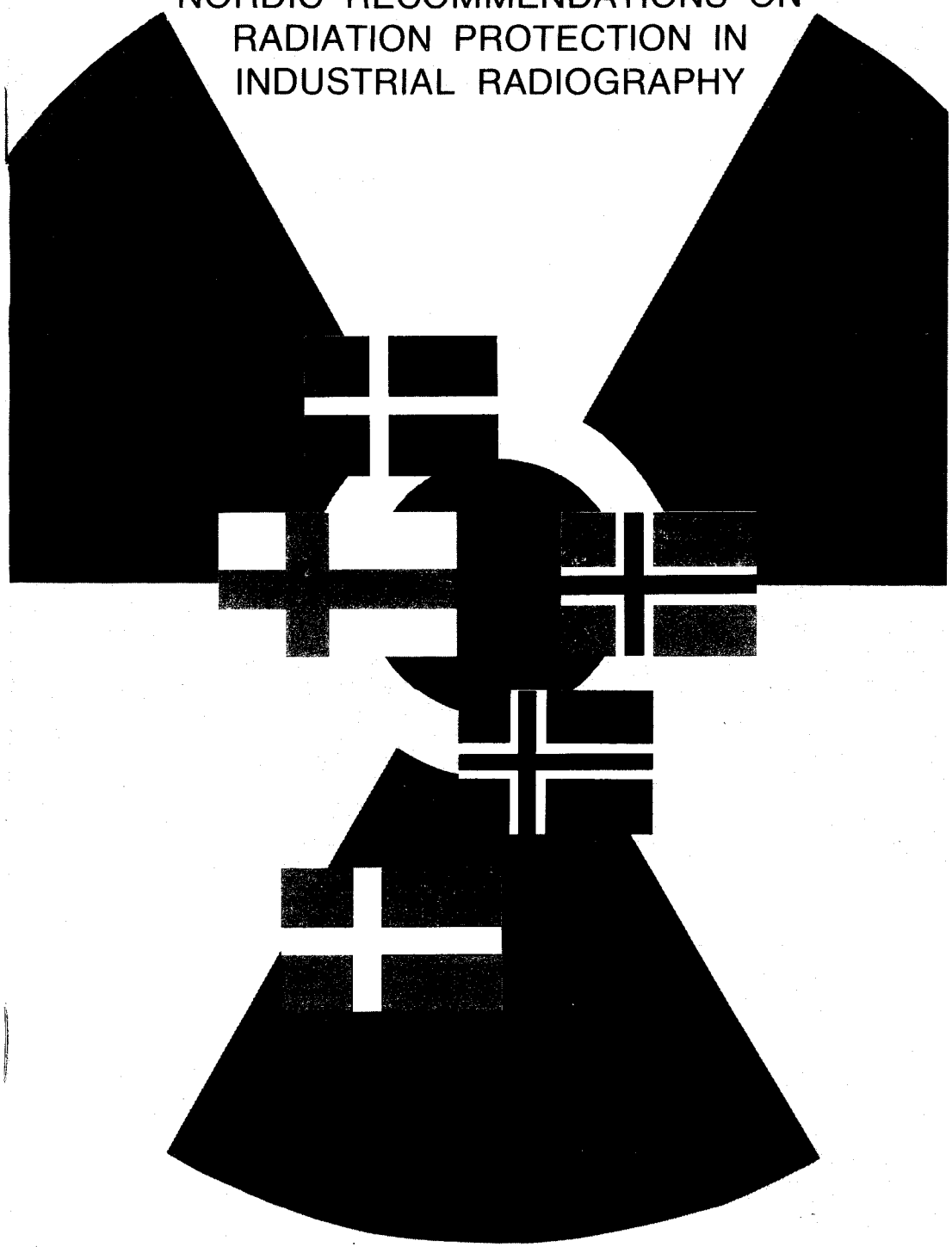
# NORDIC RECOMMENDATIONS ON RADIATION PROTECTION IN INDUSTRIAL RADIOGRAPHY



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SCANTRYK. KOBENHAVN

# NORDIC RECOMMENDATIONS ON RADIATION PROTECTION IN INDUSTRIAL RADIOGRAPHY

**The Radiation Protection Institutes in Denmark, Finland, Iceland, Norway and Sweden**
**1987**

*CONTENTS.*





ANNEXES.

# 1. INTRODUCTION

The "Report on the Applicability of International Radiation Protection Recommendations in the Nordic Countries" has, since it was issued in 1976, served as a useful guide for regulating radiation protection in the different Nordic countries.

However, the use of industrial radiography as a part of non-destructive testing has undergone extensive growth over the last few years and the need has been felt for further harmonization of the radiation protection regulations in this field. A working group was formed to prepare a new document based on Chapter 13 of the Nordic Recommendations. The main scope of the recommendations in this document is to achieve an acceptable low level of radiation risk for the radiographer and his assistants as well as for other personnel and the general public.

Since industrial radiography involves the use of relatively strong radiation sources, one of the main objectives of these regulations is the reduction of the risk for radiation accidents.

In the preparation of this document the group has taken into account the general objects and basic concepts of ICRP Publication 26 (1977). Many of the recommendations given in this document are a result of the application of the optimization principle laid down by ICRP.

The recommendations on industrial radiography equipment and instruments for measuring radiation have to a certain extent been based on existing national and international recommendations issued by the International Standards Organization (ISO), the International Electrotechnical Commission (IEC), and the American National Standards Institute (ANSI).

SI units have been introduced throughout the document. The exposure rate in milliroentgen per hour (mR/h) has been replaced by the dose equivalent rate in microsievert per hour (μSv/h). The working group has also recommended the introduction of this unit for radiation protection instruments.

Although this document is used by the Nordic countries as a basis for radiation protection regulations for industrial radiography, certain differences must be expected in the national regulations.



# 2. LICENSING AND RESPONSIBILITY

2.1 Any person or company intending to perform industrial radiography shall obtain a license from the national radiation protection authority prior to purchasing radiography equipment. The term "purchasing" here includes buying, renting and borrowing.

