IAEA Post Graduate Educational Course in Radiation Protection and Safety of Radiation Sources

Intervention for Chronic and Emergency Exposure Situations

Assessment and Response during Radiological Emergency

Response at the Scene

Lecture

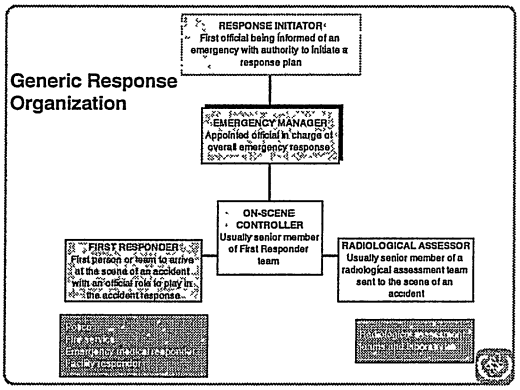
Introduction

- Radiological emergency response requires functions similar to non-radiological emergency response
- Build on existing capabilities
- The objective of this lesson is to present mean tasks to be performed at the scene of an accident by emergency responders

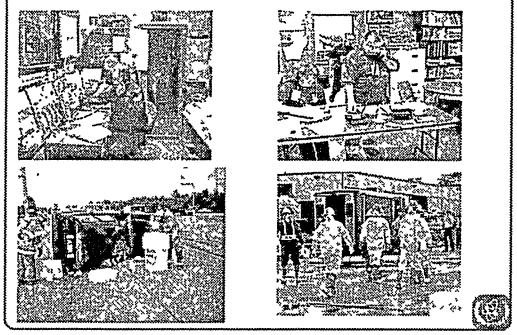
Content

- Response Initiator
- First Responder
- On-Scene Controller
- Radiological Assessor
- Communications
- Summary

Generic Response Organization



Emergency Responders



Response Initiator

- Initiates the formal response and has the authority to do so



- Examples: duty officer, emergency service dispatcher, facility radiation safety officer

Response Initiator Steps

- Obtain emergency or accident description; verify the call
- Provide initial advice to reporting person
- Alert Emergency Manager

Response Initiator

- Obtain from Emergency Manager a list of responders to be alerted/activated
- Alert and activate as required
- Record all events/actions in a logbook

First Responder

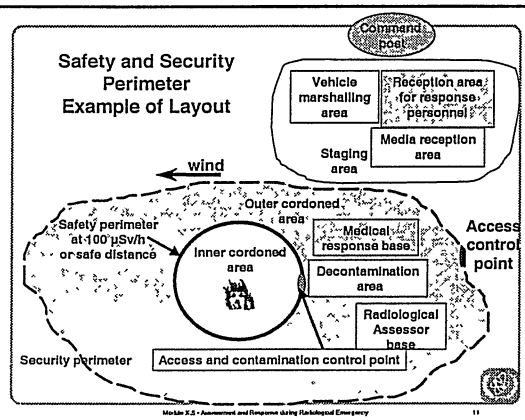
- First person or team to arrive at the scene of an accident



- Police, Fire, Emergency Medical, Facility Responder

First Responder
Police

- If first on scene, assume role of on-scene controller until relieved. If not, get briefing from on-scene controller
- Secure the accident area and assure safety of people
- Control access and egress



First Responder
Police

- Record names/addresses of those involved in the accident and those nearby
- Perform personal/equipment contamination check or request assistance from Radiological Assessor

First Responder
Fire Service

- If first on scene, assume role of On-scene Controller until relieved. If not, get briefing from On-scene Controller
- Wear dosimetry and protective clothing as required
- Use standard firefighting/spill control; minimize spread of contamination

First Responder
Fire Service

- Do not move damaged containers; avoid direct contact with damaged containers; move undamaged containers to a safe area, if feasible
- Perform personal/equipment contamination check or request assistance from Radiological Assessor

