EMERGENCY RESPONSE AND DRAFTING OF RADIOLOGICAL EMERGENCY PLAN

MMTC ASIA SDN.BHD
1330199-X

TOPIC 1

ACCIDENTS HISTORY AND LESSONS LEARNED

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Introduction

Despite considerable development of radiation safety, radiation accidents do happen

The objective of this lesson is to

- present selected cases of radiation accidents
- discuss causes and main consequences of these accidents
- present principle lessons learned

Content

- Case studies
- Lessons learned
- Conclusions
- Summary

Where Emergencies Can Occur

Almost anywhere

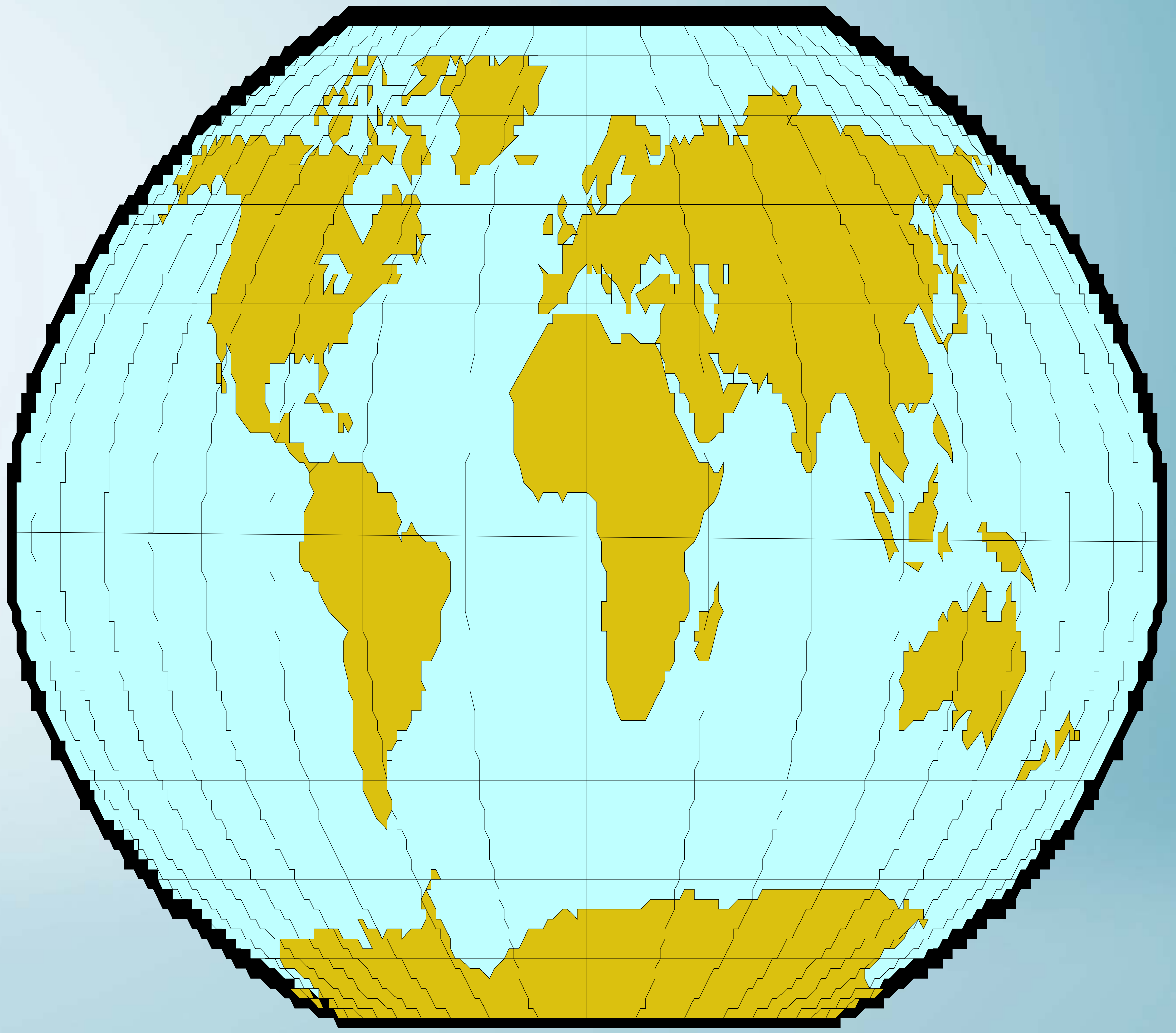
- In the field (gamma radiography sources)
- Terrorist or criminal activities
- Illicit trafficking
- In scrap yards (wrongly disposed source)
- On military premises
- Anywhere (not limited to a specific location)

Historical Facts

- ❑ What are the historical causes of radiological accidents
  - ❑ Most radiation injuries have resulted from
    - ❑ Mishandling of industrial sealed radioisotope sources
    - ❑ Inadvertent exposure to X-rays used for quality control

Case Studies

- Goiânia accident
- San Salvador accident
- Mississippi transport accident
- Kuching industrial radiography overexposure



Goiânia Accident

Brazil

Background

- Goiânia: the capital of Goiâs State, Brazil
- Population: about one million
- The accident happened in a poor section of the city, in an old abandoned radiotherapy facility

What Happened

End of 1985, a private radiotherapy institute moves to new facilities

- They forget a Cs-137 teletherapy unit in the old facility
- They do not notify the licensing authority
- The old facility is partly demolished

What Happened

September 13, 1987 two persons enter the old facility

- They remove the source assembly from the radiation head of the machine
- They take home the source assembly and try to dismantle it
- In the attempt the source capsule is ruptured
- Fragments of the source the size of rice grains were distributed to several families
- The rest of the source assembly is sold for scrap to a junkyard owner

Abandoned Radiotherapy Clinic

The Source

❑ Nuclide	Cs-137
❑ Activity (Sept.87)	50.9 TBq (1375 Ci)
❑ Chemical form	CsCl
❑ Physical form	powder
❑ CsCl mass	93 g
❑ Cs-137 mass	19.3 g
❑ Physical half-life	30 years

Discovering the Accident

- Within five days, people were showing gastrointestinal symptoms
- One of them realizes that it may be caused by the object found
- He takes the pieces to the public health department in the city
- Investigation leads to the discovery of the accident
- CNEN is notified and responds

The Response

- Monitor a large number of people
- Decontaminate
- Medical triage and treatment
- Survey a large area
- Isolate and confine contaminated areas
- If possible, decontaminate
    - Main areas, in order of priority (houses, public places vehicles, etc.)
- If not possible, destroy and remove
- Remove contaminated soil

Response Statistics

• Individuals surveyed	= 112,800
• Persons contaminated	= 271
▪ contamination on clothing and shoes	= 120
▪ internal and external contamination	= 151
• Local radiation injuries (burns)	= 28
• Hospitalization required	= 20
• Bone marrow failure	= 14
• Acute radiation syndrome	= 8
• Fatalities	= 4

More Response Statistics

- Decontamination of the city: 730 workers required
- Houses affected: 98
  - 41 evacuated
  - 6 demolished
  - 53 repaired
- Decontaminated public places: 58
  - pavements, squares, shops and bars
- Number of vehicles decontaminated: 64

More Response Statistics

- Waste storage site:
  - 20 km from the city
  - Designed to accommodate 4,000-5,000m3 of waste
- Types of waste packaging used:
  - 4,500 metal drums (200L)
  - 1,400 metal boxes (5 tonnes)
  - 10 shipping containers (32m3)
  - 6 sets of concrete packaging
- Volume of waste stored: 3,500 m3, or more than 275 construction lorry loads

The Response

- Four early fatalities
- A large number of persons contaminated
- The environment severely contaminated
- Large quantities of radioactive wastes generated
- Significant economic loss and burden
- Substantial physiological impact

Contamination Check

Looking for Hot Spots

Removing Contaminated Items

Temporary Storage Site

Lessons Learned

- Regulatory controls could have prevented this accident
- An adequate system of information is essential to avert panic
- Emergency workers should be instructed on how to convey information to the population
- Response to the psychological impact is a major element of the response strategy

Lessons Learned

- Must be prepared to work in all relevant climatic condition
  - Monitoring equipment to be used in the field should be capable of being adjusted for use in high humilities/temperatures and unstable environmental conditions
  - Personnel and equipment must be adequate for the potential harsh conditions that can be experienced (e.g. extreme high temperature)

- Prompt access to coordinated resources is an asset (this should be considered at the planning stage)
  - e.g. civil engineering infrastructure was needed for decontamination and reconstruction operations

More Lessons Learned

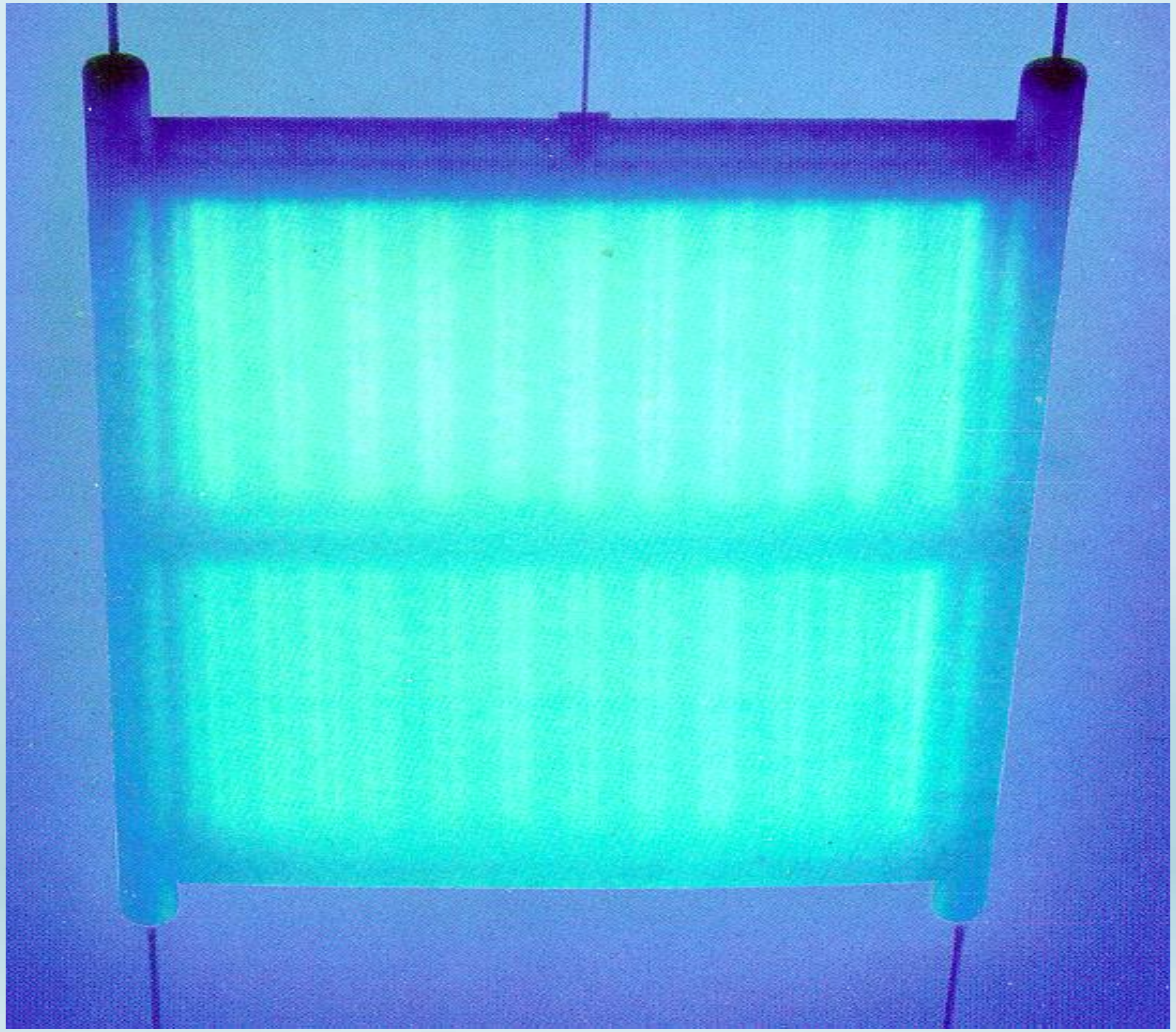
- International assistance can be timely and extremely useful
- The effectiveness of international assistance depends on the infrastructure of the country concerned
  - This should be considered at the planning stage
- Customs regulations should be amended to facilitate the import and return of goods
  - This will accelerate international assistance

Goiánia - Conclusions

- Radioactive sources taken out of the regulatory system can present a serious hazard
- Recognition by the general public of the potential danger of radiation sources is an important factor in lessening the likelihood of radiological accident
- Good plans can accelerate response and significantly reduce health impacts

San Salvador Accident

El-Salvador



Background

- Accident location: San Salvador (El Salvador)
- Facility: industrial irradiation facility
- Date: 5 February 1989
- Source: Co-60 in a movable source rack
- Activity: 0.66 PBq (18 kCi) at the time of the accident

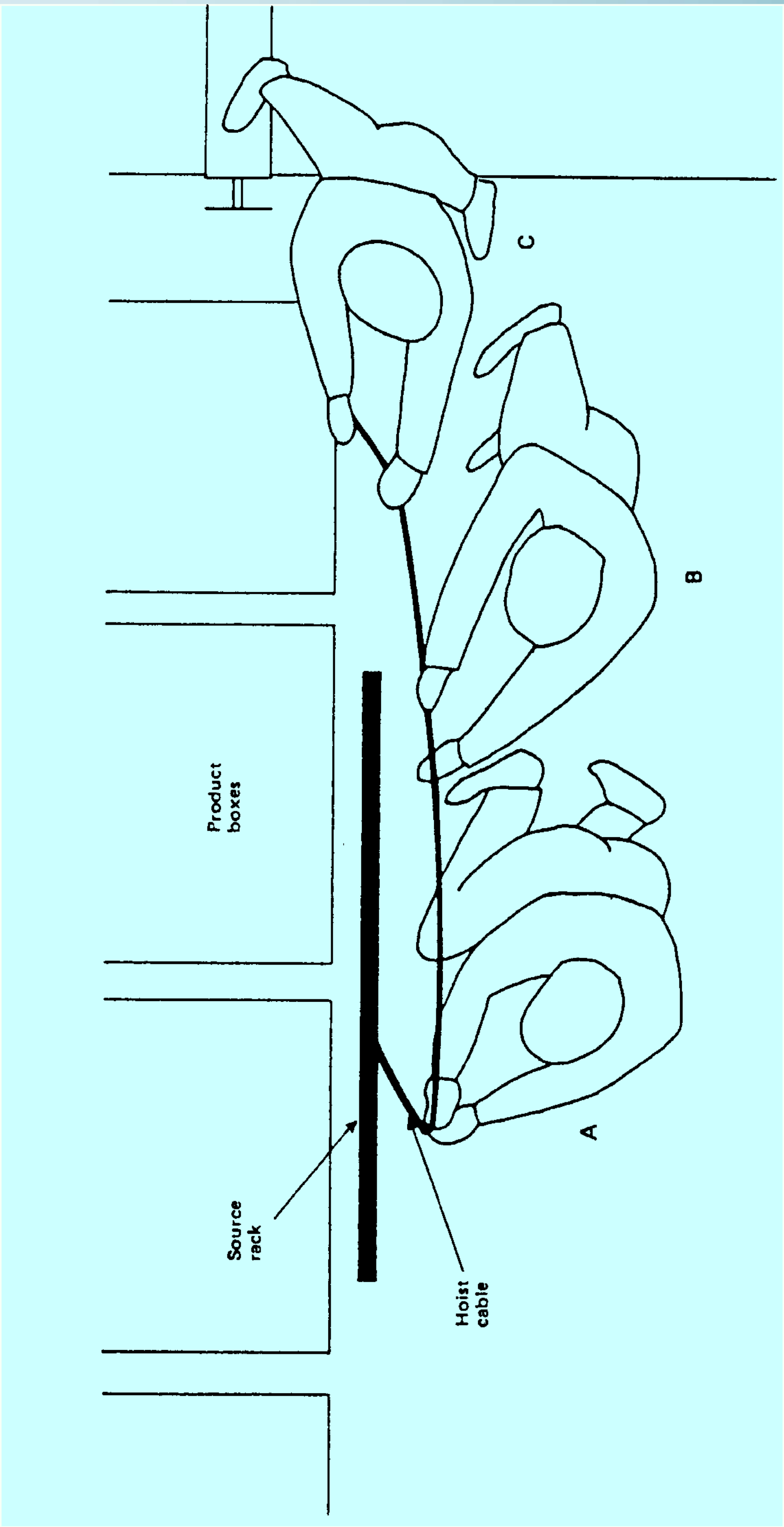
Irradiation Facility

- The product packages to be sterilized are loaded into large product boxes and moved by pneumatic cylinders around a centrally located, vertical rectangular source rack
- The source rack contains Co-60 source elements in the form of rods contained in 'source pencils'

Irradiation Facility

What Happened

- Sunday 5 February: the source rack becomes stuck in the irradiation position “ON”
- The operator bypasses the irradiator’s already degraded safety systems and enters the radiation room, soon followed by two other workers, to free the source rack manually



What Happened Next

- On the following Thursday or Friday, some pencils fell from the upper source module into the pool

- Four of the pencils from the top module, an active source pencil and tree dummy pencils, were subsequently found to have fallen into the radiation room; the others has fallen into the pool

Consequences

Three workers developed acute radiation syndrome

Two of them had their legs and feet amputated

One died six and a half months after the accident

- His death is attributed to residual lung damage due to irradiation

Response

- Dose assessment
  - Worker A 8.1 Gy
  - Worker B 3.7 Gy
  - Worker C 2.9 Gy
- Medical assessment and treatment
- Source recovery in slow time

Causes

- Component failure
  - The company did not implement measures detailed in notices from supplier designed to upgrade the safety of the facility
  - The installed safety systems had degenerated or been bypassed over the years
- Operator error
  - Operators trained by the supplier of the irradiators had left at an early stage and subsequent training was only oral and informal
- Violation of procedures
  - There was no regulatory control of radiological protection matters nor any readily available expertise in El Salvador

San Salvador - Conclusions

- Regulatory controls could have prevented this accident
- Prompt access to qualified medical resources is a requirements
- Arrangements for prompt international assistance can improve the response effectiveness

Road Transport Accident With Pharmaceuticals

Background

Accident location: Mississippi
Date: 3 December 1983
Sources:

- Liquid form: H-3, F-32, Ga-67, I-125, I-131,
- Cs-137
- Gas: Xe-133

Activity: total of 2 TBq

Accident Scenario

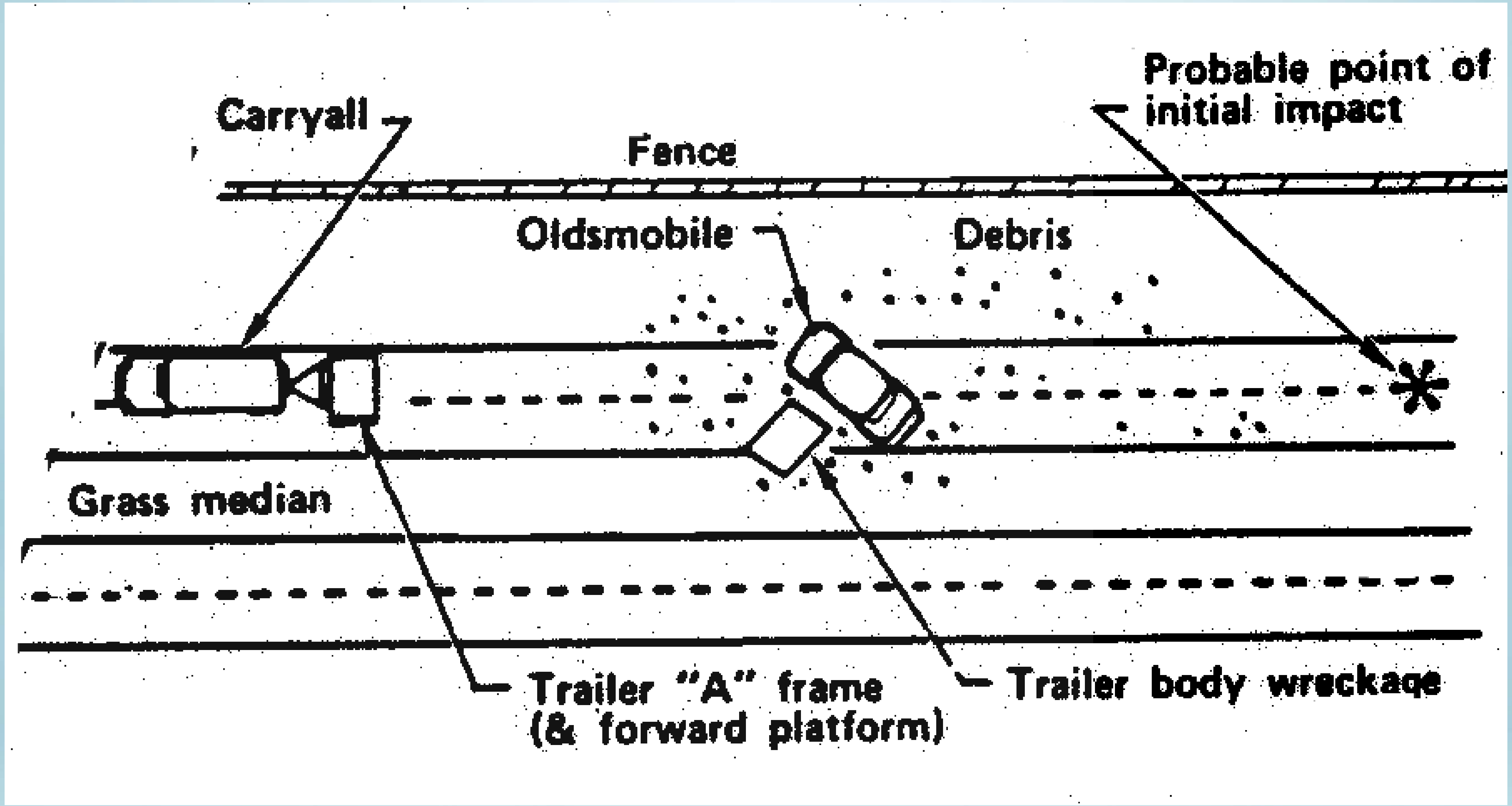
Trailer towed by a large SUV carrying pharmaceuticals collides with a car

Trailer torn away and demolished

All the cargo is ejected and dispersed over 200 m

Packages destroyed and shielding lost

Accident Scenariod



The Response

Relief driver contacts local police and emergency management agency

Police on the scene in 15 minutes

Civil defence arrives with a radiation monitor and confirms presence of radiation

Cordon off the area and wait for professional assistance, which arrives in two hours

More of Response

10 hours later, sources recovered and 0.1 m3 of top soil removed

A thorough and systematic survey was conducted

- Background readings of 8-12 µR/hr (60-100 nSv/h)

Highway washed and re-opened 16 hours after the accident

Lessons Learned

No radiological health consequences

- Procedures were followed and the response was effective
- The training and knowledge of first responders were key to the effectiveness of the response
- A well-integrated emergency response system is effective

Notable Recent Accidents

Year	Location	Source of Exposure	Consequences
1999	Peru Japan Turkey	Ir-192 Criticality Co-60	exposed worker 2 fatalities 10 persons exposed
2000	Thailand, Samut Prakrn	Co-60	10 persons exposed, 3 fatalities
2001	Georgia, Lia	Sr-90	3 persons exposed
2002	Bolivia, Cochabamba	Ir-192	12 persons exposed
2005	Chile, Nueva Aldea	Ir-192	3 persons exposed
2009	Poland Argentina Ecuador	Ir-192 Cs-137 Ir-192	2 persons exposed 2 persons exposed 1 persons exposed

Lessons Learned From Past Accidents

Local emergency services (police and fire)

- Will be the first to respond
- Do not know what to do
- May not have radiation monitoring equipment

Lessons Learned From Past Accidents

Be prepared for the following, once the emergency becomes publicly known

- Failure of normal communications
- Immediate and immense media attention
- Non-requested assistance and suggestions

Lessons Learned From Past Accidents

Psychological Consequences

- Significant psychological disorders may be caused by mental distress, among most frequent consequences of emergency

- Increased fear, insecurity, headache, depression, sleep disturbance, inability to concentrate and emotional imbalance, etc.

Lessons Learned From Past Accidents

Criteria developed after emergency did more harm than good

- Much lower than international recommendations

Based on criteria developed during emergency and associated with:

- Mistrust
- Emotions
- Political pressure

Lessons Learned From Past Accidents

- Actions are taken by decision makers and public, who:
  - Are not experts
  - Often did not understand basis for recommendations (e.g. Sv, averted dose, etc)

By Dennis Staszak

Therefore could not make informed decisions

Lessons Learned From Past Accidents

The public took inappropriate and in some cases harmful actions

Because they did not receive a plain language explanation of radiation health risks

Thousands of unjustified abortions (no detectable effects expected) after Chernobyl accident

Lessons Learned From Past Accidents

Several locations with spokespeople talking to the media at the same time resulted in: Conflicting information and mistrust

Learning From Experience

Main causes of accidents

- Human error
  - Lack of training, complacency, lack of safety culture
- Equipment error
  - Bad maintenance, lack of essential repairs, lack of equipment condition monitoring, design flaws
- Others
  - Even in the best cases, accidents can happen

Learning From Experience

Factors that can prevent radiation accidents:

- Effective regulatory controls
- Training
- Hazard awareness
- Safety culture, supported by management culture

Learning From Experience

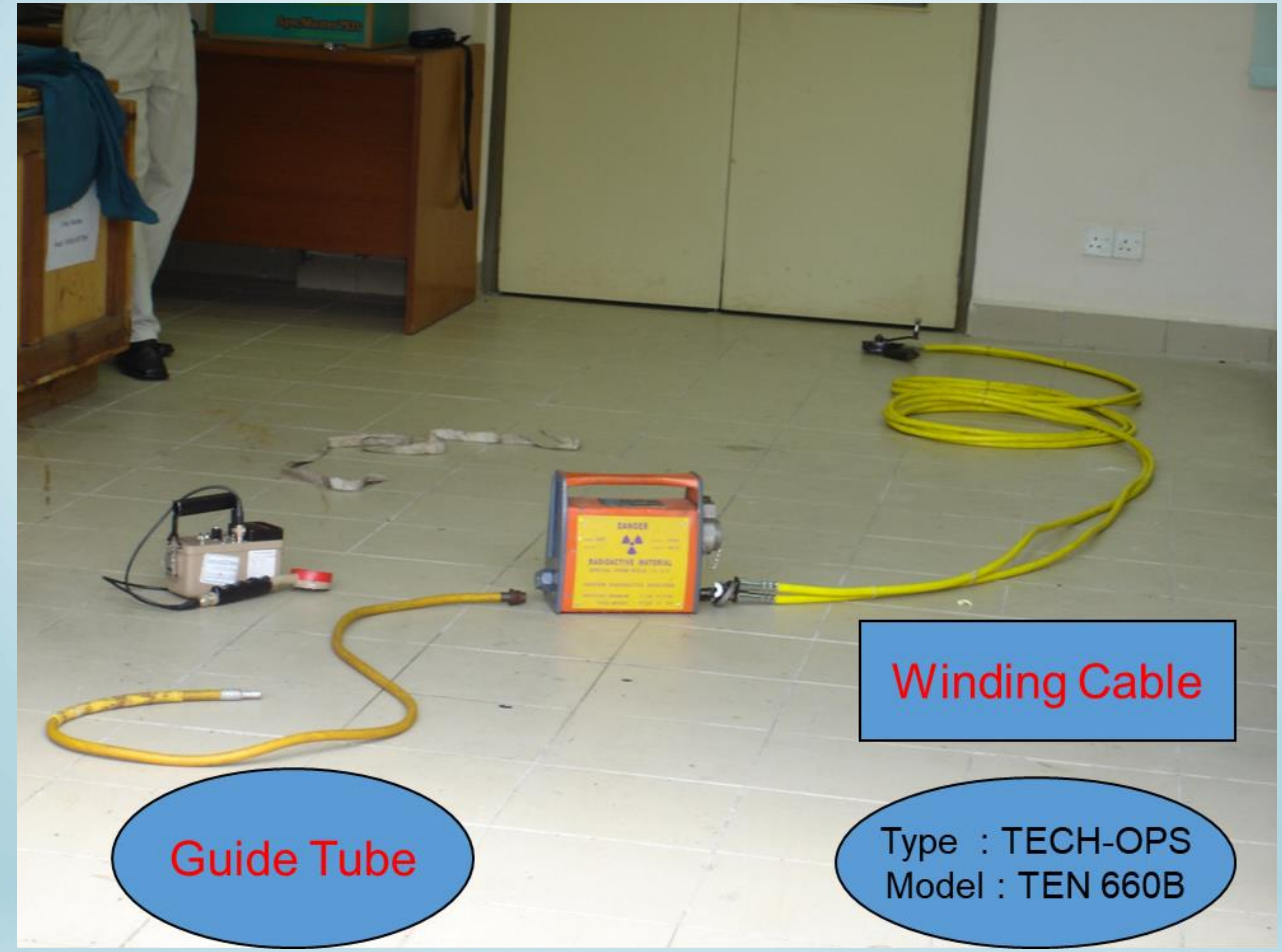
Factors that can mitigate radiation accidents

- Good emergency plans and procedures
- Prompt notification
- Radiological emergency plans that are well-integrated with conventional plans
- Prompt access to the right expertise and international assistance
- Effective public information arrangements
- Training and exercises

Radiography Incident

- The incident occurred at the Brooke Dockyard & Engineering Work Corporation premise in Kuching, Sarawak, East Malaysia.
- The incident was estimated to have happen between hours 0330 and 0530 on 18th April 2005
- The male connector has broken off and caused the Ir-192 (65 Ci) pig tail to remain in the guide tube instead of being retracted into the Gamma Projector (Tech Ops 660).
- The gamma projector has conducted by two radiation workers.

Projector Set



Radiography Incident

- This incident was realized only at hours 0530 when the radiation workers (radiographers) realized that the survey meter shows the reading is substantively very high
- The survey meter has used only at the end of their job.
- Backtracking from the number blackened films developed, it was estimated that the workers has been exposed for two (2) hours.
- Other radiation workers came over to rescue the source and take the remedial action and successfully retrieve and secured the Iridium 192 source (activity of 65 Curie) into the lead pot.

Radiography Incident

- The film badges worn by them have to Nuclear Malaysia for analysis.
- The doses estimation on the two radiographers were 861.49 mSv and 280.66 mSv respectively.
- However the doses estimation for radiation workers who responsible to recover the source were 0.37 mSv and 0.57 mSv.
- Blood samples from the radiation workers were sent to Nuclear Malaysia for chromosome aberration analysis.
- The doses from chromosome aberration analysis have shown the two radiographers have received 500 mSv and 170 mSv respectively

Radiography Incident

- Comparison

  The exposure dose from x-ray is about 0.02 mSv/time.
- The workers were referred to HKL for further treatment.
- Admitted about two months in HKL before released.

Close-up of hands of patient A on 9/5/05

Why do the Incident Happen?

- Over confident (> 10 year experience?)
- Do not follow procedure (survey meter?)
- Type of projector (No foresee lock/Old model?)
- Not Original Winding Cable/Guide Tube ?
- Less of training
- Lack of safety and security culture

Lessons Learned

- Coordination?
  Workers Vs Licensee/Licensee Vs Authority
- Medical Expertise?
- Lack of procedure?
- Lack of Communication?
- Responsibility? (Workers Vs Licensee Vs Authority)

Conclusions

In conclusion, the major causes of radiation exposure accidents are:

- 8% - procedural failure
- 15% - equipment failure
- 68% - operator error

Therefore, the greatest potential for achieving an overall reduction in all accidents lies in reducing operator error

Summary

- Better to prevent than to respond
- Be prepared to respond
- Co-ordinate and integrate
- Exercise
- Learn from others' mistakes

IAEA Accident Reports

Any Question?

THANK YOU

"The important thing is not to stop questioning"

Albert Einstein

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TOPIC 2

BASIC CONCEPTS OF EMERGENCY RESPONSE

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Introduction

Despite all the precautions that are taken in the design and operation of nuclear facilities and the conduct of nuclear activities, there remains a possibility that a failure or an accident may lead to an emergency

The objectives of the lesson are to present goals, principles and basic concepts of emergency response in case of nuclear or radiological emergencies

Content

- Objectives of emergency response and preparedness
- Basic responsibilities
- Assessment of threats
- Functional and infrastructure requirements
- Concepts of operations
- Summary

Overview

- Concepts of emergency response presented here are based on principles set out by the ICRP and recommended by the INSAG

- The concepts and principles apply to all practices and sources with the potential for causing radiation exposure or environmental radioactive contamination warranting emergency intervention, and to all countries and regions that might need to implement emergency intervention

Objectives of Emergency Response

- To mitigate the consequences of an emergency or event at its origin
- To prevent the occurrence of deterministic effects in individuals
- To render first aid and to treat injuries
- To reduce, using reasonable steps, the occurrence of stochastic effects in the population
- To limit the occurrence of non-radiological effects in individuals and in the population
- To protect the environment and property

Objectives of Emergency Preparedness

- To assure the capability to respond in a timely, effective, appropriate and coordinated manner to any nuclear or radiological emergency at all levels:
  - User or facility level
  - Local level
  - Regional level
  - National level
  - International level

Basic Responsibilities

- Adequate preparations must be established and maintained at local and national and, where agreed between countries, at the international level to respond to emergencies

- The arrangements for emergency response actions both within and outside facilities, if applicable, or elsewhere under the control of the operator, are dealt with through the regulatory process

Basic Responsibilities (cont'd)

- The regulatory body has to require that emergency plans be prepared for the on-site area for any practice or source, that could necessitate an emergency intervention
- The regulatory body must ensure that these plans are integrated with those of other response organizations as appropriate before the commencement of operation
- The country must periodically ensure, by means of an appropriate organization, that a review is conducted in order to identify any practice or event that could necessitate an emergency intervention
- It must also ensure that an assessment of the radiological threat is conducted for those practices

Assessment of Threats

- The nature and extent of emergency arrangements have to be commensurate with the potential magnitude and nature of the hazard associated with the facility or activity

- The threat assessment must be periodically reviewed to take into account changes in to the threats within and outside the country and the experience and lessons from previous events involving relevant practices and sources

Assessment of Threats (cont'd)

- The threat assessment has to identify installations, sources, practices, on-site areas, off-site areas or locations for which nuclear or radiological emergencies could warrant:

  - precautionary urgent protective actions to prevent severe deterministic health effects
  - urgent protective actions to reduce stochastic effects
  - agricultural and ingestion countermeasures and long term protective measures
  - protection for the workers undertaking an intervention

Emergency Preparedness Category

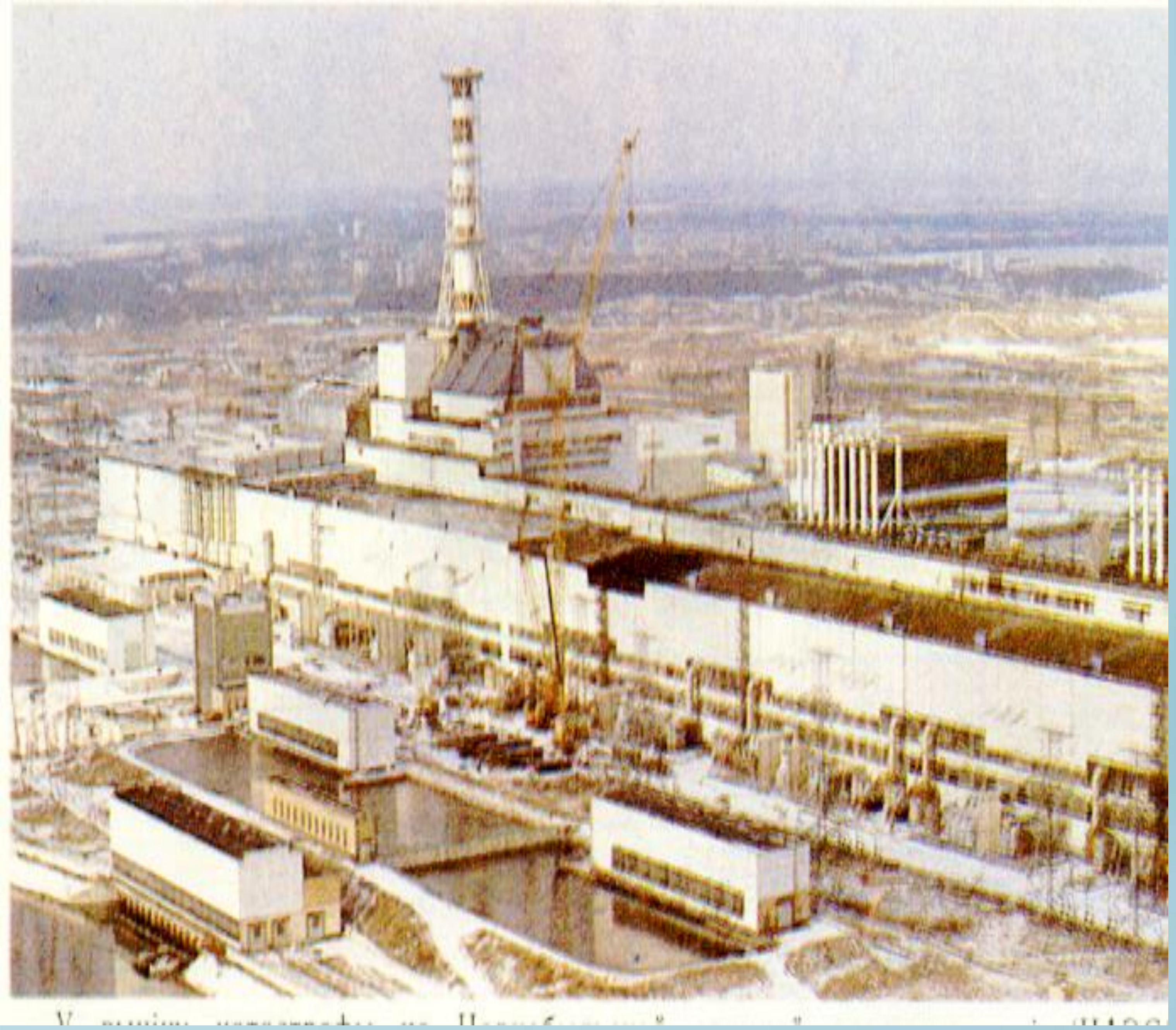
Nuclear and radiation threats are grouped according to the five Emergency Preparedness Category

Categories I through IV represent decreasing levels of hazard and therefore decreasing emergency preparedness and response requirements

- Category IV is the minimum level of threat assumed to exist everywhere and thus always applies possibly along with other categories
- Category V is a special category and may apply along with other categories

Emergency Preparedness Category I

Nuclear installations for which events that could give rise to severe deterministic health effects off-site are postulated or have occurred in similar installations, including very low probability events



Emergency Preparedness Category II

Installations for which events that can give rise to off-site doses warranting urgent protective actions consistent with international standards are postulated or have occurred in similar installations

- This category (as opposed to category I threats) has no credible events postulated that could give rise to off-site doses resulting in severe deterministic health effects

Emergency Preparedness Category III

Installations for which events that could give rise to doses on-site resulting in severe deterministic health effects are postulated or have occurred within similar installations

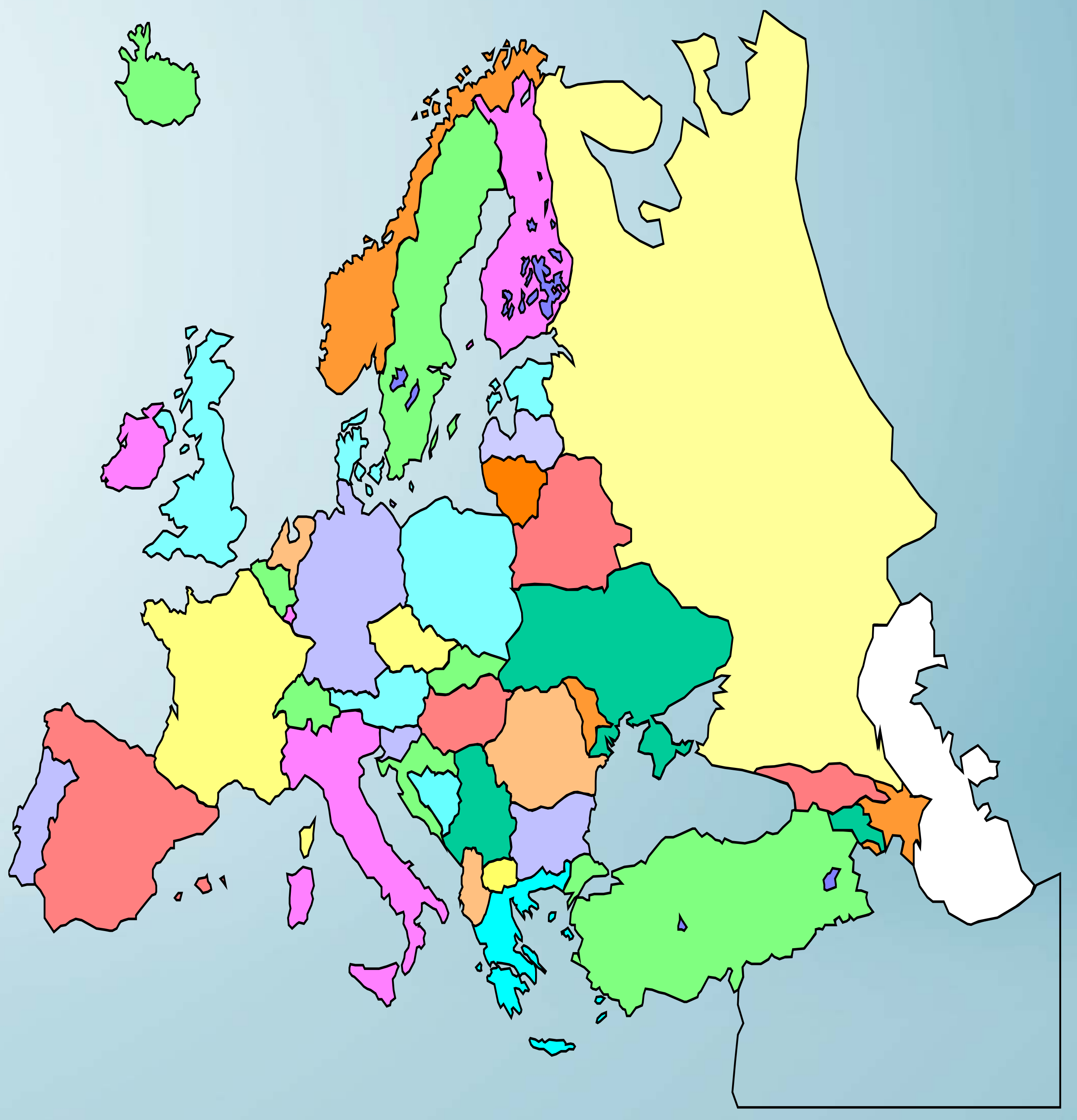
- This category (as opposed to category II threats) has no credible events postulated for which urgent off-site protective actions are warranted

Emergency Preparedness Category IV

Minimum level of threat assumed for all countries and jurisdictions

Emergency Preparedness Category V

Areas that have a significant probability of being contaminated to levels necessitating food restrictions consistent with international standards as a result of events at installations in threat categories I or II, including installations in other countries



Preparedness and Response

- Two sets of requirements
  - Functional (response) requirements
  - Infrastructure (preparedness) requirements
- The infrastructure requirements must be fulfilled to ensure that the functional requirements of a response can be performed when needed

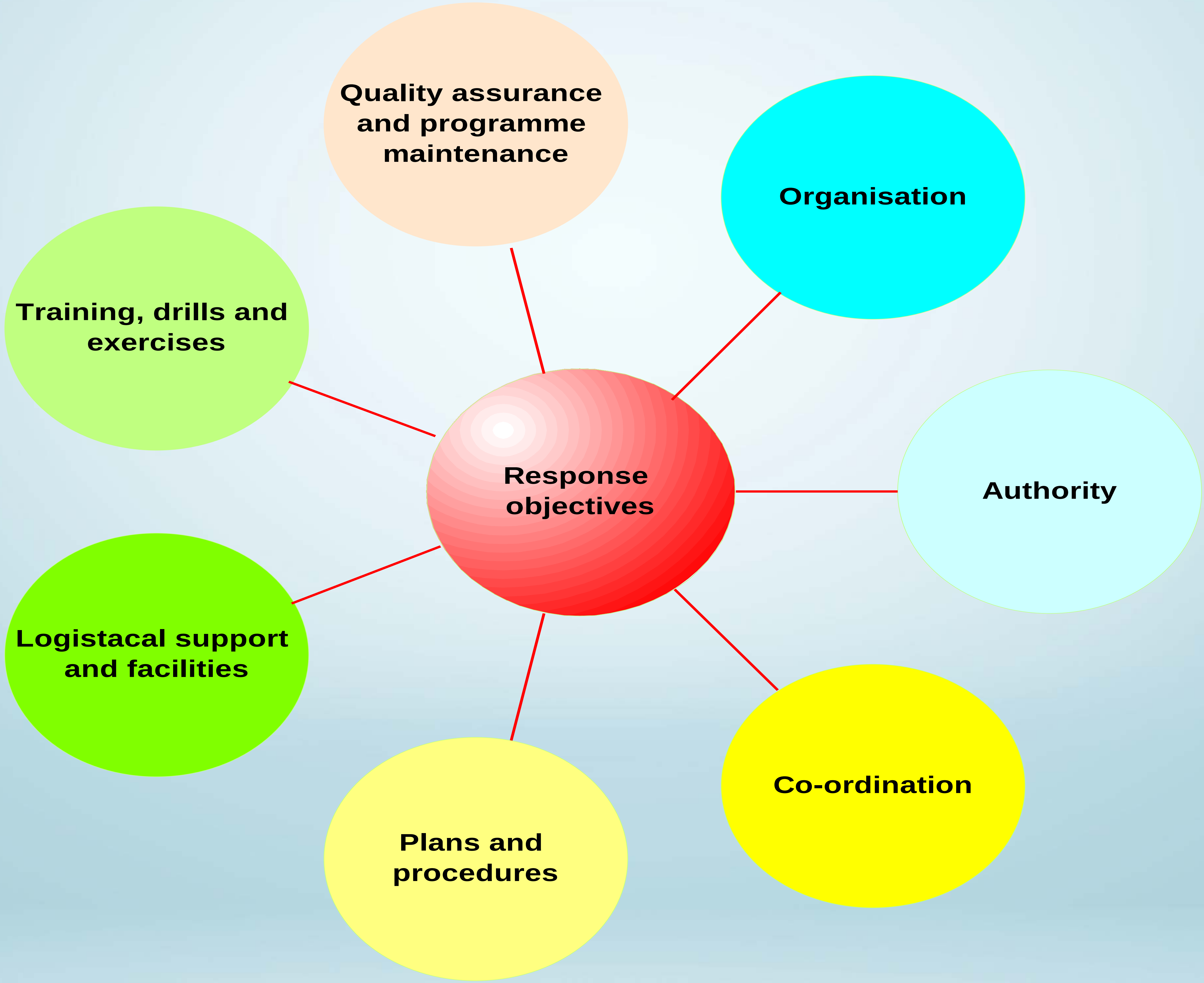
Functional Requirements

- Identification, Notification and Activation
- Emergency Source Management
- Urgent Protective Actions
- Instructing and Warning the Public
- Protection of Emergency Workers
- Initial Phase Assessment

Functional Requirements (cont'd)

- Emergency Operations Management
- Medical Management
- Informing the Public
- Agricultural and Ingestion Countermeasures and Longer Term Protective Actions
- Mitigation of Public Non-Radiological Consequences
- Recovery

Infrastructure Requirements



Integrated Planning Concept

Concepts of Operations
Emergency Preparedness Category 1

- The facility staff
  - Classifies the emergency
  - Notifies jurisdictions within PAZ and UPZ
  - Takes all possible actions to prevent or reduce the release
  - Provides protective action recommendations to off-site officials (within 15 min)
  - Rapidly monitor in PAZ and UPZ until relieved by off-site officials

Concepts of Operations
Emergency Preparedness Category 1

- Local officials
  - Provide police, fire fighting and medical assistance to the site (if requested)
  - Decide on the protective actions for the public
  - Inform the public (within 1 hour)
- National level officials
  - Notify IAEA and other countries
  - Support the local officials
  - Conduct monitoring further from the site
  - Conduct joint media briefings
  - Coordinate longer-term protective actions

Concepts of Operations
Emergency Preparedness Category II

- The facility staff
  - Classifies the emergency
  - Notifies jurisdictions within the UPZ
  - Takes all possible actions to prevent or reduce the release or shine dose
  - Provides protective action recommendations (within 15 min)
  - Monitor near the site until relieved by off-site officials

Concepts of Operations
Emergency Preparedness Category II

- Local officials
  - Provide police, fire fighting and medical assistance to the site (if requested)
  - Recommend, within 1 hour, protective actions to the people within the UPZ
- National level officials
  - Support the local officials
  - Conduct monitoring further from the site
  - Conduct joint media briefings

Concepts of Operations
Emergency Preparedness Category III

The facility

- Declares a facility emergency
- Notifies local off-site officials
- Ensures that all people on-site are provided with appropriate protection
- Conduct the environmental monitoring

Concepts of Operations
Emergency Preparedness Category III

- Local off-site officials
  - Provide police, fire fighting and medical assistance to the site if requested
  - Inform the media
- National level officials
  - Support the local officials
  - Assist in obtaining specialised treatment through the IAEA (if needed)
  - Conduct joint media briefings

Concepts of Operations
Emergency Preparedness Category IV

- First responders
  - Take life saving actions
  - Notify local off-site officials
- Local officials take precautions to confine radioactive material and to protect people in the immediate vicinity
- National officials
  - Dispatch survey and response personnel
  - Request assistance through IAEA (if needed)
  - Brief the media

Concepts of Operations
Emergency Preparedness Category V

- The country where the accident occurs notifies the potentially affected states

- Upon receipt of notification national officials
  - Provide instructions to the public and farmers
  - Conduct monitoring and sampling
  - Develop programme to deal with long-term impact

Summary

- Accidents do happen
- Concepts of emergency response are based on ICRP principles and IAEA recommendations
- Good planning in advance of emergency can substantially improve the response
- The response to a radiation emergency is basically the same as the response to any accident involving hazardous material

Any Question?