To obtain this license the licensee shall demonstrate the levels of competence and organization described in section 3.

2.2 Compliance with the national radiation protection regulations is the responsibility of the licensee.

## 3. ORGANIZATION, COMPETENCE AND PRE-OPERATIONAL DUTIES OF LICENSEE

3.1 The licensee shall issue his own safety manual defining the organization of the radiation protection work. The manual shall comprise all relevant aspects of radiation protection in order to ensure safe operation at all times.

The manual shall specify the duties and responsibilities of the different categories of employees engaged in radiography work.

The manual shall provide routines for performing audits on the manual in order to check that it complies with regulatory requirements and that the system works as intended.

3.2 The licensee shall appoint a radiation protection officer to take responsibility for all relevant aspects of radiation protection. The radiation protection officer must be given the authority necessary to perform his work in a satisfactory way.

3.3 The radiation protection officer shall be approved by the national radiation protection authority. Theoretical knowledge and practical experience shall be taken into consideration. Regarding theoretical knowledge the course described in ANNEX IV shall be considered the minimum.

3.4 Radiographers shall have satisfactory knowledge of the fundamentals of radiation protection and of the proper use of all radiography equipment which is encountered during the work. The radiation protection course described in ANNEX IV together with proper practical training is normally considered to give sufficient competence.

3.5 Assistants to the radiographer must be given sufficient information on the procedures involved in industrial radiography to be able to carry out their work satisfactorily. Information on radiation and the associated risks is important in addition to the practical guidance.



3.6 The licensee shall implement routines for purchasing radiographic equipment which ensure that both equipment and purchasing procedures comply with the relevant national regulations. Routines shall also ensure that appropriate auxiliary equipment required is purchased.

3.7 The licensee shall implement routines for regular checking and maintenance of radiography equipment. It is important to ensure that service and maintenance work involving dismantling parts of the equipment essential for compliance with the radiation protection standards is only undertaken by companies licensed to do this work. For gamma radiography apparatus see ANNEX V.

The implemented routines shall also ensure that auxiliary equipment essential for safe performance of the radiographic work such as dose equivalent meters, collimators,diaphragms,warning signs etc. is in proper condition.

3.8 The licensee shall provide a system for recording individual doses. This system shall be according to any requirements specified by the national radiation protection authority.

3.9 Contingency plans for action to be taken in case of radiation incidents shall be prepared. The obligation of immediate notification and subsequent presentation of a detailed report to the national radiation protection authority should be clearly stated in the contingency plan. For further details see ANNEX VI.

## 4. OPERATION

### 4.1 INFORMATION

4.1.1 All personnel at a location where industrial radiography is carried out shall receive the necessary information about the work. Information on safety procedures, radiation hazards and the significance of barriers, warning signs and warning lights is particularly important.

### 4.2 PLANNING

4.2.1 When planning radiography work it is important to choose radiography equipment and tecniques suitable for the work in order to minimize radiation doses and possible hazards. Careful consideration should be given to the choice of radiography equipment, the type of film and the exposure and developing techniques.
For the same reason the time and place for the performance of the radiography work must be chosen with care.

4.2.2 Industrial radiography shall preferably be performed in enclosed installations complying with the recommendations given in ANNEX I.

4.2.3 In some cases, however, the performance of industrial radiography outside enclosed installations may be justified. The sizes and positions of the objects to be radiographed can sometimes make the use of enclosed installations impossible or impracticable. The use of open installations may also be justified where radiography work is performed infrequently.

4.2.4 A radiography team operating one radiography unit shall generally consist of one radiographer and at least one assistant. In enclosed installations radiography equipment may be operated by one radiographer alone.

4.2.5 One radiography team, radiographer and assistants, is normally not allowed to operate simultaneously more than one radiography unit.



4.2.6 When more than one radiography team is working in the same area safe performance of the radiography work must be ensured through proper coordination.

### 4.3 CHECKING THE EQUIPMENT

4.3.1 The radiographer and his assistants shall be provided with personal dosimeters according to 3.8.

4.3.2 The radiography team shall be provided with at least one dose equivalent rate meter. This monitor shall comply with the recommendations given in ANNEX III.

4.3.3 In addition to the dose equivalent rate meter at least one audible-alarm dosimeter should be available for the radiography team. It is recommended that each member of the team should have such a device.

4.3.4 Before starting the radiography work the radiography team shall ensure that the radiography equipment and necessary auxiliary equipment such as dose equivalent rate meters, audible-alarm dosimeters, personal dosimeters etc. are in place and in proper working order. If not, the radiography work shall not be carried out.

### 4.4 RADIOGRAPHY IN ENCLOSED INSTALLATIONS

4.4.1 Enclosed installations should comply with the requirements specified in ANNEX I.

4.4.2 The radiographer shall ensure compliance with all the limitations on use of the enclosed installation, e.g. the limitations with respect to radiation sources and beam directions. If these conditions are not satisfied the installation is no longer considered to be an enclosed installation,and the work must be carried out according to the recommendations for open installations.

4.4.3 Before starting the exposure, the radiographer must make sure that there is nobody inside the enclosed installation.

4.4.4 The exposure shall be terminated according to the correct termination procedures. Use of safety devices such as interlocks for exposure termination is not allowable.

4.4.5 Before entering the enclosed installation after an exposure the radiographer shall make certain that the exposure has been terminated. A dose equivalent rate meter shall normally be used but reliance on some other positive indication that the exposure has terminated might be permissible.

4.4.6 When the control unit is left without attendance, the equipment must be made non-operable by locking and subsequent removal of the key.

## 4.5 RADIOGRAPHY IN OPEN INSTALLATIONS

### 4.5.a GENERAL REQUIREMENTS

4.5.1 When performing open industrial radiography, the radiography equipment and the object to be radiographed shall be placed in such a way that existing barriers will minimize the radiation doses. Temporary use of additional shielding material shall also be considered.