First Responder
On-scene Medical

- If first on scene, assume role of On-scene Controller until relieved; if not, get briefing from on-scene controller
- Wear dosimetry and protective clothing as required
- Perform search and rescue, assess injuries, treat life-threatening injuries immediately; remove injured from hazard area

First Responder
On-Scene Medical

- Perform radiological triage and isolate contaminated person(s) and personal belongings; provide appropriate treatment and transport
- Establish contact with Police to obtain names/addresses of involved population

First Responder
On-Scene Medical

- Inform receiving hospital of injuries, suspected radiological exposures/contamination, and identify radioactive materials, if known
- Perform personal/equipment contamination check or request assistance from Radiological Assessor

First Responder
Facility Responder

- Alert the facility's Radiological Assessor and facility management
- Use standard first aid (if qualified) on injured; remove injured from hazard area as soon as possible; do not delay life saving actions due to presence of radiation
- Confine and mitigate the hazard

First Responder
Facility Responder

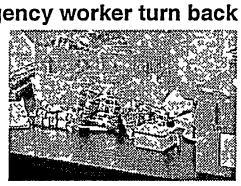
- If on-site and/or off-site emergency responders were alerted, remain at scene until they arrive. Brief On-scene Controller of situation
- If facility radiological expertise and resources are available, provide assistance to emergency responders
- Perform personal/equipment contamination check or request assistance from Radiological Assessor

First Responder
Facility - X ray machines and accelerators

- Turn off electrical power; alert facility radiological assessor and management
- Perform radiation survey to confirm that the device (tube) is de-energized
- Do not move device; record device details
- Do not use the device until examined and repaired, post malfunction notice on device

Personal Protection Guide

- Applies to any member of the on-scene response team
  - General Instructions
  - Thyroid Protection
  - Emergency worker turn back guidance

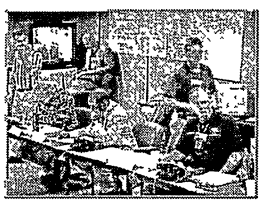


On-Scene Controller

- On-scene Controller is responsible for tactical management of response actions at the scene of an accident
- Importance of identification in the planning stage
- Decreases frequency asking "Who's in charge?"

On-Scene Controller

- Generic response steps can be divided into three parts
  - On notification
  - At the scene
  - Post-emergency



On-Scene Controller

- On Notification
  - Alert the Radiological Assessor and establish contact with the Emergency Manager
- At the scene
  - Approach scene cautiously; assess the scene; if you have survey meters measure dose rates and check for contamination
  - Remove non-essential personnel from accident area; separate suspected contaminated individuals

On-Scene Controller

- Use standard first aid methods for injured - do not delay life saving actions due to the presence of radiation
- Supervise response actions
- Ensure that emergency responders are aware of personal protection guides and that they are using appropriate precautions
- Ensure proper contamination control procedures are implemented

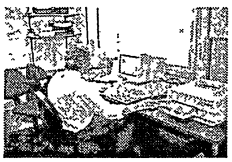
On Scene Controller

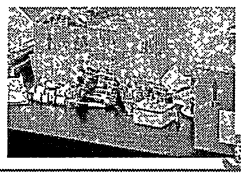
- Get regular briefings from the radiological assessor
- Adjust safety perimeter, implement protective actions approved by Emergency Manager
- Provide regular updates to Emergency Manager

- Post-emergency
  - Evaluate response, develop lessons learned, report to Emergency Manager

Radiological Assessor

- Role - assess radiological situation, survey, recommend actions for personal protection, protective action recommendations, and recovery/cleanup
- Likely Persons





Radiological Assessor

- Generic response steps can be divided into three phases:
  - On notification
  - At the scene
  - Post emergency activities



Radiological Assessor
On Notification

- Obtain briefing on radiological situation
- Perform preliminary evaluation of radiological situation
- Establish communication with the Emergency Manager; recommend initial protective actions
- Prepare necessary measuring instruments and personal protective equipment

