratory practice in using the above instruments	Dosimeters Personal alarm Dosimeters Direct Reading Dosimeters Survey Meters Survey techniques Laboratory practice in using the above instruments
Working practices to limit Doses and maintain them as low as reasonably achievable;	ALARA aspects of local rules How to take advantage of time, distance and shielding	ALARA aspects of local rules How to take advantage of time, distance and shielding	Monitoring and assessing work practices and working conditions to reduce Doses Inspecting equipment How to use dosimetry to identify weak work practices.
Storage of Radioactive Sources;	Licensee's local rules for Storage, with emphasis on keeping sources secure and locked when not under direct surveillance, including Storage on site Storage at client sites In transit Storage in vehicles	Licensee's local rules for Storage, with emphasis on keeping sources secure and locked when not under direct surveillance, including Storage on site Storage at client sites In transit Storage in vehicles	Requirements for a Storage facility How to write local rules for Storage. The above should reflect FANR-Reg-24, Article (18) (3), FANR-REG-24,Secuirty of Radioactive Sources, and recommendations in this Reg Guide Articles (7) (12) and (10) paragraph (10)
Correct operation and Maintenance of radiography equipment;	Licensee's local rules for performing radiography safely in shielded enclosures and on site, specifically including: Equipment checks Monitoring Actions to take if checks or monitoring reveal problems	Licensee's local rules for performing radiography safely in shielded enclosures and on site, specifically including: Equipment checks Monitoring Actions to take if checks or monitoring reveal problems	How to write local rules for performing radiography safely in shielded enclosures and on site. The local rules should reflect recommendations in this Reg Guide for equipment checks (Article (7) (15)); monitoring (Article (6) (5) & (6)); radiography in shielded enclosures (Article (9)); and on site radiography (Article (10)); Actions for Radiation Protection Officer to take if problems are reported
Protection and Safety Programme:			
Local rules;	All Licensee's local rules that apply to assistant radiographers' radiological Safety activities and how to implement them	All Licensee's local rules that apply to radiographers' radiological Safety activities and how to implement them All Licensee's local	Thorough understanding of all Licensee's local rules that apply to radiological Safety How Licensees should develop, approve and implement local rules,

Topic	Assistant Radiographers	Radiographers	Radiation Protection Officers
		rules that apply to assistant radiographers' radiological Safety activities and how to implement them	including worker training This should be consistent with the Licensee's Safety Assessment and FANR-RG-007 Article (10) (7)
Management of Radiation Protection;	N/A	N/A	Content of a protection and Safety programme How to develop and implement a protection and Safety programme and how to assess its effectiveness Monitoring radiography activities and radiographers' performance Inspecting equipment How to train others The protection and Safety programme should reflect recommendations in this Reg Guide Article (4) and in FANR RG-007 Article (10)
Transport of Radioactive Sources;	Licensee's local rules for transport with emphasis on; Disconnecting ancillary equipment Locking exposure devices Securing devices within vehicles Maintaining surveillance	Licensee's local rules for transport with emphasis on; Disconnecting ancillary equipment Locking exposure devices Securing devices within vehicles Maintaining surveillance	How to write local rules for transport, including, for transport to another site, with emphasis on the following: Sources are likely Special Form Radioactive Material Sources will likely require Type B(U) packages Hazard indices Labelling and notification requirements Local rules for transport to another worksite should reflect FANR REG 13 and FANR Reg Guide 006
End-of-life considerations for sources following decay;	N/A	N/A	Importance of controlling and managing all sources, regardless of state of decay, including: Maintaining inventories Providing secure Storage Transferring only to authorized receivers How to comply with FANR-REG-24 Article (30)
Accidents and other incidents involving radiography sources, their consequences	Major causes of accidents Description of three	Major causes of accidents Description of three	Major causes of accidents Description of three incidents taken from IAEA

Topic	Assistant Radiographers	Radiographers	Radiation Protection Officers
and lessons learned;	incidents taken from IAEA records, including: Deliberately defeating alarms Failing to use survey meter Inadequate equipment Maintenance	incidents taken from IAEA records, including: Deliberately defeating alarms Failing to use survey meter Inadequate equipment Maintenance	records, including: Deliberately defeating alarms Failing to use survey meter Inadequate equipment Maintenance
Emergency Plans;	Purpose and description of an Emergency Plan	Purpose and description of an Emergency Plan	How to develop an Emergency Plan, including: Potential industrial radiography incidents and their risks, including leaking sources Procedures for dealing with these incidents Assignment of responsibilities Emergency equipment Training and exercises The Emergency Plan should reflect recommendations in this Reg Guide for Emergency Plans (Article (12))
Emergency Preparedness and Response.	Emergency Response responsibilities and actions. These should be consistent with Annex 3 of this Reg-Guide.	Emergency Response responsibilities and actions. These should be consistent with Annex 3 of this Reg Guide.	Emergency Response responsibilities and actions. These should be consistent with Annex 3 of this Reg Guide. Responsibilities and actions should particularly include: Assessment of a radiological incident Management of Licensee response to a radiological Emergency.

Annex 3

Industrial Radiography Emergency Plans

This Annex discusses the incidents that industrial radiography Emergency Plans should address; the scope of an Emergency Plan, Emergency equipment, and Emergency procedures.