4.5.2 A controlled area inside which the exposures take place shall be established by means of physical barriers to prevent all access to this area. The dose equivalent rate shall not exceed 60 µSv/h outside this area during exposure.



4.5.3 Where permanent barriers are not available, temporary barriers shall be erected. When performing radiography in open fields with excellent supervision, guards may be used instead of physical barriers.

4.5.4 The presence of persons inside the controlled area during exposure is not permissible. Exceptions can be made for the radiographer and his assistants if this is considered essential for the safe performance of the work.

4.5.5 A supervised area shall be established to be under supervision by the radiography team during exposure. The dose equivalent rate shall not exceed 7.5 µSv/h outside this area during exposure.

4.5.6 No workplace within the supervised area may be occupied during exposure. Workers associated with the radiography work are however allowed to pass through the area. The presence of members of the general public in the supervised area during exposure is not normally permissible.

4.5.7 Where it is difficult to control access to the supervised area or where it is difficult to prevent trespassing into the supervised area, erection of barriers should be considered when establishing the supervised area.

4.5.8 The control unit shall be located in such a way that the radiography team has the best possible supervision over the controlled and supervised areas. The radiographer or one of the assistants shall be in attendance near the control unit during every exposure in order to take immediate corrective measures if any unplanned entry into the areas takes place.

4.5.9 The dose equivalent rate at the position of the radiographer and the assistants shall be as low as reasonably achievable and shall not exceed 20 µSv/h during exposure. Exceptions can be made if this is considered essential for the safe performance of the work.

4.5.10 Ionising radiation warning signs shall be displayed in order to discourage access to controlled areas. The signs shall be prominently displayed and sufficiently densely spread.

4.5.11 Before entering the controlled area after an exposure the radiographer shall make certain that the exposure has been terminated. A dose equivalent rate meter shall generally be used.

4.5.12 When the control unit is left unattended the radiography equipment must be locked in order to prevent unauthorized use.

4.5.b SPECIAL REQUIREMENTS APPLYING TO THE USE OF X-RAY EQUIPMENT

4.5.13 During start up preparation or testing of the X-ray tube the radiation window shall be closed by a lead cap designed for this purpose.

4.5.14 A warning lamp connected to the control panel shall be prominently positioned near the X-ray tube in order clearly to indicate exposure.

4.5.15 A diaphragm shall be used to reduce the field size of the primary beam close to the minimum necessary for the performance of the work. The use of localizing cones is highly recommended for further minimization of scattered radiation.

4.5.16 The use of additional filters in excess of those specified in 5.2.2 is recommended in order to minimize low energy radiation.

4.5.17 Special attention must be paid to those exposures where part of the primary beam passes beside the object to be exposed and is thus unattenuated. The use of additional shielding is necessary in these cases. The use of additional shielding behind the object to be exposed is also generally recommended, thus allowing a reduction in the size of the controlled and supervised areas.



4.5.c SPECIAL REQUIREMENTS APPLYING TO THE USE OF GAMMA RADIOGRAPHY APPARATUS.

4.5.18 The activity of sources used for gamma radiography should be as low as practicable. In general, activities requiring exposure times of less than 1 minute should not be used.

4.5.19 The use of sources with activities exceeding

1500 GBq Ir-192,
1500 GBq Cs-137, or
400 GBq Co-60

requires a special license from the national radiation protection authority. Such a license will be issued only when the necessity for use of high activity sources is well documented.

4.5.20 Appropriate collimators shall be used for reduction of the field size of the primary beam close to the minimum size necessary for the performance of the work. This calls for the use of different kinds of collimators for different kinds of directional and panoramic exposures.

4.5.21 When using gamma radiography apparatus in which the radioactive source is moved through a projection sheath to the working position, this sheath should be as short as practicable.

4.5.22 When using gamma radiography apparatus in which the radioactive source is moved out of the exposure container to the working position, the dose equivalent rate during the exposure can be used to establish the controlled and supervised areas in spite of the fact that the dose equivalent rate might be higher during the movement of the source.

4.5.23 The radiography team shall pay special attention to secure fastening of the exposure container, the collimator and the remote control when preparing for exposure.

4.5.24 After terminating the exposure, the radiographer shall use a dose equivalent rate meter to confirm that the source is in its shielded position.

4.5.25 Whenever gamma radiography apparatus is outside of locked storage rooms it should not be left unattended. However, during shorter breaks in premises inaccessable to the general public it is acceptable that the locked apparatus is left in an irremovable state e.g. secured by a chain.

4.5.26 If the radioactive source has got out of control the radiographer shall:

- ensure that other people leave the area
- prevent access to all areas where the dose equivalent rate exceeds 60 µSv/h
- inform the Radiation Protection Officer of the company
- proceed further according to the company's contingency plan.(See ANNEX VI)

4.5.d ADDITIONAL REQUIREMENTS FOR THE USE OF HIGH-ACTIVITY GAMMA SOURCES IN OPEN INSTALLATIONS

4.5.27 When using sources with activities exceeding the limits given in 4.5.19, the radiography work must be performed by at least two fully qualified radiographers.

4.5.28 When using high activity sources, the remote control cables and sheaths must be long enough to allow a distance of at least 15 m between the remote control and the exposure container.

4.5.29 When using high activity sources, emergency equipment specified by the national radiation protection authority, e.g. additional shielding material etc., should be present at the site where the work is performed.



4.6 TRANSPORT AND STORAGE

4.6.1 Radioactive sources used for industrial radiography shall be transported according to the requirements in the current edition of "Regulations for the Safe Transport of Radioactive Materials" published by the IAEA and relevant national regulations.

4.6.2 Gamma radiography apparatus shall be stored in locked rooms complying with the recommendations given in ANNEX II.

4.6.3 Storage of gamma radiography apparatus in motor vehicles is generally prohibited. Exceptions might be made when a transport is interrupted for example during the night and no better storage facilities have been found. Gamma radiography apparatus thus left in motor vehicles shall be securely attached to the vehicle and considered as being under transport. The vehicle shall be locked and the choice of parking place shall be made with due attention to the possibility of theft.