THANK YOU

"The important thing is not to stop questioning"

Albert Einstein

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TOPIC 3

EMERGENCY MONITORING OVERVIEW

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Content

- Objectives of emergency monitoring
- Generic monitoring organization
- Emergency monitoring strategy
- Emergency staff
- Instrumentation
- Basic survey methods
- Quality assurance system
- Summary

Overview

- One of the most important aspects of managing a radiological emergency is the ability to promptly and adequately assess the need for protective actions

- Protective action accident management must make use of the key relevant information available

- Emergency monitoring is one of the main sources for obtaining the needed information

Purpose

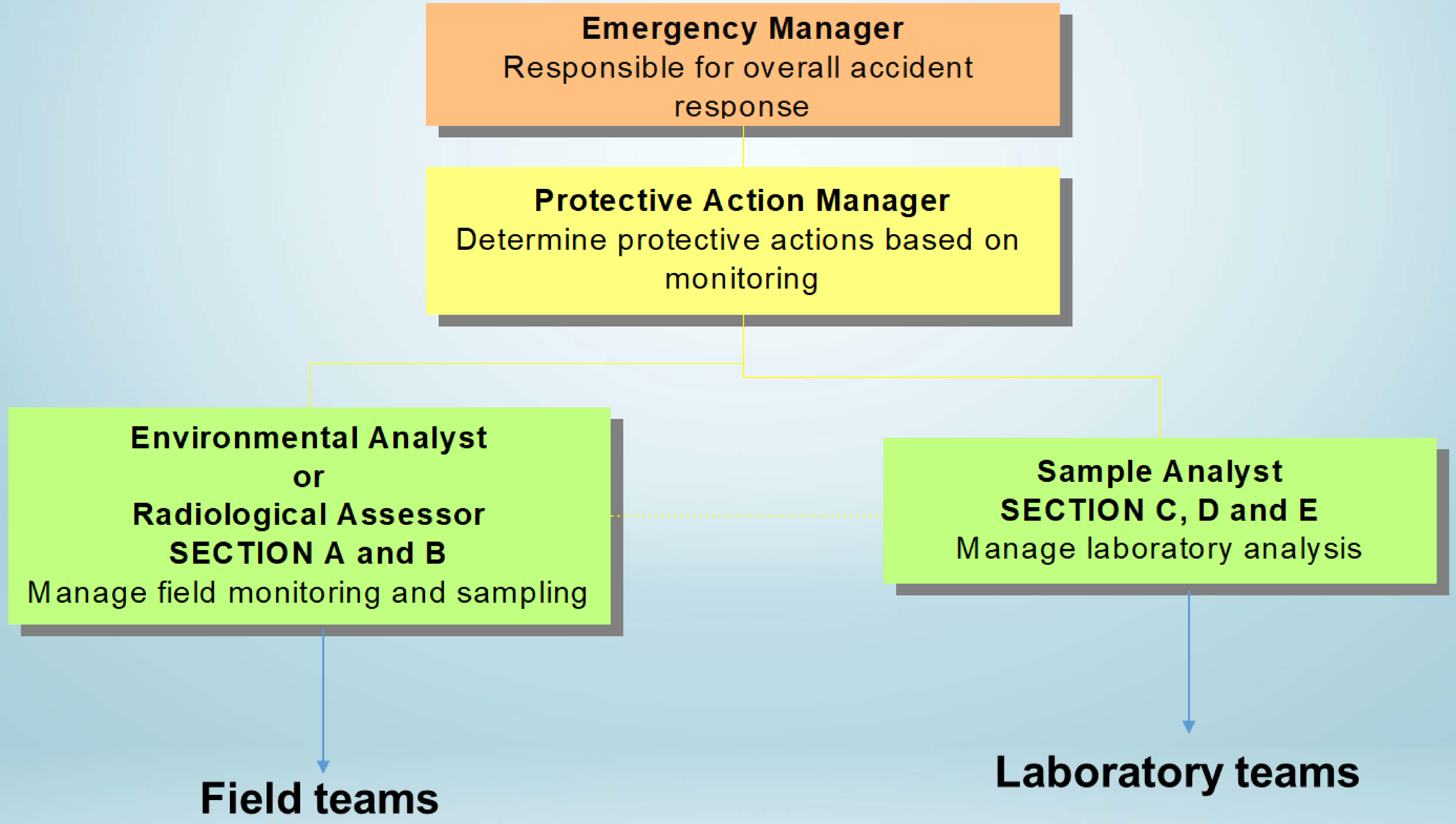
- The primary purpose of emergency monitoring is to provide timely information on which decisions on protective actions can be confirmed or revised

- This requires detection of radioactive material, determination of its location and its nature

General Objectives

- The objectives of emergency monitoring in general are:
- To provide information for accident classification
- To help decision makers to assess the need for protective actions and interventions on the basis of operational intervention levels (OILs)
- To assist in preventing the spread of contamination
- To provide information for protection of emergency workers
- To provide accurate and timely data on the level and degree of hazards resulting from a radiological emergency
- To determine the extent and duration of the hazard
- To provide detail on the physical and chemical characteristics of the hazard and
- To confirm the efficiency of remedial measures such as decontamination procedures etc.

Generic Monitoring Organization



Field teams

Environmental Survey Team
Measurements of gamma/beta dose rates, evaluation of unknown situations

Air Sampling Team
Collect air samples, measurements of gamma/beta dose rates

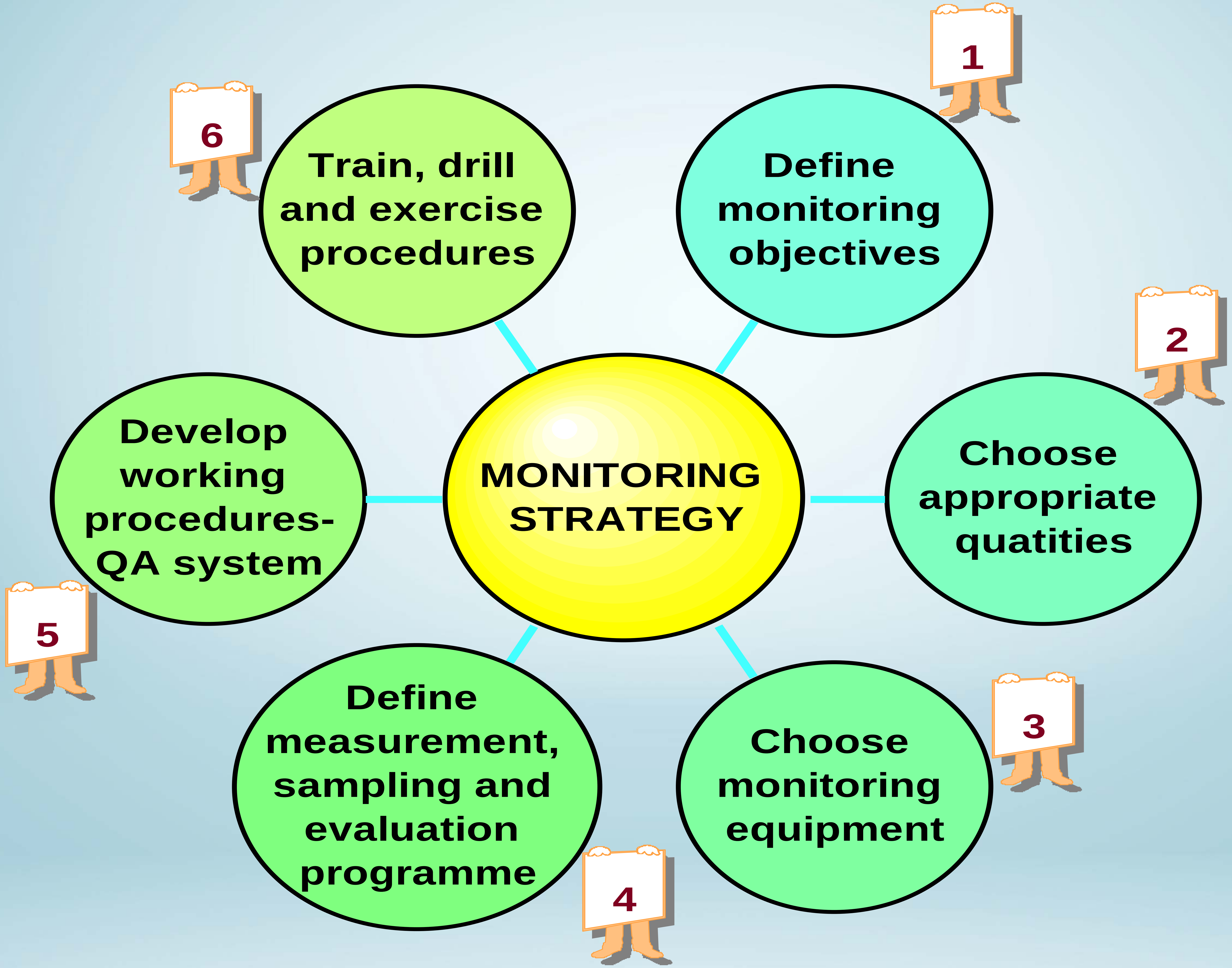
In-situ Gamma Spectrometry Team
Measurements of radionuclide ground concentrations and composition

Personal Monitoring and Decontamination Team
Personnel and equipment monitoring, decontamination of people

Environmental and Ingestion Sampling Team
Collect samples of potentially contaminated soil, food and water

Laboratory teams

Isotopic Analysis Team
Determine radionuclide concentrations of samples:
- sample preparation
- gross alpha/beta measurements
- gamma spectrometry
- radiochemical analysis


MONITORING STRATEGY
1
Define monitoring objectives
2
Choose appropriate quatities
3
Choose monitoring equipment
4
Define measurement, sampling and evaluation programme
5
Develop working procedures-QA system
6
Train, drill and exercise procedures

Design of EM Programme

- The design of the emergency monitoring and sampling programme will be determined:

  - By the primary objectives for which it has been established
  - By the scale of the accident envisaged and
  - The availability of qualified teams to respond to radiological emergency

Decision Sequence Tree

Emergency

Question	Action
Is there a possible external radiation hazard?	- Monitor dose rates - Monitor or estimate personal doses
Is there a release of radioactive material into the air?	- Monitor air concentration - Monitor external dose rates downwind
Is there a spill or spread of radioactive materials over surfaces or ground?	- Monitor external radiation dose rates - Monitor surface contamination levels on the ground, buildings, vehicles
Have people been contaminated?	- Monitor skin and clothing contamination - Assist in monitoring during decontamination
Has there been fall out on crops and pastures?	- Monitor and sample crops and pastures

Decision Sequence Tree - **Cont'd**

Emergency

Question	Action
Is the accident ongoing with continuing release of radioactive material to the environment?	- Optimise monitoring and sampling to focus on persons and industries at greatest risk
Is the accident short duration?	- Consolidate monitoring and sampling programme - Assist in recovery operation
Have waterways and/or water bodies been contaminated?	- Sample fish, shellfish, crops, animals - Analyse
Have drinking water supplies been contaminated?	- Sample drinking water supplies - Analyse
Have animals raised for human consumption eaten contaminated food?	- Sample milk, meat, and foodstuffs. - Analyse

General Priorities in Designing EM Response

- In the initial response, the determination of affected areas which are truly “dirty” and where people can be affected should be the first priority

- The priority for monitoring and sampling should then take into account the composition of the affected area: residential, agricultural, rural, commercial, and industrial activities, public services and infrastructure elements

Emergency Staff - General Guidance

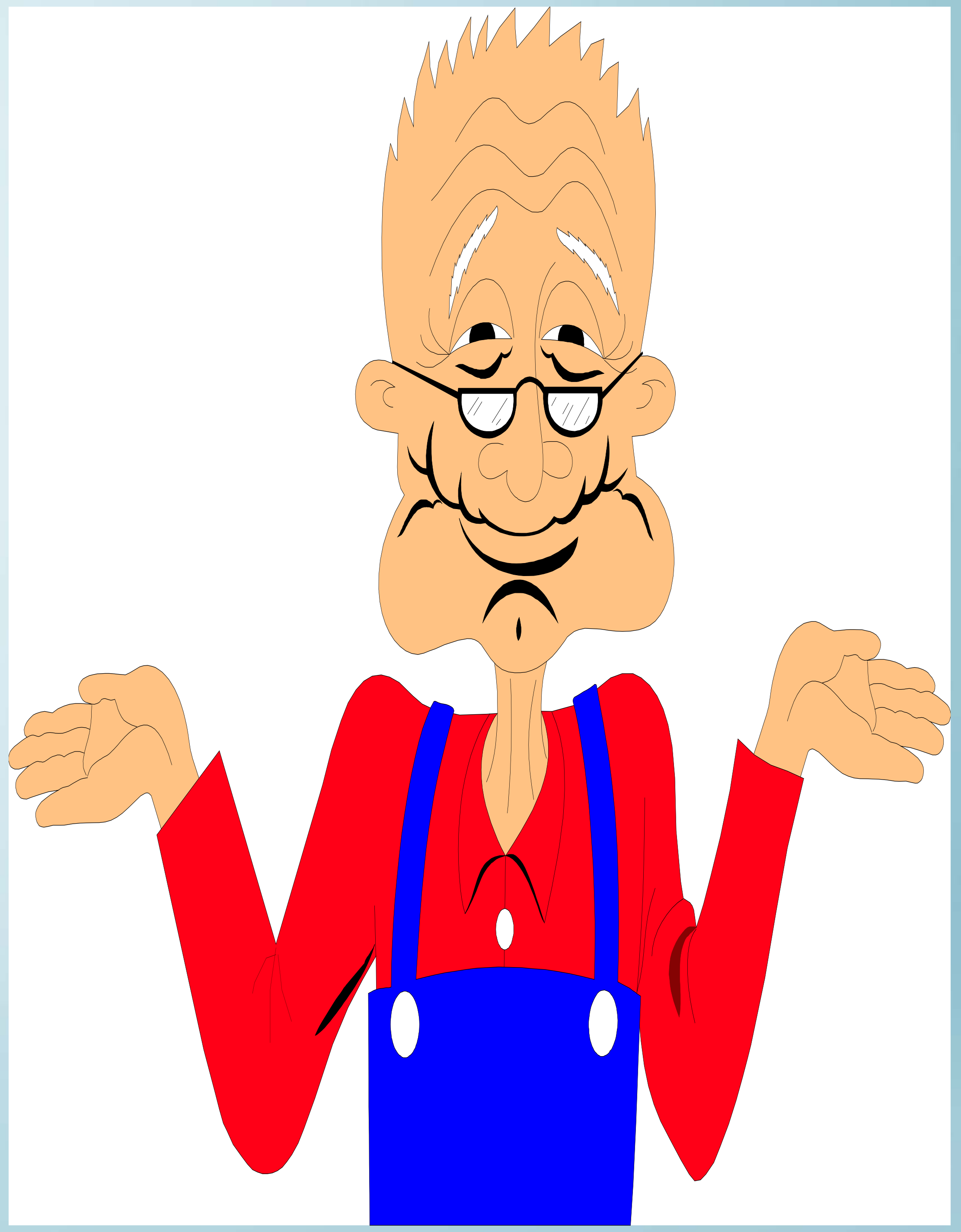
- Use persons who are skilled and experienced
- Persons performing routine monitoring and sampling should receive specific training for non-routine and emergency monitoring and sampling
- Teams should be well trained and properly equipped with personal protective equipment and be acquainted with turn back guidance

Emergency Manager

- Emergency manager is the person who will be in overall charge of an emergency and carry the ultimate responsibility for the emergency response
- He might simply be
  - The most senior member of staff of the premises where an accident has occurred
  - A senior police officer, or
  - A local or senior government official

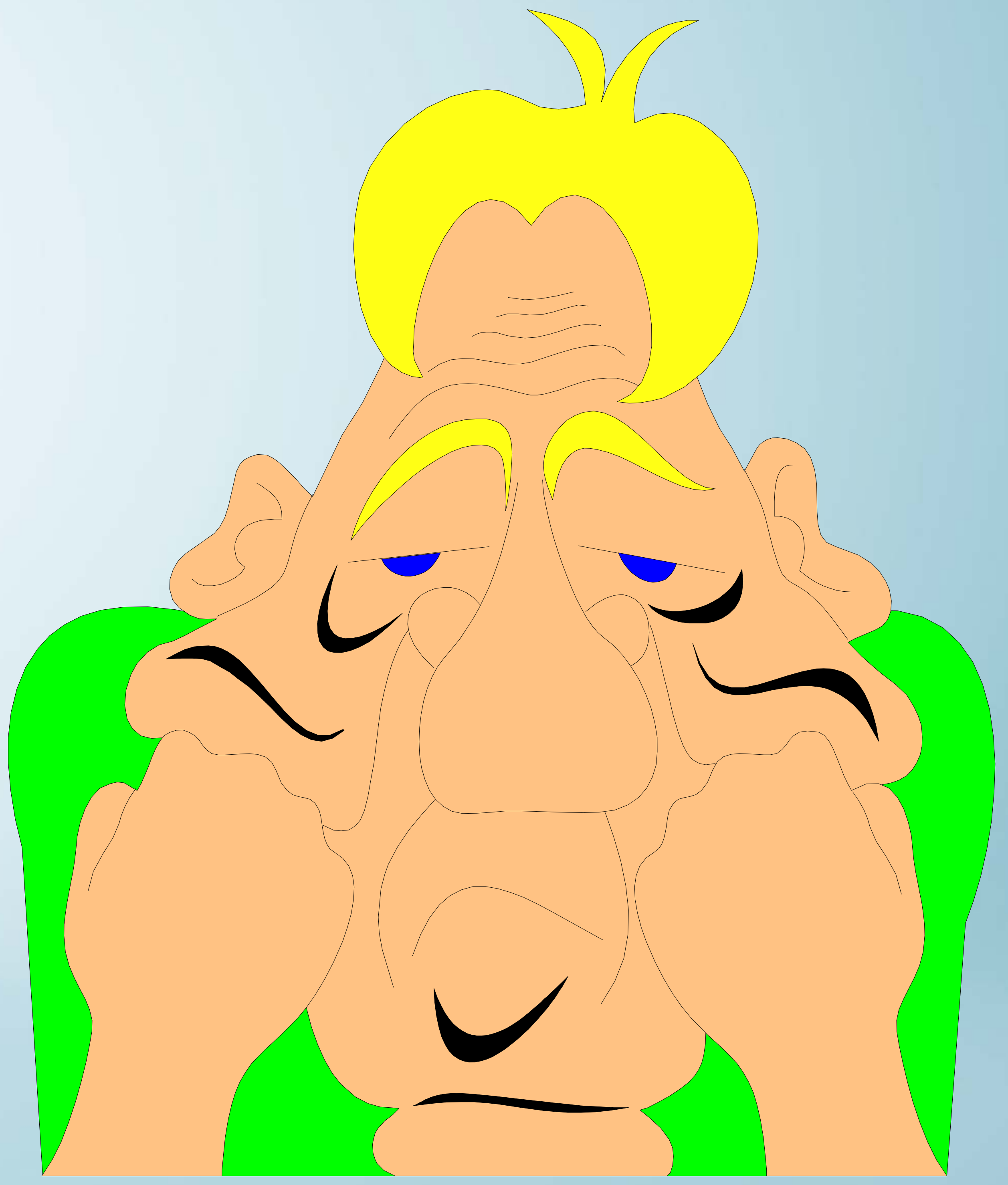
Protective Action Manager

- The Protective Action Manager is the officer responsible for determining protective actions based on accident classification and environmental monitoring and is normally a professional health physicist



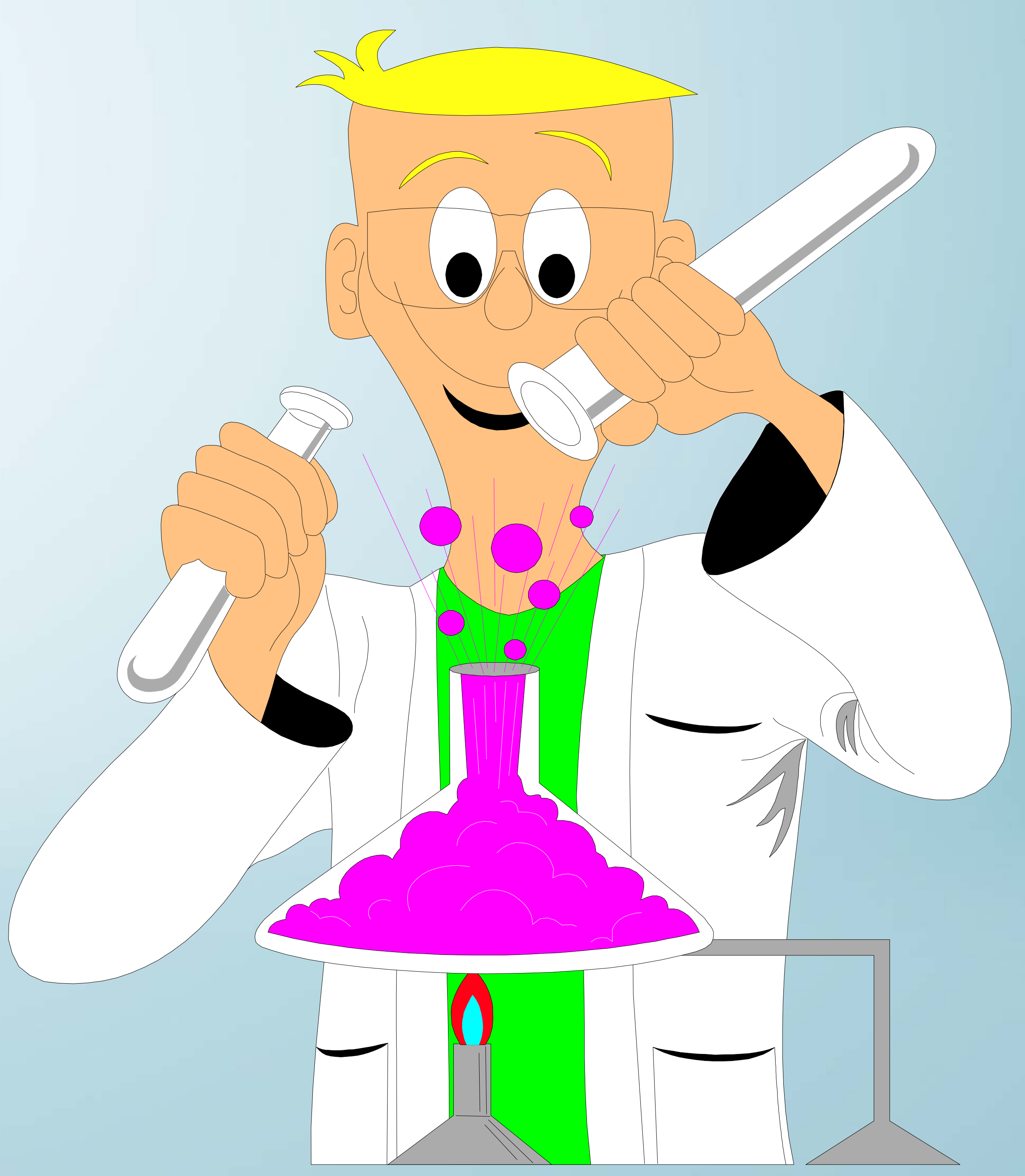
Environmental Analyst / Radiological Assessor

- Most likely a professional operational or environmental health physicist knowledgeable and experienced in monitoring techniques and in the use of OILs but not necessarily highly skilled in specific analytical laboratory techniques



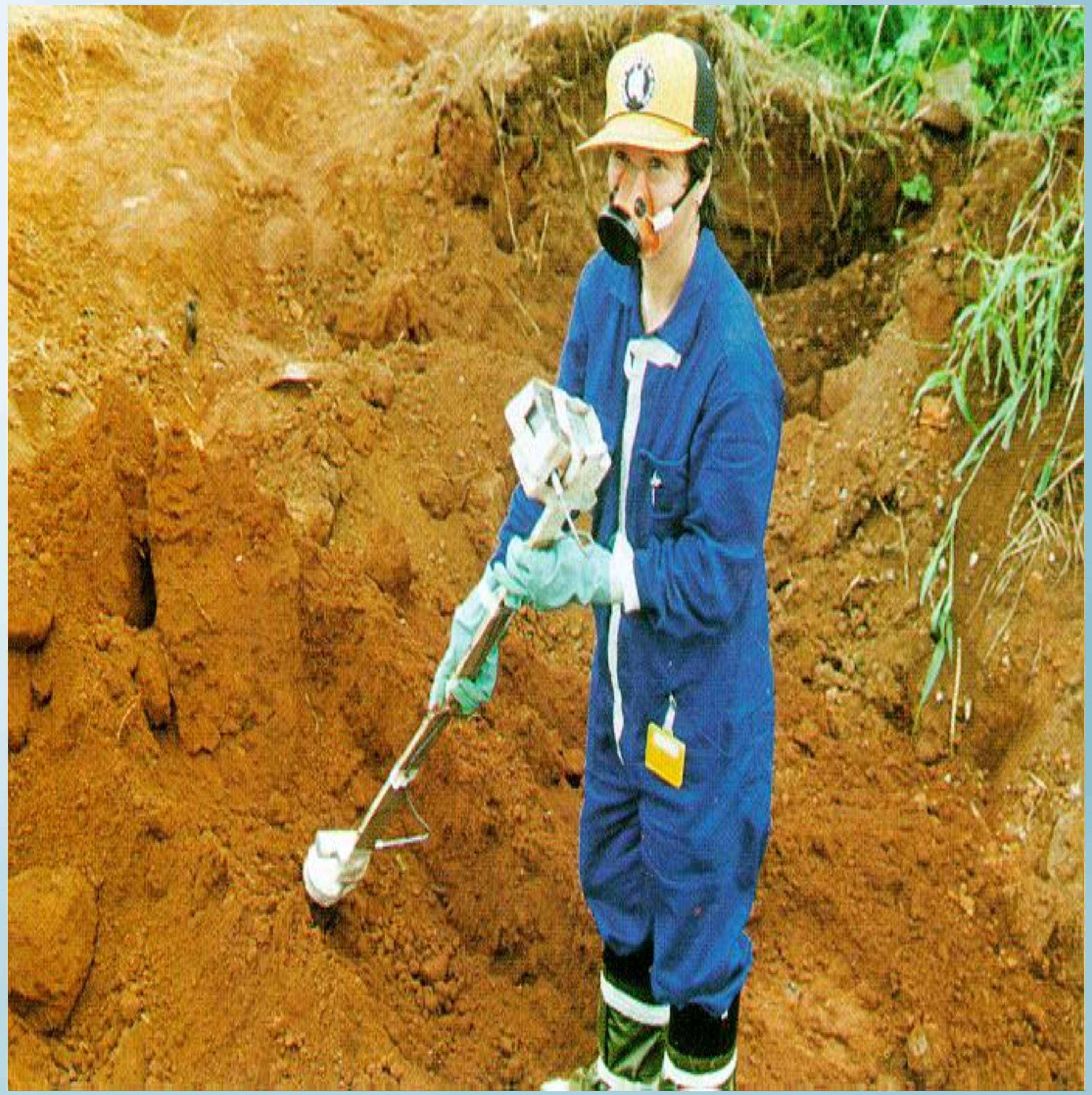
Sample Analyst

- He/she is a specialist in environmental monitoring data interpretation and is most likely an environmental health physicist or a specialist in sample analyses for radionuclide content



Environmental Survey Team

- Environmental Survey Team should be technical personnel trained in:
  - radiation dose rate measurements
  - surface contamination measurements
- Team should be regularly exercised in emergency response scenarios
- They may also be trained in aerial survey methods



Air Sampling Team

- Air Sampling Team should be skilled:
  - at taking air samples
  - external dose rate measurements
  - contamination monitoring

- It may also require training in field assessment of air samples using portable radiation monitoring instruments prior to placing the sample in a suitable sealed and labeled container

In-situ Gamma Spectrometry Team

- In-situ Gamma Spectrometry Team is a specialist team skilled in the use of gamma spectrometers in field situations
- Such persons may be drawn from environmental laboratories or geological surveyors skilled in radiometric assessments of the Earth's surfaces
- Team may also be trained in aerial survey procedures

Personal Monitoring and Decontamination Team

- Members need to be skilled in the use of contamination monitors
  - To assess contamination
  - To prevent the spread of contamination
  - To monitor the efficiency of decontamination of people and surfaces
- All such persons should receive regular re-familiarization training in such techniques

Environmental and Ingestion Sampling Team

- Team members need to be experienced environmental sampling personnel or personnel well instructed in correct sampling procedures for the particular types of sample required

- Teams may also need to be experienced in radiological assessment techniques to monitor their own safety and to provide field radiological data if requested to do so

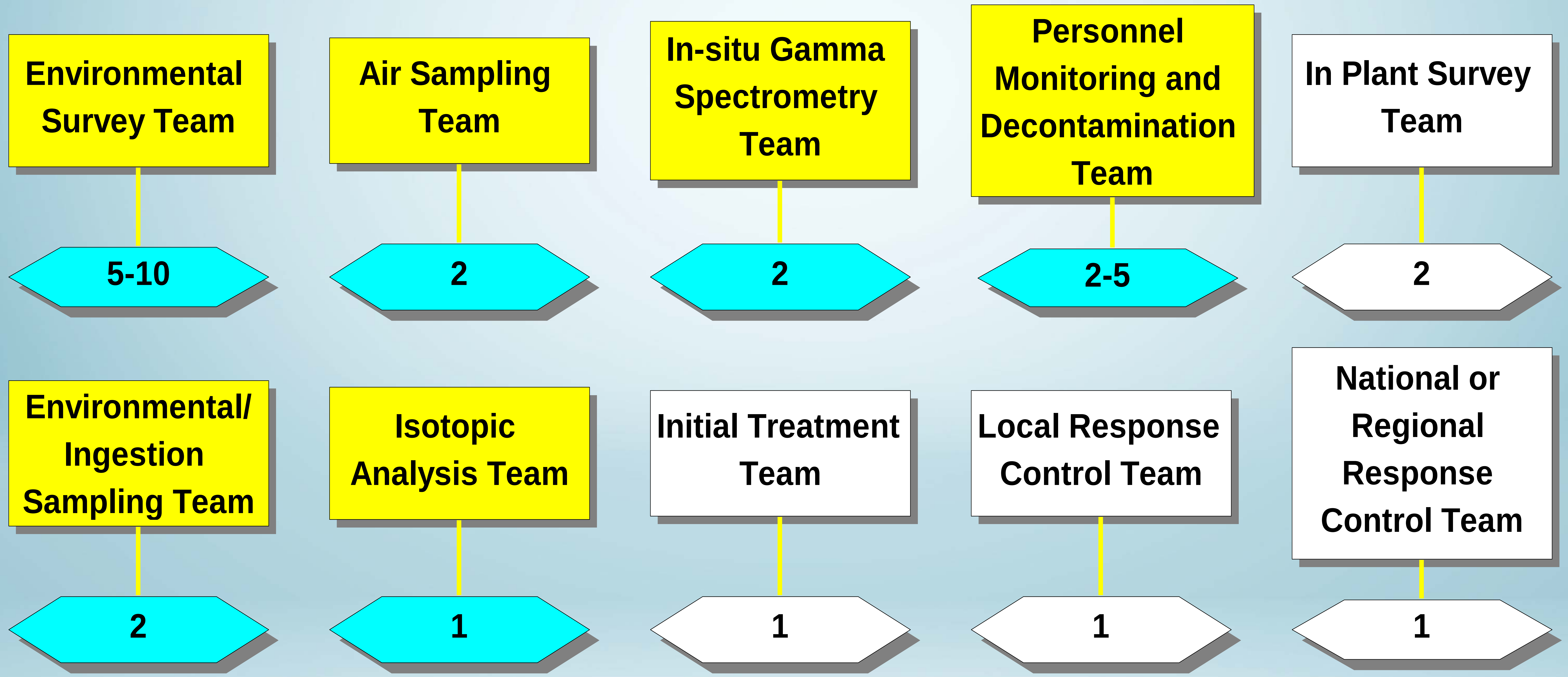
Isotopic Analysis Team

- Team is composed of persons well trained in

- sample preparation
- gamma spectrometry
- other radionuclide
- analyses techniques

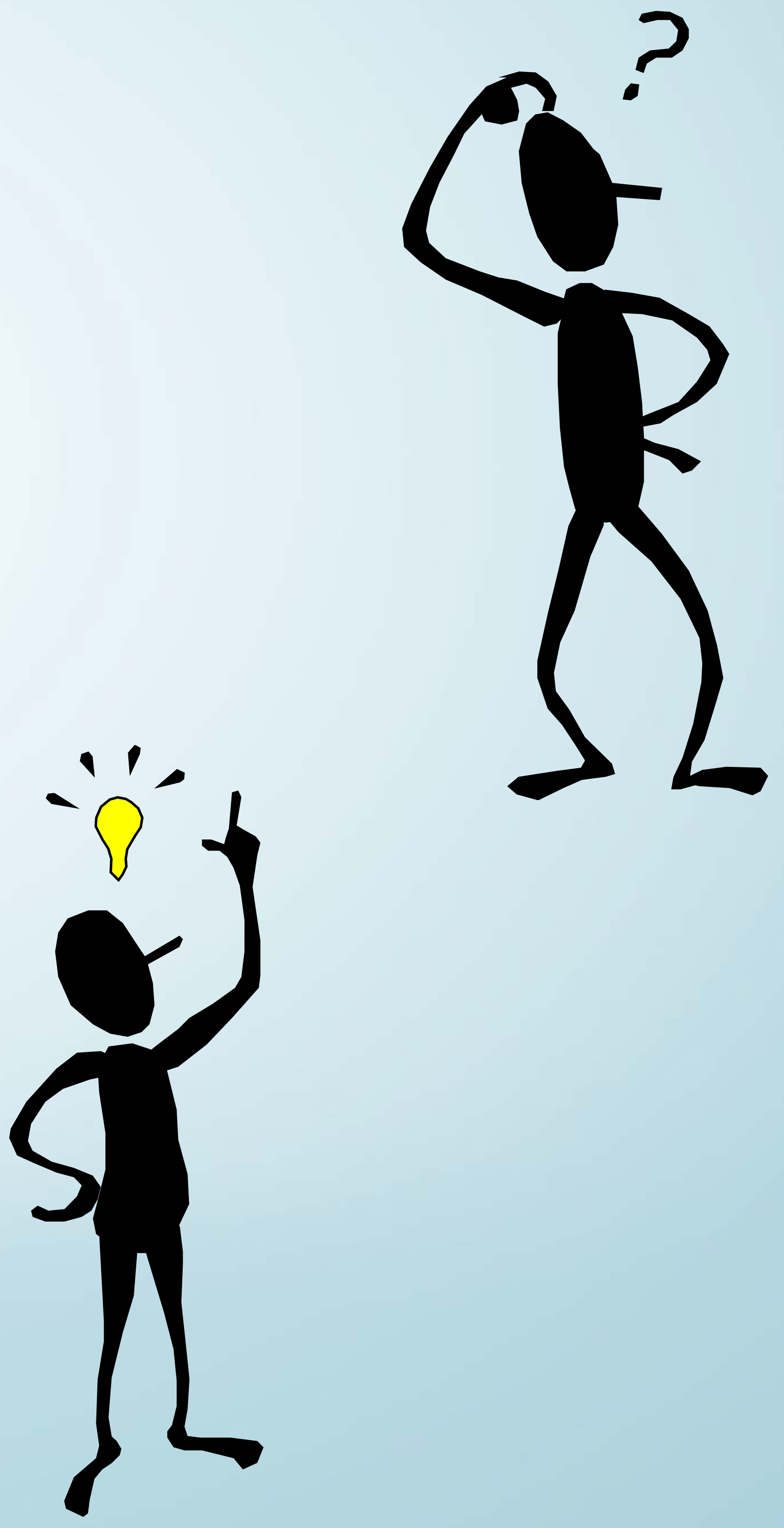
- Such persons should be routinely engaged in such analyses, with well-calibrated equipment and utilizing recognized and validated analytical techniques

Example: Suggested Number of Teams for Reactor Accident Response



Instrumentation - General Guidance

- Choose appropriate equipment
- Properly calibrate equipment
- Maintain equipment readiness



Types of instrumentation

- Radiation monitoring equipment
- Contamination monitors
- Air samplers
- Dosimeters
- Gamma spectrometers
- Gross alpha/beta counting
- Laboratory analytical equipment






Basic Survey Methods

- Ground survey
- Aerial survey
- Personal monitoring
- Sampling and sample analysis

Ground Survey

- Plume survey
- Ground deposition survey
- Environmental dosimetry
- Source monitoring
- Surface contamination survey

- Ground survey can be performed:
  - with automatic measuring stations
  - on foot with hand held instruments
  - from an adequately equipped vehicle
    - mobile radiological laboratory

Mobile Radiological Laboratories (MRL)