Incidents

1. An Emergency Plan should address the following incidents as appropriate:
   a) For gamma radiography:
      i. A source becomes stuck in the guide tube or the collimator, or near the entrance to the exposure device.
      ii. The shielding of the exposure device is damaged.
      iii. A source becomes disconnected from its drive cable and remains in the guide tube.
      iv. A source is projected out of the end of the guide tube.
      v. A pipeline crawler becomes stuck in a pipe with the source exposed.
      vi. A source is lost.
      vii. There is a fire.
      viii. Unauthorized Persons are present in the controlled area during an exposure.
      ix. Appropriate transportation incidents
   b) For X-ray Radiation Generators:
      i. Generation of radiation fails to terminate after the intended time period.
      ii. An X-ray radiation generator is unintentionally energized.
      iii. A radiographer fails to terminate a manually controlled generation of radiation.
      iv. A Safety system or warning system malfunctions, including deliberate actions to override a system.
      v. A malfunction causes X-rays to be generated in an uncontrolled manner.
      vi. Physical damage occurs that affects the shielding or filtration.
      vii. Unauthorized Persons are present in the controlled area during an exposure.

Scope

2. The Emergency Plan should include:
   a) Advice on when to implement the Emergency Plan;
   b) identification and duties of Persons who will implement the plan.
   c) description and location of Emergency Response equipment;
   d) training for Persons who will implement the plan;
   e) technical data and data relevant to radiological protection for each incident;
   f) procedures to be followed at various stages, specific to each type of Emergency;
      i. Initial stage: Contain the situation
      ii. Planning stage: Plan and rehearse recovery
      iii. Recovery stage: Regain control of the situation
      iv. Post-Emergency stage: Return the situation to normal
      v. Reporting stage: Prepare a report, including an Assessment of Doses
      vi. Referral to medical experts following overexposure, if indicated

g) and identification of all Persons and organisations who should be contacted at the various stages of the plan, as well as their telephone numbers, fax numbers and email addresses.

Equipment

3. For Licensees using gamma sources, the following Emergency equipment should be available:

a) Radiation survey meters that measure both high and low Dose rates;

b) personal alarm dosimeters and direct reading dosimeters (preferably electronic personal dosimeters rather than quartz fibre electroscopes);

c) extra personal dosimeters (thermoluminescent dosimeters and/or film badges);

d) barrier materials and notices;

e) bags of lead shot, and extra lead sheet;

f) suitable tool kit and source recovery equipment such as long handling tongs, pliers, screwdrivers, bolt cutters, adjustable wrench (spanner), hacksaw and flashlight (torch);

g) spare shielded container for Emergency use;

h) communication equipment such as radiotelephones and mobile phones;

i) spare batteries for survey meters, electronic personal dosimeters, mobile phones and flashlights (torches);

j) pens, paper, calculator and an incident log book; and

k) equipment manuals.

Procedures

4. Recommended specific Emergency procedures for gamma sources are:

a) Radiographers should:

i. Recognize that a situation has arisen that might be an Emergency.

ii. If a source may be exposed, do not touch the source.

iii. Remain calm and move away from the exposed source. Tell others who are nearby that there may be a problem.

iv. Measure the radiation Dose rates and record any Doses measured by direct reading dosimeters.

v. Establish or re-establish controlled area barriers based on Dose rate reference levels.

vi. Prevent access to the new controlled area.

vii. Do not leave the controlled area unattended.

viii. Inform the RPO and the client, and seek assistance.

b) RPOs should:

i. Implement the established Emergency procedures, taking care to minimize Doses.

ii. If source recovery is appropriate;

a) Practice recovery actions outside the controlled area.

b) Implement recovery actions. Never let the source come into contact with the hands or other parts of the body.

c) If recovery actions are unsuccessful, leave the controlled area and plan what to do next while keeping watch on the area.

iii. Notify the Authority as required.

iv. Call for technical assistance, if necessary, from a qualified expert or from the manufacturer.

v. When the Emergency is over and the source has been made safe, record the names and relative locations of persons in the vicinity of the incident to allow estimates of exposures.

vi. Return personal dosimeters to the dosimetry service to get an accurate Assessment of exposures.

vii. Assess the Doses received and prepare a report.

viii. Have damaged or malfunctioning equipment examined and repaired by the manufacturer or a qualified expert before reuse.

ix. Prepare an incident report and submit it to the Authority.

c) If the source capsule might have been damaged, radiographers should take extra care, because Radioactive Material could leak out and there could be a risk of contamination. Detecting and measuring radioactive contamination needs specialized monitoring equipment and expertise, which Licensees may not have. If the source capsule has been ruptured, Licensees should promptly seek advice from a qualified expert. This person's contact information should be included in the emergency plan.

5. Recommended specific Emergency procedures for X-ray radiation generators are:

a) Radiographers should:

i. Recognize that a situation has arisen that might be an Emergency.

ii. Turn off the electrical power to the radiography equipment.

iii. Perform a radiation survey to confirm that the tube is de-energized.

iv. Do not move the radiography equipment until details such as position, beam direction and exposure settings (tube voltage, current and time) have been recorded.

v. Inform the RPO of what has happened.

b) RPOs should:

i. Notify the Authority as required.

ii. Record the names and relative locations of persons in the vicinity of the incident to allow estimates of exposures.

iii. Return personal dosimeters to the dosimetry service to get an accurate Assessment of exposures.

iv. Assess the possible Doses that could have been received and prepare a report.

iv. Prepare an incident or accident report and provide it to the Authority as appropriate.