4.6.4 X-ray equipment shall be stored in locked rooms with limited access. Due attention must be paid to the risk of electrical failures caused by humidity.

# 5. REQUIREMENTS FOR INDUSTRIAL RADIOGRAPHY EQUIPMENT

## 5.1 GAMMA RADIOGRAPHY APPARATUS*

5.1.1 Apparatus for gamma radiography shall be designed with due attention to the desirability of faultless operation. Designers and manufacturers must therefore give particular consideration to the following:

a) Durability and resistance to corrosion.

b) Prevention of ingress of water, sand and other foreign matter into vital parts of the apparatus.

c) Damaging effects of extreme temperatures.

d) Damaging effects of radiation on non-metallic components such as rubbers and plastics.

5.1.2. Apparatus for gamma radiography shall in general comply with the requirements in the international standard ISO 3999. Additional requirements specified in this document shall also be complied with.

5.1.3 Exposure containers of mobile or portable type, considered as transport packages, shall comply with the requirements for type B(U) in the current edition of "Regulations for the Safe Transport of Radioactive Material" published by the IAEA. Relevant national transport regulations shall also be complied with.

5.1.4 Apparatus for gamma radiography shall have remote control.

* The most common components of a gamma radiography apparatus are shown in figure 1 on page 42.



5.1.5 The exposure container shall provide shielding so that a sealed source corresponding to the maximum permitted activity locked in the secured position shall not give dose equivalent rates exceeding:

a) 2000 μSv/h on the surface of the container

b) 20 μSv/h 1 m from the surface of the container

5.1.6 The sealed radioactive source shall comply with the international standard ISO 1677 having a classification according to ISO 2919 of at least C 43515. For apparatus in which the source stays inside the exposure container during exposure a classification of C 43313 would be acceptable. In addition, all radiography sources should comply with the "Special Form" requirements given in the latest edition of "Regulations for the Safe Transport of Radioactive Material" issued by the IAEA.

5.1.7 The source holder shall be designed to prevent accidental release of the radioactive source.

5.1.8 The exposure container shall be provided with a "non-removable" lock which secures the sealed source in the fully-shielded position and which can only be operated when the source is in that position. It shall be possible to unlock the exposure container only with a special key for which there is no easily available substitute. It shall not be possible to make the exposure container non-lockable by removal of the key.

5.1.9 Apparatus which is not manually operated shall be designed so that activation system failure automatically causes the apparatus to enter the secured mode. In addition, this equipment shall be provided with a manual safety device which makes it possible to bring the apparatus to the secured mode without undue exposure to the personnel to radiation.

5.1.10 Apparatus which is manually operated shall have safe and positive physical connection between the remote control and the source or the shutter. Unintentional detachment shall not be possible.

5.1.11 If the connection between the remote control and the exposure container has not been properly made, it shall not be possible to move the source out of the fully shielded position.

5.1.12 The remote control shall be clearly marked to indicate how the start and stop of exposure is controlled.

5.1.13 Remote controls with a control cable shall have a stop on the cable in order to prevent accidental disengagement of the cable from the drive.

5.1.14 Remote control cables and sheaths supplied shall allow a distance of at least 15 m between the remote control and the exposure container. Remote control cables and sheaths allowing a maximum distance down to 8 m between the remote control and the exposure container shall be supplied on request.

5.1.15 For apparatus in which projection sheaths are used, different lengths from 0,5 m and upwards shall be supplied. Only projection sheaths in one piece (not coupled) shall be supplied.

5.1.16 Collimators giving different field sizes for different kinds of directional and panoramic exposures shall be supplied. The collimators should provide an attenuation corresponding to at least 2 tenth value layers (TVL).

5.1.17 Collimators designed to be mounted directly on the exposure container should be supplied.

5.1.18 The collimators must be so designed that they do not endanger safe operation by introducing additional strains on parts of the apparatus. The collimators shall be designed for secure attachment while arranging the apparatus for exposure.



5.1.19 Covers to prevent the ingress of water and other foreign matter into vital parts of the apparatus shall be attached to exposure container, remote control and sheaths as relevant.

5.1.20 Apparatus for industrial gamma radiography shall have a marking complying with the international standard ISO 3999 requirements. In addition IAEA transport regulation marking requirements shall be complied with for portable and mobile types of apparatus.

5.1.21 An instruction manual for each particular model of apparatus shall be issued written in the language of the country.

## 5.2 X-RAY EQUIPMENT*

5.2.1 An X-ray tube shall be enclosed in a tube housing in such a way that the dose equivalent rate from leakage radiation measured at a distance of one metre from the focus does not exceed the following values for the given applied voltages and the corresponding maximum tube currents:

| | | |
|---|---|---|
| up to 150 kV | : | 1000 µSv/h |
| above 150 up to 200 kV | : | 2500 µSv/h |
| above 200 kV | : | 5000 µSv/h |

For discharge X-ray equipment, the dose equivalent rate shall be defined as the dose equivalent in one hour at the highest pulse rate.

5.2.2 The tube head shall provide a total filtration at least equal to the following values corresponding to the maximum voltage for which the tube head is designed :

| | | |
|---|---|---|
| up to 50 kV | : | no requirement |
| above 50 up to 100 kV | : | 2 mm Al or the equivalent (1st HVL: 2.5 mm Al/100 kV) |
| above 100 up to 200 kV | : | 3 mm Al or the equivalent (1st HVL:0.2 mm Cu/200 kV) |
| above 200 up to 300 kV | : | 4 mm Al or the equivalent (1st HVL: 0.6 mm Cu/300 kV) |
| above 300 kV | : | 0.5 mm Cu or the equivalent (1st HVL: 2.2 mm Cu/350 kV) |

* The most common components of an X-ray equipment are shown in figure 2 on page 43.



5.2.3 For special purposes, equipment with lower total filtration may be supplied. Additional filters easily installed shall be supplied for use in those cases when extremely low filtration is not required.