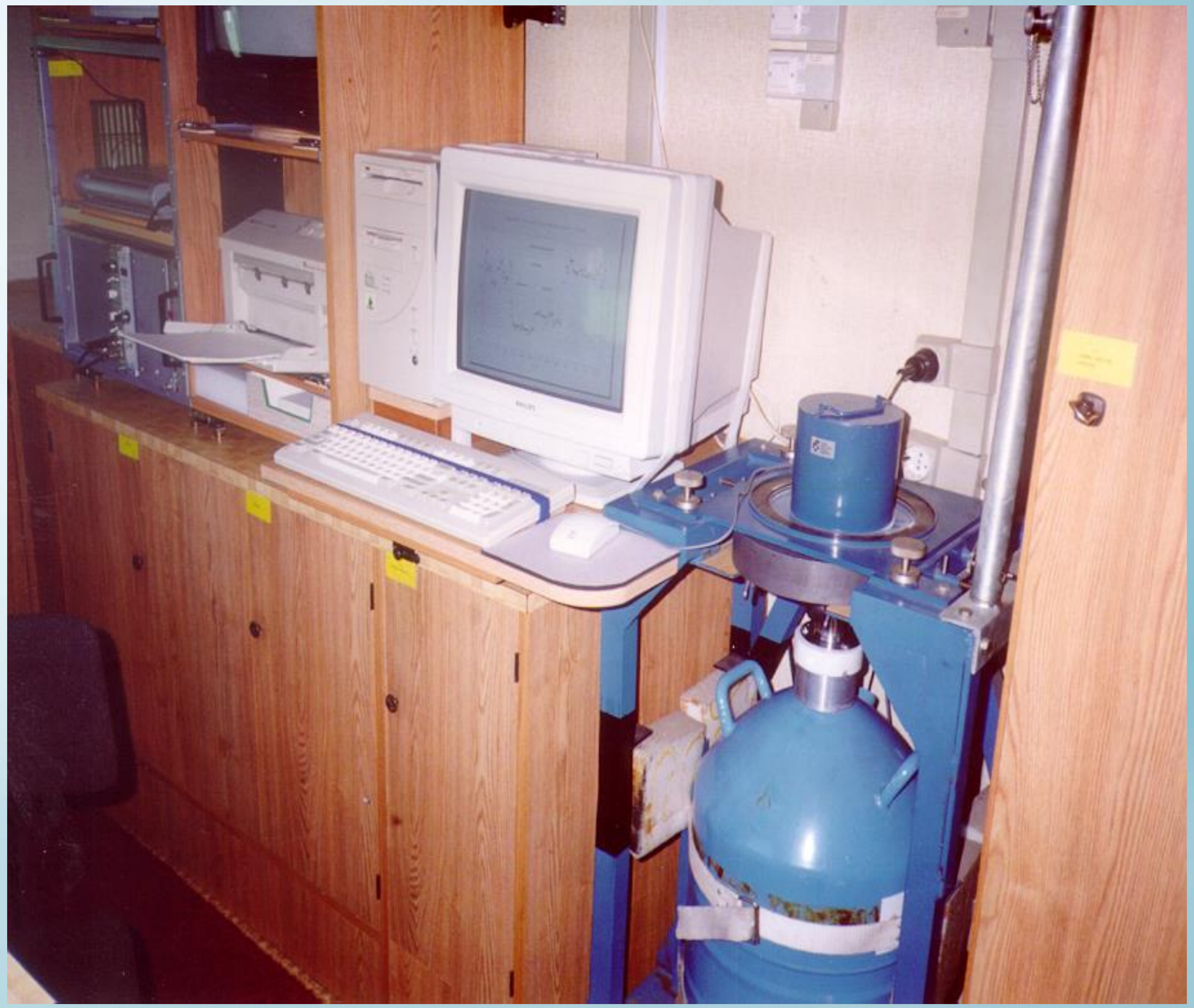
- To perform rapid analyses at or near an emergency site an appropriate equipped mobile radiation laboratory can be the best solution
- Vehicles range in size from van or lorry based to commercial semi-trailer or articulated lorry

Use of the MRL

- Mobile laboratories are set up for a specific purpose:
  - to provide rapid analyses following radiation accident
  - to provide analyses for routine environmental studies
  - to provide survey in
    - lost source events
    - events where the source material is not known
    - nuclear weapons accidents, and
    - incidents of nuclear terrorism

Equipment

- Common equipment placed inside mobile laboratories:
  - gamma spectrometers
  - gross alpha/beta counters
  - liquid scintillation systems
  - other detection equipment
- The choice of equipment for a mobile laboratory is crucial to ensure that samples can pass through the laboratory quickly



Sample preparation capability

- Simple sample preparation is called for in an emergency
- It is recommended that sample preparation is not performed in the mobile laboratory
- Either a sample preparation capability should be built into another vehicle, or be set up in whatever space or facilities are available locally

Sample preparation laboratory

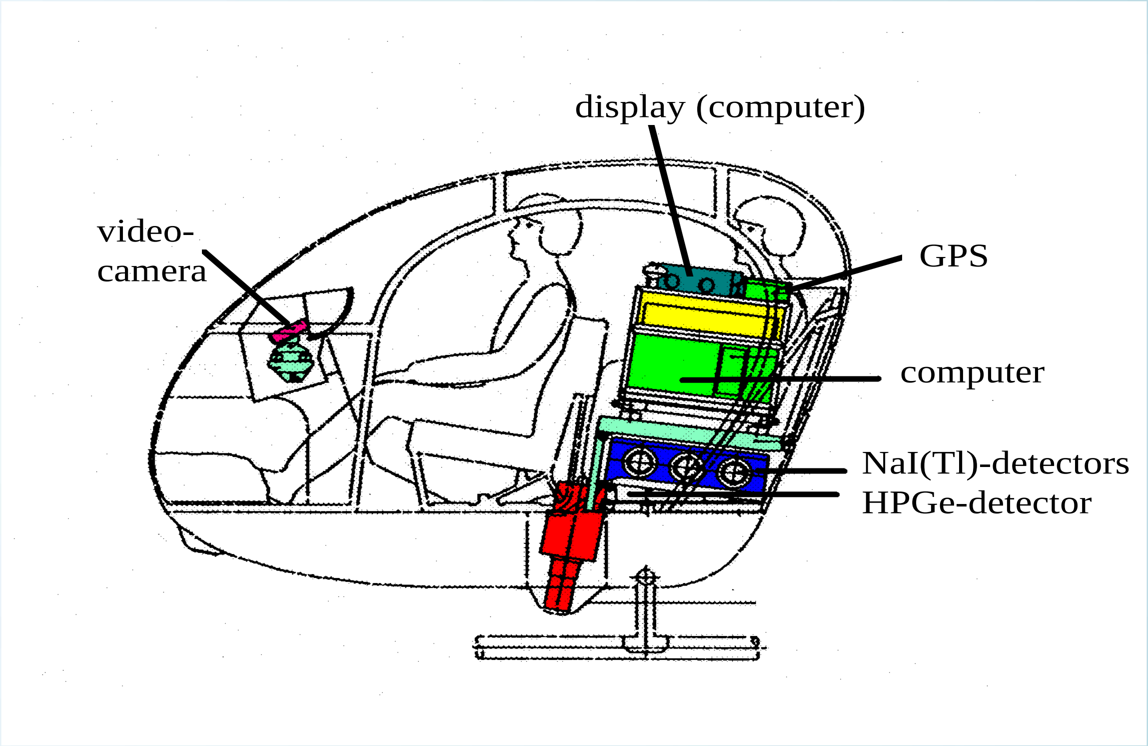
- Placement of the sample preparation laboratory relative to the mobile laboratory in the field is important

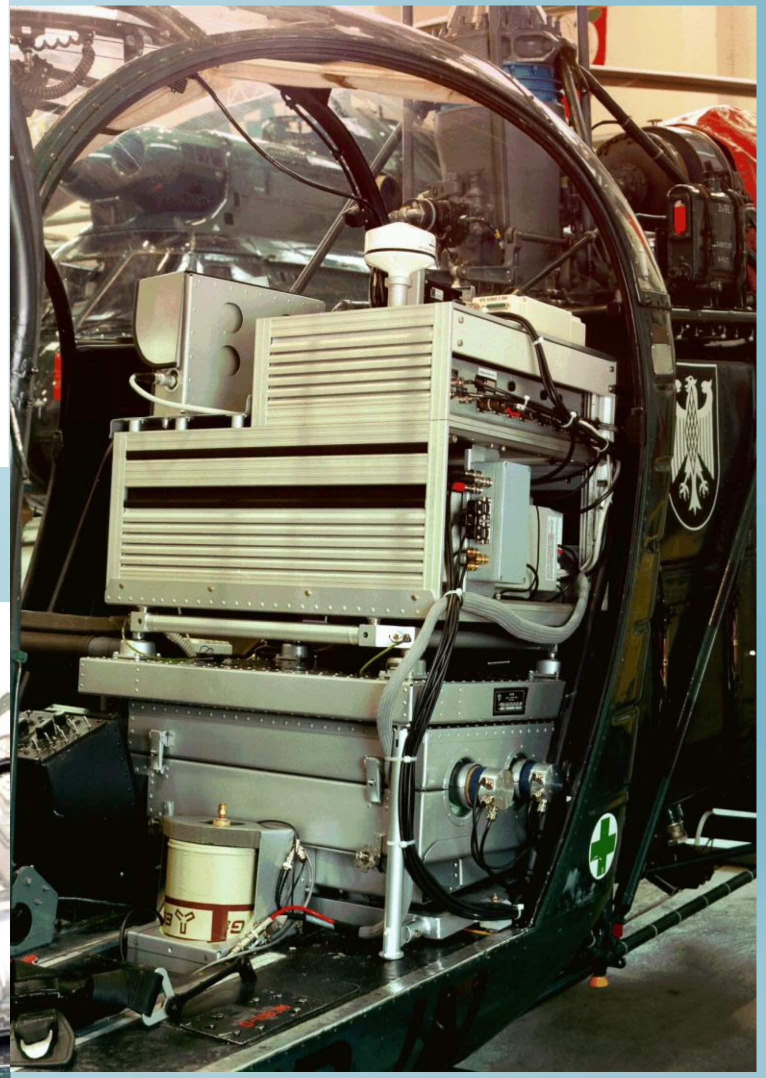
- The mobile laboratory should be away from sample preparation area by a good distance, and the mobile laboratory must be much further from sample control (where samples are initially received before processing starts)

Aerial Survey

- Aerial monitoring can be regarded as an appropriate method for a rapid survey
  - to provide information on large area surface contamination (ground contamination survey) or
  - to search, detect localize and identify gamma-emitting source(s) over large areas in order to render the source safe

- For aerial surveys high HPGe detectors or Na(I) detectors are the favorite detectors
- Systems based on pressurized ionization chambers, proportional counters, GM detectors or other suitable dose rate meters may be also used





Personal Monitoring

- To control personal exposure and contamination of response personnel and in particular field monitoring teams
- To monitor persons from the accident area for skin and clothing contamination before, during and after decontamination
- To monitor thyroid for radioiodine uptake

Sampling - General Guidance

- Take representative samples to enable the level and extent of contamination of air, ground, water, foodstuffs, vegetation etc. to be accurately and rapidly determined
- Sampling techniques should be consistent between sampling teams
- Samples should be taken at locations representative for the area and where contamination is more likely rather than at the most accessible sampling sites

Sample Analysis

- Samples can either be assessed in the field or returned to a specialist laboratory

- Standard analytical procedures may need to be replaced by rapid methods to cater for larger numbers of samples and the need for results as soon as possible

- Sample screening techniques may be employed

Confidence in the Monitoring Results

- Confidence in the monitoring results and international acceptability can be achieved only by implementing effective quality assurance system

- The system basically consists of
  - quality assurance (QA) programme
  - quality controls (QC) and
  - audits / appraisals

Procedures

- Measuring procedures
- Calibration procedures
- Evaluation procedures
- QA and QC procedures

What procedures???

Field measurements and sampling

- Techniques
- Preparation and storage of samples
- Coding and record keeping

Instrumental Analyses

- Instruments
- Calibrations
- Background evaluations
- Checks of the stability of the instruments
- Field and laboratory records
- Data reporting

Summary

- Monitoring organization and emergency team protective guides should be adapted to reflect country specific system in emergency response

Any Question?

THANK YOU

"The important thing is not to stop questioning"

Albert Einstein

MMTC ASIA SDN BHD

TOPIC 4

PERSONAL PROTECTIVE EQUIPMENT, DEVICES AND PROCEDURES

MMTC ASIA SDN.BHD
1330199-X

Introduction

- In a radiation emergency, emergency workers could be exposed to radiation or become contaminated

- Personal protective equipment have to be used to avoid or minimize the risks of contamination and exposure

- The lesson presents personal protective equipment and train the student in proper dressing and undressing, and explain the functions of a contamination control point

Content

- BSS recommendations
- Personal protective equipment
  - Measuring devices
  - Contamination control barriers
- Anti-contamination clothing
  - Dressing
  - Undressing
- Contamination control point
- Summary

BSS Recommendations

- BSS establishes that employers, registrants and licensees shall ensure, for all workers, that
  - … appropriate protective devices and monitoring equipment be provided and arrangements made for its proper use
  - … suitable and adequate human resources and appropriated training in protection and safety be provided, as well as periodic retraining and updating as required in order to ensure the necessary level of competence …
  - … use properly the monitoring devices and protective equipment and clothing provided
  - … accept such information, instruction and training concerning protection and safety as will enable them to conduct their work in accordance with the requirements of the Standards …

Personal Protective Equipment And Devices

- Measuring Devices
  - Dose rate meters
  - Contamination monitors
  - Personal dosimeters

- Contamination Control Barriers
  - Anti-Contamination Clothing
  - Respiratory protection

Dose Rate Meters and Contamination Monitors

- Used for general radiation monitoring applications
- Could be based on Geiger-Müller (GM) detectors, proportional counters, ionisation chambers or solid state detectors (sodium-iodine crystals)
- Contamination measurements usually require calibration for specific radionuclide

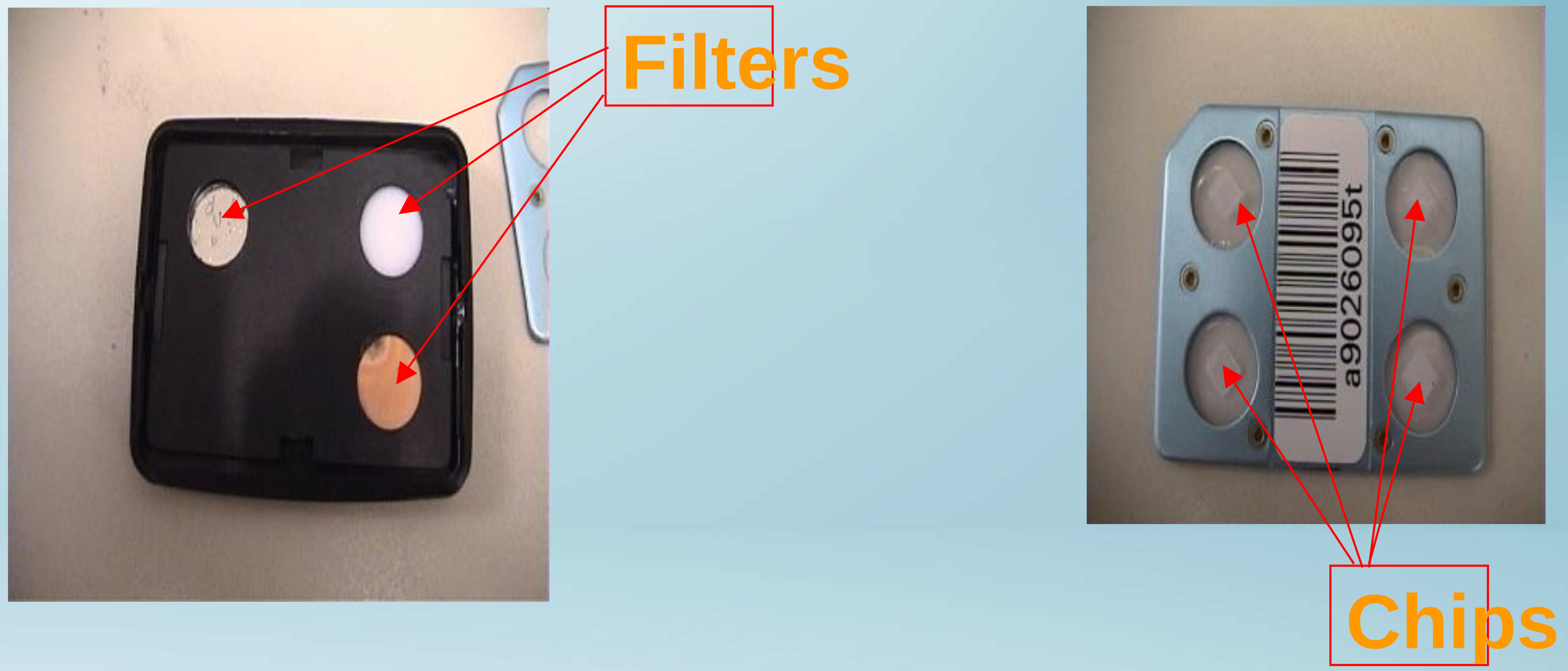
Geiger-Müller (GM) Detector

Personal Dosimeters

- Types:
  - Passive: TLD or RPL or OSL
  - Active: Pocket ion chamber and electronic pocket dosimeters
- None of the above dosimeters can detect low energy beta emitters
- Passive dosimeters cannot be used for contamination surveys
- Alarms and turn back values

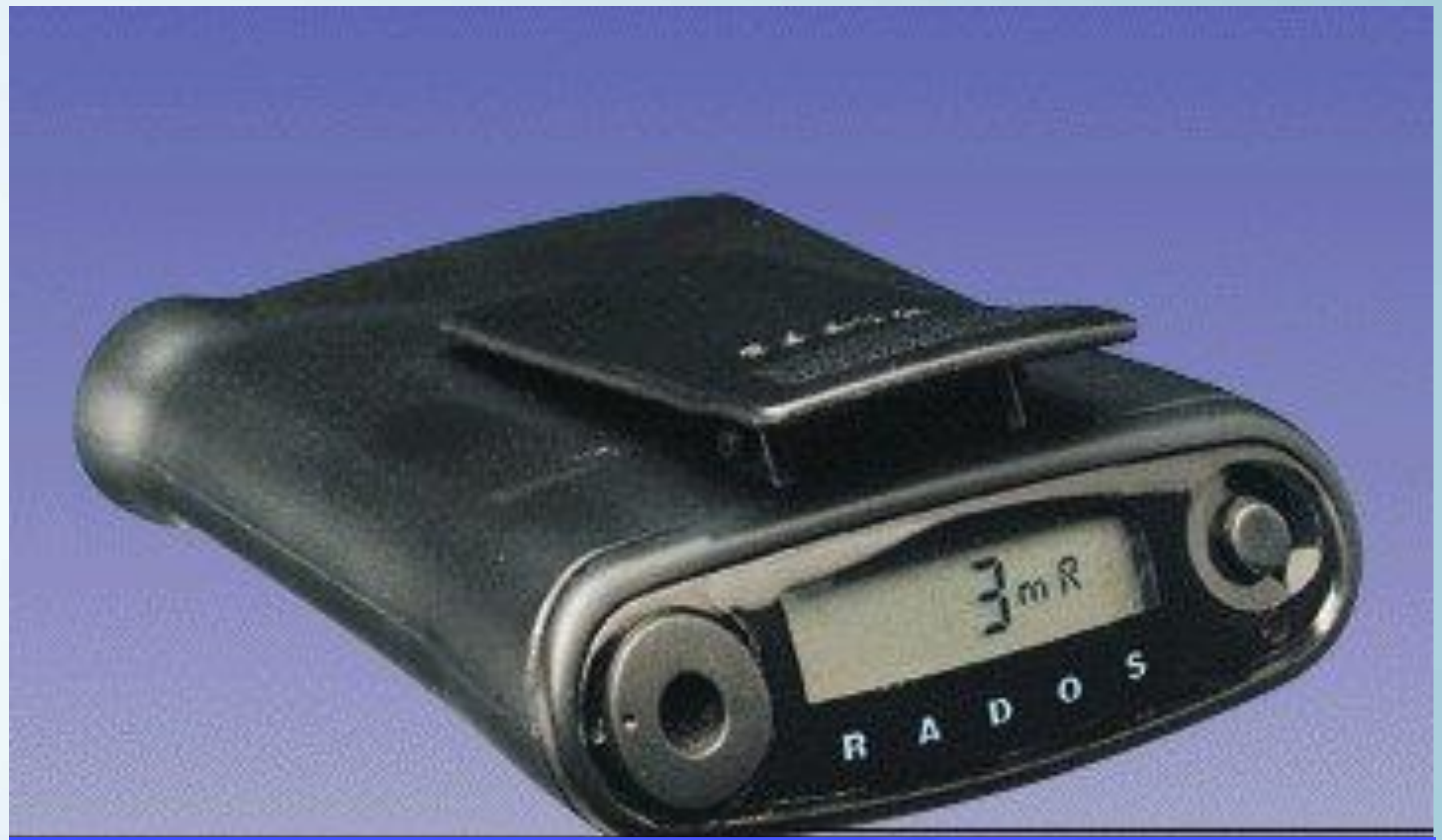
Thermo Luminescent Dosimeters - TLD

- Crystalline material
- Excited electrons remain in metastable state until heated
- Heating releases electrons
- Reusable but no permanent record
- Dose rate response curve is flat
- Dose response does not saturate



Electronic Personal Dosimeter

- Similar to PIC
- Reads dose or dose rate
- Alarms for dose or dose rate
- No permanent record



Contamination Control Barriers

- External
  - prevent contamination of the skin
  - help minimize the spread of contamination
  - do not provide protection against external exposure
- Internal
  - prevent contamination from entering the body
  - require specialized equipment

External Barriers = Anti-**C's**

- Cotton Gloves
- Overalls
- Shoe Covers
- Vinyl Gloves
- Hood
- Foul weather gear

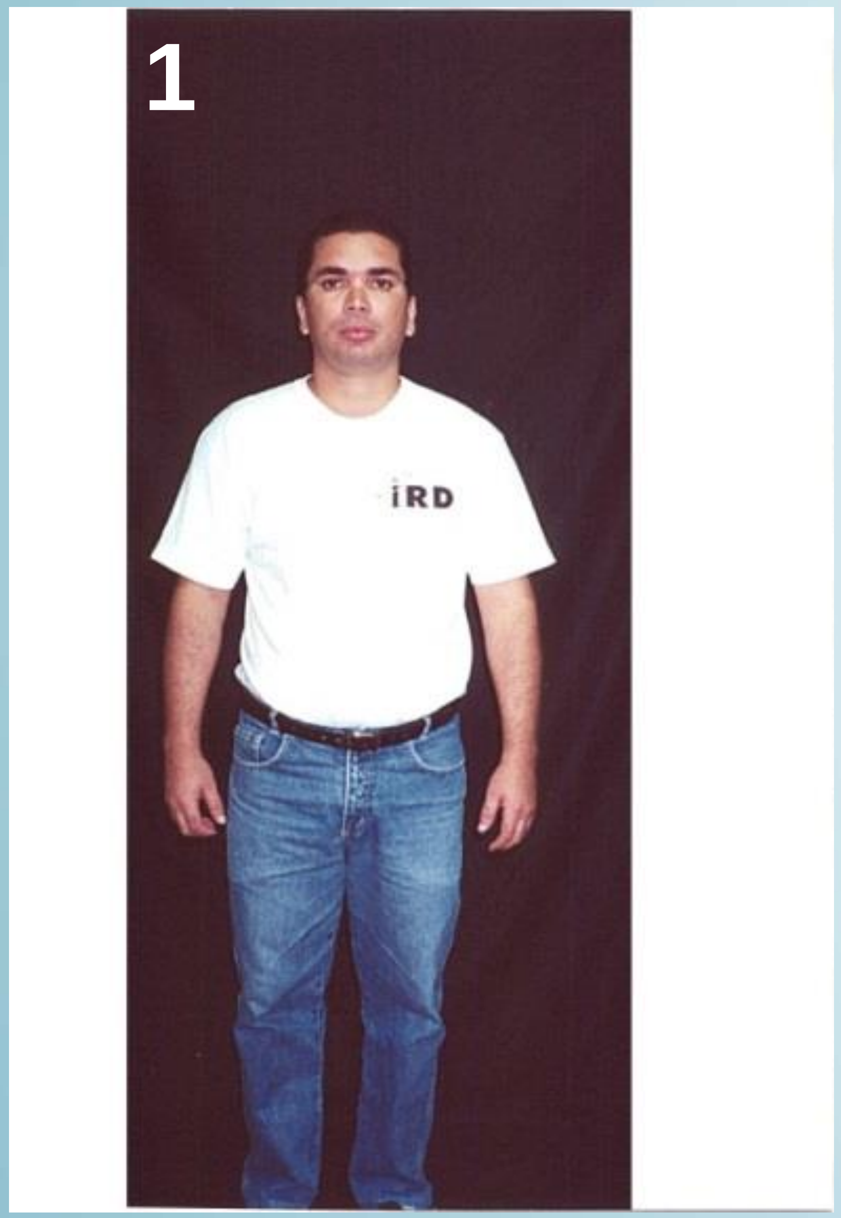
Internal Barriers = Respirators

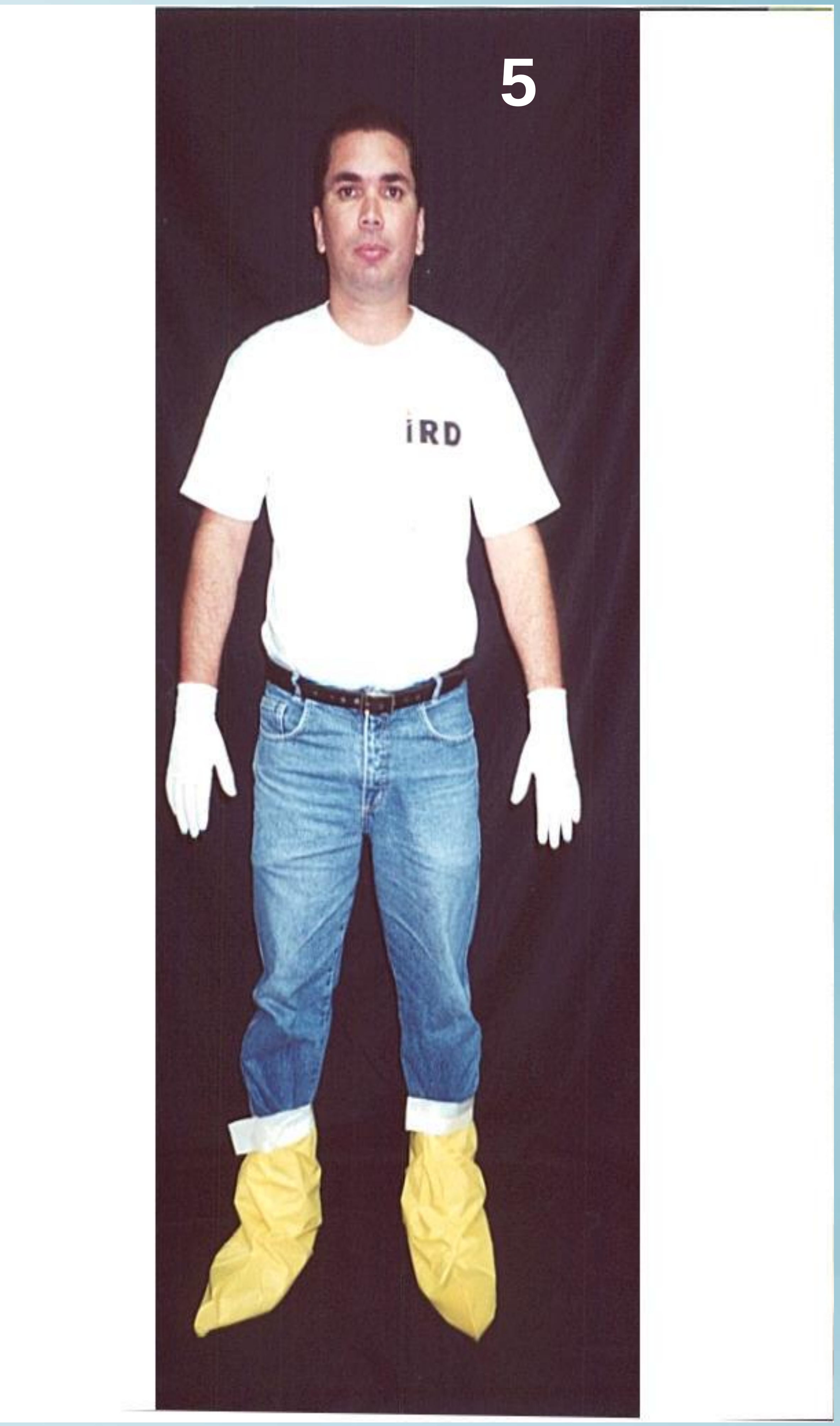
- Dust filters
- Half-face respirator
- Full-face respirator
- Self contained breathing apparatus
- Air Supplied Hoods

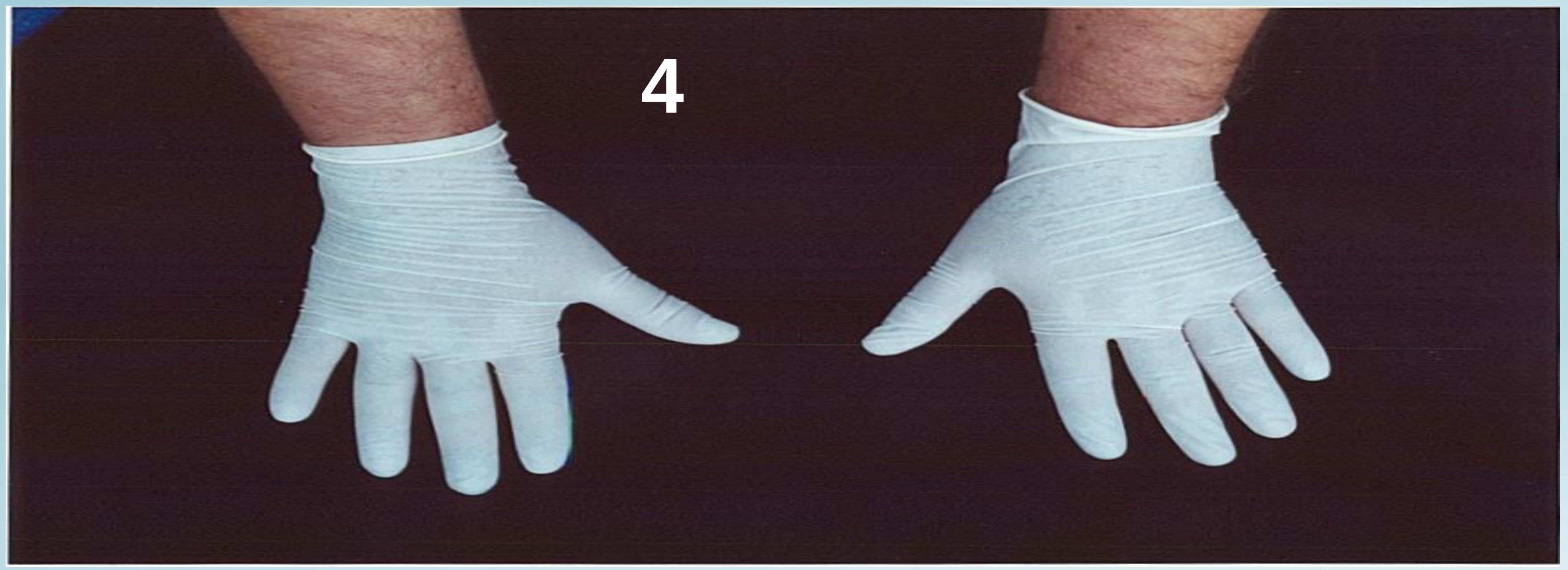
Donning Anti-Contamination Clothing

- There are three layers of protection
  - First layer: gloves and overshoes
  - Second layer: cotton overall, second gloves and overshoes, cotton hood, passive dosimeter
  - Third layer: plastic overall, third gloves and overshoes, respirator (mask) and direct reading dosimeter

Donning Anti C's: 1st Layer

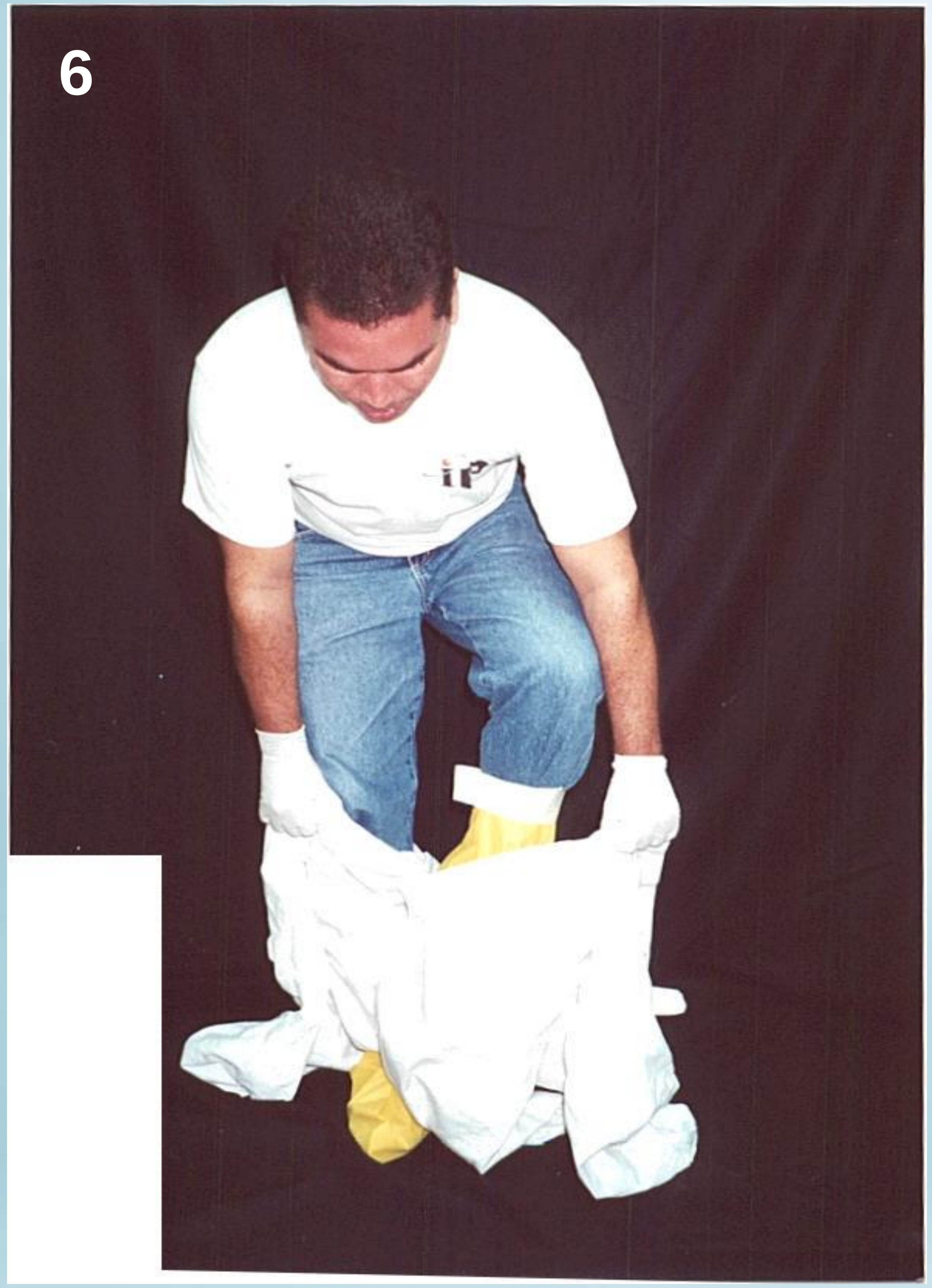


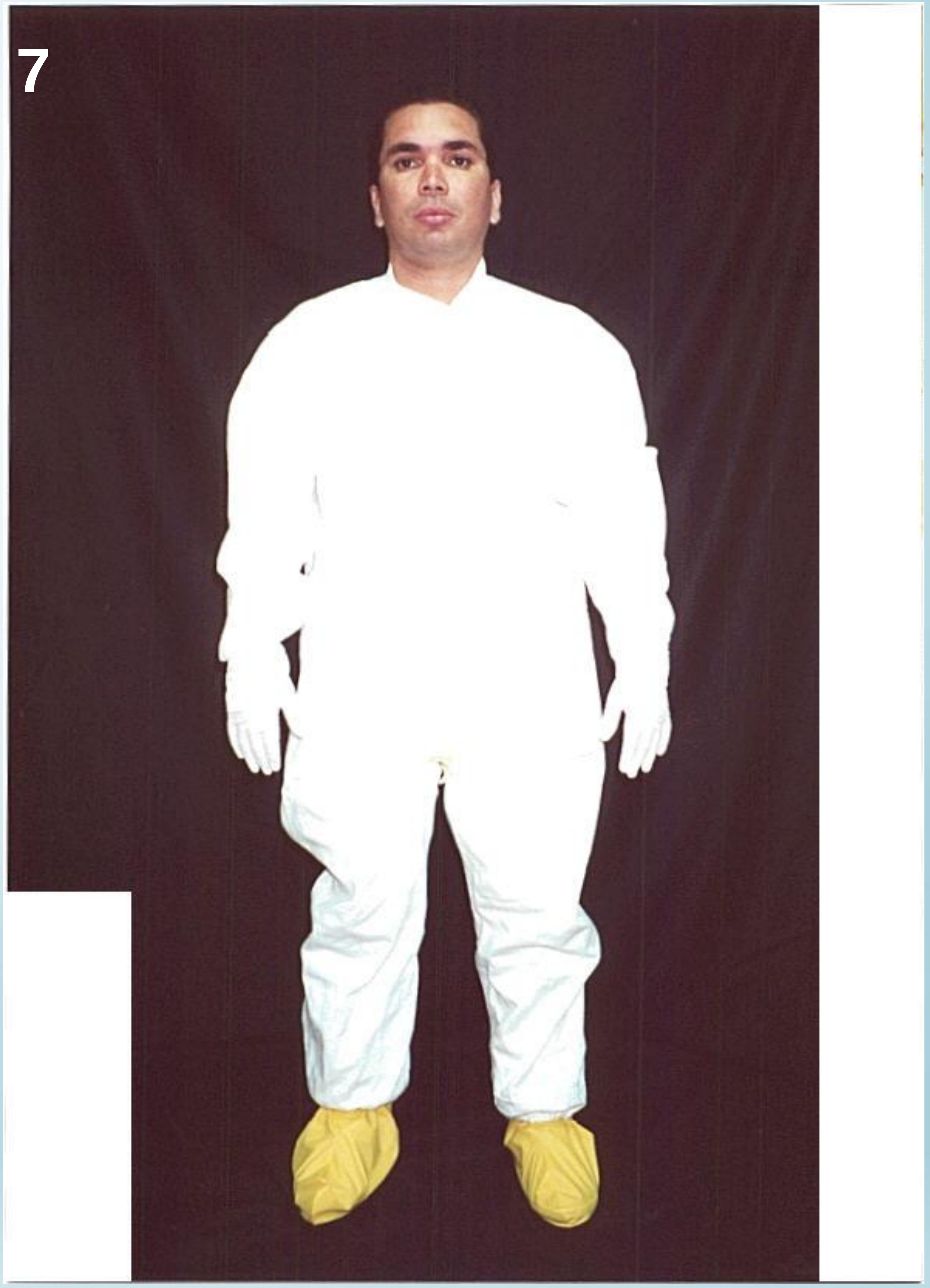




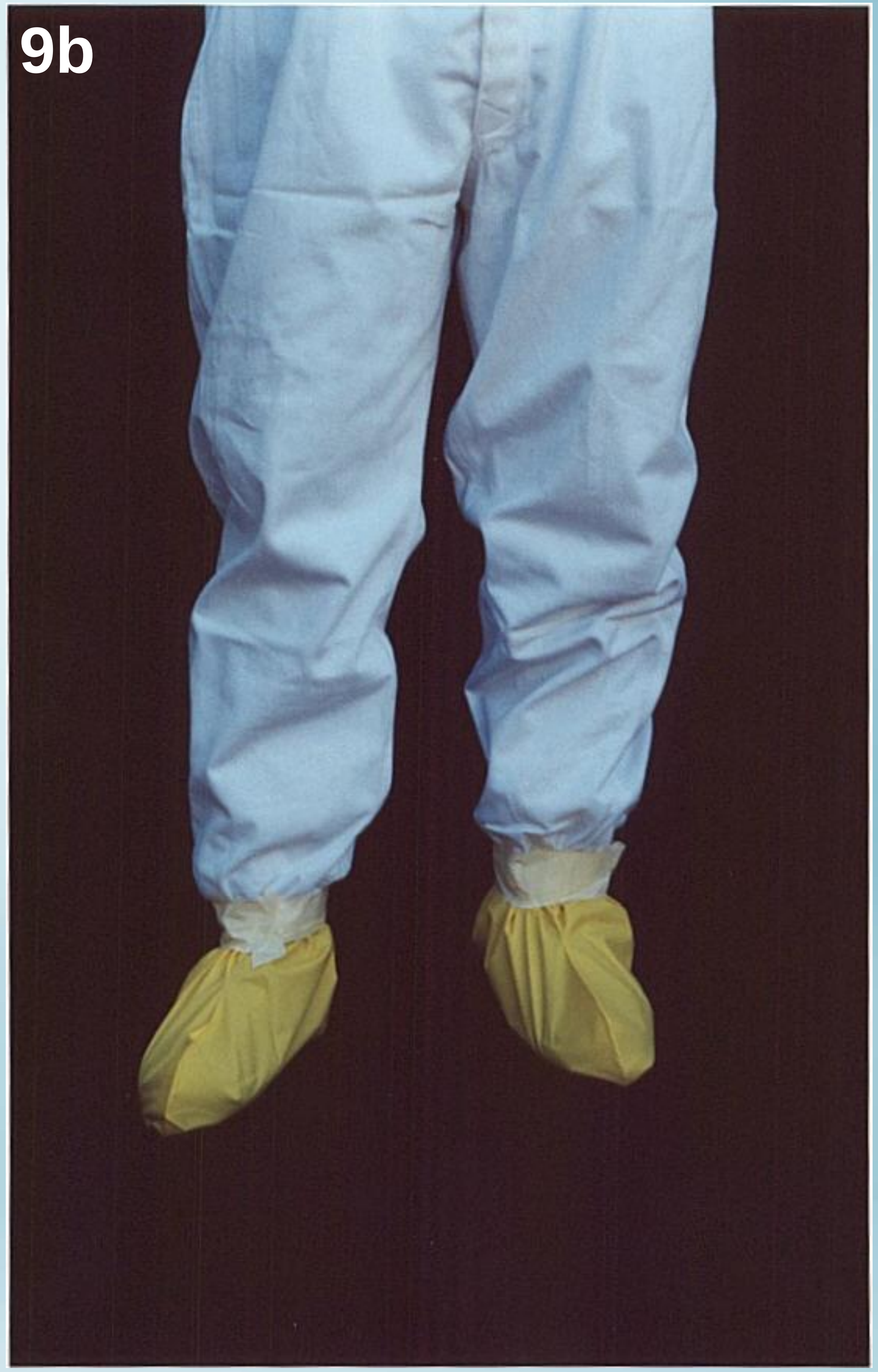
1st layer is complete

Donning Anti C's: 2nd Layer

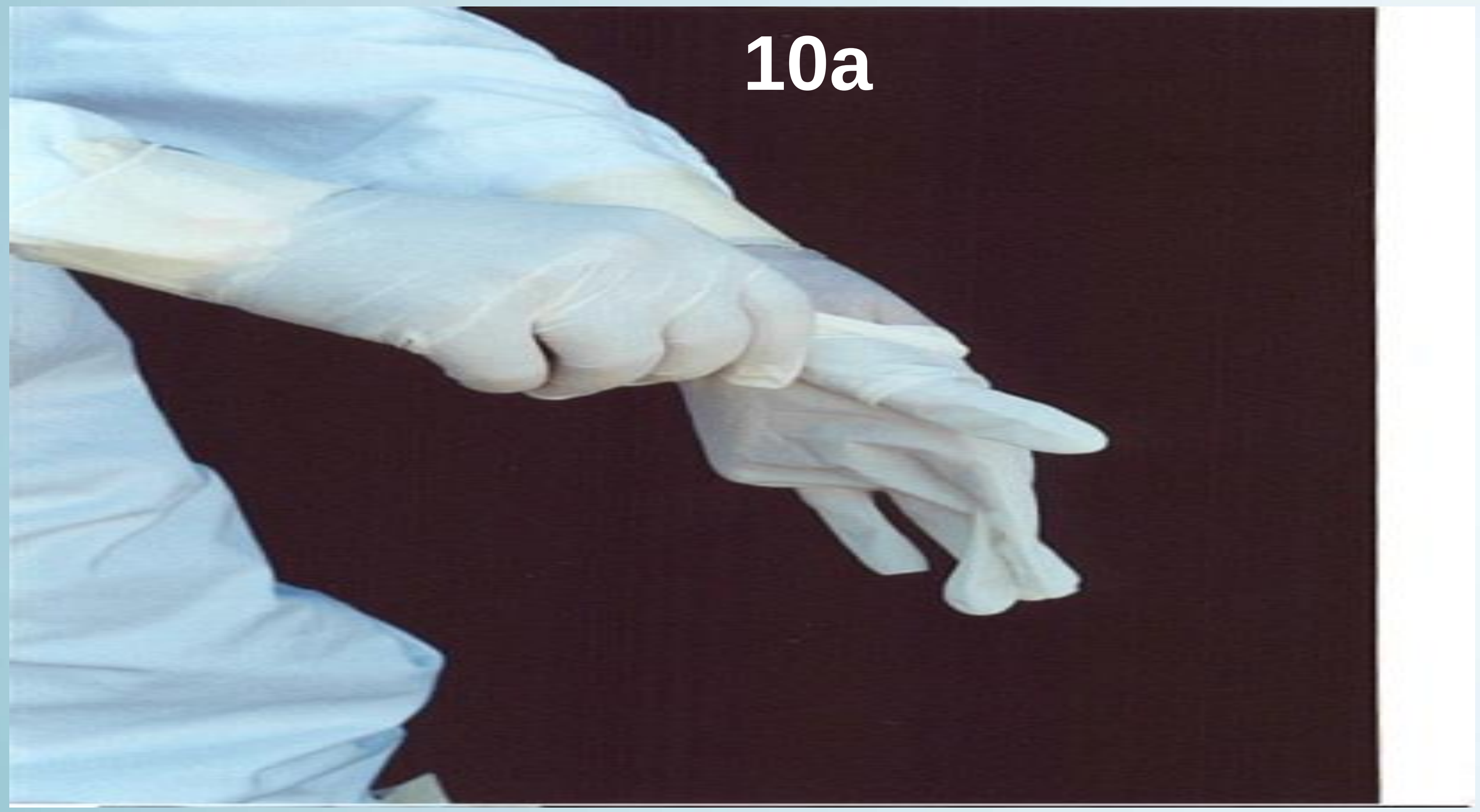


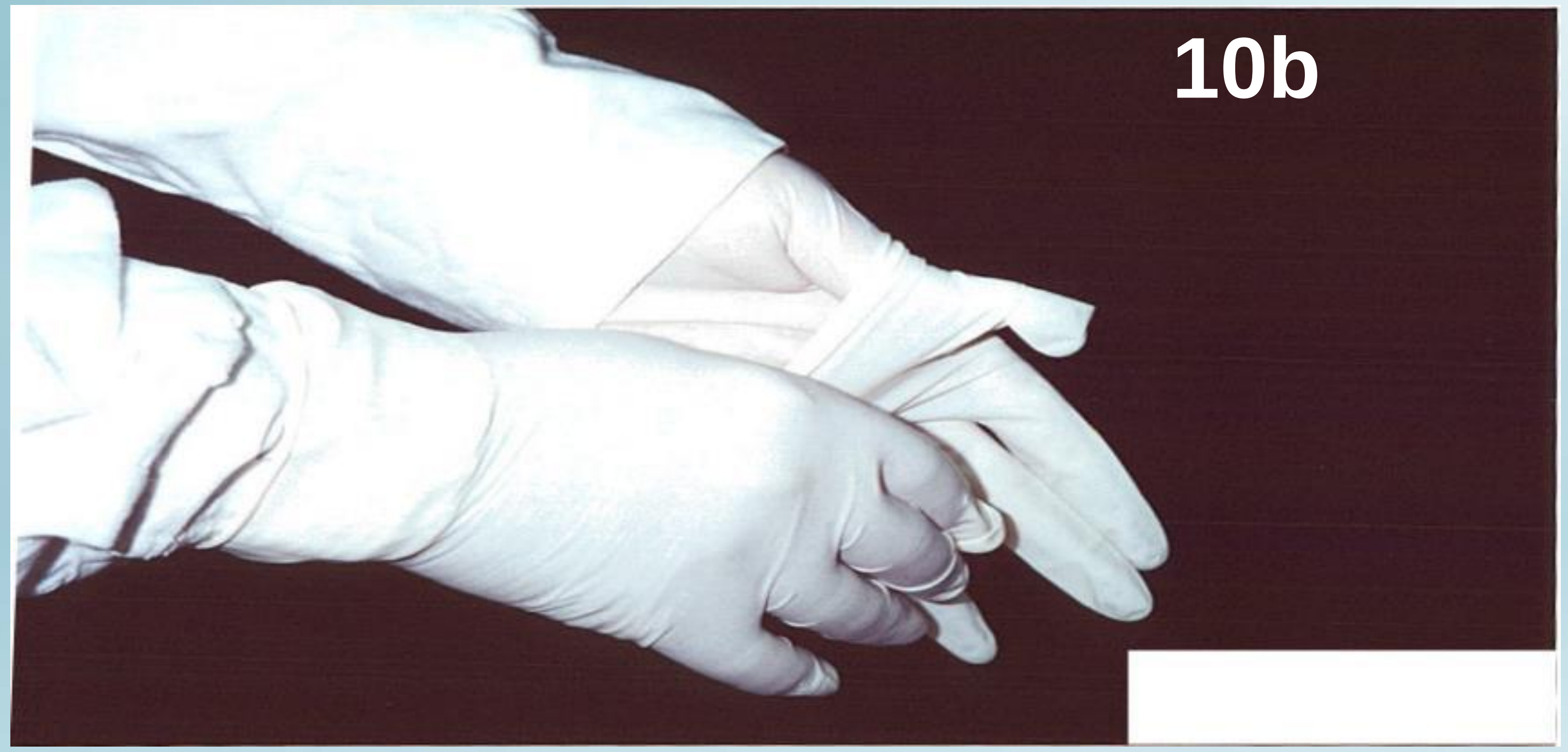


Donning Anti C's: 2nd Layer (cont'd)

