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GOVERNMENT OF INDIA

AERB SAFETY GUIDE

HANDLING OF RADIATION EMERGENCIES IN INDUSTRIAL RADIOGRAPHY

ATOMIC ENERGY REGULATORY BOARD

Handling Of Radiation Emergencies In Industrial Radiography

Issued on : March 31 1989

Atomic Energy Regulatory Board,
'Vikram Sarabhai Bhavan'
4th floor, Anushaktinagar,
Bombay – 400 094.

Price :

Orders for the copies of this Guide should be addressed to:

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FOREWORD

The wide-spread utilisation of ionising radiations in multifarious applications – in industry, medicine, agriculture and research – has brought in its wake the need for exercising regulatory control to ensure safety both of the user and of the general public. The Atomic Energy Regulatory Board (AERB) constituted by the Government of India in November 1983, is entrusted with the responsibility of developing and implementing appropriate regulatory measures aimed at ensuring radiation safety in all applications involving ionising radiations. One of the major objectives of AERB is to develop and publish specific codes, guides and manuals which deal with radiation safety aspects of various applications of ionising radiations. Such codes and guides cover the entire spectrum of operations starting from planning, design and installation of radiation equipment to their ultimate decommissioning/ disposal.

Accordingly, AERB has constituted Advisory Committees which will review the codes and guides developed by AERB. An Advisory Committee on Codes and Guides for Industrial Applications of Radiation has been constituted as follows.

1.	Dr. G. Venkataraman (Chairman)	... Division of Radiological Protection, Bhabha Atomic Research Centre, Bombay.
2.	Shri R.R. Wamorkar	... Radiation Technology Division, Bhabha Atomic Research Centre, Bombay.
3.	Shri E.B. Ardhanari	... Walchandnagar Industries, Walchandnagar.
4.	Shri A.K. Lahiri	... Larsen & Toubro Ltd., Bombay.
5.	Shri A.S. Prasad	... Tata Iron & Steel Co. Ltd., Jamshedpur.
6.	Shri S.K. Bose	... Regional Research Laboratory, Bhopal.
7.	Dr. I.S. Sundara Rao	... Atomic Energy Regulatory Board Bombay.
8.	Dr. D. Singh (Member-Secretary)	... Atomic Energy Regulatory Board Bombay.

Experience during the last few years indicates that accidents and over-exposures are still occurring in industrial radiography work and that could easily be avoided. Accidents occur primarily as a result of failure to monitor sources properly, the improper handling of sources, faulty or badly maintained radiography equipment, poor communications and violation of stipulated safety provisions to carry out radiography work. The Atomic Energy regulatory Board has prepared a safety guide entitled "Handling of Radiation Emergencies in Industrial Radiography" to provide information to the users of radiography equipment on handling of radiation emergencies that may arise during various stages of industrial radiography work including transport of industrial radiography sources in public domain.

The first draft of this document was prepared by Shri A.U. Sonawane of AERB. The report of the Task Group-IV on Review and Analysis of Unusual Occurrences in Non-DAE Institutions, which was issued in 1986 by AERB, mainly formed the basis in preparation of this document.

(A.K. De)
Chairman,
Atomic Energy Regulatory Board

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1. INTRODUCTION

1.1 **Purpose and Scope**

The purpose of the guide is to provide information to the users of radiography equipment on handling of radiation emergencies that may arise during various stages of industrial radiography work including the transport of industrial radiography sources in the public domain. This guide also outlines measures to prevent/ minimise occurrence of such emergencies in industrial radiography work.

This document does not include neutron radiography using a subcritical assembly or nuclear reactor.

1.2 **Explanation of Physical and Radiological Terms Used**

1.2.1 Certified Radiation Workers: Radiation workers who possess the qualification and training prescribed by the Competent Authority and whose appointment by the employer is approved by the Competent Authority.

1.2.2 Collimator: A device used for restricting the useful radiation beam to a specific direction and size.

1.2.3 Competent Authority: An officer or authority appointed by the Central Government by notification under Radiation Protection Rules, 1971.

1.2.4 Contamination: The presence of a radioactive substance or substances in or on a material or in a place where they are undesirable or could be harmful.

1.2.5 Control Console: Panel having controls and indications for tube potential, current, exposure time of the X-ray tube and any other parameters.