5.2.4 Additional easily changable filters shall be available in order to minimize low energy radiation.

5.2.5 A lead cap to be used for covering the radiation window during testing and start up preparation of the tube shall be supplied. The lead cap shall attenuate the primary beam so that the leakage radiation limits are not exceeded.

5.2.6 The lead cap shall be easy to mount correctly. For panoramic X-ray equipment the lead cap (belt) must be mechanically strong.

5.2.7 Diaphragms giving different field sizes of the primary beam shall be supplied.

5.2.8 The diaphragms shall be easy to mount correctly. Panoramic X-ray equipment shall be supplied with diaphragms enabling directional beam exposure. This is not required for X-ray crawlers.

5.2.9 X-ray equipment shall be equipped with a control cable for remote exposure control. The length of this cable shall be at least 20 m. For X-ray equipment with extremely low output a shorter control cable can be accepted.

5.2.10 The control panel shall be provided with a key activated control. Without this key the control panel shall be inoperable. Removal of the key after exposure must not result in any damage to the equipment e.g. overheating.

5.2.11 Proper operation of the control panel shall be the only way of controlling exposures. Accidental grounding of an electric conductor shall not result in generation of X-rays.

5.2.12 Two independent means which indicate when X-rays are being generated shall be provided on the control panel. One of these indicators shall be a red lamp of reliable design.

5.2.13 The control panel shall be provided with door switch connectors for use in enclosed installations. This system shall be designed in such a way that when exposure has been interrupted by the opening of a door altering the switch circuit status, it shall be possible to resume generation of X-rays only by use of the control panel after all the doors have been closed again.

5.2.14 The control panel shall be provided with a connection to an external warning lamp.

5.2.15 The tube head shall be distinctly marked with the following information:

- maximum tube voltage (kV)
- maximum tube current (mA)
- location of focus
- anode side
- primary beam angle
- filtration
- special warning if the X-ray tube is of the beryllium-window type
- for panoramic units the cylindrical window shall be marked with a color distinctly different from that of the rest of the housing.

5.2.16 A brief guidance, written in the language of the country, shall accompany the unit (if convenient in the control panel cover). The guidance shall contain a warning concerning radiation hazards, and an indication that the installation must be operated by qualified personnel only.



5.2.17 The instruction manual for the use of X-ray installations shall be written in the language of the country and shall only deal with the type of apparatus concerned.

## 5.3 X-RAY CABINETS

5.3.1 An X-ray cabinet means an enclosed installation in the form of a cabinet, a box or the like, designed to be used for radiography or fluoroscopy purposes. The X-ray cabinet should be of relatively small dimensions, in principle so small that nobody can enter it.

5.3.2 Parts of the radiation protection enclosure which can be opened to permit access to the interior of the cabinet are defined as follows:

- "door" means a part of the enclosure which is designed to be easily opened for routine operation purposes.

- "access panel" means a part of the enclosure which is designed to be opened for the purpose of maintenance and service and which can not be opened without appropriate tools.

5.3.3 Openings in the radiation protection enclosure which are designed to remain open during operation of the cabinet are defined as follows:

- "port" means an opening in the enclosure for the purpose of conveying the material to be irradiated into and out of the cabinet.

- "aperture" means an opening in the enclosure other than a port.

5.3.4 X-ray cabinets shall be lockable in such a way that it shall not be possible to generate X-rays with the key removed.

5.3.5 X-ray cabinets shall be provided with at least one control for starting and stopping of the exposure. The use of these controls shall be the only possible way of starting the exposure.



5.3.6 The dose equivalent rate at any position 0.05 m from the external surface of the X-ray cabinet or at normally accessible places during operation shall not exceed 5.0 µSv/h at any specified tube rating. In the case of a discharge X-ray tube, the dose equivalent rate shall be defined as the dose equivalent in one hour at the highest pulse rate.

5.3.7 Accidental grounding of an electric conductor shall not result in the generation of X-rays.

5.3.8 It shall not through any port be possible to expose any part of the human body to dose equivalent rates exceeding 2000 µSv/h.

5.3.9 It shall not be possible to insert any part of the human body through any aperture.

5.3.10 Each door of an X-ray cabinet shall have at least two safety interlocks. One but not all of the interlocks shall be constructed in such a way that the opening of the door would result in physical disconnection of the energy supply circuit to the high voltage generator.

5.3.11 Each access panel shall have at least one safety interlock.

5.3.12 When exposure has been automatically stopped due to the opening of a door or an access panel it shall be possible to resume generation of X-rays only by means of the control referred to in 5.3.5 after all doors and access panels have again been shut.

5.3.13 Failure of any single component shall not result in the failure of more than one of the required safety interlocks.

5.3.14 If the tube head can be taken out of the cabinet (e.g. for portable use), a special arrangement shall ensure that the safety interlocks are put into function automatically when the tube head is replaced in the cabinet.

5.3.15 Two independent means which indicate when X-rays are being generated and which are visible from the place where the X-ray generation can be initiated shall be provided.

5.3.16 Failure of any single component shall not result in the failure of both of the two required indicators in their intended function.

5.3.17 One of the indicators shall be an optical warning signal legibly labelled "X-RAY ON" (written in the language of the country). This warning signal shall be of a reliable type and clearly visible. As an example a warning signal can contain two electric bulbs connected in parallel.

5.3.18 Additional optical warning signals as described in paragraph 5.3.17 shall be provided, if necessary, to ensure that at least one signal is visible from each door, access panel or port.

5.3.19 A clearly legible warning sign labelled "CAUTION: X-RAYS PRODUCED WHEN ENERGIZED" (written in the language of the country) shall be permanently affixed or inscribed at the location of any control for initiation of X-ray generation.

5.3.20 A clearly legible warning sign labelled "CAUTION X-RAYS: DO NOT INSERT ANY PART OF THE BODY WHEN SYSTEM IS ENERGIZED"(written in the language of the country) shall be permanently affixed or inscribed adjacent to each port of the X-ray cabinet.