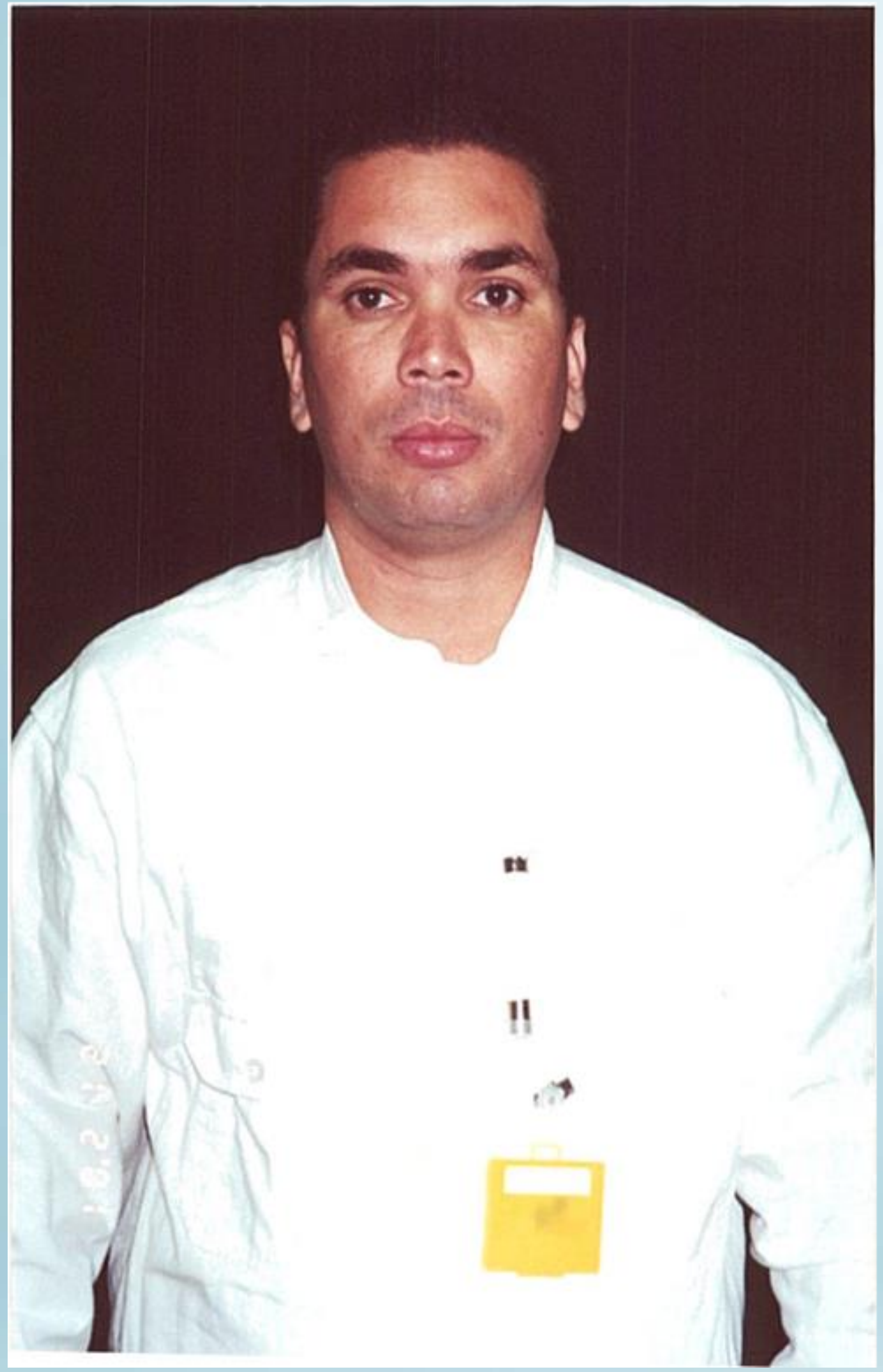


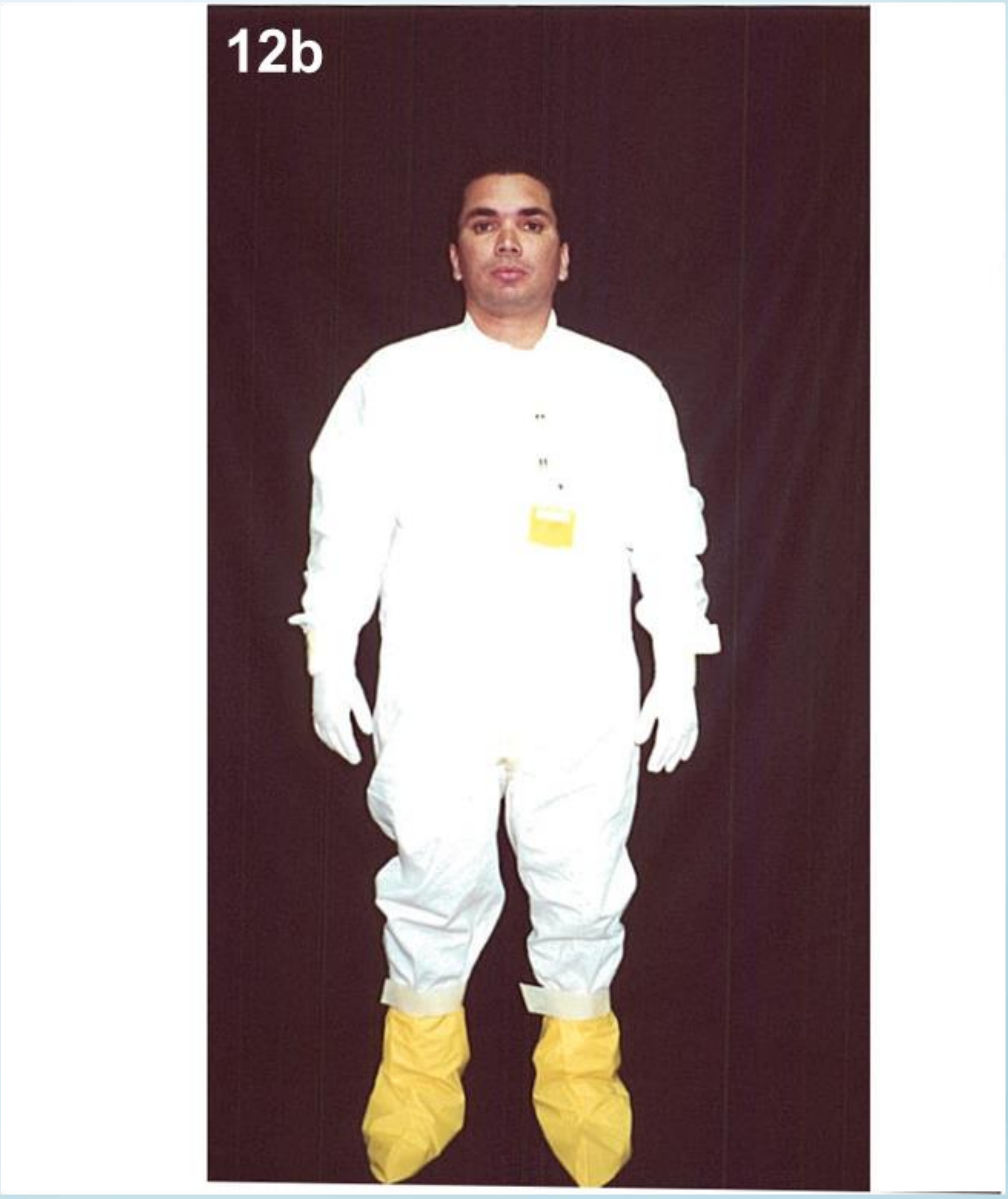
Donning Anti C's: 2nd Layer (cont'd)





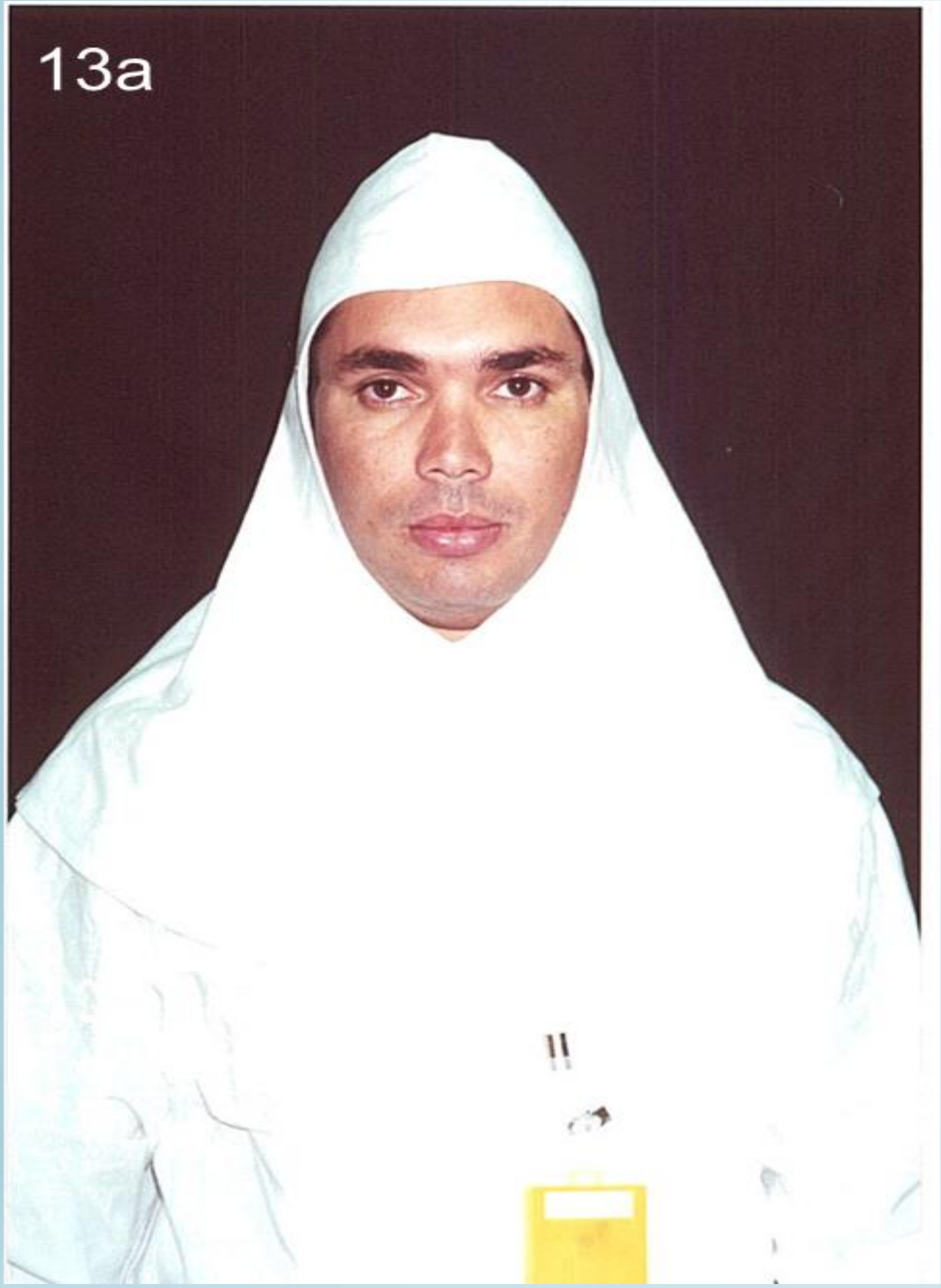
Donning Anti C's: 2nd Layer (cont'd)

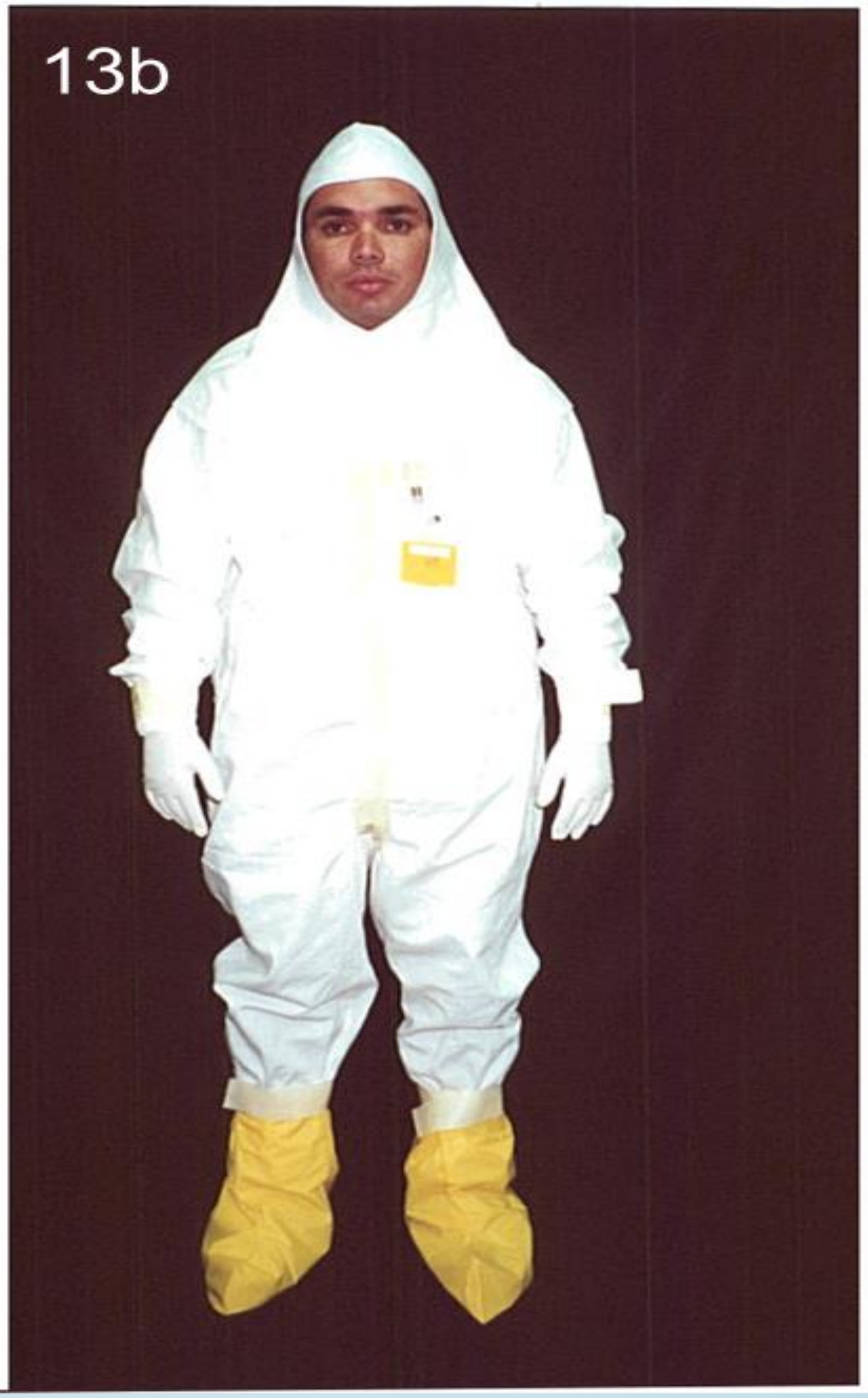




View after
step 12

Donning Anti C's: 2nd Layer (cont'd)



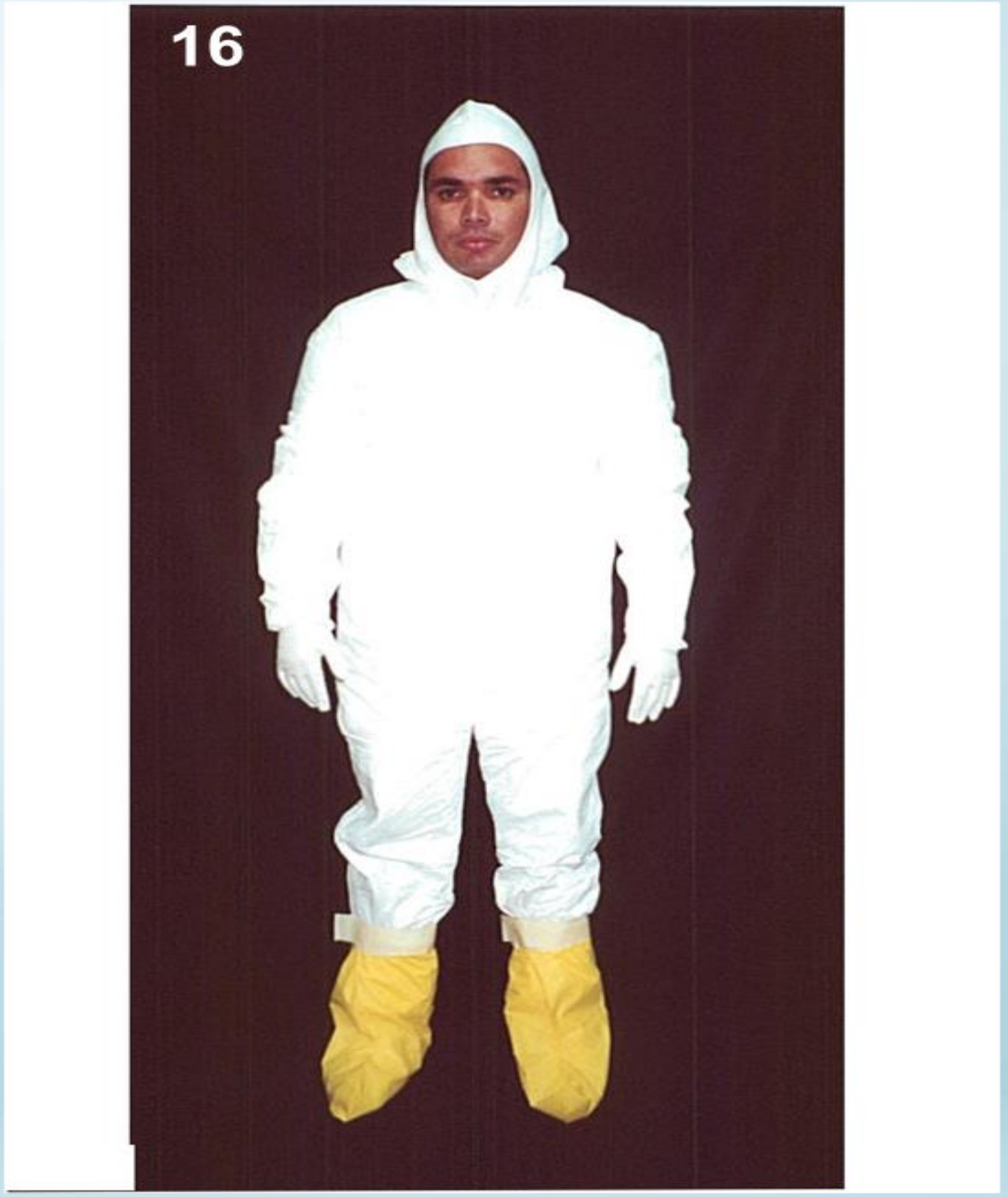


2nd layer is complete

Donning Anti C's: 3rd Layer (cont'd)

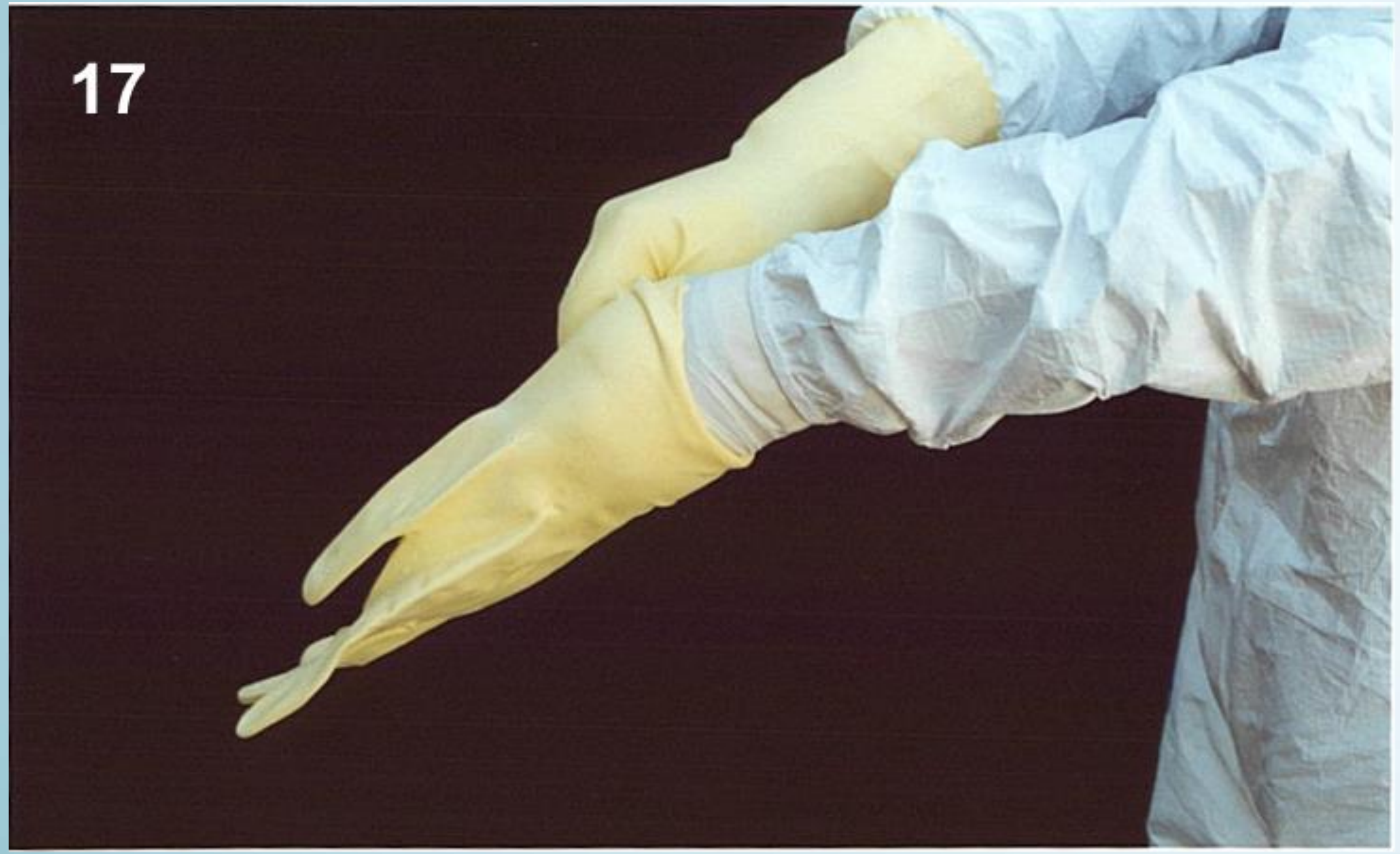
View after step 14

Donning Anti C's: 3rd Layer (cont'd)



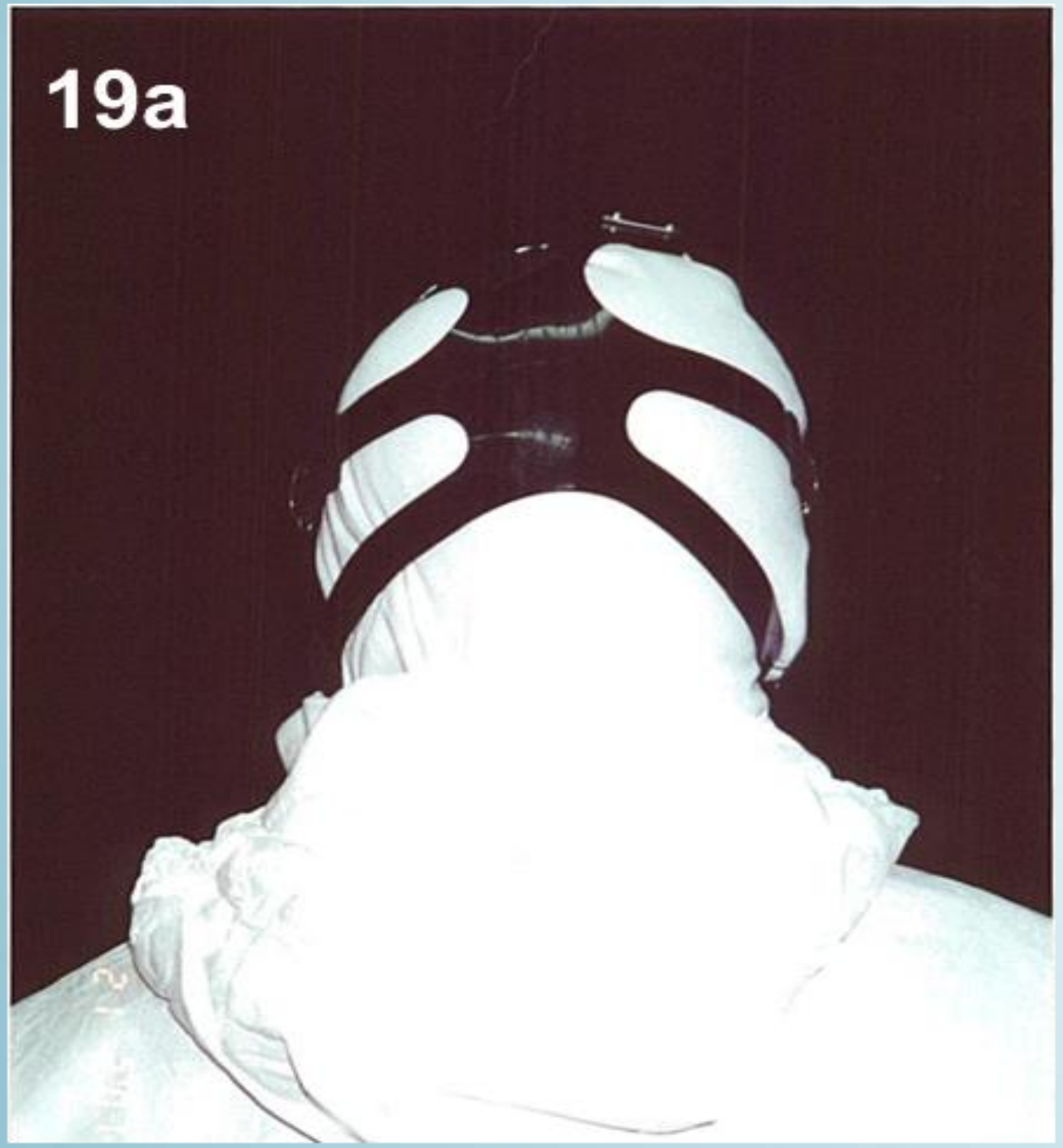
View after step 16

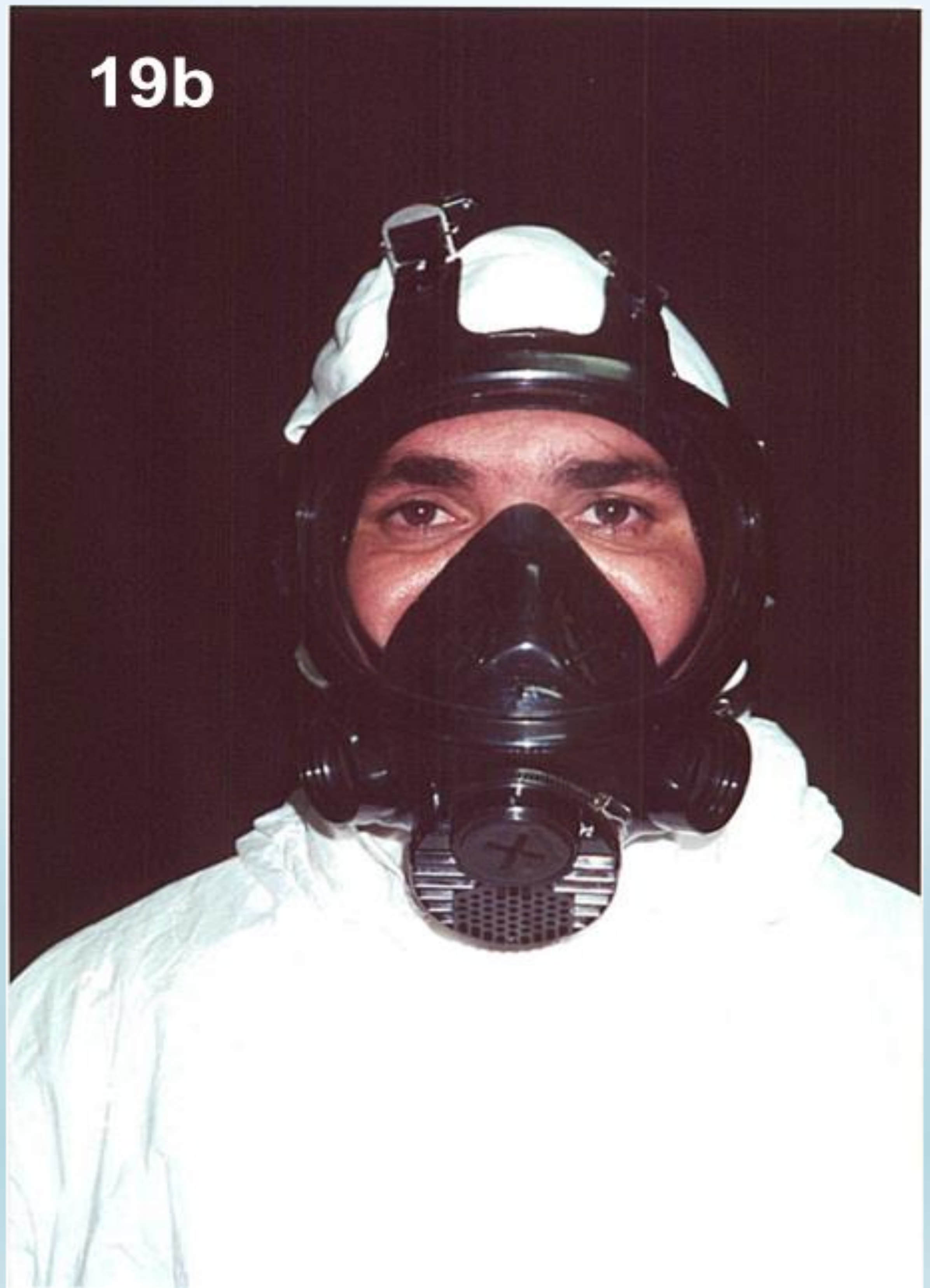
Donning Anti C's: 3rd Layer (cont'd)

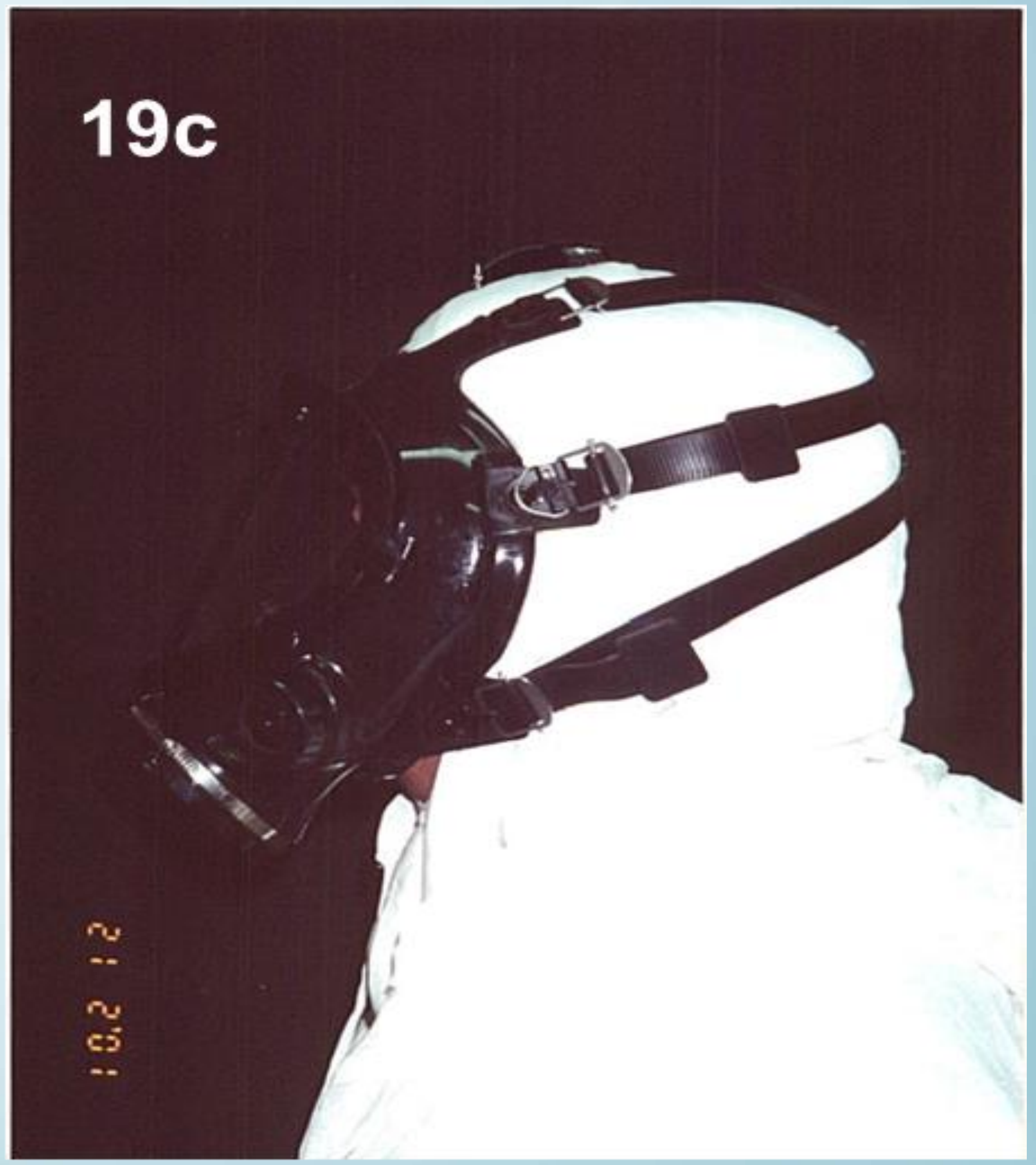


View after step 18

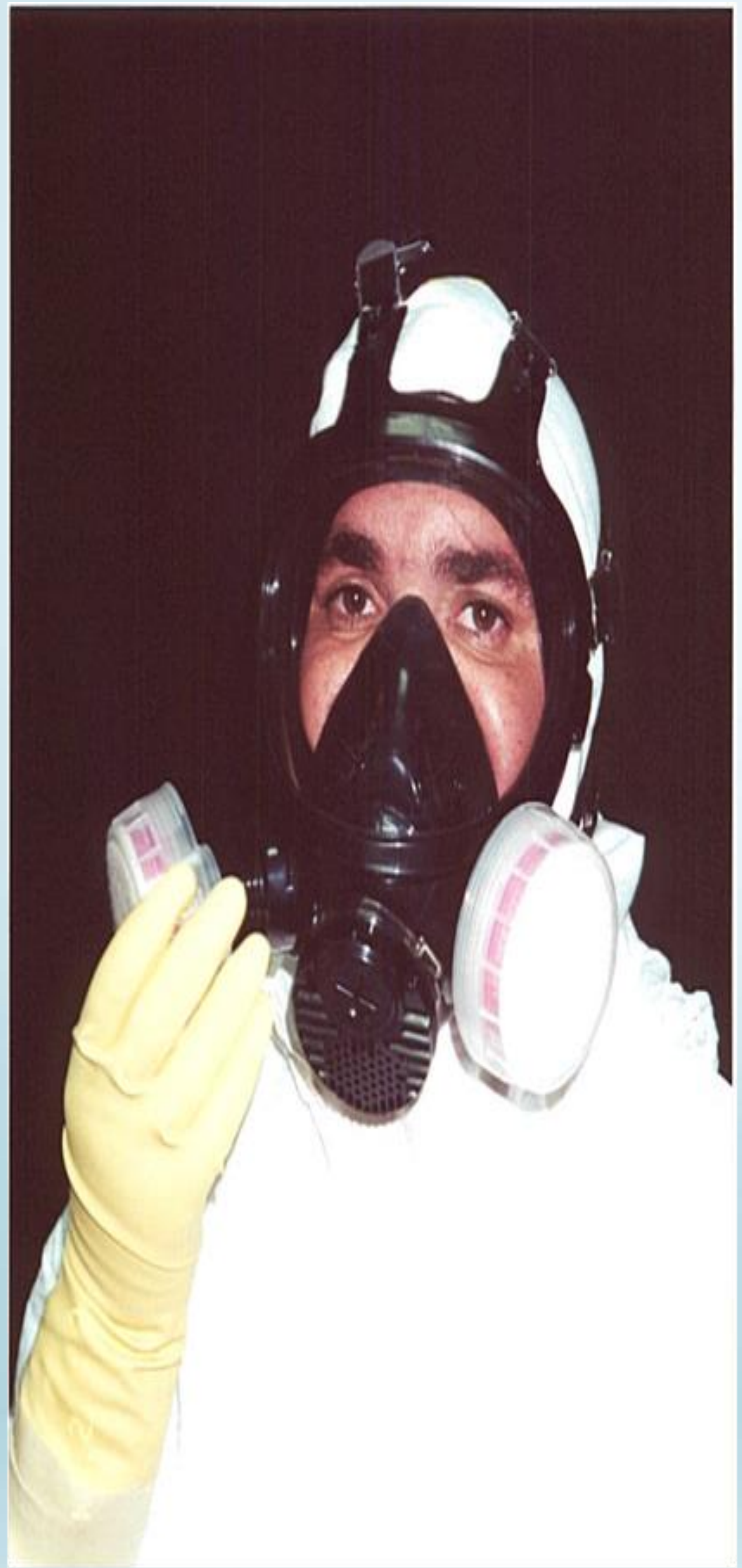
Donning Anti C's: 3rd Layer (cont'd)