Radiological Assessor
On Notification (Cont'd)

- Decide on necessary personal protective actions
- Instruct team(s) on personal protection; inform Emergency Manager
- Establish exposure control for emergency workers
- Brief team(s) on the current radiological situation and the tasks; dispatch team(s) to the event site

Radiological Assessor
At the Scene

- On arrival, report to the On-Scene Controller
- Approach the scene carefully with the instruments turned on; survey the entire perimeter
- Assess the radiological hazards based on the measurements
- Establish and supervise an access and contamination control point
- Establish (if needed) an area for decontamination and disposal of contaminated objects and clothing

Radiological Assessor
At the Scene (Cont'd)

- Take air samples (if air contamination suspected)
- Make sure that respiratory equipment is used, if appropriate; make decisions regarding thyroid blocking
- Supervise implementation of protective actions and control exposure
- Continuously provide radiation protection assistance to emergency responders

Radiological Assessor
At the Scene (Cont'd)

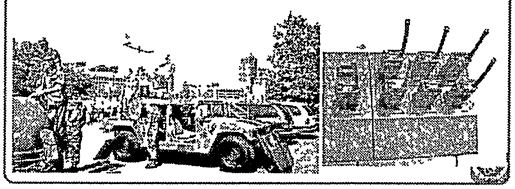
- When the primary cause of the emergency is under control AND the source is confined, AND all contamination is contained, consider the need for:
  - Recovery of the scene/removal of the radioactive material
  - Decontamination of people and equipment
  - Initial cleanup of the site and disposal of radioactive wastes

Radiological Assessor
Post Emergency Activities

- Make dose assessment for victims, emergency workers and the public
- Assess the need for longer term protective actions
- Prepare report for the Emergency Manager

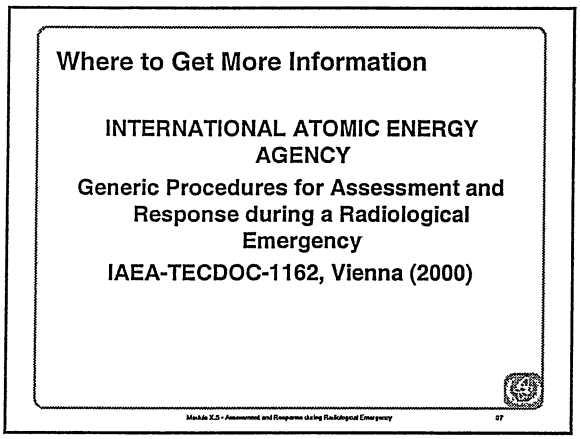
Emergency Communications

- Integrated communications system
- Communication on-scene
- Communication with the Emergency Manager



Summary

- Overview of other emergency responder tasks
  - Response Initiator
  - First Responder
  - On-scene Controller
  - Radiological Assessor
- Importance of communication links


Where to Get More Information
INTERNATIONAL ATOMIC ENERGY AGENCY
Generic Procedures for Assessment and Response during a Radiological Emergency
IAEA-TECDOC-1162, Vienna (2000)

IAEA Post Graduate Educational Course in Radiation Protection and Safety of Radiation Sources

Intervention for Chronic and Emergency Exposure Situations

Assessment and Response during Radiological Emergency

Dose Assessment Overview

Lecture

Introduction

- This lesson provides various methodologies for calculating doses and dose rates based on the type of sources or radioactive materials involved and the circumstances of the emergency situation
- The Radiological Assessor may also find the formulas and tables in this section useful in developing protective action recommendations for the Emergency Manager during the early stages of an emergency situation when information regarding the radiation source or material is readily available

Module X.5 • Assessment and Response during Radiological Emergency 2

Content

- Pathways of exposure
- Estimation of effective dose
  - Point source
  - Line source and spill
  - Ground contamination
  - Skin contamination
  - Inhalation
  - Ingestion
- Summary
- Problems