5.3.21 The X-ray cabinet shall be distinctly marked with the following information:

- maximum kV for which the cabinet is dimensioned
- restrictions on X-ray beam directions if any
- maximum kV, mA and filtration of the X-ray tube fitted
- special warning if the X-ray tube is of the beryllium-window type



5.3.22 A brief guidance, written in the language of the country, on the operation of the cabinet and the associated radiation risks shall be affixed to the cabinet.

5.3.23 The instruction manual for use of the cabinet shall be written in the language of the country and shall only deal with the type of cabinet concerned. The instruction manual shall contain information on:

- operation of the cabinet
- radiation hazards
- safety devices (interlocks, warning signals etc.), their intended function and how to check their proper working order
- regulations in force
- license, approval
- service and maintenance of the equipment with emphasis on the radiation risks.

ANNEX I

SPECIFICATIONS FOR ENCLOSED INSTALLATIONS

Enclosed installations for industrial radiography should be designed in compliance with the following recommendations:

1. An enclosed installation is a permanent enclosure in which the radiation source and the object to be exposed are located, while the remote control is placed outside the enclosure.

2. Enclosed installations shall have positive indication of exposure prominently displayed.

3. Enclosed installations in which X-ray equipment or electrically activated gamma radiography apparatus are installed shall have interlock systems which prevent exposure if one of the entrance doors is open before exposure or opened during exposure. Resumption of exposure shall be possible only by manual restart at the control panel after the doors have been closed.

4. Enclosed installations in which manually activated gamma radiography apparatus are installed shall have a safety system which either prevents access to the installation during exposure or gives an audible alarm if attempts are made to enter during exposure.

5. The dose equivalent rate at a distance of 1 m from the outer surface of an enclosed installation shall not exceed 7.5 μSv/h when the properties of the radiation source correspond to the maximum ratings stated for that enclosed installation.

6. In enclosed installations having more than one entrance door, the doors that are not controlled by the radiographer shall be lockable from the inside.



7. Enclosed installations shall be provided with an emergency device that makes it possible for a person accidentally left in the room easily to open one of the doors and leave.

8. Enclosed installations shall be properly marked with signs warning against ionising radiation.

9. Enclosed installations shall be provided with a sign stating the maximum rating and limitations on the primary beam directions established for that installation.

ANNEX II

SPECIFICATIONS FOR RADIOACTIVE MATERIAL STORAGE FACILITIES

Storage facilities for radioactive material should comply with the following recommendations:

1. When designing storage facilities for radioactive material necessary attention should be paid to the possibility of fire. In general storage rooms for radioactive material should be built from nonflammable building materials.

2. Radioactive material shall not be stored together with explosives or highly inflammable material.

3. The dose equivalent rate at accessible places outside a permanent storage room shall not exceed 7,5 µSv/h.

4. The annual dose equivalent to any person from stored radioactive sources shall not exceed 1000 µSv. This might imply a dose equivalent rate limit of 0.5 µSv/h for permanent workplaces.

5. The storage room shall be lockable and access to the room shall be limited.

6. Entrance doors leading to the storage room shall have a standard sign warning against ionising radiation.



ANNEX III

REQUIREMENTS FOR DOSE EQUIVALENT RATE METERS

The dose equivalent rate meters refered to in the main document should comply with the IEC Standard 395 for class II instruments.

For low energy industrial X-ray radiography dose equivalent rate meters in compliance with the above requirements will not be sufficient. For this practice special dose equivalent rate meters will be required.

In the following the most important requirements in the IEC Standard 395 are summarized:

1. The requirements apply to portable assemblies intended to measure dose equivalent rate due to X-rays or gamma rays of energies between 50 keV and 3 MeV for the purposes of radiation protection.

2. The reading scale shall indicate dose equivalent rate and shall be graded in SI units.

   In the case of an assembly provided with a substantially linear scale, it should be possible to change the ranges of measurement by switching in such a way that the scaling factor between adjacent ranges does not exceed 10. If an assembly with a substantially logarithmic scale is provided with more than one measurement range, there should be an overlap of one decade between adjacent ranges.

3. Intrinsic error in dose equivalent rate indication shall not exceed $\pm$20% of conventionally true dose equivalent rate or $\pm$6% of scale maximum.

4. The response in the calibration direction to incident radiation of energy between 50 keV and 3 MeV shall not differ more than $\pm$ 25% from the response to the reference gamma radiation from Co-60 or Cs-137.

5. The response of the assembly to radiation incident at any angle not exceeding $45^0$ from the direction of maximum response of the assembly shall be not less than 80% of this maximum response. At any angle of $90^0$ from the direction of maximum response the indication shall be not less than 50% of the maximum response. When exposed to the reference gamma radiation of Co-60 or Cs-137, the indication of the assembly shall not vary by more than $\pm$10% from that indicated in the reference orientation of use for any orientation of the assembly.

6. The response time shall be such that, if there is a sudden change in the dose equivalent rate, the indication will reach the following value in less than 8 seconds:

$$N + \frac{63}{100} (N' - N)$$

where N is the initial indication and N' the final indication.

7. For high dose equivalent rates, it is recommended that, whenever possible, the response time is reduced, while conforming to the limits laid down for the statistical fluctuations.

8. Battery power shall always be provided. Facilities shall be provided to check the battery condition under maximum load. The minimum battery check indication for which the performance of the assembly will remain within the requirements of the recommendation shall be clearly marked on the meter scale. Batteries may be connected in any desired manner but shall be individually replacable; the correct polarity shall be clearly indicated on the assembly by the manufacturer.

9. Portable assemblies shall be able to withstand, without any damage mechanical shocks from all directions involving an acceleration of 30 g (1 g = 9,81 m $s^{-2}$) for a time interval of 18 ms.



10. For dose equivalent rates greater than those corresponding to scale maximum, the indication of the assembly shall be out of scale at the higher end of the scale range and shall remain so. For assemblies with more than one scale range, this requirement shall apply to each scale range.

11. For assemblies intended for outdoor use, the manufacturer shall state the precautions that have been taken to prevent the ingress of moisture.