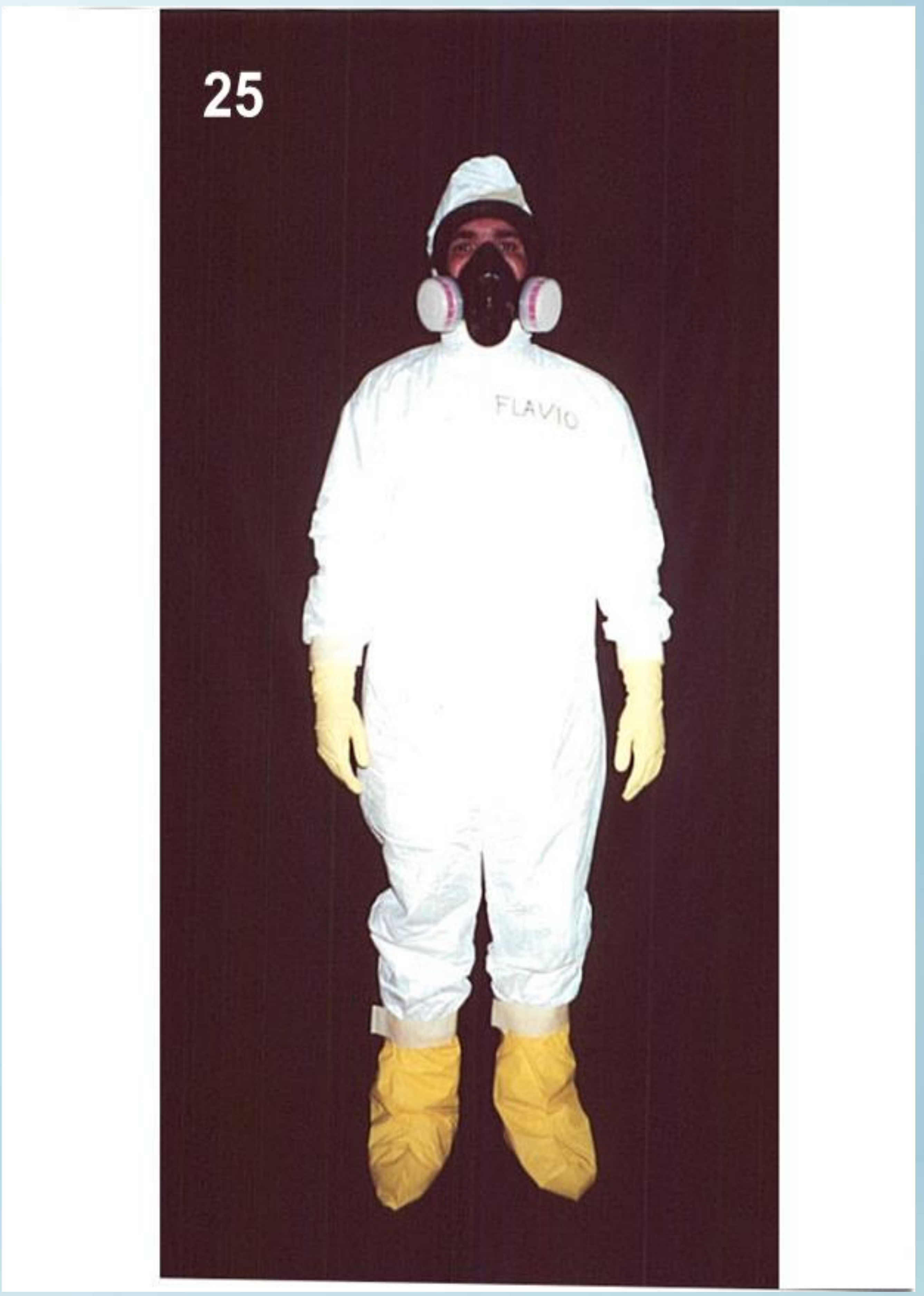




Donning Anti C's: 3rd Layer (cont'd)

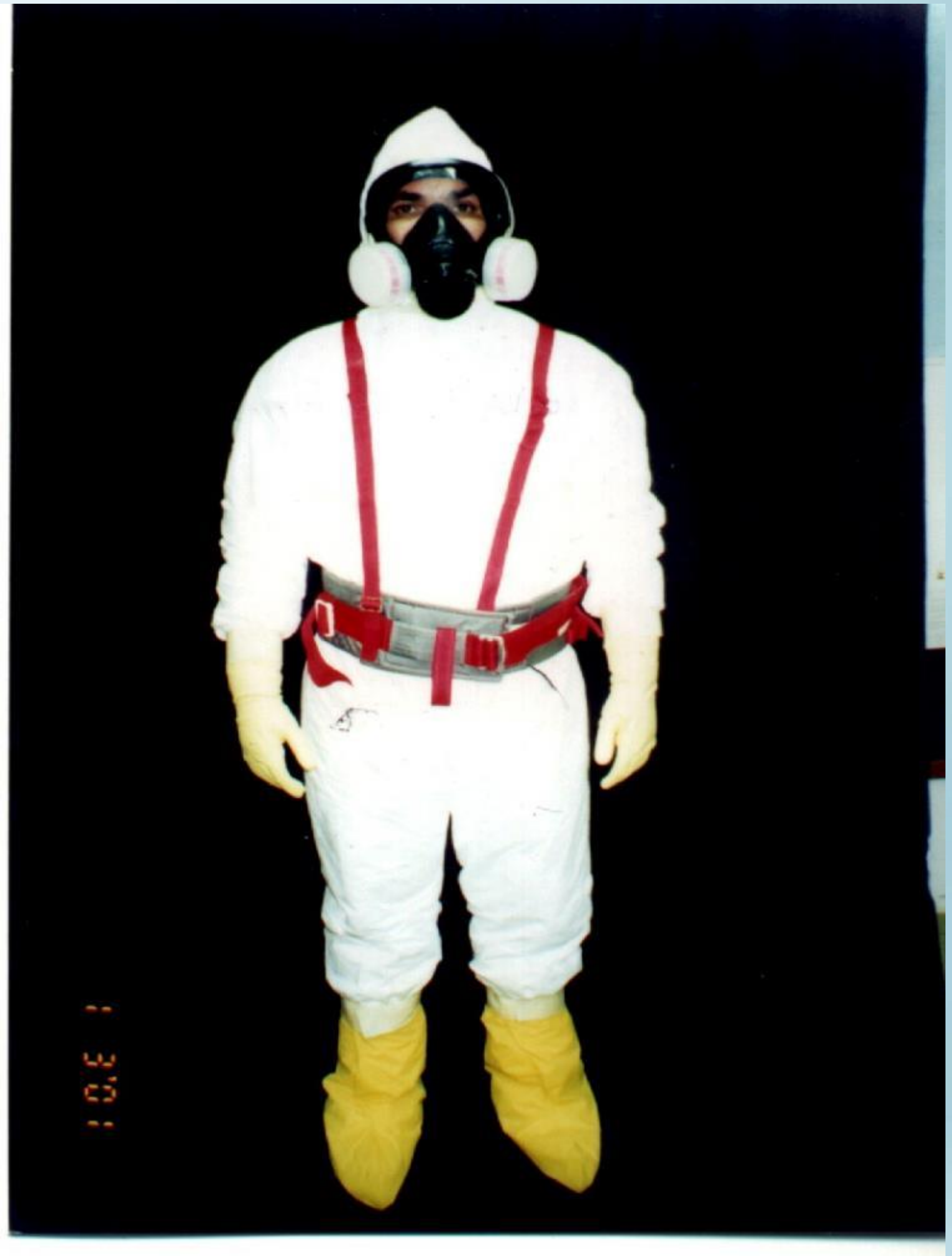


Donning Anti C's: 3rd Layer (cont'd)



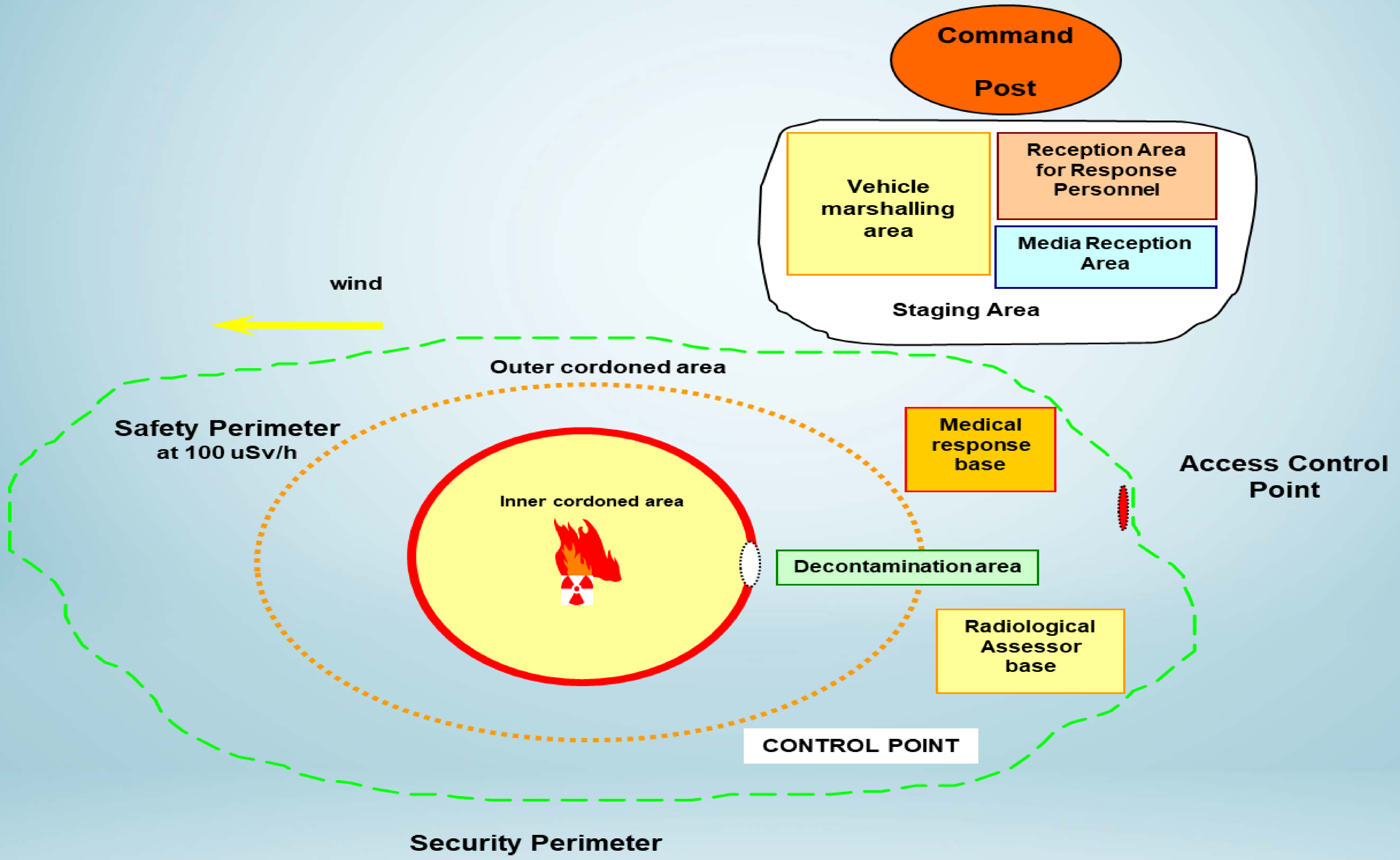
Donning Anti C's - Overview

- First Layer
- Second Layer
- Attach dosimeters
- Third Layer
- Put on respirator
- Attach alarm dosimeter

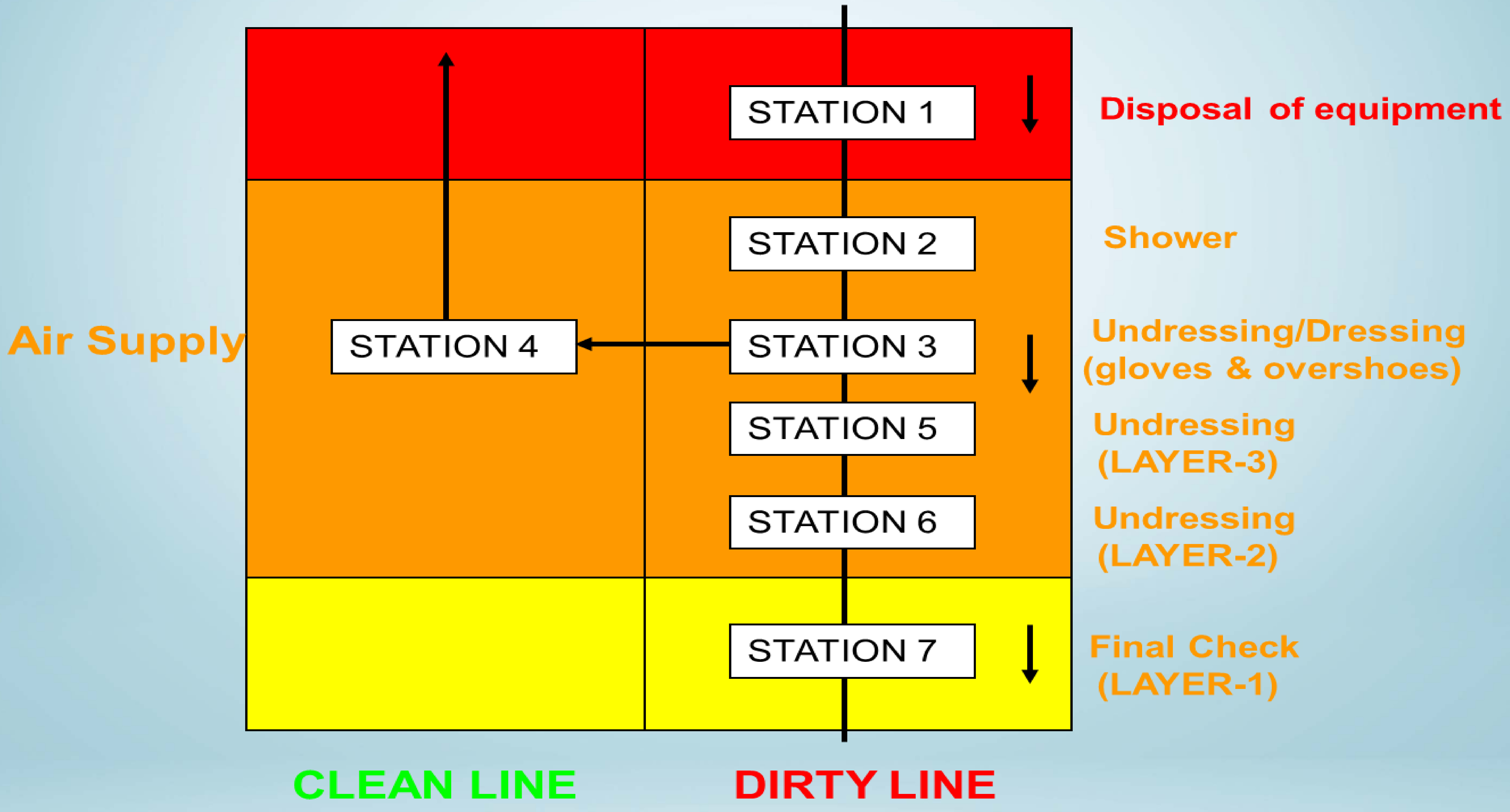


Emergency Worker

Accident Scene Set-up



Control Point - Hazmat Procedure



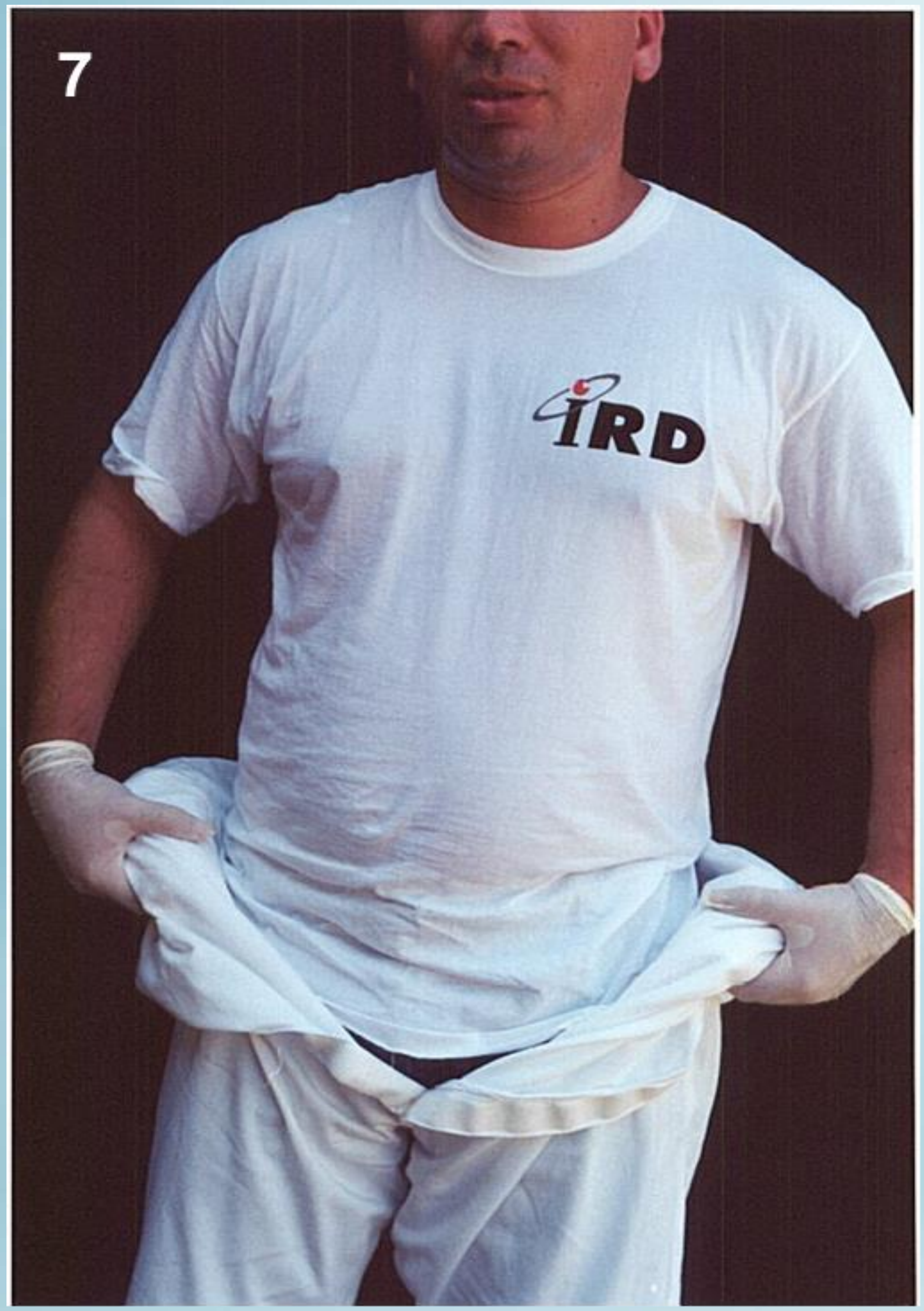
Removing Anti-C’s

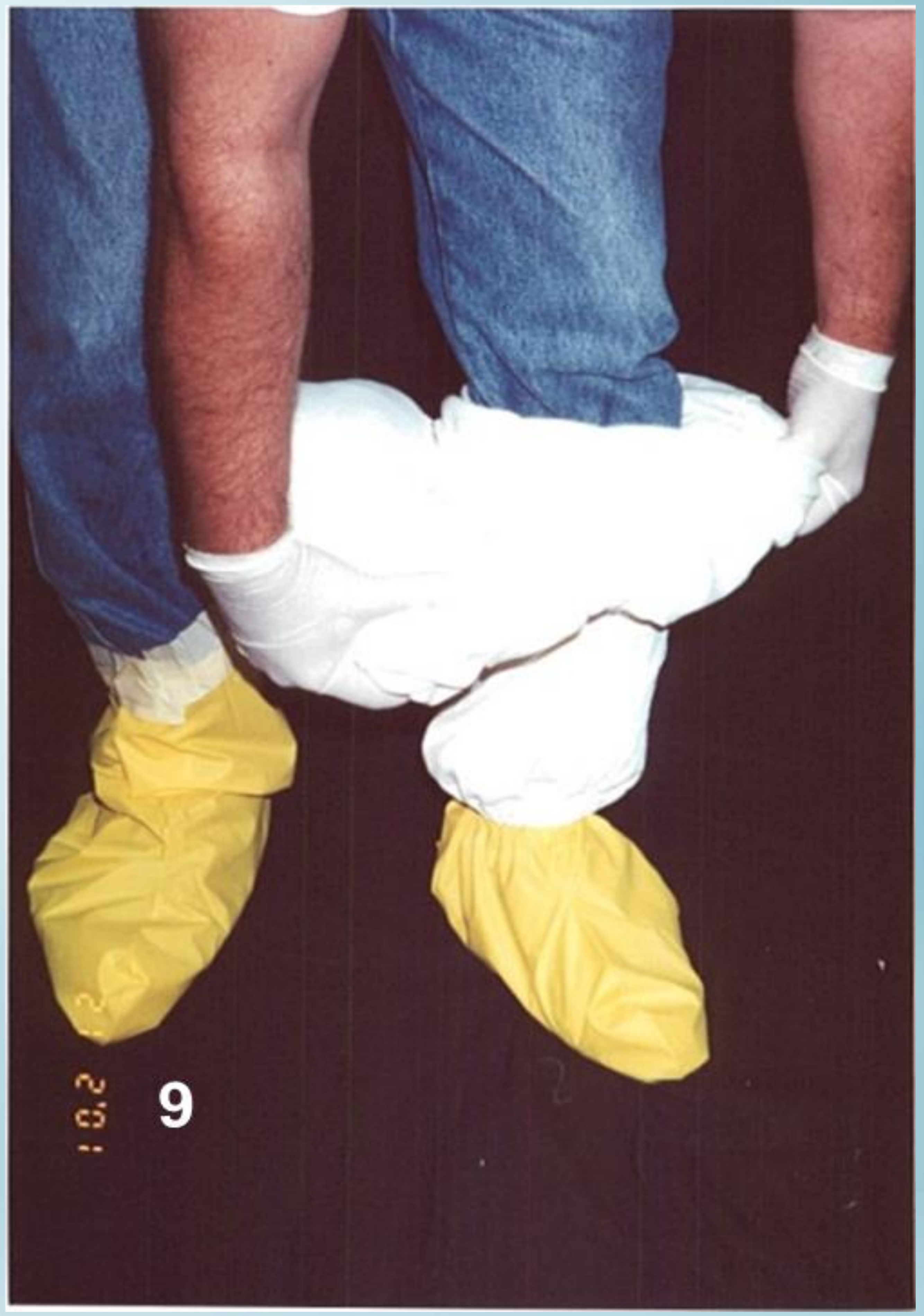
- Remove Anti-C’s in the following order
  - Outer overshoes
  - Outer gloves
  - Direct reading dosimeter
  - Inner overshoes
  - Inner overalls
  - Respirator
  - Inner gloves

Removing Anti-C's: 3rd Layer

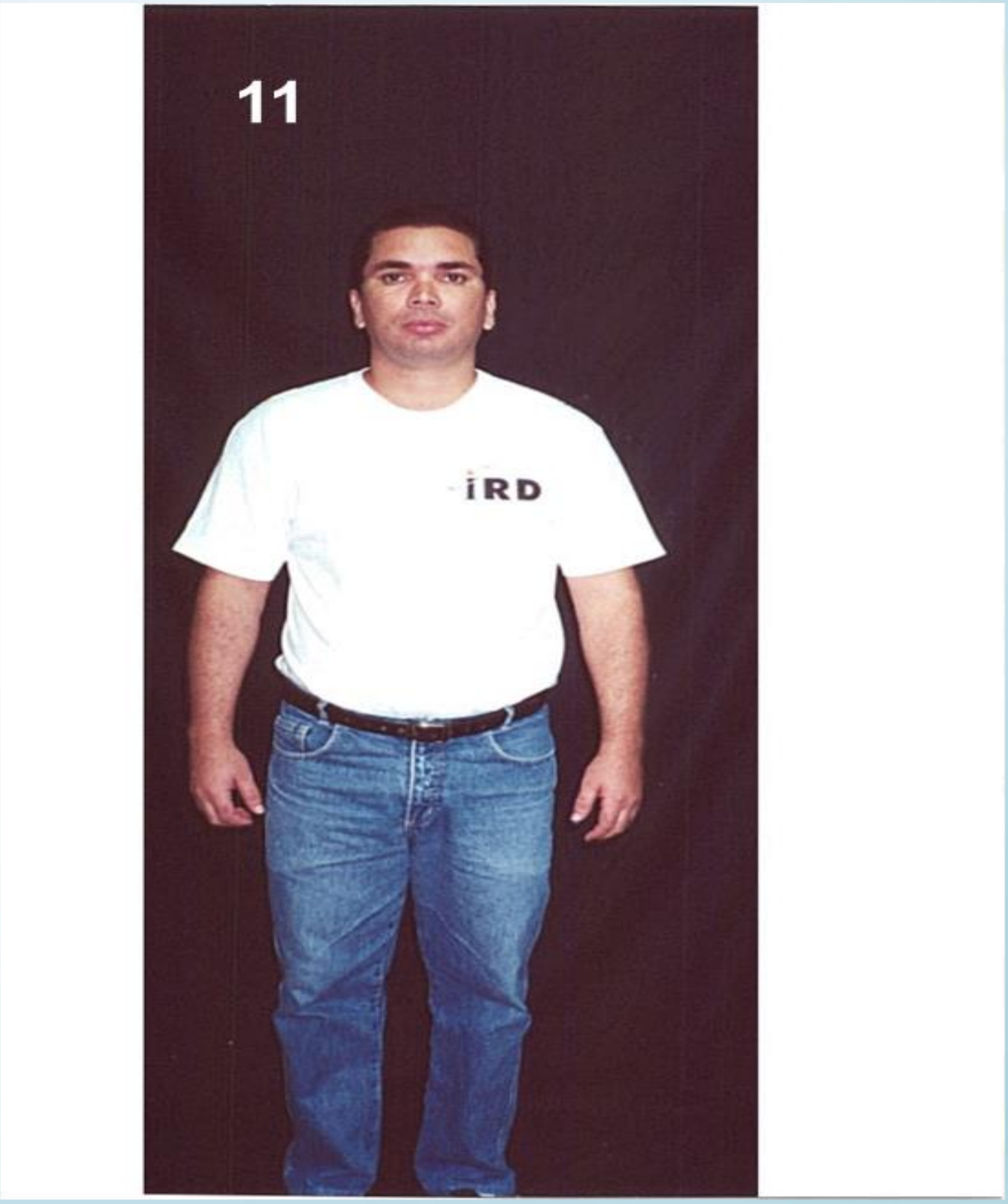
Removing Anti-C's: 3rd Layer

Removing Anti-Cs: 2nd Layer





Removing Anti-Cs: 1st Layer



You are
free to go

Summary

- Personal protective equipment protects the worker from both external and internal contamination
- The presence of radiation can be detected only through radiation monitoring
- A Control Point has always to be set up

Any Question?

THANK YOU

"The important thing is not to stop questioning"

Albert Einstein

MMTC ASIA SDN BHD

TOPIC 5

NUCLEAR AND RADIOLOGICAL RESPONSE PLAN UNDER ACT 304

MMTC ASIA SDN.BHD
1330199-X

Content

- Introduction
- Types of Emergencies
- Emergency Plan
- Objectives of Emergency Plan
- Contents of Plan
- Emergency Organisation
- Emergency Monitoring
- Emergency Procedure
- Reporting Procedure

Introduction

- Radiological emergency means any situation which gives rise to an abnormal or unexpected radiation hazard.
- Personnel exposure, contamination or both and it can happen at any time or place.
- The licensee have to prepare the necessary plan of action for emergencies and incidents.

Types of Emergencies

- Local emergency
  - Accident or occurrence in the work area in which personnel may have been exposed to excessive radiation or radioactive contamination.
  - This category of emergency includes small radioactive spill and loss of shielding of small radioactive sources in the work area.
  - It can easily be corrected with the help of two or three people.

Types of Emergencies

- Site Emergency
  - Site emergency is more serious than local emergency. It may affect the whole facility area.
  - Example of site emergency:
    - Fire or explosion causing damage to a room or its contents, where sealed or unsealed radioactive materials are used or stored.
    - Loss of shielding of large radiation sources
    - Major spillage of radioactive materials in work areas.

Emergency Plan

- Emergency plan should consider all possible sources of radiological emergency associated with the facility.

- Emergency planning could be different for each practice.

Objectives of Emergency

- To reduce the risk or mitigate the consequences of the accident at its source.

- Prevent serious deterministic health effects (e.g., death), and

- Reduce the likely stochastic health effects (e.g. cancer) as much as reasonably achievable.

Contents of Plan

- Develop an emergency response plan defining authorities, roles and responsibilities of the various organizations involved.
- Identify a coordinator for emergency planning.
- Develop procedures which cover all critical tasks.
- Use a standard format for procedure, identifying each response position, date approved and steps to be performed.
- Ensure that all procedure, reference materials and documents required to perform a function are available at the location where the function is to be carried out.

Contents of Plan

- Conduct a periodic review of the plan and the procedures.
  - Note: Take into account lessons learned from similar accidents around the world and during drills and exercises.
- Update all perishable information quarterly (phone number, etc)
- Correct deficiencies to plans and procedure within 12 months.

Contents of Plan

- Develop a means for routinely conducting inventory checks.
- Establish a maintenance programme for the equipment, including a check list of location and routine inspections to ensure that the equipment is available and operational.
- Provide personal protection equipment for emergency workers, including for each person self-reading dosimeter.

Contents of Plan

- Periodically test communication equipment components that are not normally used.
- Establish training requirements for each position and team.
- Develop a programme that provides the training identified for each position in the emergency organization.
- Audit the attendance to ensure the training is being received.

Contents of Plan

- Develop a set of training materials
- Hold periodic table top exercise of all the major organizations that will have a role in the response to radiological emergencies.
- Develop a process to record lessons learned from training, drills and exercises and take corrective actions

Contents of Plan

- Develop procedures to promptly identify an accident.
  - Note: Facility events that should be identified include fires, spills, lost sources and overexposure.

- Establish a quality assurance process
  - Note: A distribution list should be developed.
  - Procedures and changes to procedures should not be implemented until the appropriate personnel are adequately trained.

Emergency Organization

- Emergency organization is one of the components of the plan. It is important to indicate who are the groups of people involved in the emergency response action and what are their assigned responsibilities.

Emergency Monitoring

Objectives

- To locate the plume
- To determine isotope concentrations in air
- To determine ground and surface contamination
- To locate hot spots
- To determine ground deposition isotope concentrations
- To determine isotope concentrations in foodstuff, milk, water, etc.
- To assist in source term estimation
- To confirm the efficiency of remedial measures
- To assist in preventing the spread of contamination

Radiation Emergency Response

Respiratory Protection And Protective Clothing

PURPOSE - Respiratory Protection and Protective Clothing

- Respiratory Protection - To provide an uncontaminated air supply when in a contaminated environment - airborne dust, gas, particles and vapour

- Protective Clothing - To protect the wearer from contamination when in a contaminated environment

Environmental Sampling Team

Purpose:

- for the assessment of gamma emitting ground surface contamination.

Minimum staffing per team:

- 2 persons, experienced in experienced environmental sampling

Minimum equipment per team:

- Sample collection tools, containers, labels
- Radiation survey instruments

Disposable Half Face Mask

CAUTION AVOID

Protection Factor 1

No gas protection

Little dust protection

Poor fit

False sense of security

Inexpensive

Half Face Mask With Filters

Protection factor 5
Poor gas protection
Fair dust protection
Filter dependent
Good fit essential
No beards
light weight
Inexpensive

Full Face Mask With Filters

Protection factor 100
Good protection
Filter dependent
Good fit (no beards)
Hot & visor misting
Light weight
Eye protection
inexpensive

Self Contained Compressed Air Breathing Apparatus

Protection factor 1000
Good protection
Good fit (no beards)
Heavy
Difficult to use
Limited working time
High level training
Expensive

Full Impermeable Suit With Air Supply Line

Protection factor 1000
Good protection
Good for extended use
Requires compressor, air supply panel and air hoses
No hats or helmets
Uncomfortable if hot

Structural Firefighter Gear with SCBA

- Excellent respiratory protection (PF ^{3} 10,000)
- Limited liquid protection
- Estimated protection against skin absorption of vapors/aerosols (PF ~ 10)

Levels of Protection

Greater Hazard

Level A

Level B

Level C

Level D

Bunker Gear ?

Higher Burden

Protective Clothing Selection

Effective protection
Suitable for conditions
Durable
Puncture proof
Impermeable
Comfortable
Easy decontamination
Compatible

Decision Making For Found Source Or Contamination

Found source or contamination

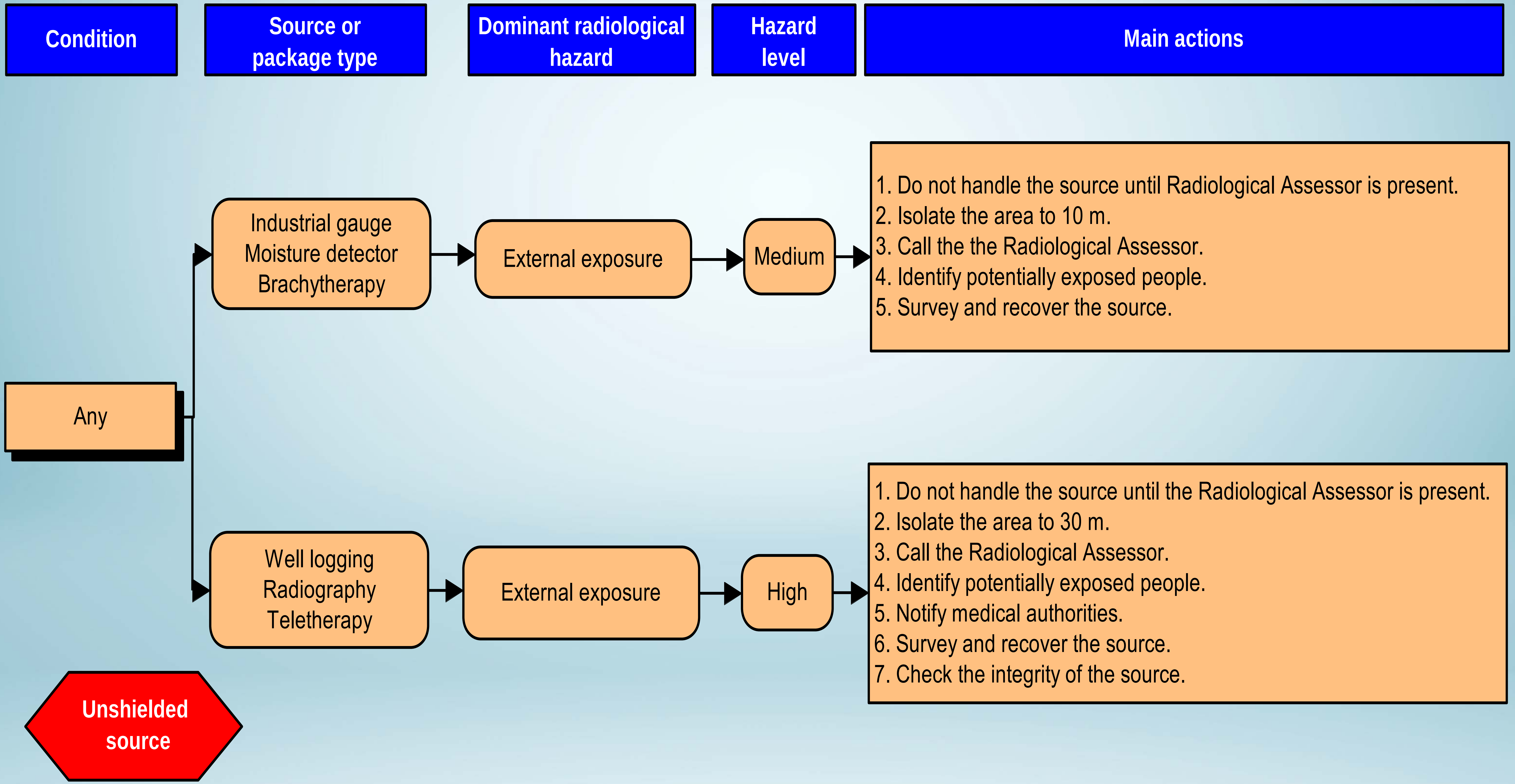
Condition	Source or package type	Dominant radiological hazard	Hazard level	Main actions
Shielded source	Unknown	External exposure	Low	1. Recover the source. 2. Ensure source is in its shielding and not missing. 3. Check the integrity of the source and shielding. 4. Find owner of the source.
Unknown conditions or damaged source	Unknown	External exposure Surface contamination	Low to high	1. Do not handle the source until the Radiological Assessor is present. 2. Isolate the area to 30 m. 3. Call the Radiological Assessor. 4. Identify and segregate potentially exposed or contaminated people. 5. Survey and recover the source. 6. Find the owner of the source. 7. Survey area and clean up as required.
	Consumer product Calibration source	Negligible	Low	1. Recover the source. 2. Find the owner of the source.
	Industrial gauge Well logging Moisture detector	External exposure Surface contamination	Medium to high	1. Do not handle the source until Radiological Assessor is present. 2. Isolate the area to 10 m. 3. Call the Radiological Assessor. 4. Identify and segregate potentially exposed or contaminated people. 5. Survey and recover the source. 6. Find the owner of the source. 7. Survey area and clean up as required.
	Brachytherapy Radiography Teletherapy	External exposure Surface contamination Inhalation Ingestion	High	1. Do not handle the source until the Radiological Assessor is present. 2. Isolate the area to 30 m. 3. Call the Radiological Assessor. 4. Identify and segregate potentially exposed or contaminated people. 5. Notify medical authorities. 6. Survey and recover the source. 7. Find the owner of the source. 8. Survey area and clean up as required.

Missing Radioactive Source

Condition	Source or package type	Dominant radiological hazard	Hazard level	Main actions
Unknown	Consumer product Calibration source	Negligible	Low	1. Investigate.
Unknown	Industrial gauge Well logging Moisture detector	External exposure Surface contamination	Medium to high	1. Investigate. 2. Call the Radiological Assessor. 3. Search for the source. 4. Issue public advisory. 5. Notify medical authorities. 6. Recover the source and check the integrity of the source. 7. Identify and segregate potentially exposed or contaminated people. 8. Survey the area around the source and clean up as required.
Unknown	Brachytherapy Radiography Teletherapy	External exposure Surface contamination Inhalation Ingestion	High	1. Investigate. 2. Call the the Radiological Assessor. 3. Search for the source. 4. Issue public advisory. 5. Notify medical authorities. 6. Implement public protective actions. 7. Recover the source and check the integrity of the source. 8. Identify and segregate potentially exposed or contaminated people. 9. Survey the area around the source and clean up as required.

Missing source

Unshielded Source



Laboratory Accident

Condition	Source or package type	Dominant radiological hazard	Hazard level	Main actions
Spill*	Any	External exposure Surface contamination Inhalation	Low	1. Isolate the spill area. 2. Call the Radiological Assessor. 3. Monitor and decontaminate person(s). 4. Clean up the area as required.
Major spill	Any	External exposure Surface contamination Inhalation	Medium to high	1. Isolate laboratory. 2. Shut off the ventilation but leave fume cupboard on. 3. Call the Radiological Assessor. 4. Identify and segregate potentially contaminated person(s). 5. Survey area and monitor involved personnel. 6. Decontaminate person(s). 7. Clean up the area as required.
Fire or explosion	Any	External exposure Surface contamination Inhalation	High	1. Treat as conventional hazard. 2. Wear respiratory protection. 3. Isolate the laboratory or the facility. 4. Call the Radiological Assessor. 5. Identify and segregate potentially exposed or contaminated person(s). 6. Notify hospital if contaminated injury. 7. Survey and recover the source(s). 8. Decontaminate person(s). 9. Clean up the area as required.

Laboratory accident

Transport Accident

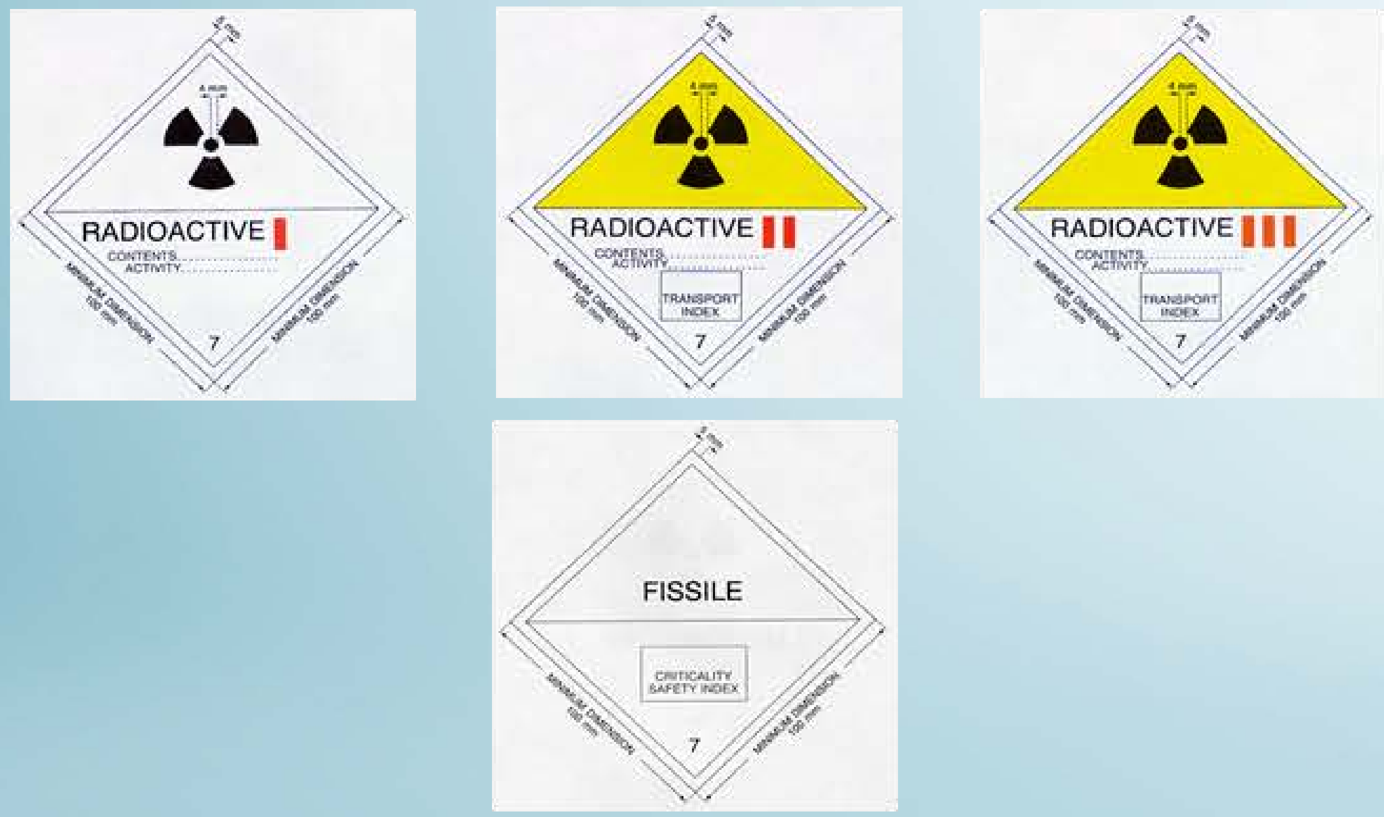
Condition	Source or package type	Dominant radiological hazard	Hazard level	Main actions
Package appears intact	I-WHITE, II-YELLOW, III -YELLOW	External exposure	Low	1. Handle the package carefully and store as required.
	Type B Spent fuel	External exposure	Medium	1. Do not handle the package until the Radiological Assessor is present. 2. Isolate the accident area. 3. Call the Radiological Assessor, consignee and the owner. 4. Survey and recover the package - handle the package with gloves. 5. Check the integrity of the package- confirm that there is no contamination.
Package appears to be damaged or leaking	Unknown	External exposure Surface contamination	Low to high	1. Do not handle the package until the Radiological Assessor is present. 2. Isolate the accident area. 3. Keep non-essential personnel away from the accident area. 4. Call the Radiological Assessor. 5. Survey and recover the package - handle the package(s) with gloves. 6. Survey surroundings for possible contamination; monitor personnel. 7. Identify and segregate potentially contaminated or exposed ones. 8. Clean up as required.
	I-WHITE, II-YELLOW, III -YELLOW	External exposure Surface contamination	Medium to high	1. Do not handle the package until the Radiological Assessor is present. 2. Isolate the accident area, keep non-essential personnel away. 3. Call the Radiological Assessor, consignee and the owner. 4. Notify hospital if contaminated injury. 5. Survey and recover the package, handle the package(s) with gloves. 6. Survey the area and personnel. 7. Clean up as required.
	Type B Spent fuel	External exposure Surface contamination	High	1. Evacuate 100 m around and 200 m downwind. 2. Do not handle the package until the Radiological Assessor is present. 3. Isolate accident area, keep non-essential personnel away. 4. Call the Radiological Assessor, consignee and the owner. 5. Identify and segregate potentially contaminated people. 6. Notify hospital if contaminated injury. 7. Survey and recover the package. 8. Survey the area and the personnel; clean up as required.
Fire or explosion - spill or fumes present	Type B Spent fuel	Inhalation External exposure Surface contamination	Medium to high	1. Treat as conventional hazard. 2. Evacuate up to 300 m around. 3. Wear respiratory protection and protective clothing. 4. Call the Radiological Assessor. 5. Notify hospital if contaminated injury. 6. Survey and recover the source; survey cool transport flask. 7. Monitor personnel and survey the area. 8. Clean up as required.