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Overview

- In the event of a radiation emergency exposure of emergency workers or members of the public may occur
- Exposure may be external or internal and may be incurred by various pathways
- The various routs by which individuals may be exposed will determine the method to estimate the effective dose

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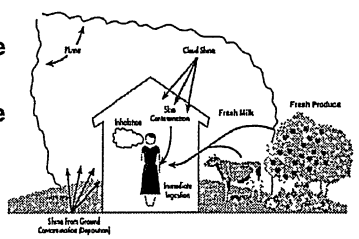
Pathways of Exposure

- External exposure
- Internal exposure



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Total Effective Dose

- Take into account all dominant routes by which individuals were exposed in an accident and sum up the contributions

- E_T = total effective dose
- E_{ext} = effective dose from external radiation
- E_{inh} = committed effective dose from inhalation
- E_{ing} = committed effective dose from ingestion

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Dosimetric Information

- Direct readings from personal dosimeters
- Dose assessments from personal dosimeters such as film badges or TLDs
- In case of inhalation: nose blows should be taken using material suitable for assessing the activity removed
- In case of ingestion: the need to collect urine and faecal samples should be considered
- The need for whole body or thyroid monitoring should be considered

Doses From External Radiation

- Where direct means of assessing doses is available, principally the use of personal dosimeters for external exposure, this should be used
- If external doses are not measured directly they must be assessed by another means

Point Source

- Possible input data
  - Activity of the point source
  - Distance from the point source
  - Exposure duration
- Output
  - Effective dose
  - Dose rate
  - Distance to a point source
  - Activity

Point Source

- The effective dose

$$E_{ext} = \frac{A \cdot CF_6 \cdot t \cdot (0.5)^{\frac{d}{d_{1/2}}}}{2}$$

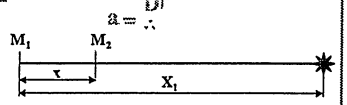
- The dose rate

$$\dot{D} = \frac{A \cdot CF_7 \cdot (0.5)^{\frac{d}{d_{1/2}}}}{2}$$

Point Source

- The distance

$$X_1 = \sqrt{\frac{\dot{D}r}{a}}$$



- The activity

$$A = \frac{\dot{D} \cdot X_1^2}{d_{1/2}}$$

Line Source (Pipe)

- Input
  - Source activity
  - Distance from the source
  - Time of exposure
- Output
  - External effective dose
  - Dose rates
  - Source activity from dose rate measurements
- Effective dose

$$E_{ext} = \frac{\pi \cdot CF_6 \cdot A \cdot t}{r}$$

- Dose rate

$$\dot{D} = \frac{\pi \cdot CF_7 \cdot A}{r}$$

- The activity

$$A = \frac{\dot{D} \cdot r}{\pi \cdot CF_7}$$

Spill

- Effective dose

$$E_{ext} = 2\pi \cdot CF_3 \cdot A_s \cdot T_e \cdot \ln\frac{X^2+R^2}{X^2}$$

- Dose rate

$$\dot{D} = 2\pi \cdot CF_\gamma \cdot A_s \cdot \ln\frac{X^2+R^2}{X^2}$$

- The activity

$$A_s = \frac{\dot{D}}{2\pi \cdot CF_\gamma \cdot \ln\frac{X^2+R^2}{X^2}}$$

Ground Contamination

- Effective dose from exposure to ground contamination can be assessed based on:
  - Comprehensive radionuclide concentrations on ground
  - Based on ambient dose rates
  - Based on marker radionuclide concentration levels
- Input
  - Radionuclide concentrations on ground
  - Ambient dose rate
- Output
  - Effective dose from deposition