12. A certificate shall accompany each assembly, giving at least the following information:

- Manufacturers name or registered trade mark
- Type of the assembly and serial number
- Class number of the assembly
- Scale limits for each measuring range
- Response as a function of radiation energy
- Location and dimensions of the sensitive volume
- Materials of the wall surrounding the sensitive volume and surface mass of each of them (in $mg/cm^2$)
- Energy at which compliance with the angle of incidence requirements has been checked.

ANNEX IV

INDUSTRIAL RADIOGRAPHY RADIATION PROTECTION COURSE

A course consisting of 20 hours of theoretical education in the topics:

- Ionising radiation
- Units
- Regulations
- Biological effects of ionising radiation
- Use of equipments
- Protective measures

and 10 hours of relevant practical exercises is regarded as sufficient. A test of competence should be included in the course.

The course is considered to give satisfactory radiation protection competence for a period of 5 years or for radiographers extensively working with industrial radiography a maximum of 10 years. After this period or when it is considered necessary, the radiographer has to reattend the course.

Only radiation protection courses recognized by the national radiation protection authority will be accepted as fully qualifying.



ANNEX V

PROGRAM FOR PERIODIC CHECKING OF GAMMA RADIOGRAPHY APPARATUS

The items of a gamma radiography apparatus specified below - intended for use in connection with gamma radiography - shall be submitted for periodic checking and service.

1 The projection sheaths and remote control cables and sheaths

2 Exposure containers (shielding)

3 Source holders

The radiation protection officer shall ensure that the apparatus is checked. This work shall only be performed by companies being licensed to perform such work. Whenever possible a plate shall be attached to each checked item showing when the latest approved check was performed.

Full documentation concerning every periodic check of all items of the apparatus shall be available at the licensee's premises. Any item of the apparatus which has not been checked and serviced within the prescribed time shall be regarded as unuseable and shall not be used.

1. Projection sheath and remote control

1.1 The projection sheath shall be checked at least once a year and the following checks shall be made:

1. The sheath including the connecting device shall not be damaged.

2. The sheath including the connecting device shall not be worn out or aged, e.g. in such a way that it has become brittle or cracked.

3. The connecting device to the exposure container shall function correctly.

4. The protective covers shall be undamaged and attached in the specified manner.

5. The inside of the projection sheath shall be undamaged and clean.

1.2 The remote control cable shall be checked at least once a year and the following checks shall be made:

1. The cable shall not have damaged strands; such damage occurs most frequently adjacent to the connection to the source holder.

2. The cable shall not be bent. The cable must be replaced if it is bent to such an extent that it cannot be straightened without the use of tools.

3. The cable shall be clean, properly lubricated and free from corrosion.

4. The connecting device shall be undamaged.

5. The connection to the source holder shall have the correct dimensions. The joint between the control cable and the source holder shall have been tested to withstand a force of 400 N.

Damaged remote control cables shall be replaced.



1.3 The remote control sheath shall be checked at least once a year and the checks shall be the same as for projection sheaths specified in 1.1.

1.4 The control mechanism shall be checked at least once a year and the following check shall be made:

1. The control mechanism shall be dismantled to such an extent that it is possible to check for excessive wear or damages that would endanger correct operation.

1.5 A check shall be made to ensure that the remote control system functions faultlessly.

2. Exposure container (shielding)

The exposure container shall be checked each time the radioactive source is changed or at least once a year.

The checking may be carried out with the container loaded or unloaded.

The shielding material, the shutter and the locking mechanism may not be dismantled in connection with this checking.

The following checks shall be made:

1. The container shall be marked in accordance with the specifications in 5.1.20 given in the requirements for gamma radiography apparatus. The isotope plate shall be in place only if the container is loaded.

2. The marking plate shall be legible and firmly attached.

3. The container shall not show any signs of external damage that can affect the functioning or the shielding properties (e.g. deformation), and shall be complete.

4. The exposure container shall be dismantled to such an extent that it is possible to check internal parts for excessive wear or damage. Especially the internal tubing shall be checked for wear caused by the source holder.

5. No screws or nuts shall be loose or missing.

6. The connections to the projection sheath and the remote control cable and sheath shall be clean and undamaged.

7. The connector on the back of the source holder shall be undamaged and clean and shall have the correct dimensions.

8. The source holder shall not be contaminated.A wipe test shall be made to verify this.

9. The shutter or locking mechanism (as relevant) shall not show signs of external damage.

10. The shutter or locking mechanism (as relevant) shall function faultlessly.

11. The colour codings or other markings on the shutter or locking mechanism (as relevant) shall be clean, undamaged and easily seen.

12. The locking device shall function faultlessly.

13. The protective covers shall be undamaged and attached in the prescribed manner.



3. Source holder

3.1 Source holders containing Ir-192 sources shall be replaced when necessary and after two years of use at the latest. In order to make it possible to make a check on each source holder, all source holders shall be provided with individual markings. If this marking cannot be read when the source holder is in the exposure container, a record shall be kept showing which source holder is in each exposure container and when the source holder was put into use. If the marking can be read when the source holder is in the exposure container, the record need only show when the source holder was put into use. Source holders which are always replaced together with the source need no individual marking.

3.2 Source holders containing Co-60 shall be replaced when a new source is loaded. If a source is not replaced within a period of 5 years, checks shall be made in accordance with points 1,5 and 7 under 3.3 after a maximum of 5 years. Source holders shall not be used for a period exceeding that specified by the manufacturer and source holders for which no time is specified shall be replaced after a maximum of 15 years.

3.3 Each time a source is loaded into the apparatus the following checks shall be made:

1. The exposure container shall contain the correct source holder.

2. The source holder shall not be too old.

3. The source holder shall be marked so that it can be identified.

4. The correct type of source holder shall be used .

5. The source holder shall be undamaged.

6. The source shall not leak. The leak test should be carried out according to the ISO/TR 4826 and the results given in a leak test certificate.

7. The leakage radiation from the exposure container shall be checked after each loading of a new source.

3.4 The person who performs the loading of a new source shall supply information concerning which source was fitted into the exposure container.