Accidents with X-Rays

Condition	Source or package type	Dominant radiological hazard	Hazard level	Main actions
Malfunction or violated procedures	Beam or post beam radiation	External expossure	Low to medium	1. Turn off the electrical power. 2. Call the Radiological Assessor. 3. Identify potentially exposed person(s). 4. Perform a radiation survey to confirm that the device is de-energized. 5. Record details such as position, beam direction, exposure settings, etc. 6. Post a notice on the device regarding its malfunctions.

Accidents with X-ray machines and accelerators

Initial Safe Distances



Situation	Initial safe distance
Intact package with a I-WHITE, II-YELLOW or III-YELLOW label	Immediate area around the package
Damaged package with a I-WHITE, II-YELLOW or III-YELLOW label	30 m radius or at readings of 100 µSv/h
Undamaged common source (consumer item) such as smoke detector	Immediate area around the source
Other unshielded or unknown source (damaged or undamaged)	30 m radius or at readings of 100 µSv/h
Spill	Spill area plus 30 m around
Major spill	Spill area plus 300 m around
Fire, explosion or fumes, spent fuel, plutonium spill	300 m radius or at readings of 100 µSv/h
Explosion/fire involving nuclear weapons (no nuclear yield)	1000 m radius

Accident Investigation and Reporting

- ❖ All accidents/incidents must be investigated and reported to relevant authorities.
- ❖ Objective of investigation is to find root cause of the accident.
- ❖ Accident investigation must be planned, include consideration of what needs to be done before and during investigation.

Accident Investigation and Reporting

❖ Among activities that need to be done before investigation includes:

- Having a policy requiring all accidents to be reported.
- Identifying and trained the investigator.
- Assembling the tools for investigation.
- Deciding on who supposed to read the report and implement the recommendations made.

Accident Investigation and Reporting

- Activities during investigation - include acquisition of all information that would explain the accidents causes.

- Licensee must prepare an accident report, which shall include findings of the investigation. The accident report must be submitted to AELB within 30 days after accident.

Content of Accident Report

- Name, telephone number of reporting person
- Position of reporting person ; public, supervisor, security, etc.
- What happened ? Try to get short description of the accident & facility address and location
- When it happened ?
- Information on injuries, radiological or non-radiological ?
- How you know this could be radiological accident ?
- What radioactive material is involved ? Or type of x-ray machine
- What is the activity (if known)? or kVp, mA
- What are chemical or physical characteristic of the source (if known)
- Results of any radiation or contamination measurements carried out
- What assistance is required ?

Any Question?

THANK YOU

"The important thing is not to stop questioning"

Albert Einstein

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TOPIC 6

RADIOLOGICAL RISK ASSESSMENT

MMTC ASIA SDN.BHD
1330199-X

Definitions

"Risk" means a quantitative quantity of probability that states a catastrophe, danger or opportunity for a dangerous or harmful consequence associated with actual or potential exposure

Risk Assessment

Atomic Energy Licensing (Basic Safety Radiation Protection) Regulations 2010

Monitoring of work place

- Regulations No. 22(1)(c)

  21. (1) The licensee shall establish, maintain and keep under review a monitoring programme in the supervised area and controlled area under the supervision of the radiation protection officer or qualified expert employed under regulation 16.

  (2) The monitoring programme shall include–

  (c) assessment of the levels of radiation risks associated with an accident or emergency situation;

- By using the "risk matrix".

Radiological Potential Risk

NO.	LISTED EVENTS	EXAMPLES
1.	Naturally Occuring Factor	Flood, Fire
2.	Technology System Failure	Electricity Failure, Interlocking System Failure
3.	Human Related Failure	Stolen of Machine Accessories
4.	Factor Involving Hazardous Material	Small Hazmat Incident, Radiological Exposure (Internal)

Risk = Probability x severity

Probability of Occurrence Scale

SCALE	CRITERIA	PROBABILITY OF OCCURENCE	
0	None	Improbable Occurrence	(0% probability)
1	Low	Possible Occurrence	(up to 25% prob.)
2	Moderate	Often	(26 – 50% prob.)
3	High	Common Occurrence	(more than 50% prob.)
		Already Occured	

Choose probability of occurrence base on Known Risk or Historical Data using the criteria set above.

Severity of Incident (Magnitude Factor)

MAGNITUDE FACTOR	DEFINATION	ISSUE TO BE CONSIDER
Human Impact	Possibility of death or injury	Potential for staff death/injury
Property Impact	Physical losses and damages	Replacement cost Cost to set-up temparory replacement Repair cost
Business Impact	Interuption of services	Business interuption Employess unable to report work Financial impact/burden Customer unable to reach facilities

Magnitude Factor Scale

SCALE	CRITERIA	MAGNITUDE FACTOR SCALE CRITERIA
0	Not Applicable	Not Applicable
1	Low	Minimal impact to human, property or business
2	Moderate	Minor impact to human, property or business
3	High	Death to human due to incident, Company reputation damaged, Need very high cost to recovery.

Mitigation Factor

MITIGATION FACTOR	DEFINATION	ISSUE TO BE CONSIDER
Preparedness	Pre-planning	Readiness of current Emergency Plan Frequency of drills Schedule training plan for ET Insurance coverage
Internal Response	Time, effectiveness, resources	Availability of backup/emergency system disasters/survivability
External Response	Community/Mutual Aid Staff and supplies	Coordination with local and state government agencies (Eg. BOMBA, AELB etc.)

Mitigation Factor Scale

SCALE	CRITERIA	MAGNITUDE FACTOR SCALE CRITERIA
0	Not Applicable	Not Applicable
1	Low	Highly prepared no improvement needed
2	Moderate	Moderate preparation
3	High	No preparation or minimal preparation

Determine the Ranking of Hazard Specific Relative Risk

IMPACT POINTS (%)	SIGNIFICANCE RATING	PRIORITY RANKING
1 ~ 33	Low significance	Lowest priority
34 ~ 66	Moderate significance	Medium priority
67 ~ 100	High significance	Highest priority

Conclusion

- Risk assessment is part of the aspects that need to be implemented in developing a comprehensive emergency plan.

- Risk assessment can be perform with many approved tools (not limited to one tools)

- The complete evident, history and fact related to facility need to be prepare before perform the Risk assessment

Reference

- Atomic Energy Licensing (Basic Safety Radiation Protection) Regulations 2010
- IAEA Safety Requirements GSR-2 Preparedness and Responses for a Nuclear or a Radiological Emergency
- LEM / TEK / 66 Pind. 2 : Guide to Preparation and Testing of Radiological and Nuclear Emergency Plans
- Radiological Emergency Plan - Licensee

Any Question?

THANK YOU

"The important thing is not to stop questioning"

Albert Einstein

TOPIC 7

PROCEDURES IN ABNORMAL SITUATION (EMERGENCY)

MMTC ASIA SDN.BHD
1330199-X

Contents

- Introduction
- Sources of Emergency
- Types of Emergency
- Emergency Plan
- Emergency Preparedness
- Emergency Equipment
- Response Action

Introduction

- Radiation emergency may be defined as any situation which gives rise to an abnormal or unexpected radiation hazard to workers.
- Emergency occurrence and situation is unplanned and largely unpredictable
- It may lead to personnel exposure, contamination or both
- To reduce the level of unpredictability in an emergency response, a comprehensive and operational emergency plan and procedure must be in place.
- Besides reducing the impact of an emergency, an emergency plan and preparedness are required to help return the emergency state to normal.

Sources Of Emergency

There are several factors that cause radiation emergency. It can arise due to:

- Human Error / Loss of Control of Personnel
- Radiation Machine / Irradiating Apparatus
- Radioactive Material
- Conventional Accident
- During Transportation

Sources Of Emergency

1. Loss of Control of Personnel
    - ❖ Access to control and supervised areas in a work area is restricted to authorize personnel only
    - ❖ Loss of control of personnel is due to failure in administrative control or human error

2. Loss of Control of Radiation Machine
    - ❖ Involves the loss of control of irradiating apparatus, such as X-ray machine, electron beam etc.

Sources Of Emergency

3. Loss of Control of Radioactive Materials
   - Sealed Source
     - Failure of shutter to close thereby emitting uncontrolled radiation
     - Stolen or misplace source
     - Unauthorized operation of radiation devices
   - Unsealed Source
     - Emergency involve spillage and contamination of radioactive sources onto workers, working area and environment.
     - Usually unsealed sources are in liquid form

Sources Of Emergency

4. Conventional Accident
   - ❖ Emergency initiated by a non-radiation emergency such as natural disaster
   - ❖ For example flood, earthquake, fire, theft or even sabotage

5. Transportation Accident
   - ❖ This is quite likely in the case of industrial radiography / sales / nuclear gauge because the equipment used is in the portable form and it is being moved quite common. Accidents involving vehicles that carrying those equipment may lead to possible damage caused on exposure to the device on board.

Types Of Emergency

A. Local Emergency

- ❖ Involves an accident or occurrence in the work area which personnel may be exposed to excessive radiation exposure or radioactive contamination
- ❖ Include small radioactive spill and loss of shielding of small radiation sources in the work area.
- ❖ Has no potential of becoming severe
- ❖ Should be no adverse effect to the facility and people nearby work areas.
- ❖ Need less people to handle the emergency

Types Of Emergency

B. Site Emergency

- ❖ More serious occurrence
- ❖ Evacuation of the facility site is not anticipated, but evacuation or isolation of certain facility area may be necessary
- ❖ Have potential small release of radioactive airborne that could result in an off site radiological dose
- ❖ Effect to the whole facility and people nearby work areas.
- ❖ Examples of site emergency are:
  - i. Fire or explosion that cause damage to sealed and unsealed source storage room
  - ii. Loss of shielding of large radiation sources
  - iii. Major spillage of radioactive materials
  - iv. Loss or damage to transport container for sealed and unsealed sources

Types Of Emergency

Four levels of emergency

Level 1

- Consequences are limited to a single room/ laboratory/ building

Level 2

- Consequences are limited to the perimeter of the facility

Level 3

- Consequences might have significance outside the outer perimeter of the facility involved

Level 4

- Consequences might have a trans-boundary effect as defined in the early notification convention

Emergency Plan

The objectives of emergency plan are:

- To restrict the exposure to As Low As Reasonably Achievable (ALARA)
- To control and bring the situation back to normal immediately after an accident happened
- To obtain information for the purpose of assessment and taking corrective action

Emergency Plan

The Characteristic of Emergency Plan

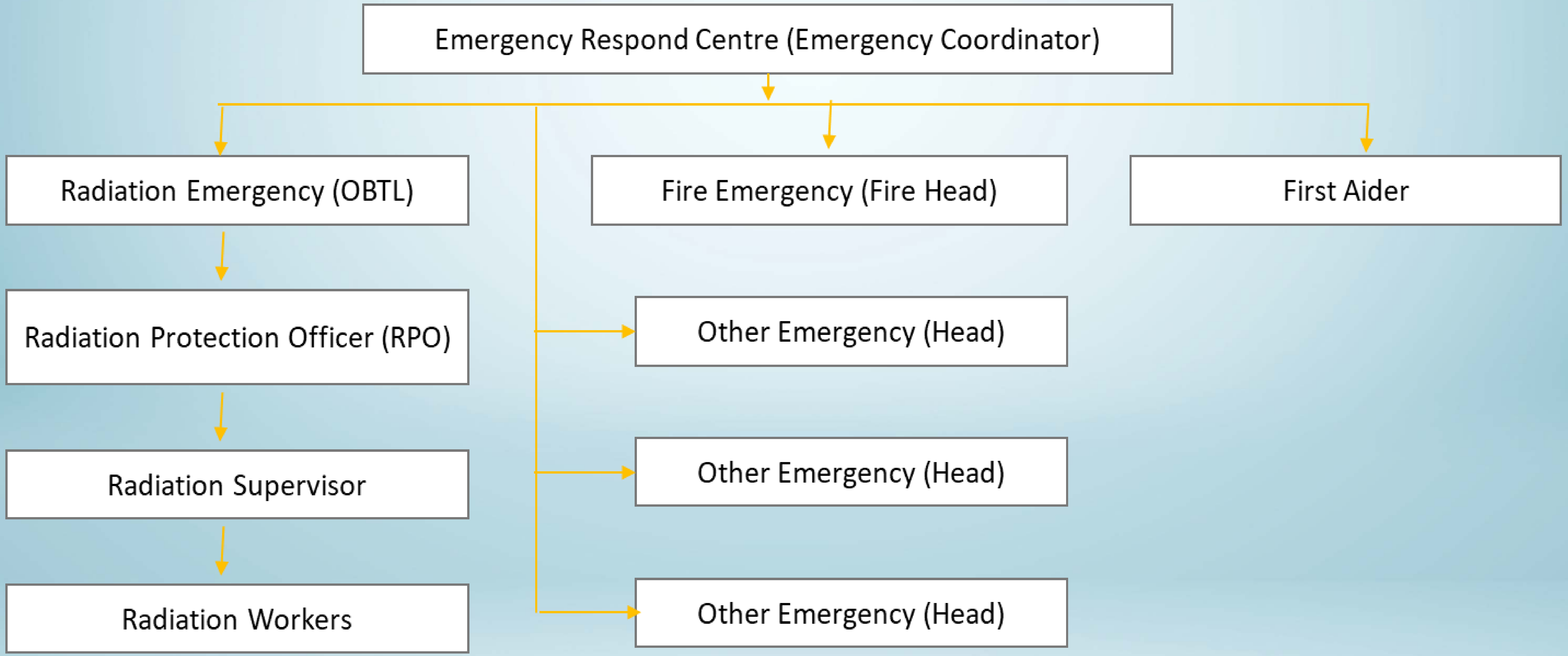
- ❖ The plan should be simple, clear, specific, concise and easily understood by all workers involved.

- ❖ The plan must also meet all local requirements and needs

- ❖ The plan should be able to:
  - ❑ Address all possible accidents that can happen with all radiation sources belong to a licensee
  - ❑ Identify the emergency organization involved and response action taken during the accident

Emergency Plan

Hierarchy of Emergency Respond



Emergency Plan

Notification Procedures:

- Notification procedures of an emergency may be divided into three
  - Notification of an accident to the organization's emergency respond team to request for an emergency respond
  - Notification of an accident to the organization for the purpose of accident investigation
  - Notification of an accident to the Atomic Energy Licensing Board (AELB) or appropriate authority

Emergency Plan

Review of Plan:

- ❖ Consequently all plan and preparedness must be reviewed periodically for its relevancy and accuracy

  - ➢ Management must be responsible for the review
  - ➢ Management must identify competent individual or set up a competent committee to review all emergency plan
  - ➢ Plan must be reviewed periodically and when there is a special need for it
  - ➢ Review of plan must include the scope, procedures and equipment used in an emergency

Emergency Plan

Reporting Procedures:

- Notification to Radiation Protection Officer (RPO)
  - The radiation workers should immediately notify the RPO of any abnormal situation in order to allow the RPO to initiate emergency response and investigation of the accident

- Notification to the Regulatory Authority
  - In all cases of the emergency the licensee must inform the AELB as soon as possible within 24 hours

  - These information must be included
    1. Type of radioisotope and activity level
    2. Location and general status of the problem
    3. Time of accident
    4. Personal involved

  - RPO shall submit full accident investigation report within 30 days of the accident.

Emergency Preparedness

Training

- There four main areas should be included in the training
  1. General radiation protection principles
  2. Relevant emergency procedures
  3. Use and maintenance of emergency instruments and equipment
  4. Emergency organization and their responsibilities

- Training program should be provided at two basic levels
  1. For 'first-on-the-scene' personnel: this basic training is designed for those first-on-the-scene such as police, and fire and rescue department personnel
  2. Technical experts: these people shall receive a more extensive training that will enable them to advice the first-on-the-scene personnel.

Emergency Preparedness

Exercise

- Exercise is a drill carried out to simulate response in an emergency scenario

- Objectives of having exercise are:
  1. To reveal shortcomings in personnel, equipment and procedures so that they can be corrected and improved
  2. To familiarize those likely to be involved with any future real accident with the emergency plan, procedures and equipment

Emergency Equipment

- Management with the advice of the Radiation Protection Officer (RPO) must provide and maintain suitable type and number of emergency equipment

- There are two categories of radiological emergency equipment:
  i. Detectors and counters
  ii. Radiation protection equipment and tools (PPE)

- Types of equipment used are determined by the quantity of the radiation exposure, quantity of radionuclides and sources and types of emergency

Emergency Equipment

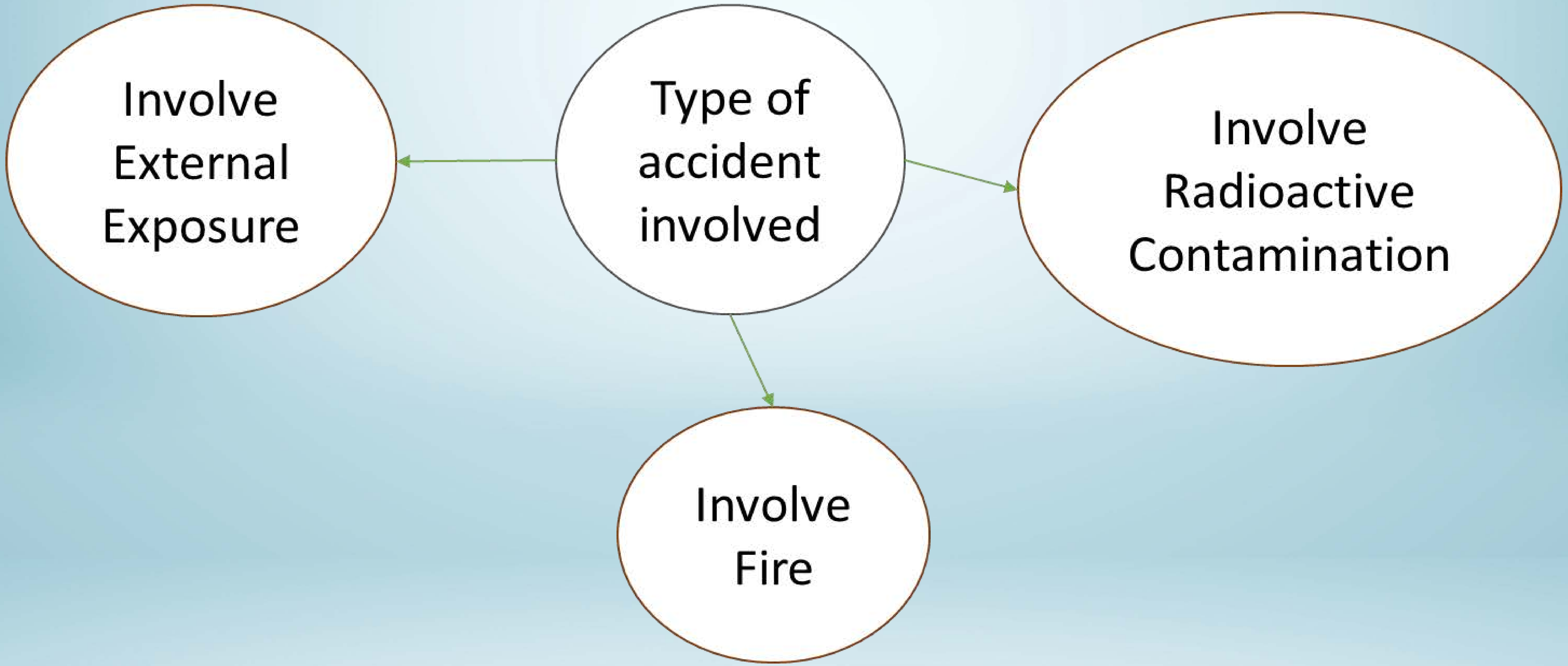
- List of emergency equipment
  1. Survey meters
  2. Personal dosimeters
  3. Breathing apparatus, respirators, and dust masks
  4. Fully impervious clothing
  5. Footwear and gloves
  6. Decontamination agents and equipment etc.

- All emergency equipment must be maintained, calibrated according to the requirement of the manufacturer and the authority, and in good working condition

- All personnel involved in the use of such equipment must be trained to use it effectively

Response Action

Procedure for taking action are depending on types of accident involved.



Accident Involving Radioactive Contamination

Procedure/Steps:

1. Shut off all mechanical ventilation system and close all outside opening
2. Cover radioactive spillage with absorbent paper to prevent widespread
3. Evacuate the area concerned
4. Rope off contamination area and post radiation signage
5. Monitor clothing and body for any sign of contamination

Accident Involving Radioactive Contamination

6. Persons contaminated by radioactive spill should immediately remove clothing affected and thoroughly wash hands and other contaminated areas of body

7. Injured persons should be attended to immediately. If injured person is found contaminated, decontamination should be accomplished with the advice of Medical Officer

8. Assess whether there is internal contamination and estimate the total exposure of person concern

9. Evaluate personal dosimeter (film badge or TLD)

10. Collect urine or fecal sample if internal contamination is suspected

Accident Involving Radioactive Contamination

11. Carry out fine decontamination of contaminated person

12. Personnel designated for decontamination work should then enter the areas concerned with appropriate protective clothing and equipment

13. The extent of contamination is determined and appropriate steps taken to decontaminate the area concerned

14. Inform the Licensing Authority immediately for example AELB

15. Write full report

Accident Involving External Exposure

Procedure/Steps

1. Stop operations, block access to the source of radiation and post warning sign
2. Leave the area concerned
3. Identify persons subjected to exposure
4. Determine the operational parameters in case of radiation-generating machine or parameters of radioactive sealed source
5. Estimate the exposure time and dose equivalent accumulated by all persons involved

Accident Involving External Exposure

6. Inform the Licensing Authority immediately e.g. AELB
7. Evaluate the personal dosimeter (TLD/OSLD)
8. Consult medical officer
9. Locate the radiation sources by survey meter
10. Write full report

Accident Involving Fire

Procedure/Steps

1. Immediately call nearest Fire Department and AELB

2. Make an immediate attempt to extinguish the fire or prevent it from spreading by means of fire fighting devices available

3. Shut down equipment and stop the work

4. When firemen arrives, Radiation Protection Officer (RPO) or area supervisor should give advice to fire crew on whereabouts of radioactive materials and on the proper handling of the materials

Accident Involving Fire

5. Before leaving scene of fire, the fire crew and all others involved in fire-fighting should be monitored for any contamination.

6. After fire is put out, an assessment should be carried out to determine the cause of fire, the extent of damage and whether there is any radioactive contamination.

7. Any damage should be restored and if there is found to be contamination, the area should be decontaminated as soon as possible

Any Question?

THANK YOU

"The important thing is not to stop questioning"

Albert Einstein

MMTC ASIA SDN BHD

TOPIC 8

RADIOLOGICAL AND NUCLEAR EMERGENCY PLAN DEVELOPMENT CHECKLIST

MMTC ASIA SDN.BHD
1330199-X

Introduction

- February 15, 2010, Introduction of Atomic Energy Licensing (Basic Safety Radiation Protection) Regulations 2010 [P.U. (A) 46] - effective after 2 years to replace Radiation Protection (Basic Safety Standard) Regulations 1988
- Allows appropriate response to be taken to correct any emergency situation that has been identified in Regulation 68, P.U. (A) 46. (Emergency plans)
- A new provision has also been introduced, namely Regulation 68 (7) where training on the Emergency Plan that has been developed must be conduct together with the Atomic Energy Licensing Board (AELB) and other relevant authorities at the appropriate time range.
- Hazard Assessment are base on respective Emergency Preparedness Category (EPC

Emergency Preparedness Category (EPC)

EPC	Description
EPC I	Facilities, such as nuclear power plants, for which on-site events (including very low probability events). It is considered that to produce such effects, the reactor power has to exceed 100 MWth.
EPC II	Facilities, such as some types of research reactors, for which on-site events are postulated that could give rise to doses to people off-site that warrant urgent protective actions in accordance with international standards. It is considered that reactor power levels greater than 2 MWth and less than 100 MWth (power reactors, nuclear ship and research reactors) fall in this category.
EPC III	Facilities, such as industrial irradiation facilities, for which on-site events are postulated that could give rise to doses that warrant or contamination that warrants urgent protective actions onsite,
EPC IV	Activities and acts that could give rise to a nuclear or radiological emergency that could warrant protective actions and other response actions to achieve the goals of emergency (a) transport of nuclear or radioactive material and other authorized activities involving mobile dangerous sources such as industrial radiography sources, nuclear powered satellites or radioisotope thermoelectric generators; and (b) theft of a dangerous source and use of a radiological dispersal device or radiological exposure device. This category also includes: (i) detection of elevated radiation levels of unknown origin or of commodities with contamination; (ii) identification of clinical symptoms due to exposure to radiation; and (iii) a transnational emergency that is not in category V arising from a nuclear or radiological emergency in another State. Category IV represents a level of hazard that applies for all States and jurisdictions.
EPC V	Areas within emergency planning zones and distances in a State for a facility in category I or II located in another State

Administrative Element

Strategic Plan

- (vision, mission, goals and objectives)

Operation plan

- Organization Chart (Emergency plan)
- Responsibilities of staff during emergencies
- Authorities Involved

Risk Assessment

Prevention Plan (interim and long-term action to eliminate risk by taking into account risk assessment results)

- Natural disaster
- Hazmat
- System (Technology) Failure
- Human

Risk Assessment

- The process of identifying the level of danger and its possible occurrence and exposure to humans, property, the environment

- Impact analysis to determine potential hazards that can have an impact

Risk Assessment (Natural Disaster)

A. PENILAIAN BAHAYA SINARAN AKIBAT SITUASI YANG DISEBABKAN OLEH BENCANA ALAM

SITUASI	KEBARANGKALIAN	KETERUKAN = (MAGNITUD - PENGURANGAN)						RISIKO
		KESAN PADA MANUSIA	KESAN PADA HARTA	KESAN PADA PERNIAGAAN	PERSEDIAAN	TINDAK BALAS DALAMAN	TINDAK BALAS LUARAN	
	Kemungkinan Ianya Berlaku	Kemungkinan Berlaku Kematian dan Kecederaan	Kerugian Dan Kerosakan Fizikal	Gangguan Perkhidmatan	Pra Perancangan	Masa, Keberkesanan Dan Sumber	Komuniti/Bantuan Kakitangan Dan Bekalan	Ancaman Relatif
SKOR	0 = T/B 1 = rendah 2 = sederhana 3 = tinggi	0 = T/B 1 = rendah 2 = sederhana 3 = tinggi	0 = T/B 1 = rendah 2 = sederhana 3 = tinggi	0 = T/B 1 = rendah 2 = sederhana 3 = tinggi	0 = T/B 1 = rendah 2 = sederhana 3 = tinggi	0 = T/B 1 = rendah 2 = sederhana 3 = tinggi	0 = T/B 1 = rendah 2 = sederhana 3 = tinggi	0 - 100%
Banjir								
Taufan								0%
Puting Beliung								0%
Ribut								0%
Gempa Bumi								0%
Ombak Besar/ Tsunami								0%
Suhu Melampau								0%
Kemarau								0%
Kebakaran								0%
Tanah Runtuh								0%
Wabak								0%
Empangan Pecah								0%
SKOR PURATA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0%

Risk Assessment (Technology)

B. PENILAIAN BAHAYA SINARAN

AKIBAT KEGAGALAN SISTEM (FAKTOR TEKNOLOGI)

SITUASI	KEBARANG-KALIAN	KESERIUSAN (SEVERITY) = MAGNITUD - MITIGASI						RISIKO
		KESAN PADA MANUSIA	KESAN PADA HARTA	KESAN PADA PERNIAGAAN	PERSEDIAAN	TINDAK BALAS DALAMAN	TINDAK BALAS LUARAN	
	Kemungkinan Yang Akan Berlaku	Kemungkinan Berlaku Kematian Dan Kecederaan	Kerugian Dan Kerosakan Fizikal	Gangguan Perkhidmatan	Pra Perancangan	Masa, Keberkesanan Dan Sumber	Komuniti/ Bantuan Kakitangan Dan Bekalan	Ancaman relatif
SKOR	0 = N/A 1 = rendah 2 = sederhana 3 = tinggi	0 = N/A 1 = rendah 2 = sederhana 3 = tinggi	0 = N/A 1 = rendah 2 = sederhana 3 = tinggi	0 = N/A 1 = rendah 2 = sederhana 3 = tinggi	0 = N/A 1 = tinggi 2 = sederhana 3 = rendah	0 = N/A 1 = tinggi 2 = sederhana 3 = rendah	0 = N/A 1 = tinggi 2 = sederhana 3 = rendah	0 - 100%
Kegagalan bekalan elektrik								0%
Kegagalan janakuasa								0%
Kekurangan bahanapi								0%
Kegagalan pengangkutan								0%
Kegagalan gas asli								0%
Kegagalan sistem air								0%
Kegagalan sistem pembetungan								0%
Kegagalan penggera kebakaran								0%
Kegagalan sistem komunikasi								0%
Kegagalan Sistem HVAC								0%
Kegagalan Sistem Informasi								0%
Kebakaran (Dalaman)								0%
Banjir (Dalaman)								0%
Dedahan HAZMAT (Dalaman)								0%
Kekurangan Bekalan								0%
Kerosakan Struktur								0%
SKOR PURATA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0%

* Ancaman meningkat mengikut peratusan

Risiko	=	Kebarangkalian	*	Keseriusan (*Severity*)
0.0		0.00		0.00

Risk Assessment (Human Factor)

C. PENILAIAN BAHAYA SINARAN DISEBABKAN FAKTOR MANUSIA

SITUASI	KEBARANGKALIAN	KETERUKAN = (MAGNITUD - PENGURANGAN)						RISIKO
		KESAN PADA MANUSIA	KESAN PADA HARTA	KESAN PADA PERNIAGAAN	PERSEDIAAN	TINDAK BALAS DALAMAN	TINDAK BALAS LUARAN	
	Kemungkinan Yang Akan Berlaku	Kemungkinan Berlaku Kematian Dan Kecederaan	Kerugian Dan Kerosakan Fizikal	Gangguan Perkhidmatan	Pra Perancangan	Masa, Keberkesanan Dan Sumber	Komuniti/Bantuan Kakitangan Dan Bekalan	Ancaman Relatif
SKOR	0 = N/A 1 = rendah 2 = sederhana 3 = tinggi	0 = N/A 1 = rendah 2 = sederhana 3 = tinggi	0 = N/A 1 = rendah 2 = sederhana 3 = tinggi	0 = N/A 1 = rendah 2 = sederhana 3 = tinggi	0 = N/A 1 = tinggi 2 = sederhana 3 = rendah	0 = N/A 1 = tinggi 2 = sederhana 3 = rendah	0 = N/A 1 = tinggi 2 = sederhana 3 = rendah	0 - 100%
Kejadian Yang Melibatkan Banyak Mangsa (Trauma)								0%
Kejadian Yang Melibatkan Banyak Mangsa (Perubatan/Berjangkit)								0%
Keganasan, Biologi								0%
Keadaan VIP								0%
Situasi Tebusan								0%
Gangguan Awam								0%
Tindakan Buruh								0%
Kemasukan Forensik								0%
Ancaman Bom								0%
SKOR PURATA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0%

Risk Assessment (HAZMAT)

D. PENILAIAN BAHAYA SINARAN

DISEBABKAN SITUASI YANG MELIBATKAN BAHAN BERBAHAYA (HAZMAT)

SITUASI	KEBARANGKA-LIAN	KESERIUSAN (SEVERITY) = MAGNITUD - MITIGASI						RISIKO
		KESAN PADA MANUSIA	KESAN PADA HARTA	KESAN PADA PERNIAGAAN	PERSEDIAAN	TINDAK BALAS DALAMAN	TINDAK BALAS LUARAN	
	Kemungkinan Yang Akan Berlaku	Kemungkinan Berlaku Kematian Dan Kecederaan	Kerugian Dan Kerosakan Fizikal	Gangguan Perkhidmatan	Pra Perancangan	Masa, Keberkesanan Dan Sumber	Komuniti/Bantuan Kakitangan Dan Bekalan	Ancaman Relatif
SKOR	0 = N/A 1 = rendah 2 = sederhana 3 = tinggi	0 = N/A 1 = rendah 2 = sederhana 3 = tinggi	0 = N/A 1 = rendah 2 = sederhana 3 = tinggi	0 = N/A 1 = rendah 2 = sederhana 3 = tinggi	0 = N/A 1 = tinggi 2 = sederhana 3 = rendah	0 = N/A 1 = tinggi 2 = sederhana 3 = rendah	0 = N/A 1 = tinggi 2 = sederhana 3 = rendah	0 - 100%
kejadian HAZMAT yang melibatkan banyak mangsa (iaitu mangsa lebih dari 5 orang)								0%
kejadian HAZMAT yang melibatkan sedikit mangsa (iaitu mangsa kurang dari 5 orang)								0%
Tumpahan Dalaman (Sedikit)								0%
Tumpahan Dalaman (Banyak)								0%
Dedahan terhadap Radiologi (Dalaman)								0%
Dedahan terhadap Radiologi (Luaran)								0%
Keganasan, Radiologi								0%
SKOR PURATA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0%

Ancaman meningkat mengikut peratusan

Risiko	=	Kebarangkalian	*	Keseriusan (*Severity*)
0.0		0.00		0.00

Emergency Plan Development

- Mitigation Plan (interim and long-term action to reduce the risk that cannot be eliminated
- Recovery Plan (priority in the near future and in the long term for the restoration of functions, services, resources, facilities, programs and infrastructure
- Service Continuity Plan (identify stakeholders to be informed, critical and time-sensitive applications, alternative work sites, key records, contact number lists, processes and functions to be maintained as well as staff)

Emergency Plan Development

- Proses Perancangan dan Penilaian Semula (dilakukan pada julat yang ditetapkan atau apabila berlaku perubahan yang boleh menjejaskan keberkesanan pelan)

- Prosedur Pengoperasian dan Pengurusan Kejadian/Kemalangan (prosedur dan polisi bagi menyelaras aktiviti tindakbalas, kesinambungan tindakan dan pemulihan)

Emergency Plan Development

- Resource Management and Logistics (personnel, equipment, inventory, response time, shortages, costs and liabilities in relation to resource use as well as assignments

- Other Sources (internal or external and how to get it)

Emergency Communications

- Communications and Warnings (communication systems and procedures as well as testing their effectiveness on staff responding and warning the public.
- The notification process to the authorities in the prescribed situation
- Public Communication and Information Crisis (procedure for disseminating and responding to requests for emergency information to the public through the authorities)

Emergency Drill

- Training (developing a training curriculum covering aspects of awareness and skills improvement, providing training, training with authorities within a specified range and updating training records
- Exercise, Drill, Assessment and Corrective Action (to evaluate the effectiveness of the Emergency plan and corrective action from teaching and weaknesses as well as corrective action)

Emergency Drill

- Reassessment should also be based on analysis and reports of incidents / accidents that have occurred, lessons learned and performance appraisals.

- The exercise should be designed to test the essential elements in the main plan or the overall plan.

- Procedures for taking corrective action against any identified weaknesses should be developed.

Allocations

- Finance and Administration (procedures for supporting plans before, during and after an emergency)

Testing Of Emergency Plan

Emergency Plan Testing (frequency of conducting training on its own and with the authorities with partial or comprehensive scope as well as the testing application process)

Bidang	Kekerapan latihan dengan kehadiran AELB	Kekerapan latihan yang dilakukan sendiri
Tolok	setiap 5 tahun	setiap tahun
TENORM	setiap 5 tahun	setiap tahun
IPT	setiap 5 tahun	setiap tahun
Radiografi Industri	setiap 4 tahun	setiap tahun
Irradiator (Sel Penyinaran)	setiap 3 tahun	setiap tahun
Reaktor Penyelidikan	setiap 2 tahun	setiap tahun

Testing Emergency Plan Involving AELB

- Application in writing to the AELB
- AELB staff role as observers only
- Can participate in responding in accordance with the role of AELB in the training / exercise where the level of involvement will be determined by SPKS based on the planned exercise scenario
- Fee (if applicable)

BORANG PERMOHONAN MENGADAKAN LATIHAN/EKSASAIS KE ATAS PELAN KECEMASAN DENGAN KEHADIRAN AELB

BUTIRAN MAKLUMAT		
1.	No. Lesen/ Nama Syarikat	
2.	Pegawai Bertanggungjawab	
3.	No. Telefon	
4.	Email	
5.	Cadangan Tarikh Latihan/Eksasais	
6.	Lokasi Latihan/Eksasais	
7.	Objektif	
8.	Senario (sila kepilkan lampiran jika ruangan tidak mencukupi)	
9.	Lain-lain Agensi Yang Terlibat (sila kepilkan lampiran jika ruangan tidak mencukupi)	
10.	Bahan Radioaktif Terlibat Dalam Latihan/Drill	
11.	Bilangan Kakitangan Terlibat	
12.	Tarikh Latihan/Drill Sebelumnya	

Any Question?

THANK YOU

"The important thing is not to stop questioning"

Albert Einstein

MMTC ASIA SDN BHD

TOPIC 9

PLANNING AND EMERGENCY PROCEDURES IN INDUSTRIAL RADIOGRAPHY

MMTC ASIA SDN.BHD
1330199-X

Contents

1.0 Introduction

There are two types of radiation sources commonly used in industrial radiography:

- Radioactive sealed source
- Irradiating apparatus (X-ray machine)

1.0 Introduction (continued)

The emergency can be classified into 4 levels

Level	Consequences	Action Level
Level 1	Limited to a single room within premise	Internal response team
Level 2	Limited to perimeter of premise	Internal response team
Level 3	Significance effect outside the outer perimeter of a premise	Internal and external response team
Level 4	Might have a transnational boundary effects	External and internal response team

1.0 Introduction (continued)

Measures to be taken to prevent the occurrence of accident and unwanted incident in industrial radiography, include:

- Radiographers should familiar with all of the equipment, its mode of operation and potential problem.
- The radiography work should only be carried out when the radiation exposure devices are in good working conditions.
- Before leaving the site, radiation worker should conduct visual inspection to ensure that the radiation exposure device has not been dented. This includes checking the source assembly and male connector using No-Go gauge.
- Only survey meter with valid calibration certificate and a well maintained radiation exposure device should be used.

2.0 Source of Radiological Emergency

2.1 Loss of control of radiation workers.

2.2 Loss of control of irradiating apparatus.

2.3 Loss of control of radioactive sources.

2.1 Loss of control of radiation workers.

Examples

- ❖ Negligence of the operator to terminate exposure.
- ❖ Failure of operator to perform radiation level survey prior to manipulating the tube assembly.
- ❖ Entry into no entry barrier during operation of exposure device.
- ❖ The tube assembly is unintentionally energized.
- ❖ Failure to retract the source.
- ❖ Failure to perform adequate radiation monitoring survey.

2.2 Loss of Control of Irradiating Apparatus

Examples

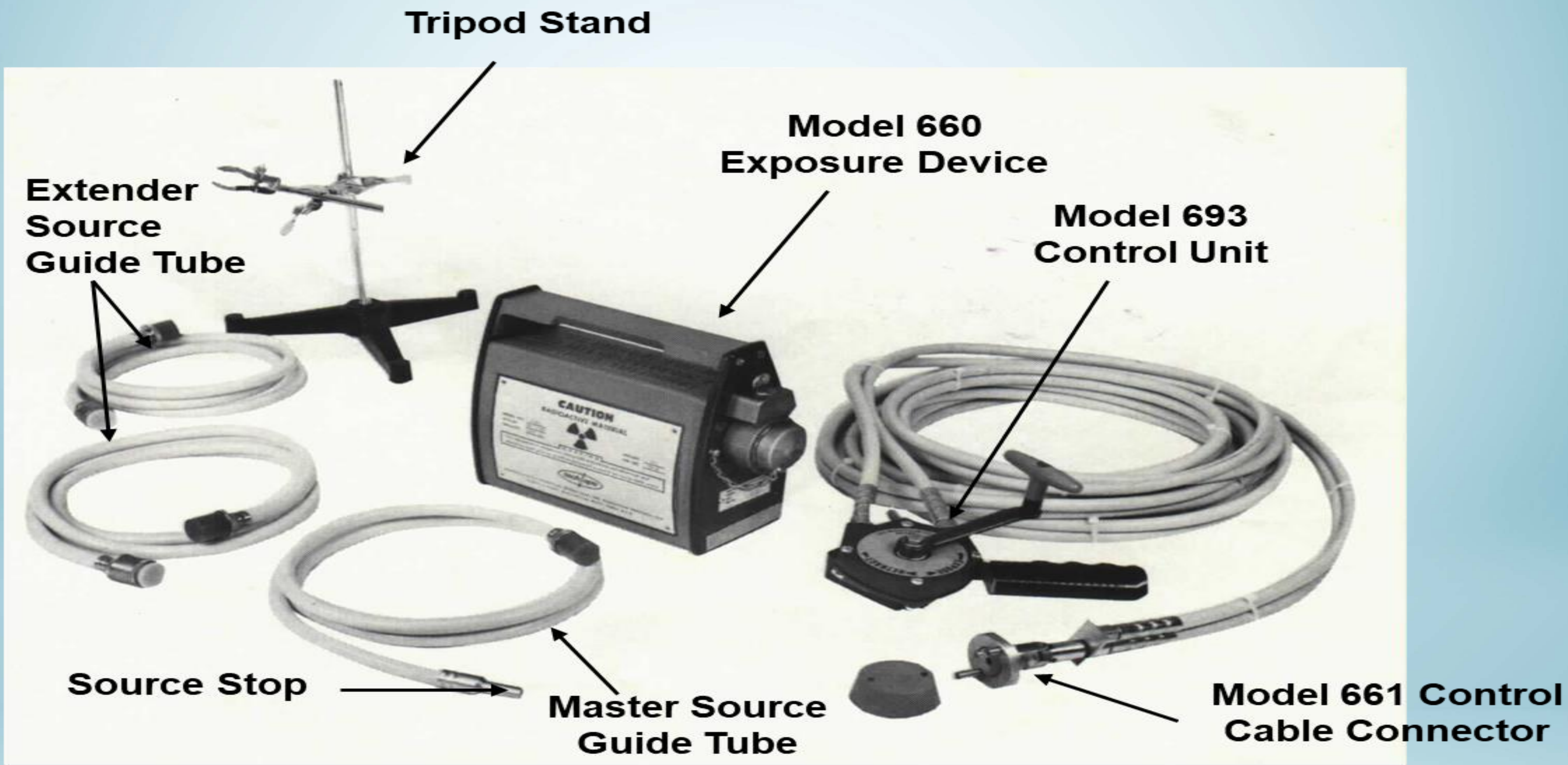
- ❖ Failure of automatic x-ray equipment to terminate exposure after completing the job.
- ❖ Malfunctioning of interlocks thus damaging safety feature designed for the system.
- ❖ Damage to safety feature designed for the system.
- ❖ Physical damage affects the shielding or filtration system of the equipment

2.3 Loss of control of radioactive sources

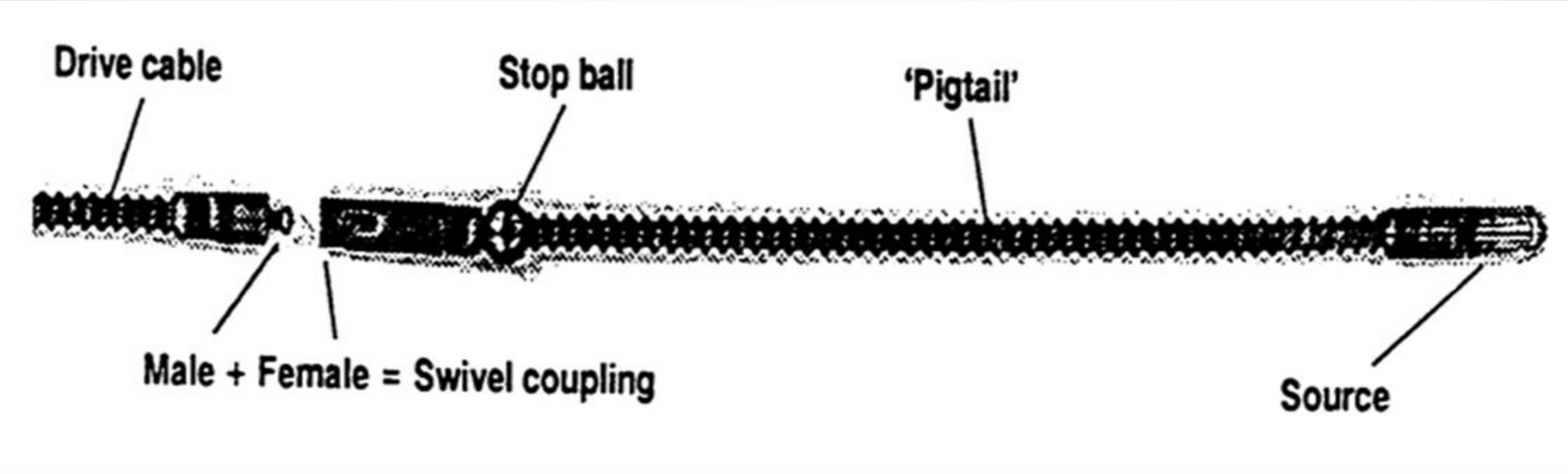
Examples

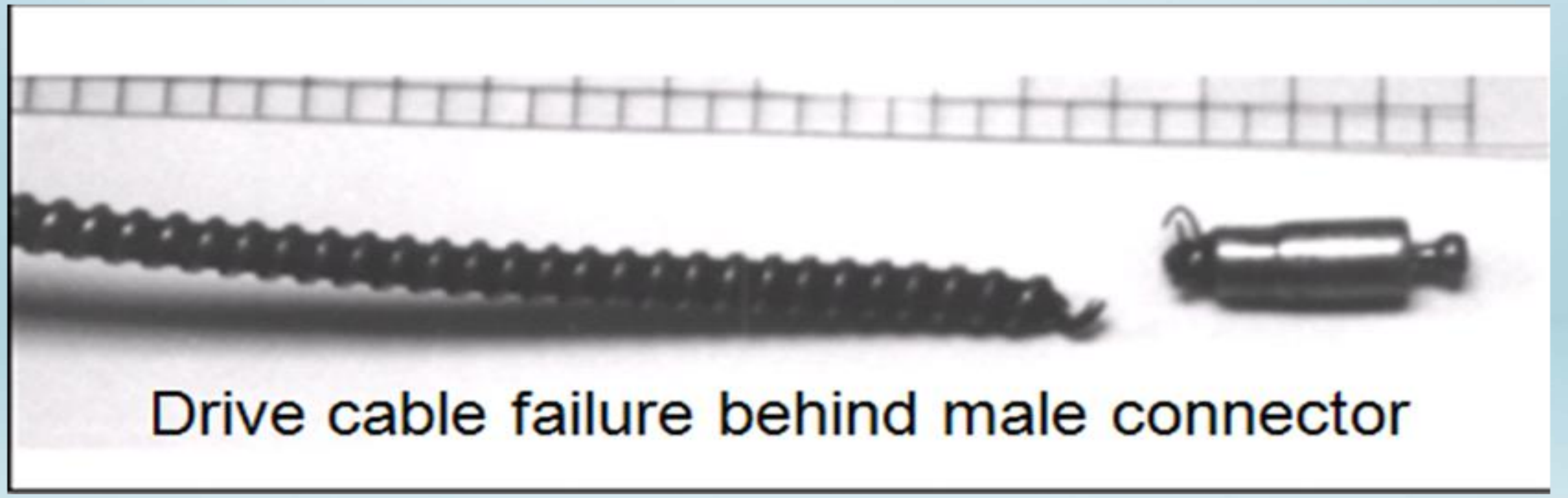
- ❖ Source stuck in the guide tube, collimator or near the entrance to the exposure container.
- ❖ Source disconnected from the gamma projector cable.
- ❖ Source stuck in the exposed position due to problem such as failure of shutter to close when a task is completed.
- ❖ Theft of the exposure device or source assembly.
- ❖ Malfunction or deliberate defeat of the safety control system.
- ❖ Contamination due to leaking or damaged sources assembly.