1.2.6 Emergency: Radiation incident leading to unforeseen circumstances where the radiation exposure to workers and members of the public is not under control and may lead to potentially hazardous situation.

1.2.7 Industrial Radiography Institution: The institution carrying out industrial radiography operations.

1.2.8 Manipulator Rod: A rigid or hollow rod normally of two metre length for remote handling of source holder (pencil).

1.2.9 Non-Stochastic Radiation Effects: Radiation effect for which a threshold exists above which the severity of the effect varies with the dose.

1.2.10 Radiographer: A radiation worker who performs industrial radiography operations employing radiation sources, who meets the qualifications specified for radiographer in para 13 (i) of schedule **GSR 735, 30 January 1980** and who possesses a valid certificate duly issued or recognised by the competent authority for this specific purpose.

1.2.11 Radiography Exposure Device: An exposure device or an equipment containing radiation source employed for industrial radiography operations.

1.2.12 Radiography Equipment: It comprises a radiography exposure device, source drive system or remote control or cranking unit, guide tube, manipulator rod, collimators, X-ray machines, accelerators, control console and other machines employed for industrial radiography work.

1.2.13 Radiological Safety Officer: A person who possesses valid RSO's certificate duly recognised or issued by the competent authority for this specific purpose and who further meets the qualifications specified for RSO in para 13 (i) of schedule **GSR 735, 30th January 1980,** entitled "The Industrial radiography (Radiation Surveillance) Procedures" published in the Gazette of India, July 12, 1980 pp. 1505-1509.

1.2.14 Site-in-Charge: A person who is so designated by the employer and who possesses a valid certificate for site-in-charge duly recognised or issued by the competent authority for this specific purpose and who further meets the qualifications specified for site-in-charge in para 13 (i) of schedule **GSR 735, 30th January 1980,** entitled "The Industrial Radiography (Radiation Surveillance) Procedures" published in the Gazette of India, July 12, 1980 pp. 1505-1509.

1.2.15 Source (Radiation Source): A radioactive substance which spontaneously emits ionizing radiation.

1.2.16 Source Drive System (Remote Control or Cranking Unit): Flexible cable system to drive the source holder to the desired position in a guide tube.

1.2.17 Source Holder: An assembly consisting of an encapsulated radioactive source pellet suitably encased, and, sometimes, a shield plug, with provision for attachment to a radiography exposure device or manipulator rod or flexible cable of source drive system.

1.2.18 Source Pellet: Radioactive source sealed in metallic capsule made of stainless steel or Al-Mg alloy. (The metallic encapsulation serves to absorb the beta radiation emitted by the radioactive source and it also prevents chances of contamination).

1.2.19 Stochastic Radiation Effects: Radiation effects, the severity of which is independent of dose and the probability of which is assumed to be proportional to the dose without threshold at the low doses of interest in radiation protection.

1.2.20 Survey Meter: An active device or instrument used for detecting radiation fields and measuring exposure or exposure rate.

1.2.21 Transport Index: A number expressing the maximum radiation level at 1 metre from the external surface of the package measured in mrem/h (1mrem/h = 0.01 mSv/h).

1.2.22 X-ray Cable: The cable connecting the control console and X-ray tube.

1.2.23 X-ray Tube: A vacuum tube in which X-rays are produced by a cathode ray beam incident on the anode (target).

2. GENERAL RADIATION PROTECTION CRITERIA IN RADIATION EMERGENCIES

Under normal or routine conditions, the aim of radiation protection is to prevent detrimental non-stochastic effects (or immediate radiation effects) and to limit the probability of occurrence of stochastic effects(or late effects which usually manifest after some years), to an acceptable level. This aim is achieved by the system of dose limitation (i.e. justification, optimisation and compliance with dose limits). This dose limitation system does not apply in emergency situations, when the source of exposure is not under control.

Radiation emergencies should be handled or managed in a manner such that the radiation exposure to radiation workers and members of the public is As Low As Practicable. Hence while handling the emergency situations, exposure of any part of the body should be avoided/reduced by –

i) limiting the time spent near the source
ii) keeping distance from the source and
iii) interposing shielding.

General criteria of radiation protection in case of emergency is to prevent or minimise the consequences of radiation injuries to the staff and members of the public in a manner such that risk incurred by the radiation workers and the general public is limited to a value acceptable to the society.