4. Documentation

4.1 All the information specified above shall be given in writing.

4.2 All documentation concerning the periodic checking shall be available for the national authority during inspection.



ANNEX VI

CONTINGENCY PLAN FOR RADIATION INCIDENTS

A contingency plan describing procedures to be followed in case of radiation incidents shall be prepared by each licensee. The contingency plan should comprise the following:

1. Immediate action to be taken in order to prevent excessive radiation doses.

2. Internal and external notificaton procedures.

3. Procedures for dealing with the incident bringing the situation back to normal.

4. Evaluation of the incident, finding causes and estimating consequences.

5. Medical examination.

6. Preparation of a detailed report of the incident for the national radiation protection authority.

GAMMA RADIOGRAPHY APPARATUS

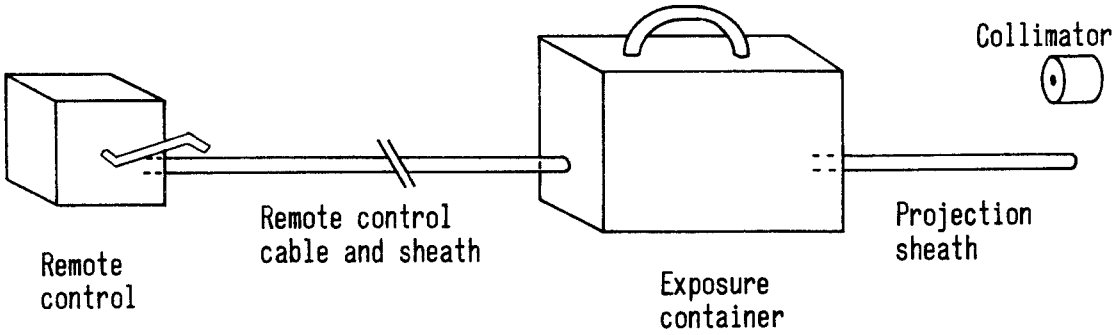


Figure 1

X-RAY EQUIPMENT

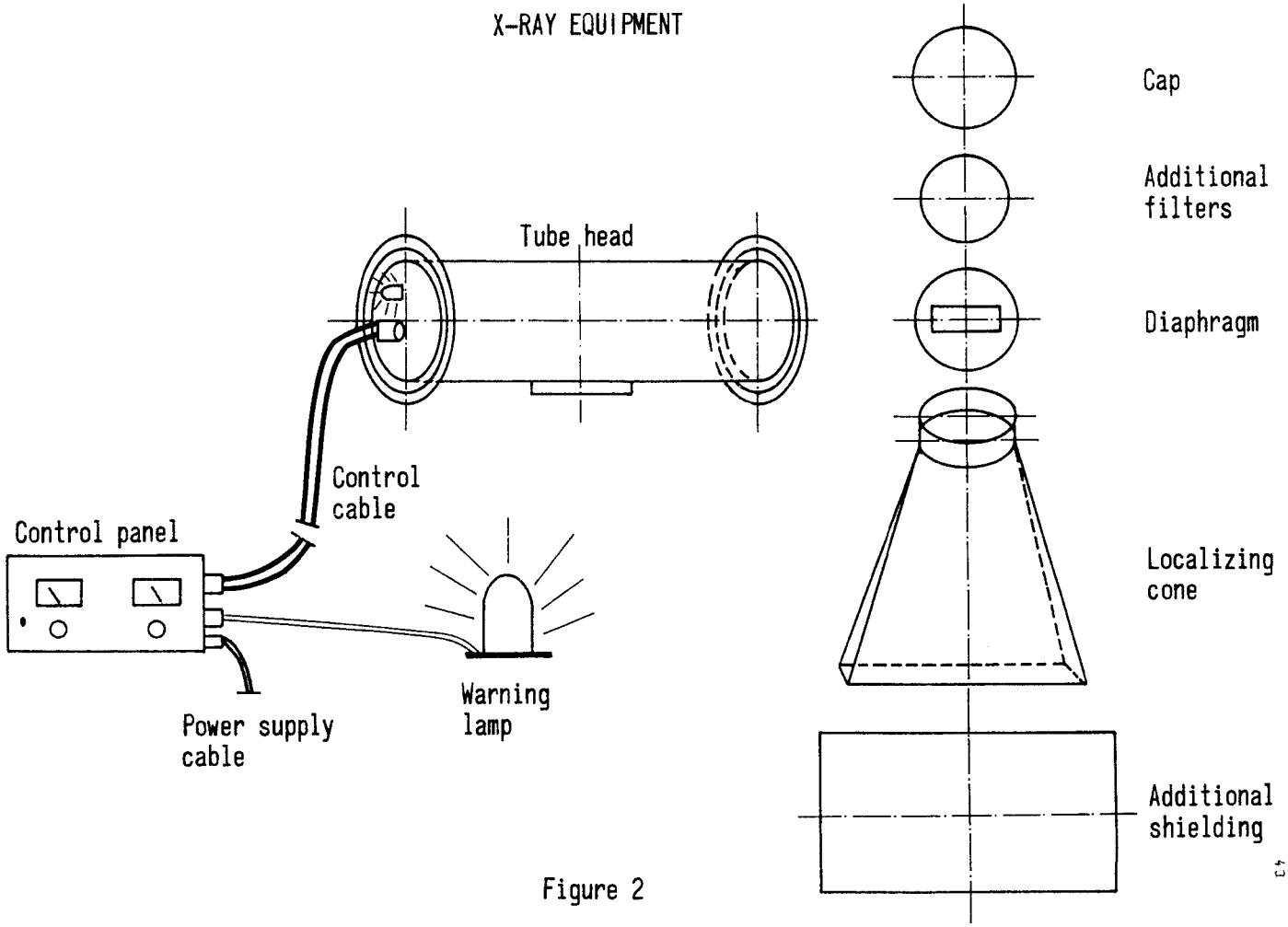


Figure 2