Ground Contamination

- Based on comprehensive radionuclide concentrations on ground

$$E_{ext} = \sum_i C_{si} \cdot CF_{si}$$

- Based on ambient dose rate

$$E_{ext} = H_B \cdot \frac{\sum_i C_{si}^{rep} \cdot CF_{si}}{\sum_i C_{si}^{rep} \cdot CF_{si}}$$

Ground Contamination

- Based on marker radionuclide concentration levels

$$E_{ext} = C_{si}^{sim} \cdot \frac{\sum_i C_{si}^{rep} \cdot CF_{si}}{\sum_i C_{si}^{rep}}$$

- Taking into account shielding and partial occupancy

Air Immersion

- Input
  - Average concentration of radionuclides in air
  - Duration of exposure
- Output
  - Effective dose from external exposure to γ radiation from the plume
- Air immersion dose

$$E_{ext} = E \cdot \sum_i C_{si} \cdot CF_{si}$$

Skin Contamination

- Input
  - Average surface concentration of radionuclides on the skin or clothing
- Output
  - Equivalent dose (beta) to the skin
- Skin beta dose

$$H_s = \sum_i H_{si}$$

Dose From Internal Contamination

- May arise from intakes of radionuclides, primary by inhalation or ingestion
- The dose depends on
  - The activity deposited in the body
  - The energy of the emitted radiation absorbed by the organ and
  - The mass of the organ at risk
- Internal doses can not be measured directly – they have to be assessed by some other means

Inhalation

- Input
  - Radionuclide concentrations in air
  - Inhalation duration
- Output
  - Committed effective dose from inhalation
  - Committed equivalent dose to the thyroid
- Committed effective dose from inhalation

$$E_{inh} = \sum_{i=1}^{n} \bar{C}_{a,i} \cdot CF_{2,i} \cdot T_e$$

- Committed equivalent dose to the thyroid

$$H_{thy} = \sum_{i=1}^{n} \bar{C}_{a,i} \cdot CF_{1,i} \cdot T_e$$

Ingestion

- Input
  - Radionuclide concentrations in food, water or milk
  - Radionuclide concentrations in soil
  - Time of intake
- Output
  - Committed effective dose from ingestion
- Committed effective dose from consumption of food or soil

$$E_{ing} = \sum_{i=1}^{n} C_{f,i} \cdot U_f \cdot DF_{f,i} \cdot CF_{3,i}$$

Summary

- Basic methodologies for assessing individual dose from external and internal exposure were discussed
- Remember
  - In general, doses to individuals cannot be measured directly; some combination of measurement and assessment is required
  - All dominant routes by which individuals were exposed should be taken into account

Where to Get More Information

- See references on cover page

Problem 1

A 150 MBq point source of Co-60 is located 2.0 m from you. What is the dose rate at your location?

Problem 2

A very long pipe contains 0.5 GBq/m of Cs-137. 5.0 m from a pipe a technician is working for 30 min. What dose he will receive?

Problem 3

An Ir-192 source was stuck in a radiography tube – unshielded. The dose rate measured at a certain point from the source was 0.65 mGy/h. 2.0 m closer in the "line of sight" the dose rate monitor showed 0.82 mGy/h. How far is the source?

Problem 4

In the air of the nuclear medicine laboratory the following concentration of I-131 was measured 250 Bq/m^3. Two technician were working in the laboratory for 3 hours. What is the committed equivalent dose to the thyroid? What is the dose from external exposure?

Problem 5

After Chernobyl accident the environment in Europe was contaminated mainly by Cs-134, Cs-137 and I-131. In one of the country the following levels of food contamination were measured:

Food	Cs-134 [Bq/L or kg]	Cs-137 [Bq/L or kg]	I-131 [Bq/L or kg]
Milk	160	330	2000
Meat	250	470	220
Vegetables	1100	2200	5600

Problem 5 - Cont'd

What is the committed effective dose to an adult if the food was consumed for 30 days?

Consumption data

Food	Consumption data [kg/d]
Milk	0.30
Meat	0.27
Vegetables	0.07