In the event of an emergency, priority should be given to avoidance of exposure to members of the public. Following are the dose limits specified for certified radiation workers with a view to ensure that no certified person is laid off from radiation work.

i) While attempting to handle an emergency, all certified radiation workers should share the exposure among themselves in such a way that no individual receives more than 5 mSv (500 mrem), whole body exposure during the operation.
ii) If RSO is the only person available at the site, he should ensure that his exposure does not exceed 100 mSv (10 rem), whole body exposure during the operation.

In industrial radiography, all emergencies at sites and enclosures can be handled, with proper planning, at exposure levels far below the values given above. Only in cases where the public is likely to receive high exposure if immediate actions are not taken, the above mentioned levels may be received while handling emergency operations.

3 RADIATION EMERGENCIES

3.1 Probable Causes of Radiation Emergencies in Industrial Radiography

Radiation emergency or an off-normal situation in industrial radiography work may arise due to –

i) malfunctioning of the radiography exposure device or source drive system

ii) failure of the source to come back to the safe storage position after the termination of exposure

iii) loss of source.

A radiation accident poses a severe radiation hazard during field radiography operations. Damage to the radiography exposure device or to the source holder occurs during use mainly because of improper positioning of the exposure device/source holder when used at a height. In the event of loss of source holder there is every possibility of inadvertant excessive radiation exposure to uninformed persons. In case of X-ray machines/accelerators, the probability of occurrence of emergency situation is less mainly because of two reasons –

i) the working period (exposure time) with X-ray machine is limited and

ii) X-ray machines do not pose a radiation hazard when not in operation.

Hence chances of occurrence of emergencies while carrying out radiography work by employing X-ray machines are rare. However preventive measures are outlined in section 4.2 of this guide.

Radiation emergencies in industrial radiography may occur under the following scenarios :

a. Improper or defective source holder locking device which might not hold the source holder firmly inside the exposure device, thus resulting in the loss of source holder either during use or transfer or storage.

b. A defective manipulator rod (bent rod or improper threading) or improper coupling between the source holder and the manipulating device might result in the loss/fall of the source holder during use or transfer.

c. Whenever the radiography equipment is left unattended at the site, unauthorised persons may either tamper with the source holder (pencil) or steal it thus resulting in damage or loss of the source holder (pencil).

d. In case of remotely operated exposure devices, improper coupling system or sharp bends and kinks in the guide cable or improper functioning of the source drive system and sagging of the source drive system with exposure device (i.e. source drive system is not lying as straight as possible with the exposure

device) may lead to non-return of the source holder to the safe position into the housing or the source holder gets stuck up in the guide tube outside the housing.

e. Exposure devices and source drive systems are not securely positioned by suitable supporting or fastening devices when used at a height.

f. Falling of heavy objects on the source drive cable or source guide tube during use, causing damage to the source drive cable or source guide tube.

g. Non-compliance with recommended procedures while transferring gamma or neutron radiography source holder from transport container to exposure device and from exposure device to transport container. This is particularly important while transferring small size neutron sources such as $^{252}C_f$ and big size sources such as ^{241}Am-Be

h. In case of X-ray machines/accelerators, emergency situation may arise due to failure in the electrical or mechanical interlocking system used for door of the enclosure or improper functioning of the control console.

3.2 Incidents in Industrial Radiography

A number of major incidents have taken place in the use of gamma radiography equipment in industrial radiography institutions. In case of remotely operated exposure devices most of the incidents have been on account of source holder getting stuck up in the guide tube or collimator of the exposure device. In such incidents persons can get very high exposure to hands as well as to whole body causing severe radiation injuries. Improper shutter mechanism of teleflex exposure devices result in severe damage to the source holder leading to the contamination of guide tube and the surrounding area. It has been observed that falling of the source holder and its consequent loss or damage occurs mainly when the radiography testing is to be carried out on an object situated at a few metres above the ground. When such a source holder is handled by any unauthorised person present at a site, a radiation burn on skin can occur. These incidents are mainly due to improper maintenance of the radiography exposure devices, non-observance of check procedures and violation of operational procedures.

3.3 Probable Causes of Radiation Emergencies in Transport of Industrial Radiography Sources

With the increasing use of radiation in industries, movement of radioactive materials from one place to other has increased. Hence it is essential to take appropriate measures to ensure that all the safety precautions related to safe transport are duly complied with.