TYPICAL GAMMA PROJECTOR

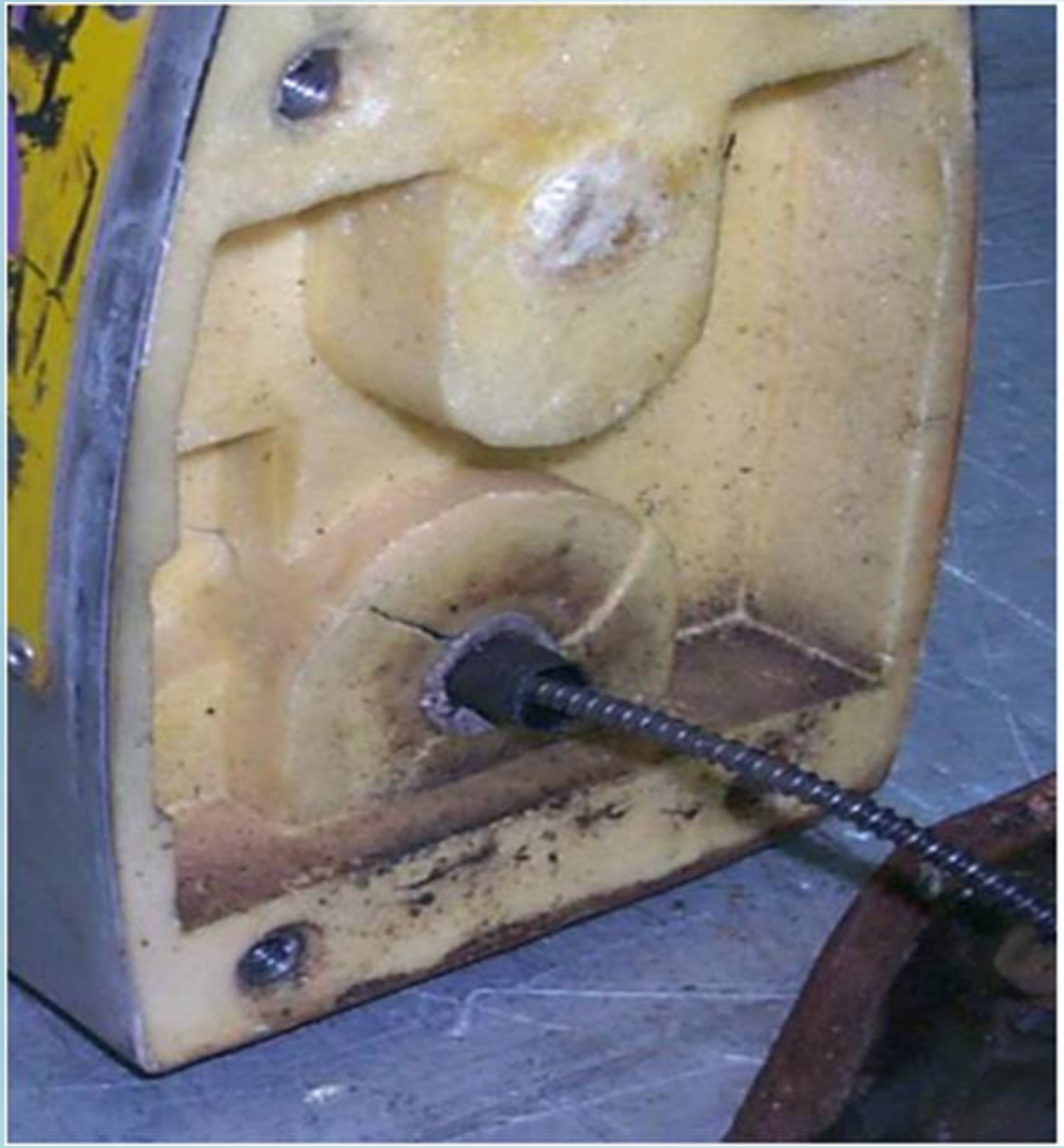


Pigtail Construction





Source Hang-up



3.0 Types of Emergency

Types of emergency can be:

3.1 Emergency at site

3.2 Emergency at off-site

3.1 Emergency at site

Category of emergency - level 1

Possible root cause of emergency:

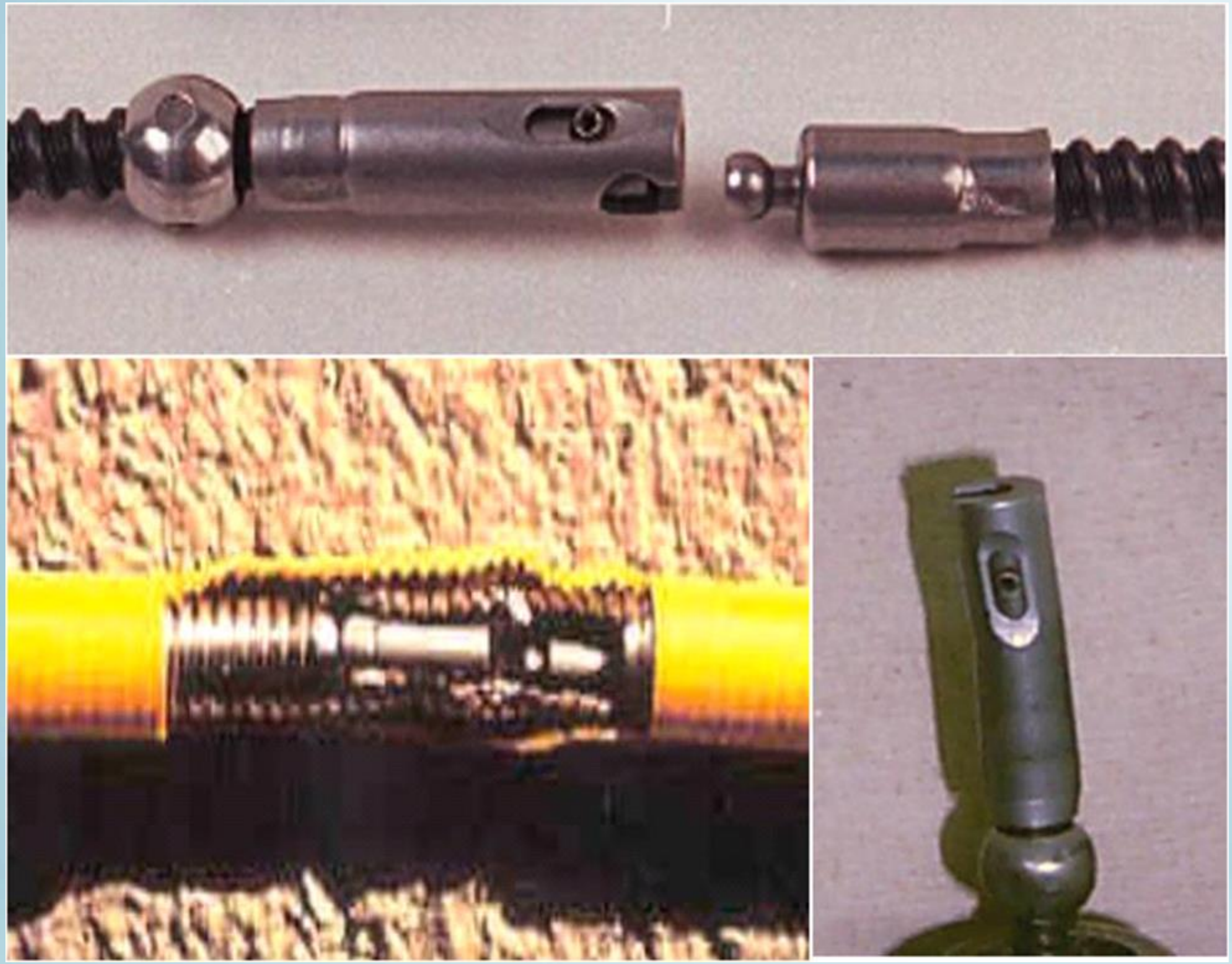
- ❖ Non-compliance to safe working procedure by the operator.
- ❖ Lack of maintenance of gamma projector system or X-ray machine.

3.1 Emergency at site

Examples.

- ❖ Source capsule assembly disconnected from its cable resulting in radiographic source lodged in collimator.
- ❖ Failure of retracting source assembly into shielded position.
- ❖ Source capsule assembly stuck in source guide tube.
- ❖ Source capsule assembly stuck in source guide tube nozzle.

Source Disconnected



Source capsule assembly disconnected from its cable resulting in radiographic source lodged in collimator leading to an emergency situation

3.2 Emergency at off-site

Category of emergency - Level 2 or level 3

Possible root cause of emergency:

❖ Conventional emergency that may lead to radiological emergency when involving source of radiation.

❖ Accident during transportation of radiation sealed source.

3.2 Emergency at off-site

Examples

- ❖ Fire involving radioactive source.
- ❖ Missing or stolen of source
- ❖ Lost of source during transportation.
- ❖ Damage to source assembly during transport accident.
- ❖ Radioactive leakage from source.

4.0 Emergency Equipment

Who should be equipped with facilities applicable in both normal and emergency situations:

❖ The whole group.

❖ Each member of the group such as OSL/RPL or TLD.

4.0 Emergency Equipment

Equipment to be made available that are applicable during normal and emergency situation include.

4.1 Radiation measuring equipment.

4.2 Radiation protection equipment and accessories.

4.3 Communication equipments

4.4 Supporting documentation

4.1 Radiation Measuring Equipment.

To the group	To each member of the group
Survey meter (measurability up to Sv/hr)	Direct reading dosimeter
Long range survey instrument	OSL/TLD/RPL
Check source	Other monitoring equipment
Contamination monitor (applicable if involve contamination)	
Integrative personnel dosimeter	

4.2 Radiation Protection Equipment and Accessories

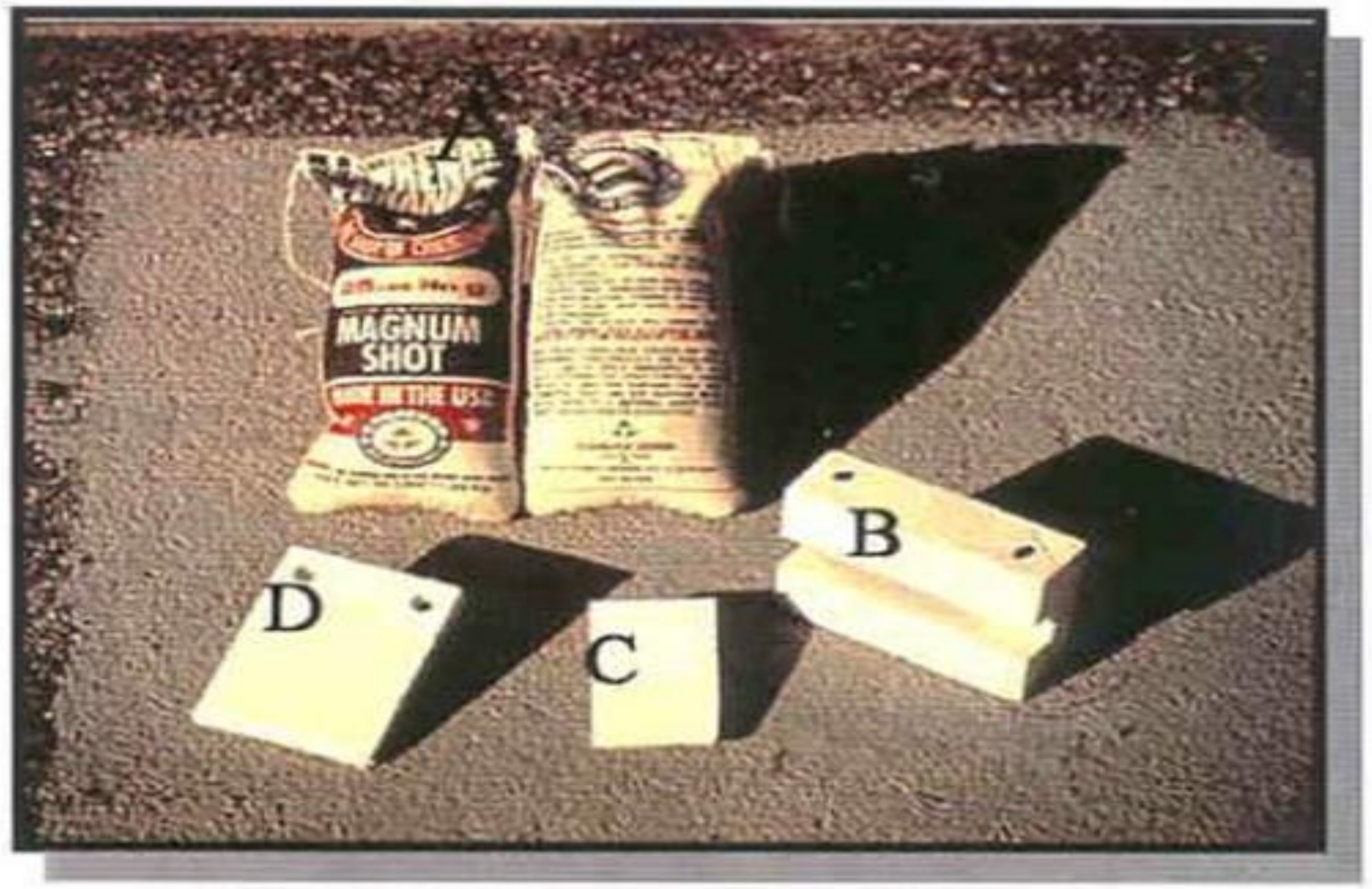
To the group	To each member of the group
Shielding material (such as lead shots and lead sheet)	Protective overall
Tong at least 1.5 m long	Overshoes
A shielded container	Gloves
Miscellaneous tools (such as pliers, cutter and etc.)	
Radiation warning labels and signage	
Plastic for preventing contamination of instruments	
Log book	
Rope	
Stop watch	

Some of the Emergency Equipment

Some of the Emergency Equipment

Some of the Emergency Equipment

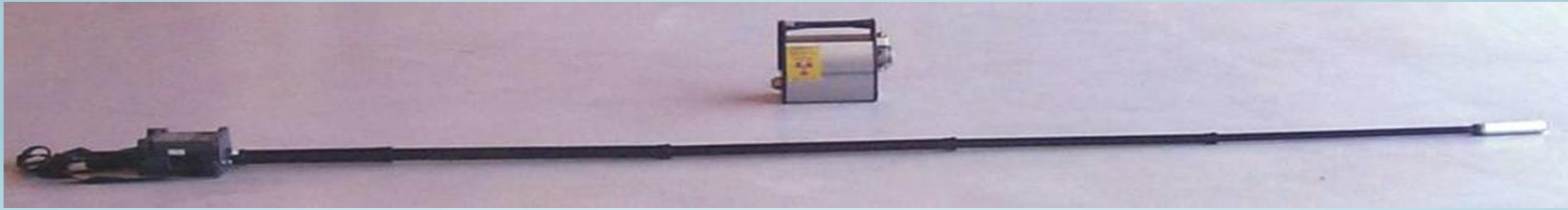
- Shielding materials
- Allows for reduction of dose rates so recovery can occur with minimal dose
- Additional shielding can usually be obtained on site



Clockwise from Top Shielding:

A. #9 Lead Shot - 25 lbs. each
B. Tunnel Lead Brick
C. Small HVL
D. Remote Use Two HVL

Emergency Equipment Teletector



4.3 Communication equipments
4.4 Supporting documentation

To the group only

Communication equipment include Walkie-talkie (more than 1 set)

Supporting documentation include:

- ❖Equipment operating manual
- ❖Emergency response procedure
- ❖Procedure for conducting monitoring
- ❖Procedure for personal radiation protection.

5.0 Emergency planning procedures

The emergency planning procedures should include:

5.1 Hierarchy of command.

5.2 Immediate control measures.

5.3 Monitoring assessment.

5.4 Coordination between appropriate authority

5.5 Recovery actions

5.6 Reporting procedure.

5.1 Hierarchy of Command

Radiation Protection Officer (RPO)

↑

Radiation Protection Supervisor (RPS)

↑

Radiographer

5.1 Hierarchy of Command

Responder	Action to be taken in case of an accident
First responder; the radiographer	Perform immediate action to mitigate the accident and immediately inform RPO
RPS	• Can be the operating manager/supervisor during normal radiographic work on site. • Responsible of the overall emergency response and manages the priorities and the protection of public and workers. • Report to RPO.
RPO	• Responsible to manage investigation of the accident that lead to emergency that include evaluation of exposure and contamination. • Radiation protection support to emergency workers and formulation of protective action recommendation. • Planning recovery actions. • Appoint External Expert Emergency Services when the situation needed.

5.2 Immediate Control Measures

The immediate control measures include:

- ❖ Turn off the x-ray machine, if involved x-rays or in case of radioactive material; return the source into source assembly.
- ❖ Control access into the site.
- ❖ Apply shelter and shield.
- ❖ Evacuate and condone the area, and
- ❖ Apply personnel protection principle to minimize radiation exposure.

5.3 Monitoring Assessment

Objective

To assess the severity of accident, control situation and return it back to normal.

Monitoring Assessment

- Film badge and/or TLD should be immediately sent to SSDL of Nuclear Malaysia to assess level of radiation exposure.
- Contamination should be assess and request trained personnel to decontamination of the area.
- The worker who has been overexposed to radiation is subjected to chromosome aberration test in addition to medical examination.

5.4 Coordination Between Appropriate Authority

- ❖ The responsibilities lies entirely on the user in case of Level 1 and level 2 accident (AELB should be inform within 24 hours).
- ❖ It is the responsibility of the user to coordinate emergency response in case of Level 3 and level 4 emergency (AELB should be inform within 24 hours).
- ❖ The external emergency response to be involved include:
  - Local authority
  - Police
  - Fire and Rescue Department
  - Medical services.

5.5 Recovery Actions

- The actions taken by the relevant workers are to mitigate the abnormal back to normal situation. Once the situation become normal, the RPO will make a final assessment and notified the relevant authorities and workers about latest situation.
- The following are actions taken during recovery process:
  - Identify the type and source of emergency
  - The emergency coordinator shall be notified in case of any emergency.
  - Make a plan to mitigate the situation

5.6 Reporting Procedure

Notification of accident shall be complete and accurate and should be done the soonest possible(RPO should report to AELB within 24 hours after the accident).

The action taken to notify the accident include:

- ❖ Inform RPO immediately of any abnormal situation-the RPO should investigate the extent of the accident and thus initiate emergency response.
- ❖ The RPO should inform AELB within 24 hours after accident. Information to inform include:
  - ✓ type and intensity of the radiation
  - ✓ location and general status of the problem
  - ✓ time of accident
  - ✓ personnel involved

5.6 Reporting Procedure (continued)

Accident investigation

It is the responsibility of RPO to initiate an accident investigation and submit full accident report to AELB within 30 days after notification of the incident.

The report should at least comprises of the following:

- ❖ Description of the accident.
- ❖ Method used to render the source of radiation safe. Assessment of exposure for workers involved in the accident, emergency workers and the relevant members of the public.
- ❖ The cause of the accident and corrective and preventive actions.

6.0 Response action during emergency

The response actions taken during accident involving two types of radiation sources:

6.1 X-ray machine

6.2 Radiographic sources

6.1 X-ray Machine

Immediate emergency response actions involving X-ray

Responder	Order of Actions
Operator	• Switch off the machine immediately • Perform radiation survey to confirm the tube is de-energized. • Record position, beam direction, exposure setting (tube voltage, current and time). • Determined who has been exposed to radiation. • Competent authority will pursue further action such as interview the person to establish the extent of exposure. • Inform person in charge of the radiation area to restrict access to the area. • Contact RPO/RPS and brief him/her on the situation. • Do not reuse the device until further notice from RPO/RPS.

6.1 X-ray Machine (continued)

Responder	Order of Actions
RPO/RPS	❑ Notify the appropriate authority (AELB within 24 hours) ❑ Form an investigation team and initiate investigation and reconstruct the accident. ❑ Send immediately the TLD/film badge to SSDL of Nuclear Malaysia for evaluation of exposure. ❑ Send suspected exposed personnel for medical check-up and for taking blood sample for chromosome aberration study.

6.2 Radiographic Sources

Immediate emergency actions involving radiographic sources

Responder	Order of Actions
Operator	1. Recognized the abnormal situation. 2. Move away from the source and remain calm. 3. Measure the radiation dose rate around the area and establish a new safe barrier. 4. Display a warning light and radiation warning notice. 5. Restrict access beyond the area. 6. Detain any person who had been within the radiation barrier during the accident. If not obtain particular of the person such as name, address and contact number.

6.2 Radiographic Sources (continued)

Immediate emergency actions involving radiographic sources

Responder	Order of Actions
Operator	7. Do not leave the controlled area unattended. 8. Plan a course of action while outside the barrier. 9. Prepare all the emergency equipment required for the rescue operation. 10. Estimate maximum time one has to spend within the radiation barrier. 11. Inform supervisor who will summon RPO/RPS for further advice.

6.2 Radiographic Sources (continued)

Responder	Order of Actions
RPO/RPS	Take the following actions if the source already in the shielded container. – Check the shielding and its interlocking system. – Do not allow anybody work in the radiation barrier unless exposure rate is established. – Send TLD/film badge to Nuclear Malaysia for immediate radiation dose evaluation.

6.2 Radiographic Sources (continued)

Responder	Order of actions
RPO/RPS	Take the following actions if source still outside shielded container. 1. Plan a course of action following previous procedure if any. Always apply the ALARA principle when doing the mitigation work. 2. Rehearse the course of action prior entering the radiation barrier. 3. Do not allow exposed workers from carry out any work within the radiation barrier until dose received from the incident has been established. 4. Check the barrier, warning signals and notices are satisfactorily function and the access into radiation area is under control.

6.2 Radiographic Sources (continued)

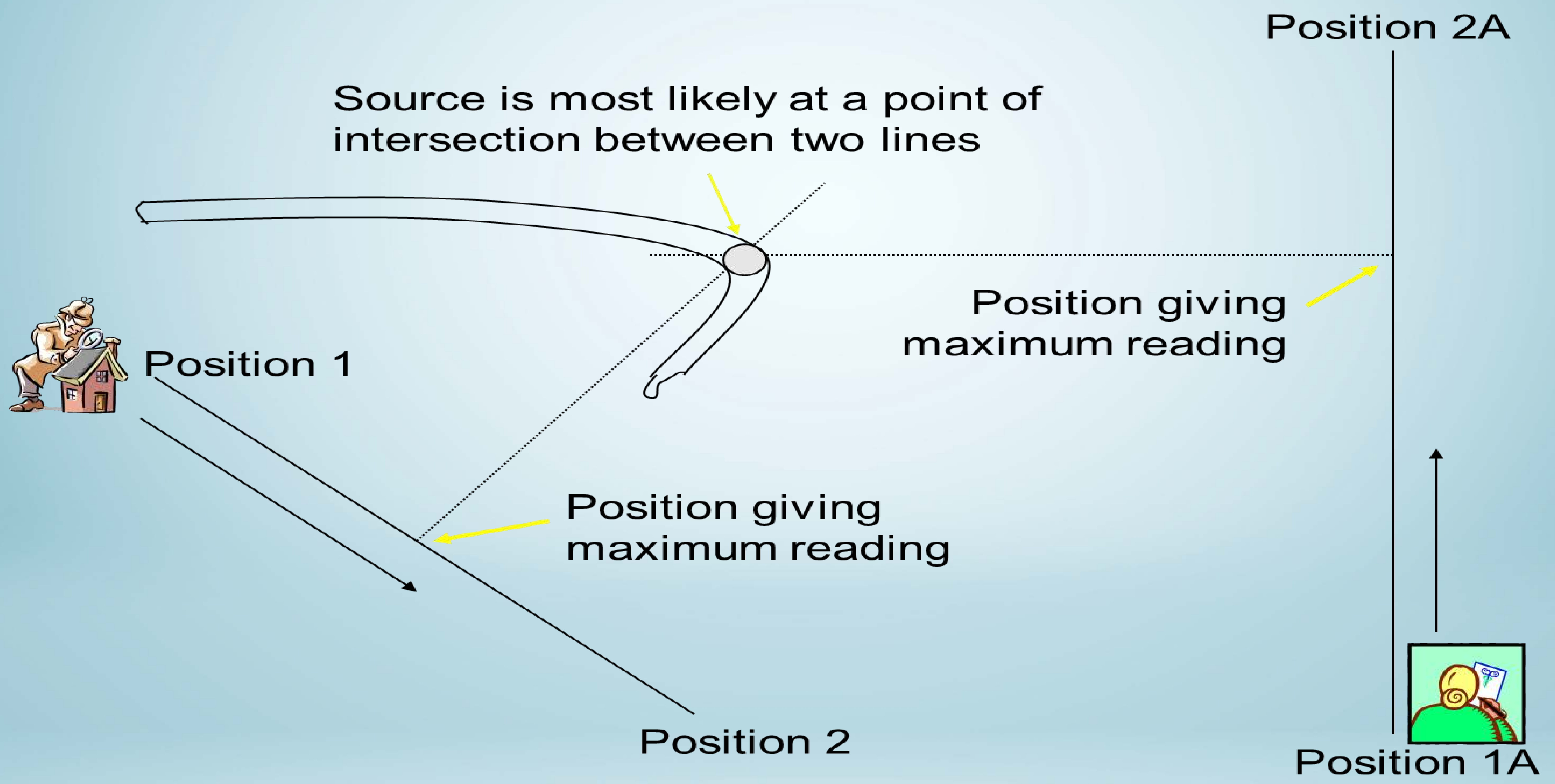
Responder	Order of Actions
RPO/RPS	Take the following actions if source still outside shielded container. 5. Make attempt to return the source into shielded container. If the course of action is unsuccessful, leave the area and consider next course of action while continuing surveillance of the controlled area. 6. Call technical assistance if needed from experts or manufactures. 7. Notify the appropriate authority as required. 8. Do not allow personnel involved in recovery operation from further radiation work until their exposure doses have been established.

Source Recovery - Maximum Allowable Time

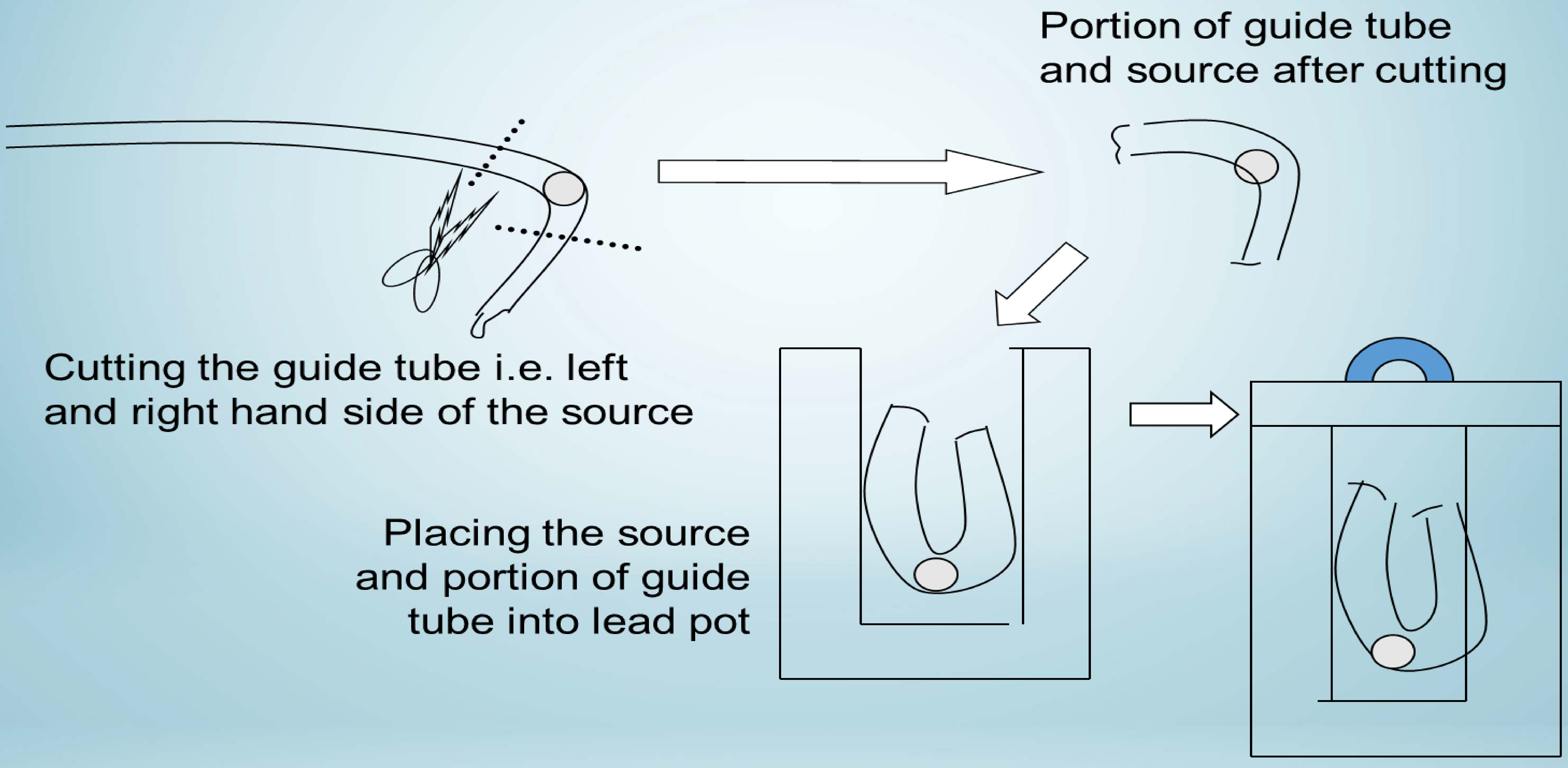
Source	Activity (GBq)	Dose Rate at 1 m (mSv/hr)	Allowable time (min)
Ir-192	37	4.8	120
	74	9.6	60
	185	24	25
	370	48	12
	740	96	6
	1850	240	2
	3700	480	1
Co-60	37	13.2	46
	185	66	9
	370	132	4.6
	740	264	2.3
	1850	660	0.9
	3700	1320	0.4

Derived from a dose of 10 mSv to the hand at 1 meter

Source Rescue



Source Rescue



6.2 Radiographic Sources

Responder	Order of actions (continued from previous slide)
RPO/RPS	9. When the emergency is resolved, reconstruct the accident, assess dose received and prepare a report. 10. Send TLD/Film badges worn by personnel involved to Nuclear Malaysia for immediate assessment. 11. Send damaged or malfunctioning equipment to the manufacturer or maintenance center for a detailed inspection before reuse.

7.0 Decontamination

Definition

Decontamination is a process to remove radioactive sources contamination from contaminated objects. It normally occur in case of unsealed source but could occur with sealed source when the projector or source container of the sealed source is broken revealed radioactive that is mobile such as in powder or liquid form.

7.0 Decontamination

In the radiographic work - Emergency with possibility of contamination of radioactive material is very minimum. The possibility of contamination may occur due to the following circumstances:

- ❖ Damage to the sealed container of source 137Cs. Since the source made of cesium salt in powder form.
- ❖ Shielding material of exposure container or projector made of depleted uranium. In such case the U (low specific radioactive material)shielding material may contaminate area and other surrounding material.

7.0 Decontamination

Monitoring is important to be carried out prior and after decontamination for two reasons:

- To detect of any contamination.
- To confirm of the radioactive material from the contaminated surface.

Notes:
It is important to note that all designated areas and equipment must be kept free of radioactive contamination at all times and must be monitored before and after work using appropriate instrument.

7.0 Decontamination

All decontamination works should be performed by trained personnel and supervised by the RPO. The work may involved to the decontamination of the following:

- ❖ Personnel
- ❖ Clothing
- ❖ Equipment and tools
- ❖ Working area.

Note

It is important to note that medical team should assist the decontamination of injured personnel.

8.0 Investigation and Accident Reports

The following items should be included in the emergency accident report to be submitted to AELB within 30 days after the emergency notification.

- Description of the accident.
- Actions taken during emergency.
- Assessment dose to workers, emergency services workers and relevant members of the public.
- The cause of the emergency, corrective and preventive actions taken.
- Any necessary improvement to enhance safety and health.

Note

The lessons from the accident should be communicated to all involved including necessary improvement taken to enhance safety and health.

Summary

- In Malaysia, most of the radiological accidents occurred in the industrial radiographic activities.

- The reason was not only because of human or technical factors but also due to the relatively higher activity or intensity of the source used for the work performance.

- Safety culture should be inculcated to minimize occurrence of accident lead to overexposure of ionizing radiation to the workers and members of the relevant public.

Any Question?

THANK YOU

"The important thing is not to stop questioning"

Albert Einstein

MMTC ASIA SDN BHD

TOPIC 10

EMERGENCY PLAN AND PROCEDURE NUCLEAR IN GAUGING ACTIVITY

MMTC ASIA SDN.BHD
1330199-X

Contents

Introduction

- Accidents can happen with nuclear gauges and X-ray analyzers.
- These may lead to personnel receiving a radiation dose exceeding the operational or annual dose limits.
- Emergency occurrence and situation is unplanned and largely unpredictable. Thus, emergency response to manage and control emergency need to be planned.
- The plan is required to minimize the impact caused by accident, to return the emergency state into normal and to fulfill the requirements of Basic Safety Standards Regulations.

The Radiological Accident in Istanbul (1998)

2 packages sold as scrap metal by a new owner of a premise, not realize what's inside. buyer broke open the shielded containers and exposed to 60Co.

10 person in the proximity fell ill and 6 of them began to vomit.

- ❖ Exposure ~ 2.1 Gy
- ❖ Amputated, the 2nd finger a year later.
- ❖ Ulcerated 3rd finger 14 months later
- ❖ Some ulcerative-necrotic changes have developed

Sources of Emergency

- Accidents and incidents involving nuclear gauges and X-ray analysers can happen as a result of:
  - Loss of control of personnel.
  - Loss of control of irradiating apparatus.
  - Loss of control of sealed source.
  - Loss of control of unsealed source.
  - Conventional accident.
  - Transport accident.

Sources of Emergency

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  - Loss of control of unsealed source.
  - Conventional accident.
  - Transport accident.

Accidents Involving a Nuclear Gauge

- ❑ Plastic film thickness gauge using Kr-85.
- ❑ Servicing of the gauge with the source shutter open

Accidents Involving a Nuclear Gauge

- ❑ Nuclear density gauge
- ❑ Cs-137 and Am-241/Be
- ❑ Gauge crushed by heavy equipment

Sources of Emergency

❖ Loss of control of irradiating apparatus:

- ❑ Due to control measures taken during design and manufacturing, occurrence of accident will be very much localized.
- ❑ Usually effect is confine only to immediate vicinity and will not spread to other areas.
- ❑ Example:

- Radiation leakage of irradiating apparatus.
- Physical damage of its housing or the analyser enclosure.

Sources of Emergency

❖ Loss of control of sealed source;

❑ Can occur as a result of failure to keep track the movements or use of the sources according to procedure, that finally can lead to accidents or incidents;

- Physical damage;
- Lost, stolen or whereabouts unknown;
- Lead to radiation leak and leakage;
- The source falls into the hand of unauthorised person.

Accidents Involving a Nuclear Gauge

- ❑ Level gauge
- ❑ Source capsule was corroded by environmental conditions (sea air) which caused leakage

Accidents Involving Well Logging

- ❑ Well logging source using Cs-137.
- ❑ The source is detached from the handling tool during the process of transferring to the probe.

Sources of Emergency

- Loss of control of unsealed source;
    - Result of a spill or accident during the production or use of unsealed radioisotopes.
    - Contamination may occur from radioactive gases or liquids.
    - Example in radiotracer work; if accidentally spilled, the material could be spread by people as they walk around.

Sources of Emergency

- Conventional accident;

  - May be caused by a non-radiation emergency such as due to natural disaster.

  - It will eventually affect the safety and security of radiation sources.

  - Example
    - Natural disaster (e.g. flood, earthquake)
    - Fire
    - Theft or Sabotage

Sources of Emergency

- Transport accident;

  - Quite probable in the case of a portable gauge because it is normally moved around quite regular.

  - May lead to possible damage caused on the exposure devices onboard.

  - Example;
    - Vehicle accident during transportation of nuclear gauge to outside premise.

Types of Emergency

- It is important for the emergency to be classified in order to:
  - Facilitate in the establishment and implementation of emergency plan; and
  - Provide an effective emergency response.
- It is classified based on magnitude of the consequences or severity of the hazard involved.

Types of Emergency

Level of Emergency	Definition	Examples of Event
Level 1	'On-site emergencies', consequences limited to a single room/laboratory/building.	Stuck ^{60}Co source in the irradiation facility
Level 2	'On-site emergencies', consequences limited to the perimeter of the facility.	Small spillage of radioactive sources with no possibility of affecting sewage system.
Level 3	'Off-site emergencies', consequences might have significance outside the outer perimeter of the facility involved.	Spillage of radioactive material and might contaminate the nearest aquatic system in the area
Level 4	'Off-site emergencies', consequences might have trans-boundary effects as defined in the convention on Early Notification of a Nuclear Accident.	Release of airborne radioactive material from the area.

Fire involving nuclear gauges and Irradiating Apparatus

- Classify the emergency into Level 1 or Level 2
- For Level 2, inform Emergency Coordinator and request for an assistance from outside support groups especially Fire Brigade.

Emergency Plan

- A simple emergency plan should be established to properly manage the situation arising from accidents or incidents - Radiation Protection (Basic Safety Standard) Regulation 1988.

- Objectives:
  - To limit the exposure to as low as reasonably achievable.
  - To control and bring the situation back to normal immediately after an accident happened.
  - To gather information for the purpose of assessment and taking corrective action.

Emergency Plan

- The plan should be:
  - Clear, specific, simple and concise.
  - Meet all the local requirements and needs.
  - Able to address all possible accidents that can happen with nuclear gauges/ X-ray analysers belong to a licensee.
  - Able to identify the emergency organisation involved and response action taken during the accident.

Emergency Plan

❖ Primary component in emergency plan:

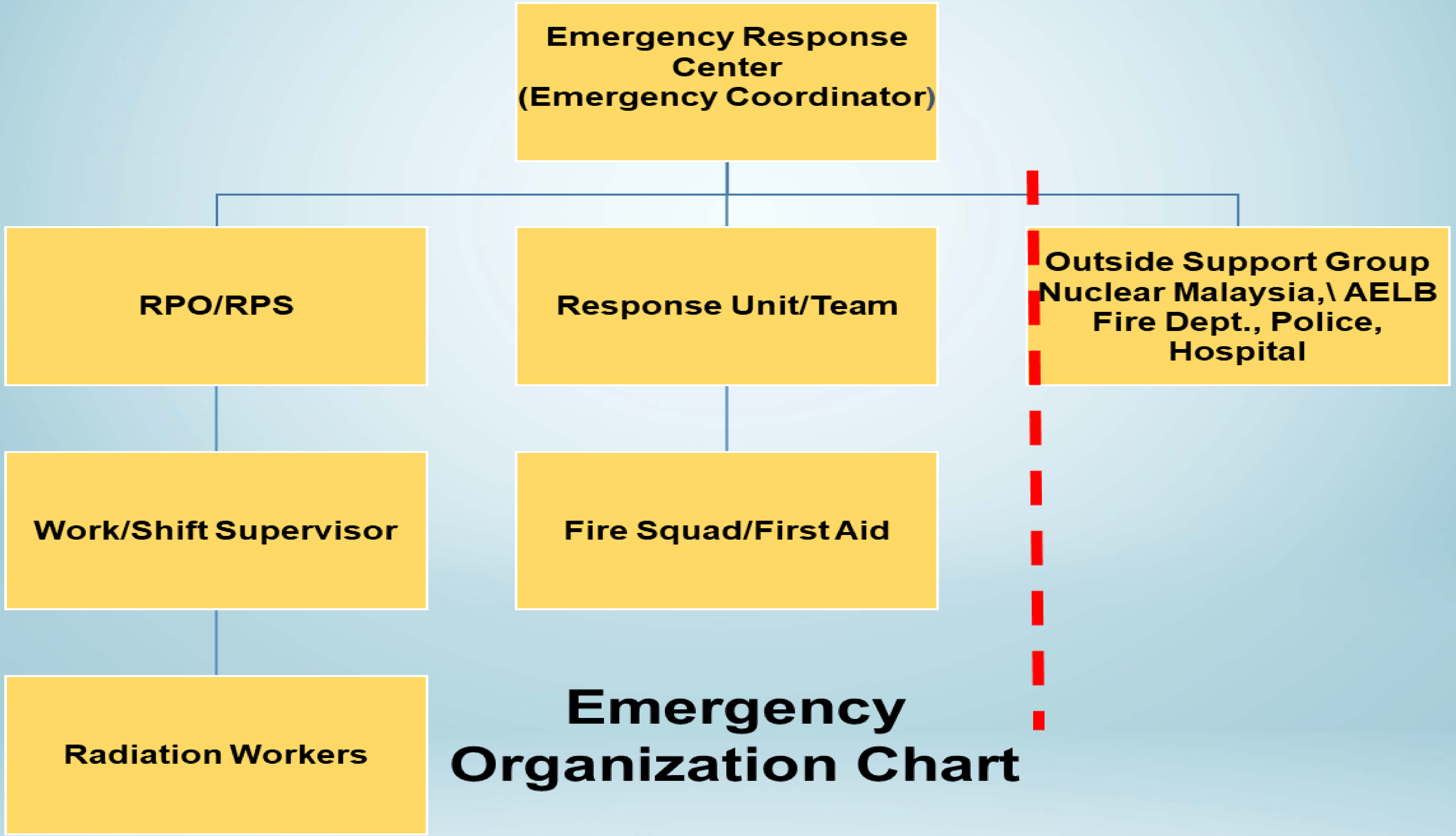
- ❑ Hierarchy of command as in emergency organisation.
- ❑ Reporting procedures and monitoring assessment.
- ❑ Immediate control measures.
- ❑ Coordination between AELB and other relevant agencies.
- ❑ Recovery actions.