The safety in transport of radioactive materials in public domain is regulated through strict controls instituted by the competent authority in the design and fabrication of packages and by specifying various safety requirements such as labelling and marking, operational controls during storage in-transit and emergency provisions to minimise consequences of incidents. The safety requirements stipulated by the competent authority are based on international regulations such as those of IAEA (International Atomic Energy Agency), ICAO (International Civil Aviation Organisation), IMO (International Maritime Organisation) etc. The strict compliance with the regulations/safety requirements has led to a good record of safety. However, there have been some serious transport incidents in the country because of negligence on the part of the consignor and disregard of the recommended safety procedures.

Transport emergencies may occur under the following scenarios:

[The outer container (may be sturdy wooden box) containing the shielded container (exposure device/lead pot) housing the source holder is called PACKAGE.]

a. The outer container is not sealed properly and source holder loaded in the shielded container is not properly locked.
b. The source holder is not properly secured in position and is not immobilised within the package.
c. Gross negligence in proper monitoring of the surface dose rate of the package prior to its despatch.
d. Tampering with the package or removal of the source holder (by unauthorised persons) due to inadequate or absence of proper labelling and marking on the package.
e. Carelessness in handling the package.
f. Disregard of the recommended transport safety procedures.

3.4 Transport Incidents

There have been a number of transport incidents reported causing excessive radiation exposures to the members of the public. In one of the serious transport incidents, source holder was found in guide tube of the teleflex exposure device which was transported all the way to Isotope Division, BARC, causing significant exposure to the members of the public and cargo handlers. This incident had happened only due to negligence in monitoring the package prior to its despatch. In a few incidents, package was tampered with and source holder was removed, resulting in avoidable exposure to the individuals and members of the public. Causes of these incidents were improper labelling and absence of warning legends on the packages. In most of the transport incidents it was observed that the source holder was lying just outside the lead pot, due to carelessness of the consignor who did not tighten the side screw of lead pot.

4. MEASURES TO PREVENT RADIATION EMERGENCIES

4.1 **Gamma Ray Radiography**

4.1.1 Ensure proper coupling between the teleflex cable and the source holder and also between the exposure device and guide tube. These should be physically verified prior to the operation of the unit. Before coupling, ensure that teleflex cable and guide cable are free from cuts, kinks, and dents and end fittings are tightly connected.

4.1.2 Avoid sharp bend (less than 90 degree angle or bend radius less than 50 cm) either in the driving cable or in the guide tube in order to facilitate the smooth and trouble-free movement of the source holder through the guide tube.

4.1.3 The source holder must never be driven under force. Operator should count the number of turns to the handle of source drive system required to reach the exposure position. Hence any deviation from the normal count will indicate a defect in the guide tube.

4.1.4 Operational check procedures for teleflex type exposure device as stipulated in AERB safety guide Nos. SG/IN-1 and SG/IN-2 must be strictly followed before using the exposure device on radiography site. For smooth functioning of the exposure device/source drive system, suitable lubricating agents like petrol, chlorothene or compressed dry air (15 Psi max.) can be used.

4.1.5 All exposure devices, source drive systems, projection accessories and handling devices should be periodically inspected by the RSO or Site-in-Charge for their proper functioning. The frequency of inspection can be decided depending on the work load. Careful attention has to be given to any change in colour of the cable at any spot as it may indicate impending brittle fracture. Defective equipment should not be put into operation unless the defect is rectified.

4.1.6. The shielding integrity of radiography exposure device must be regularly checked. Any defect in the exposure device must be rectified immediately by a person duly authorised for the purpose by the competent authority. The licensee must not undertake any repairs/modifications to radiography exposure devices. However some minor repairs such as mending hinges of the shutter, the source holder arrester lock etc. in IRC-2 or IRC-4 exposure devices and some minor repairs in remotely operated exposure devices are permitted. Exposure devices must not be repaired with the source holder in it. The source holder must be unloaded into a temporary source container (such as lead pot) prior to undertaking the repairs.

4.1.7 The exposure device should be operated only by a trained radiographer/operator.

4.1.8 A wide range survey meter (0-5 R/h) should be available at the radiography site to confirm the safe return of the source holder to the exposure device and its proper storage inside the exposure device.

4.1.9 Radiation monitoring instruments/survey meters should be available in proper working condition. These should be calibrated once in every two years in Division of Radiological Protection, BARC. A log book should be maintained in which all the relevant entries regarding checking and calibration should be made.

4.1.10 All radiography exposures should be planned in advance and executed in the minimum possible time. In case of manually operated exposure devices, trial operations, if necessary, with a dummy source holder should be made so as to minimise the time of operation.

4.1.11 The radiography work should be carried out only under the supervision and guidance of RSO/Site-in-Charge. In case of Teleflex type radiography exposure devices, the RSO should be familiar with the manuals, operation and maintenance of the exposure devices under use.

4.1.12 No attempt should be made to rectify the defects in the absence of the expert guidance.

4.1.13 Gamma zone monitor should be installed for enclosed installations where remotely operated exposure devices are used.

4.1.14 All exposure devices, which are beyond repair may be disposed off as a scrap metal and prior approval from DRP, BARC has to be sought before doing so.

4.1.15 Emergency procedures as outlined in section – 5 of this guide should be clearly written by RSO in bold capital letters to deal with any accidental situation. These procedures should be conspicuously displayed in strategic locations at the working sites.

4.2 X-ray Radiography

Unlike radioactive materials which continuously emit radiation, X-ray machines can be switched ON or OFF at operator's will. Because of this advantage the probability of occurrence of emergency situation is less in X-ray radiography. During the operation, the dose rate from the X-ray machine may be much higher than from industrial isotopic sources.

The general principles which apply to the control hazards from X-ray (or accelerators) radiography are as follows :

4.2.1 Whenever practicable, radiography by X-ray should be carried out within a shielded enclosure. Radiography with accelerators should always be carried out inside the shielded enclosure.

4.2.2 The control console for the X-ray machine/accelerator is to be located outside the radiography enclosure alongwith a locking provision to prevent the use of the X-ray machine/accelerator by unauthorised person and all equipment operations should be preferably done from the control room.

4.2.3 A suitable electrical or mechanical interlocking system for the door should be provided so that radiation beam cannot be made 'ON' when the door is open.

4.2.4 For the protection of persons accidentally shut inside the enclosure. a means of stopping exposure and communication should be provided to enable them to summon help.

4.2.5 In case of high energy X-ray machines, zone monitor with visible and audible warnings must be provided near the entrance of radiography area.

4.2.6 The radiation symbol and a legend "**RADIATION : KEEP AWAY**" in English as well as in local language along with a flashing red light must be posted at the entrance of the radiography room.

4.2.7 Technical as well as administrative procedures to be followed in the event of emergency must be prominently displayed near the control panel.

4.2.8 If two or more X-ray machines are installed in the same room, it should be ensured that only one machine is operated at a time.

4.2.9 The setting up of the objects, films etc. for radiographic inspection must be duly completed before starting the exposure.

4.2.10 Wherever possible, the radiation beam should be directed towards areas of minimum occupancy. The beam must not be pointed towards the doors, windows and the control panel and the beam limiting devices like collimators must be used wherever applicable.

4.2.11 In field radiography, the cable length between the tube head and the control console must not be less than 20 metres and the operator must make use of the full length of the cable while energising the X-ray tube.

4.2.12 All tools and handling devices required for routine or emergency use in the radiography room must be readily available in good condition in the control room of the radiography installation.

4.2.13 All personnel who operate or use X-ray machine should be given

adequate training in the correct operating procedures and in the hazards involved.

4.2.14 The radiography equipment must be kept locked when not in use. Unauthorised access to this equipment must be strictly prohibited.

4.3 Neutron Radiography

4.3.1 Whenever neutron generators are used for radiography, following precautions should be observed.

i) The neutron and gamma alarms are in proper position and in good working condition.

ii) All interlocks are in good working condition.

4.3.2 Portable containers should be checked for proper and smooth functioning of locking system prior to their transfer from one place to another.

4.4 Transport of Radioactive Materials

4.4.1 The radioactive source should be transported only in a transport container (such as lead pot or exposure device, also called shielded container) which has been approved by the competent authority.

4.4.2 The source holder must be loaded in the shielded container by means of the manipulator rod or drive cable to place it properly within the shielded container.

4.4.3 The source holder must be fastened within the shielded container by means of source holder arrester screw or the appropriate locking mechanism incorporated in the design of the shielded container.

4.4.4 The lid or shutter of the shielded container must be securely closed and locked so that the source holder would not be released during the transport.

4.4.5 The shielded container must be loaded in an outer container such as a sturdy wooden box provided with spacers within for preventing free movement of the shielded container. Outer container should be in sound condition.

4.4.6 The outer container must be closed and locked and the package must be provided with strong lifting handles.

4.4.7 An appropriate radiation survey meter calibrated and in working condition should be used to monitor the radiation levels outside the radioactive package and to determine the transport index of the package.

4.4.8 The address of the consignor and the consignee must be clearly and unambiguously written on the exterior of the package.

4.4.9 The package must not be transported as personal luggage. It should be booked as cargo by road, rail, air or ship. Also the appropriate category label must be affixed on the two opposite sides of the exterior of the package.

4.4.10 While booking the cargo a certificate must be issued by the consignor to the effect that the package containing radioactive material had been properly packed, marked and labelled and the consignment is in conformity with the requirements for the safe transport of radioactive materials as stipulated in AERB Safety code No. SC/TR – 1.

4.4.11 The radioactive package should be transported by the direct route and intermediate off-loading and reloading of the package must be avoided wherever possible.

4.4.12 The consignor must instruct the carrier that the radioactive package should not be transported along with photosensitive films/plates and dangerous goods such as explosives and inflammables.

4.4.13 Prior to despatch of the package to a destination the consignee must be duly informed and it must be ensured that the consignee would be clearing the consignment without delay.

4.4.14 Categories of people involved in transport (such as handlers for loading and unloading the packages, drivers and other associated transport personnel) should be properly instructed regarding emergency measures for transport incidents.

5. EMERGENCY PREPAREDNESS PLANS AND PROCEDURES

5.1 Preparation of Emergency Procedures

Every industrial radiography institution should have written emergency procedures to deal with radiation emergencies. These procedures should be written in block letters and displayed on placards in strategic locations at each working site. RSO/ Management of the institution should prepare the emergency procedures. The following topics should be covered in emergency procedures:

1. Situations such as failure of radiographic equipment, damage to source holder or non-retrieval of source holder to exposure device, loss of source holder etc.
2. List of names and phone numbers to be contacted such as RSO/ Site-in-Charge, management of the radiography institution, managing contractors or client and Officers of Division of Radiological Protection (see Appendix-4)
3. Recovery procedures in the case of missing sources.
4. Actions to be taken if source holder is involved in fire.

5.2 Emergency Drills and Exercises

Emergency drills and exercises are very helpful in dealing with emergencies in an effective manner by proper co-ordination between radiation workers and RSO. Emergency drills should be conducted by RSO of the institution at least once in a year. Drills such as source recovery operations, familiarisation with radiography equipment, proper implementation of planned course of actions to deal with the emergencies should be conducted by employing dummy source holder and wherever not possible by drawing and sketches.

5.3 Actions by Radiation Workers in Emergency

5.3.1 Industrial Radiography

Most of the emergencies are either due to source holder failing to return to the exposure device at the termination of exposure or source holder getting stuck up or detached into guide tube, source holder falling or getting misplaced and being lost in the process. In dealing with such emergencies special emergency equipment such as pocket alarm dosimeters, lead pots, long handled wire cutters, screwdrivers, tongs etc. should be available at the site. In the event of an emergency, radiation workers present at the site must follow emergency procedures described on placard. Emergency situation should be handled only under the supervision of Radiological Safety

ASSESSMENT OF THE SEVERITY OF RADIATION EXPOSURE FROM THE SYMPTOMS EXHIBITED BY THE EXPOSED PERSON

While dealing with emergencies in industrial radiography, the likelihood of getting very high but localised dose, confined to hands should be kept in mind. The surface dose rate of a sealed source consists of two components, the dose rate due to gamma rays and that due to the electrons produced from material used to sheath the radioactive material. For instance when a point source of Co-60, Cs-137 & Ir-192 is sheathed in a capsule of outside diameter 6.4 mm with a 0.79 mm of stainless steel wall, the dose contribution due to electrons could be between 25-45 percent of gamma dose. An acute high dose to the skin leads to skin erythema, that is reddening of the skin. An exposure of about 3 Gy (300 rad) of low energy X-ray will result in skin erythema and larger exposures may lead to other symptoms such as changes in pigmentation, blistering and ulceration giving rise to lesions which leave permanent scars on skin.

Following table will help in the approximate assessment of gamma dose for persons involved in emergency.

Radioisotope	**Dose rate in mGy/sec at following distances from the source of strength 37 GBq (1 Ci)**				
	0.5 cm	10 cm	30 cm	60 cm	100 cm
^{192}Ir	55.56	0.14	0.015	0.004	0.0014
^{60}Co	144.45	0.36	0.04	0.01	0.0036
^{137}Cs	35.56	0.09	0.01	0.0025	0.001

1 mGy = 100 mrad

GUIDANCE FOR MEDICAL MANAGEMENT

One of the important duties of RSO is to maintain complete and up-to-date medical records of all radiation workers in the institution. RSO should take such medical records of the individuals exposed to radiation in emergency situation to a qualified physician.

Following information is essential for management of the exposed person.

1) Nature of accident
2) Date and time of accident (if known)
3) Radiation involved
4) Evidence of symptoms of whole body exposure (anorexia, nausea, vomiting, diarrhoea)
5) Possibility of contamination by radioactive source
6) History of transient erythema
7) Presence of fixed erythema, epilation, oedema or evidence of skin burns.

The physician should conduct the following investigations and procedures to examine exposed individual.

a) Reassure the exposed individual, obtain history of any complaint like pain, tingling, itching or vomiting. Ascertain if there is any discolouration of the skin (erythema).

b) In case there have been no symptoms during the initial period and history of exposure is confirmed, following observations should be done:

   i) discolouration of skin
   ii) any breakdown of the skin (ulceration) during the first three weeks of the exposure.

Following investigations should be carried out:

   i) Complete blood count must be done. It can be repeated in symptomatic individual who is vomiting. The blood count should be repeated every six hours during the first 24 hours.
   ii) Chromosomal analysis in peripheral blood
   iii) Thermography
   iv) Sperm count
   v) Culture and AST (Antibiotic Sensitivity Test)
   vi) Special coloured photography.
   vii) Vascular scintigraphy.

c) Specific treatment:

Mild erythema: Skin may become dry and start itching in three to four weeks. A bland lotion or steroid ointment can be applied on affected part. No tight clothing should be worn on the affected part.

If there are no detectable clinical symptoms of radiation sickness, the exposed individual should be convinced poperly to remove any fear about radiation hazards. In case the radiation injuries and symptoms attributed to emergency radiation dose are serious, exposed individual should be taken to physician attached to any of the Atomic Energy Hospitals or DRP, BARC, Bombay for further guidance.

NAMES AND PHONE NUMBERS TO BE CONTACTED IN THE EVENT OF EMERGENCY

Name	Telephone Numbers	
	Office	Residence (if known)
1. Shri S. D. Soman Director, Health & Safety Group, BARC.	551 2601	47 2593
2. Dr. U. Madhvanath Head, DRP, BARC.	551 1917	551 1323
3. Dr. G. Venkataraman Head, IACS, DRP, BARC.	551 4910 (Ext. 2201)	—
4. Shri P. Subrahmanyam DRP, BARC.	551 2271 (Ext. 283)	—

TELEX : 011-71017 BARC IN

TELEGRAM : DRP , BARC, CHEMBUR, BOMBAY

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AERB PUBLICATIONS ON RADIATION PROTECTION

SC/MED – 1	Safety Code for Telegamma Therapy Equipment and Installations.
SC/TR – 1	Safety Code for Transport of Radioactive Materials.
SC/MED – 2	Safety Code for Medical Diagnostic X-ray Equipment and Installations.
SG/IN – 1	Radiological Safety in Enclosed Radiography Installations.
SG/IN – 2	Radiological Safety in Open Field Industrial Radiography.
SC/MED – 3	Safety Code for Brachytherapy Sources, Equipment and Installations.
SM/MED – 1	Atlas of Reference Plans for Medical Diagnostic X-ray Installations.

For obtaining the above publications, inquiries may please be sent to :

Administrative Officer,
Atomic Energy Regulatory Board,
'Vikram Sarabhai Bhavan'
4th floor, Anushaktinagar,
Bombay – 400 094.

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