Emergency Plan

❖ Hierarchy of command:

- ❑ One of the emergency plan components.
- ❑ To indicate groups of people involved in the emergency response action and their responsibilities.
- ❑ Highlights line of command for any action to be taken during an emergency.
- ❑ It must be integrated into other emergency response plans of an organisation.

Emergency Plan



Emergency Organization Chart

Emergency Plan

❖ Reporting procedures:

- All accidents/incidents must be reported for justifying actions to be taken without undue delay.

- Reporting procedures must follow the hierarchy of command given in the emergency organisation.

- A radiation worker who discovers an accident/incident must immediately take action to control it and report to his/her Work/Shift Supervisor.

- Upon receiving notice, the Work/Shift Supervisor should go immediately to the site and take preliminary actions to control the exposure and assess the situation.

Emergency Plan

Cont':

- The Work/Shift Supervisor shall inform RPO/RPS for further action. The RPO/RPS shall verify sufficiency of the control measure provided and classify the emergency into Level 1 or Level 2 (monitoring assessment).

- The RPO/RPS together with the Work/Shift Supervisor shall take action to control accident Level 1 and Level 2.

- For Level 2, if RPO/RPS unable to handle, he/she should inform Emergency Coordinator, who shall seek assistance from external support groups.

Emergency Plan

Cont':

- The RPO/RPS shall supervise personnel from external support groups involved in the emergency mitigation.

- The RPO/RPS shall inform AELB by phone of the occurrence of the accident/ incident within 24 hours and shall submit a written full accident report within 30 days from the date of occurrence.

Emergency Plan

❖ Emergency response action

- During accident, emergency response actions are needed to minimise any consequences.
- The action procedures must be standardised, established and made known to all personnel so that actions can be taken in a fast and accurate manner.
- Example of response action;

Overexposures

- ❖ Immediate control measures;

  - ❑ If personnel is suspected/found to receive higher exposure than the operational or annual dose limit, the Work/Shift Supervisor must secure the respective device involved and inform RPO/RPS for further actions.

Overexposures

- Emergency response action

The RPO/RPS should:

- Ensure immediate return of dosimeter(s) to assist enquiries of the suspected overexposure;
- Obtain details of the events leading up to suspected overexposure.
- Notify immediately the Atomic Energy Licensing Board (AELB).
- Carry out detailed investigation to assess actual doses received.
- Prepare a detailed report to be submitted to the AELB; and
- Prevent the individuals involved from taking part in further work with ionizing radiations.

Accessible High Dose Rate

- o Immediate control measures

- ❑ If nuclear gauge/X-ray analyser giving dose rate exceeding the limit designated as controlled or supervised area, Work/Shift Supervisor should:

  - Immediately clear the area and keep personnel out of the area by putting notices and alarm.
  - Provide local shielding if practicable, and set up barrier to mark new boundary of the Controlled/Supervised Area.
  - Inform RPO/RPS for further actions.

Accessible High Dose Rate

- Emergency response action:

  The RPO/RPS should:

  - Plan a means of retrieving the device;
  - Notify immediately AELB;
  - If difficulty retrieving the device, report details to Emergency Coordinator. Inform and, if necessary, obtain assistance from outside support groups;
  - If involved overexposure of personnel, implement procedures as described in Overexposure.
  - Carry out leakage test on the source if the device is to be used again.

Emergency Response Action

The RPO/RPS should (cont.):

- In loss of source, implement procedures as described in Missing Source.
- Declare that emergency situation is over and the situation is back to normal.
- Prepare detailed report to be submitted to AELB.

Physical Damage

- Immediate control measures:

  - Work/Shift Supervisor should stop/prevent usage of device until it been examined, tested and confirmed fit for reuse and inform the RPO/RPS for further actions

Physical Damage

- Emergency response action:

  The RPO/RPS should (cont.):

  - Use survey meters to assess for any possible damage of source housing.
  - If shielding damaged or shutter fail to close, provide additional shielding and store device until alternative full shielding or shutter operation can be restored.
  - Identify establish Controlled Areas by setting up barriers and notices.
  - Implement procedures as described in Leakage of Radiation Source to test for radioactive leak.
  - Declare that emergency situation is over and the situation is back to normal.
  - Prepare a detailed report to be submitted to AELB.

Missing Source

- o Immediate control measures:

  - ❑ If sealed source, gauging device or X-ray analyser is lost, stolen, mislaid or unaccounted for, the Work/Shift Supervisor should immediately inform the RPO/RPS for further actions.

2/8/09

Radioactive machine stolen

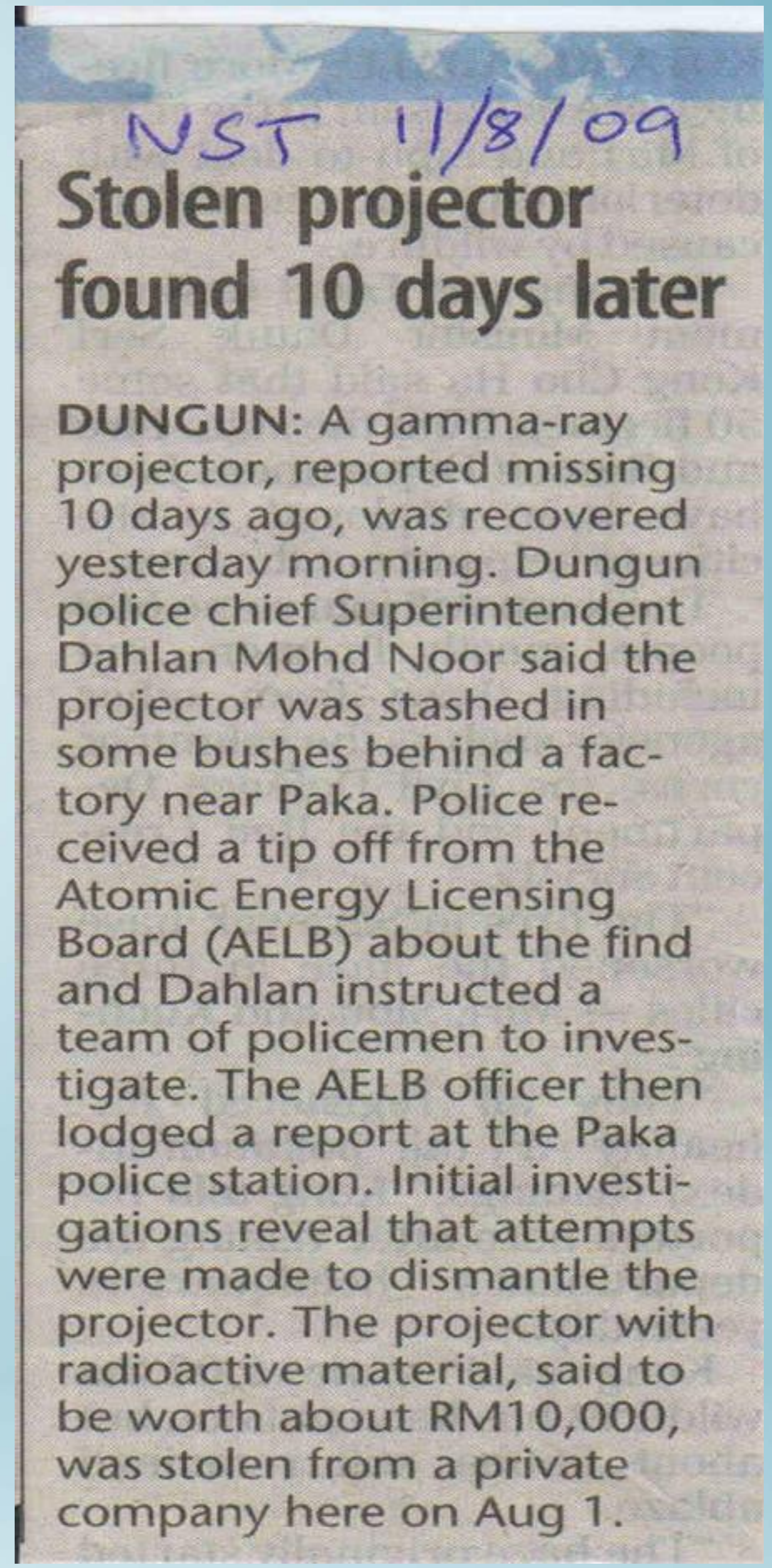
DUNGUN: A gamma-ray projector with radioactive materials, said to be worth RM10,000, was stolen from a storeroom of a company here on Friday night. Workers of the company in Kampung Cacar, Paka, discovered the 25kg machine, used to detect leaks in welding works and gas pipes, was missing when they wanted to use it at 2pm. The supervisor lodged a police report. Dungun police chief Superintendent Dahlan Mohd Noor said: "We are worried as it contains radioactive materials."

Missing Source

❑ Emergency response action:

The RPO/RPS should (cont):

- Use survey meters to search possible areas within premise.
- If not successful, the emergency is now in Level 3.
- Inform Emergency Coordinator and extend search to outside premise.
- Implement procedures as described in Physical Damage when the source, the device or the machine is found.
- When all possibilities are exhausted and the source or the device is still not found, inform the Emergency Coordinator to request for the assistance of outside support groups.
- Notify immediately to AELB and, if necessary, also the Police.
- Declare that emergency situation is over and the situation is back to normal.
- Prepare a detailed report to be submitted to AELB.



NST 11/8/09

Stolen projector found 10 days later

DUNGUN: A gamma-ray projector, reported missing 10 days ago, was recovered yesterday morning. Dungun police chief Superintendent Dahlan Mohd Noor said the projector was stashed in some bushes behind a factory near Paka. Police received a tip off from the Atomic Energy Licensing Board (AELB) about the find and Dahlan instructed a team of policemen to investigate. The AELB officer then lodged a report at the Paka police station. Initial investigations reveal that attempts were made to dismantle the projector. The projector with radioactive material, said to be worth about RM10,000, was stolen from a private company here on Aug 1.

Leak Of A Radiation Source

- Immediate control measures:

  - In the event of physical damage to sealed source/housing or potential damage caused by abnormal mechanical pressure on the source, it has to be assumed that the source is damaged and may leak radioactive substance.

    Work/Shift Supervisor should:

    - Isolate source, housing and items that have contact with them and avoid moving them unnecessarily.
    - Erect barriers around the contaminated areas, prevent access and restrict the movement of persons to that area.
    - Inform RPO/RPS for further action.

Leak Of A Radiation Source

- Emergency response action:

The RPO/RPS should:

- Inform Emergency Coordinator and request for immediate leakage test to the source.
- If source is leaking, notify immediately the AELB.
- Obtain further guidance from AELB of any contamination, the collection and disposal of contaminated items and assessment of internal doses;
- Declare that emergency situation is over and the situation is back to normal.
- Prepare detailed report to be submitted to AELB.

Coffee Break

Fire Involving Nuclear Gauges

- Immediate control measures:

  Work/Shift Supervisor should:

  - Immediately vacate the area of any personnel;
  - Switch off ventilation system and electric supply to affected areas.
  - Extinguish the fire using available fire fighting equipment. Request assistance of in-house fire fighting team.
  - If fire cannot be put out, inform the RPO/RPS for further action.

Fire involving nuclear gauges

- Emergency response action:

  The RPO/RPS should:
  - Classify the emergency into Level 1 or Level 2.
  - For Level 2, inform Emergency Coordinator and request for an assistance from outside support groups especially Fire Brigade
  - Erect barriers around the site, prevent access and restrict the movement of persons that entered the area.

Fire Involving Nuclear Gauges

- Emergency response action

The RPO/RPS should (cont.):

- Supervise Fire Brigade and other personnel involved.
- Notify immediately the AELB;
- Declare that emergency situation is over and the situation is back to normal.
- Prepare detailed report to be submitted to AELB.

Transport Accident

- Relevant only for portable nuclear gauges.
- Transportation of portable nuclear gauges is done according to Transport Regulations 1989.
- There should be a transport document prepared by consignor, which describes immediate response actions to be taken during emergency.

Transport Accident

- Immediate control measures:

  - If vehicle involved in accident, driver should take immediate action according to instructions given in transport document. In addition, the driver should:
    - Put up physical barrier and warning signs around the accident site.
    - Immediately inform the RPO/RPS and provide all necessary information to him/her.
    - Take further action based on advice of the RPO/RPS.

Transport Accident

- Emergency response action:

  The RPO/RPS should:

  - Advise driver on further actions to be taken for emergency Level 1.
  - For emergency Level 2, inform Emergency Coordinator and request for assistance from nearest outside support groups.
  - Together with driver, supervise outside support personnel involved.

Transport Accident

- Emergency response action:

  The RPO/RPS should (cont.):

  - Notify immediately the AELB and consignor.
  - Declare that emergency situation is over and the situation is back to normal.
  - Prepare detailed report to be submitted to AELB.

Emergency Equipment

- Emergency equipment - protective devices and radiation measuring equipment.

- The equipment should be of the right number and type;.
  - For X-ray analysers - survey meter, personnel dosimeters and radiation protection devices such as lead apron, lead glasses, lead glove and warning signs,
  - For nuclear gauges (sealed source) - survey meter (teletector) that can measure both radiation and contamination, personnel dosimeters and radiation protection devices such as ropes, lead apron, lead glasses, lead glove, remote handling tong, shielding material and warning signs.
  - For unsealed source - coverall , rubber glove, footwear, safety goggle and visor, respirator and breathing apparatus, decontamination kits, lead container, disposable plastic bag.

Emergency Equipment

Used	Equipment
Common	▪ Survey meters ▪ Personal dosimeters ▪ Radiation warning sign ▪ First aid kit
External radiation	▪ Tong ▪ Lead apron ▪ Goggle
Internal radiation	▪ Breathing apparatus, respirators and dust masks ▪ Fully impervious clothing ▪ Footwear and gloves; and ▪ Decontamination agents and equipment

Emergency Equipment

- Management with the advice of RPO must provide and maintain suitable type and number of emergency equipment.

- Two categories of radiological emergency equipment to be made available:
  - Monitoring equipment
  - Radiation protection equipment and tools

- Types of equipment used are determined by the radiation quality, quantity of radionuclide and source and types of emergency.

Decontamination

- Decontamination is a process to remove radioactive sources of contamination (unsealed sources) from contaminated objects or personnel.

- Monitoring is important to be carried out prior and after decontamination for two reasons;
  - ✓ firstly to detect contamination
  - ✓ secondly to confirm its removal.

Decontamination

❖ Fundamental principles applicable to decontamination are:

- Wet decontamination methods should always be used in preference to dry.
- Mild decontamination methods should be tried before resorting to treatment which can damage the surfaces involve.
- Precautions must always be taken to prevent further spread of contamination during decontamination operations.
- Where possible, contamination involving short-lived activities should be isolated and segregated to allow natural decay.

Decontamination

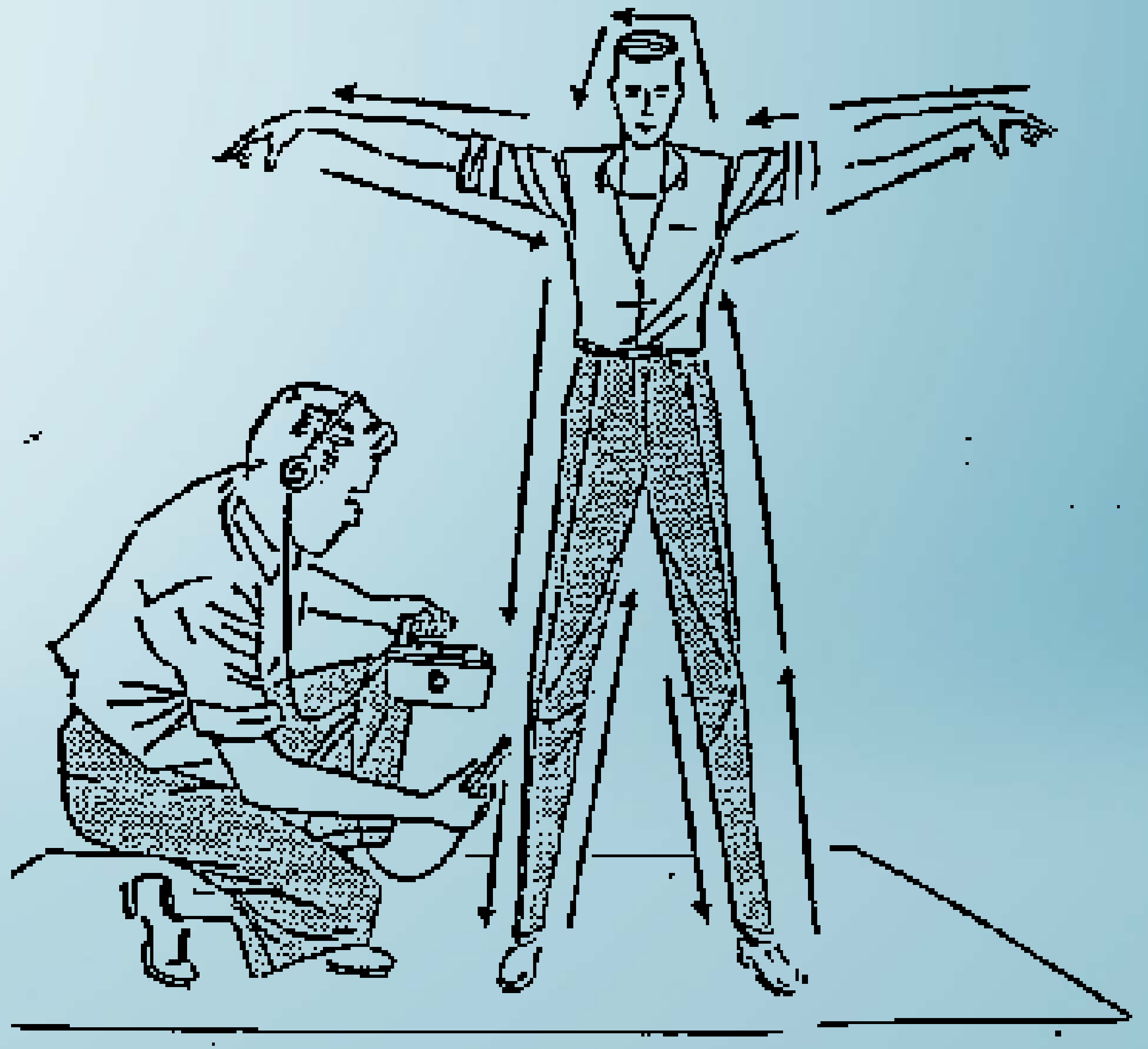
Contaminated Injured Person

- Assist medical staff in their assessment and initial handling of the patient by doing rapid contamination assessment.
- If the patient requires transfer to hospital, allocate team member to accompany the ambulance or arrange monitoring team to be available at hospital.
- Advise ambulance officers of contamination levels
- If appropriate, complete worksheet and give to ambulance personnel to take with the patient.

Decontamination

Personal Decontamination Monitoring

- Material used in decontamination process may become contaminated. Prevent spreading of contamination.
- Perform all monitoring in an area of low background
- Avoid unnecessary exposure to radiation.
- Probe about 1 cm from the body (not to touch);start checking at the top of the head
- If contaminated, record results and perform decontamination



Personal Decontamination Guide

Skin, hand, body	
• Soap and water	• wash 2-3 minutes and check activity levels • repeat washing 2 times
• Soap, soft brush and water • Dry abrasives (cornflower)	• use light pressure with heavy lather • wash for 2 minutes, 3 times, rinse and monitor • use care not to erode the skin
• Soap powder or similar detergent • Standard industrial skin cleaner	• make into a paste • use with additional water and a mild scrubbing action • use care not to erode the skin
• Wash hands, arms and face in sink, use showers for rest of body • After decontamination apply lanolin or hand cream to prevent chapping	

Decontamination

Personal Decontamination Guide

Eyes, ears, mouth	
• Flushing	• Eyes: roll back eyelids and gently flush with water • Ears: clean the opening of the ear canal with cotton swabs • Mouth: rinse with water - do not swallow
• Be cautious not to damage ear drum; rolling back the eyelids should be done out by medical or suitably trained personnel	

Decontamination

Personal Decontamination Guide

Hair	
• Soap and cold water	• use light pressure with heavy lathery • wash for 2 minutes, 3 times, rinse, and monitor
• Soap, soft brush and water	• make into a paste • use addition water and a mild scrubbing action • do not erode the skin
• Haircut • Shave head	• remove the hair to decontaminate scalp • use skin decontamination methods
• Hair should be back washed to minimize ingestion via mouth or nose • Use only after other methods fail.	

Decontamination

Decontamination of Clothing

- Lab coat must always be worn while working with unsealed radioactive sources.
- Rubber gloves and disposable apron must be worn over the lab coat when handling liquid or powdered radioactive materials.
- Any contamination could easily be overcome by disposing of the rubber gloves and apron.
- Contaminated lab coat could be washed in a washing system whereby the water is collected and stored for subsequent disposal as radioactive waste.
- Stubborn contamination of certain clothing might be more economical to let the activity die down naturally to within the permissible levels, or dispose of it as waste.

Decontamination

Decontamination of Equipment and Tools

- Disposable of some contaminated equipment and tools as radioactive waste may be more economical than decontaminating.
- Otherwise it is better to let the activity decay down naturally to within the permissible levels.

❖ Example of decontamination kit;

- Disposable overall and shoe covers
- Respirators
- Radiacwash
- Radiacwash Towelettes
- Radiacwash Spray
- Poly Bags
- 12" Niptong
- Sponge, mop, scrub brush, pail, rope and signs

Decontamination

- Radiacwash - formulated to decontaminate contamination from radioisotopes and fission products, without affecting surfaces as acids and reagents do.

- Control radioactive contamination by two-way action;

  1st - sequester metallic ions which contaminate surfaces.

  2nd - lifts up and firmly suspends the contaminating particles, allowing contamination to be rinsed away with hard, soft or salt water.

Decontamination

Decontamination of Working Area

- ❖ Decontamination measures depend upon the nature of contamination:
- ❖ Loose form: loose contaminants may be removed using vacuum cleaners with special filters. Do not brush or dust off.
- ❖ Relatively fixed: relatively fixed contamination can only be removed by using the wet method. If the contaminants remain stubbornly attached to the surface then it may be necessary to remove the contaminated surface.

Any Question?

THANK YOU

"The important thing is not to stop questioning"

Albert Einstein

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TOPIC 11

CALCULATION FOR SHARING DOSE DURING RADIOLOGICAL EMERGENCY

MMTC ASIA SDN.BHD
1330199-X

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.

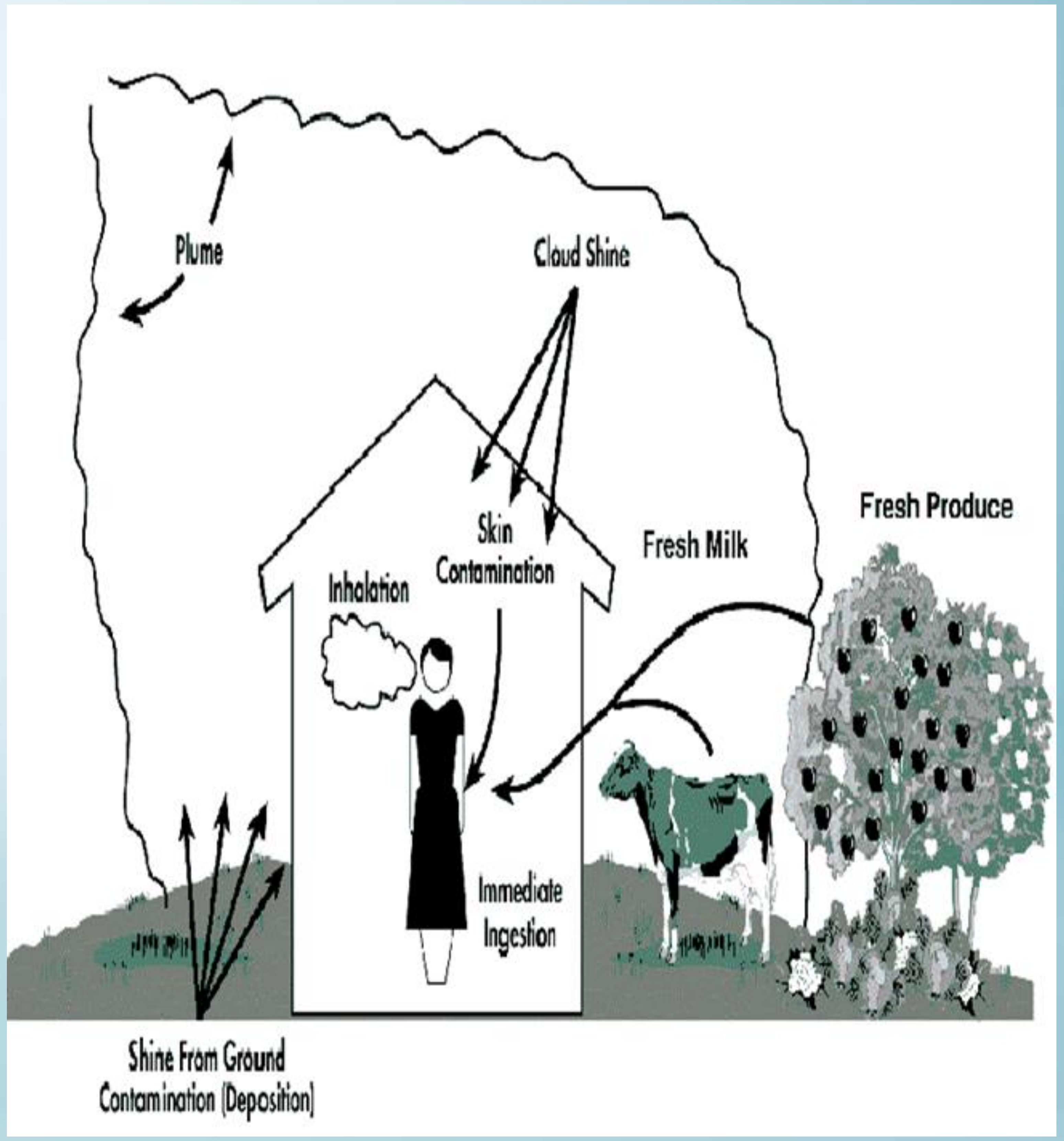
- The Radiological Assessor may also find the formulas and tables in this section useful in developing protective action recommendations for the Emergency Manager during the early stages of an emergency situation when information regarding the radiation source or material is readily available

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



Total Effective Dose

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

$$E_T = E_{ext} + E_{inh} + E_{ing}$$

- 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

Dosimetric Information

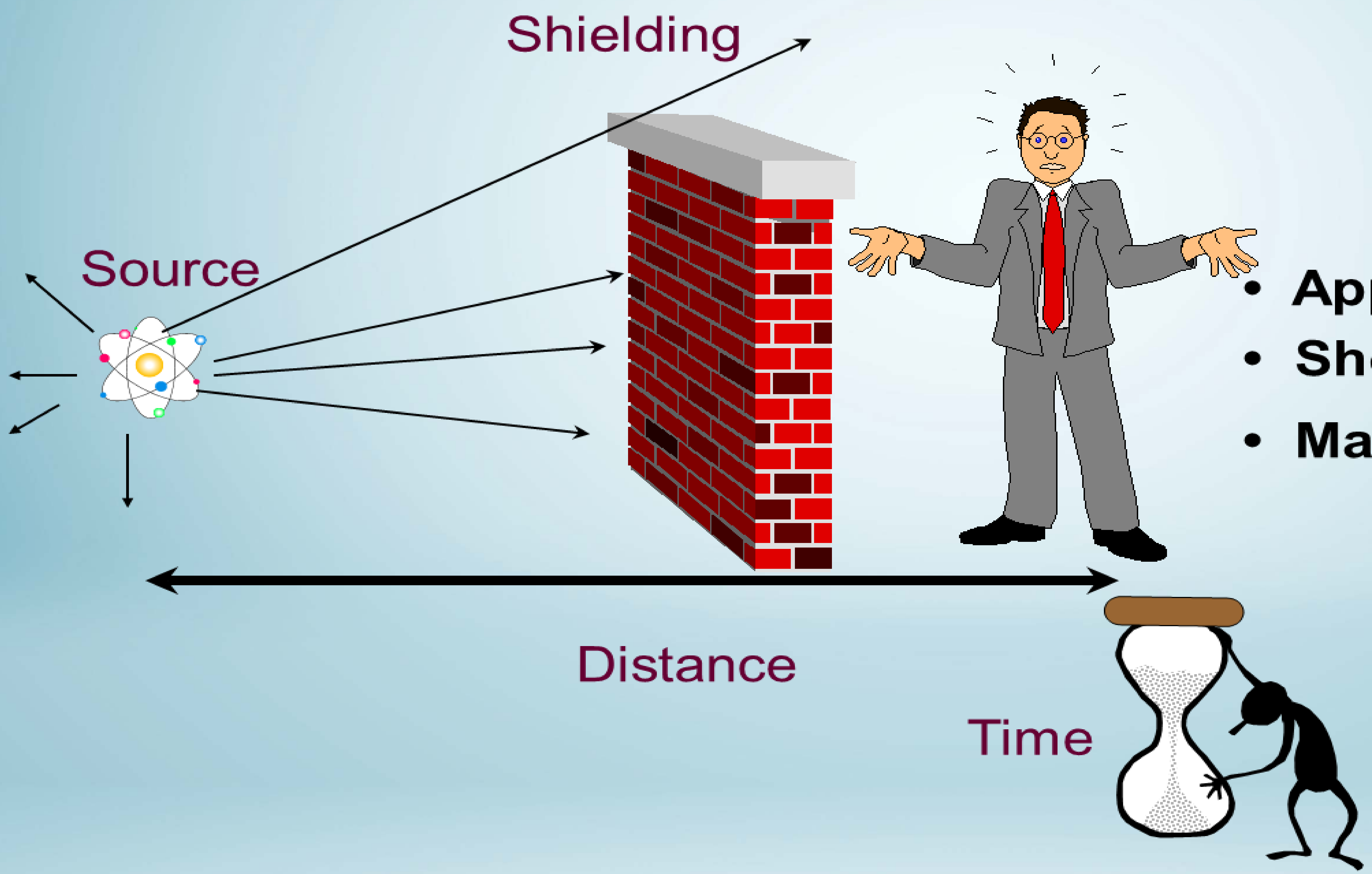
- Direct readings from personal dosimeters
- Dose assessments from personal dosimeters such as film badges or TLDs
- In case of inhalation: nose blows should be taken using material suitable for assessing the activity removed
- In case of ingestion: the need to collect urine and faecal samples should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

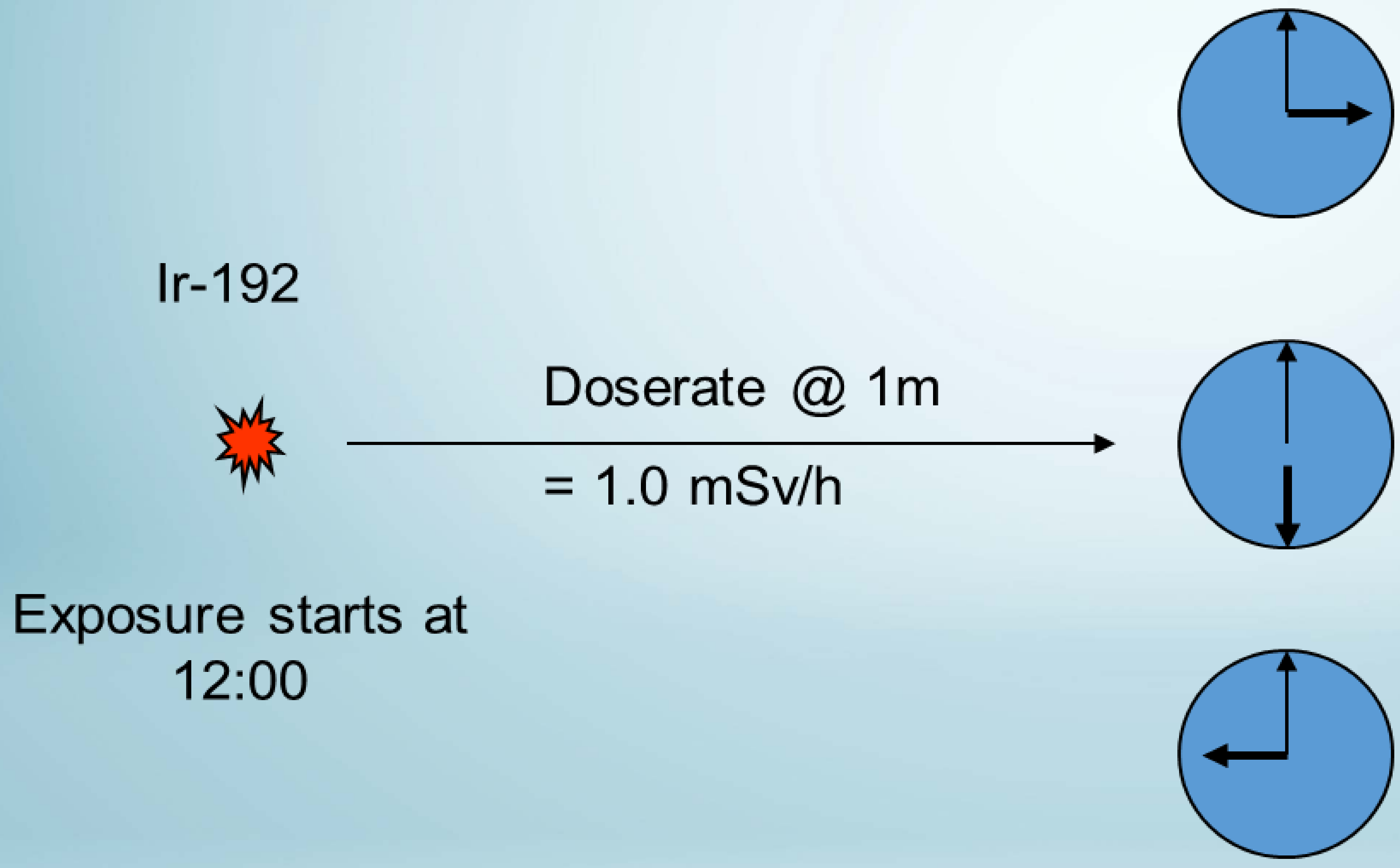
Protection Against External Radiation Exposures



- Appropriate Shielding
- Shortest Time
- Maximum Distance

Time

Dose = Dose rate x Time



1.0 mSv/hr x 3 hr = 3.0 mSv

(1.0 mSv/hr x 3 hr) x 2 = 6.0 mSv

(1.0 mSv/hr x 3 hr) x 3 = 9.0 mSv

Example Calculations 1

A technician is in an area for 10 minutes and the reading on the survey meter is 5mR/h. What dose of radiation does the technician receive?

= 5mR/h / 60 min./h
= 0.0833 mR/min.
0.0833 mR/min. x 10 minutes
= 0.833 mR total dose.

Example Calculations 2

A technician wants to receive no more than a 1.0 mR dose knowing the above conditions. What is the maximum time the technician can stay in the area?

= 1.0 mR / 0.0833 mR/min.
= 12 minutes

The calculated dosages would be approximations.
The actual dosages may vary due to scattering and other considerations.
The TLD or personal monitoring device should be used to determine dosage received by an individual.

Inverse Square Law

Calculating Intensity with the

$$I_1 / I_2 = D_2^2 / D_1^2$$

- I_1=Intensity 1 at D_1
- I_2=Intensity 2 at D_2
- D_1=Distance 1 from source
- D_2=Distance 2 from source

Example Calculation 1

The intensity of radiation is 530 R/h at 5 feet away from a source. What is the intensity of the radiation at 10 feet?

- Rework the equation to solve for the intensity at distance 2

$$I_2 = I_1 \times D_1^2 \ / \ D_2^2$$

- Plug in the known values

$$I_2 = 530R/h \times (5ft)^2 \ / \ (10ft)^2$$

- Solve for I_2

$$I_2 = 132.5 \ R/h$$

- In this instance the distance has been doubled and the intensity at that point has decreased by a factor of four.

Example Calculation 2

A source is producing an intensity of 456 R/h at one foot from the source. What would be the distance in feet to the 100, 5, and 2 mR/h boundaries.

Convert R/hour to mR/hour

456R/h x 1000 = 456,000 mR/h

Rework the equation to solve for D_2

$$D_2 = \sqrt{\frac{I_1 \times D_1^2}{I_2}}$$

Plug in the known values and solve

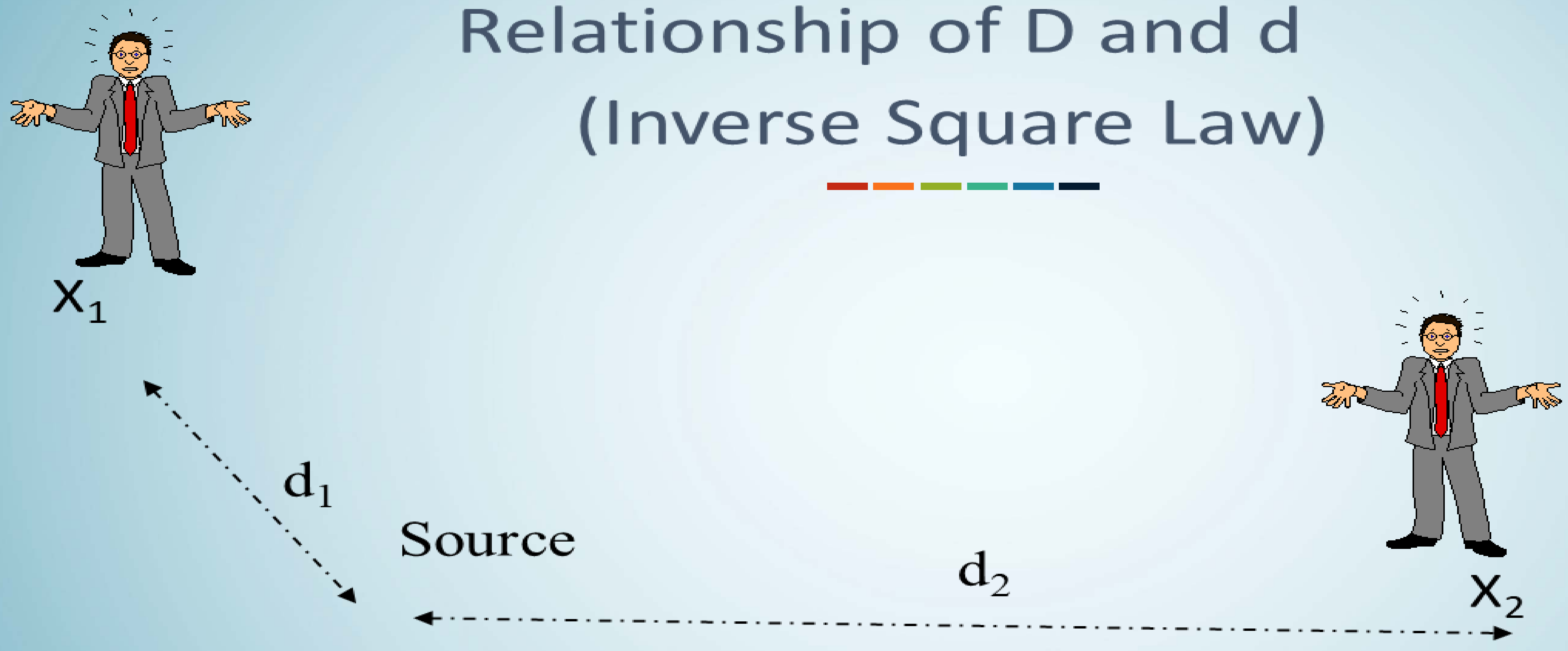
$$D_2 = \sqrt{\frac{456{,}000\ mR/h \times (1\ ft)^2}{100\ mR/h}}$$

D_2= 67.5 feet

Using this equation the 100mR/h boundary would be at 68 feet, the 5mR/h boundary would be at 301.99 feet, and the 2mR/h boundary would be at 477.5 feet.

Sources are seldom operated for an entire hour, and collimators are often used which reduce these distances considerably.

Relationship of D and d (Inverse Square Law)



$$X_2 = \frac{(X_1 d_1^2)}{d_2^2}$$

$$X_1 d_1^2 = X_2 d_2^2$$

Where:

X_1 : dose rate at a distance d_1 from the source

X_2 : dose rate at a distance d_2 from the source

Example Calculation 1

Dose rate at a distance of 2 meter from a source is 100 μSv/hr. What is the dose rate at a distance of 1 meter from source?

$$X_1 d_1^{\,2} = X_2 d_2^{\,2}$$

$$100\ \mu Sv/hr \times (2\ m \times 2\ m) = I_2 \times (1\ m \times 1\ m)$$

$$I_2 = \frac{100\ \mu Sv/hr \times 4\ m^2}{1\ m^2}$$

$$= 400\ \mu Sv/hr$$

Example Calculation 1

The dose rate at 2 meter from an X-ray machine is 400 μSv/hr. At what distance will it give a dose rate of 25 μSv/hr?

Solution

Inverse square law: $X_1 d_1^2 = X_2 d_2^2$

Given: X_1 = 400 μSv/hr

d_1 = 2 meter

X_2 = 25 μSv/hr

Therefore

$400 \times (2^2) = 25 \times d_2^2$

$d_2^2 = (400 \times 4) / 25$

$= 64$

d_2 = 8 meter

Shielding

Half-Value Layer

The half-value layer (HVL) is commonly used for this purpose and to determine what thickness of a given material is necessary to reduce the exposure rate from a source to some level.
For example, if a Gamma source is producing 369 R/h at one foot and a four HVL shield is placed around it, the intensity would be reduced to 23.0 R/h

Approximate HVL for Various Materials when Radiation is from a Gamma Source

	Half-Value Layer, mm (inch)				
Source	Concrete	Steel	Lead	Tungsten	Uranium
Iridium-192	44.5 (1.75)	12.7 (0.5)	4.8 (0.19)	3.3 (0.13)	2.8 (0.11)
Cobalt-60	60.5 (2.38)	21.6 (0.85)	12.5 (0.49)	7.9 (0.31)	6.9 (0.27)

Approximate Half-Value Layer for Various Materials when Radiation is from an X-ray Source

	Half-Value Layer, mm (inch)	
Peak Voltage (kVp)	Lead	Concrete
50	0.06 (0.002)	4.32 (0.170)
100	0.27 (0.010)	15.10 (0.595)
150	0.30 (0.012)	22.32 (0.879)
200	0.52 (0.021)	25.0 (0.984)
250	0.88 (0.035)	28.0 (1.102)
300	1.47 (0.055)	31.21 (1.229)
400	2.5 (0.098)	33.0 (1.299)
1000	7.9 (0.311)	44.45 (1.75)

Example:

HVL for Cs-137 is 6.5 mm. of lead. What is the thickness of lead needed to reduce the dose rate from 40 mR/hr to 2.5 mR/hr ?

$$\text{No. of HVL, } 2^n = \frac{\text{Dose rate before shielding}}{\text{Dose rate after shielding}}$$

$$= 40 / 2.5 = 16$$

$$n \ln 2 = \ln 16 \Rightarrow n = \ln 16 / \ln 2 = 4$$

Therefore, thickness required = n x No. of HVL

= 4 x 6.5

= 26 mm. of lead

Question:

A lead shield is used to block ^{60}Co radiation field of 96 μSv/hr. Calculate the final dose rate after passing through 6.2 cm lead. Given, HVL for lead in ^{60}Co is 1.24 cm.

Answer:

Given 1 HVL for lead is 1.24 cm, therefore 6.2 cm of lead is equivalent to 5 HVL

$$2^n = \frac{I_o}{I_x}$$

$$2^5 = \frac{96}{I_x}, \quad \text{therefore } I_x = \frac{96}{32} = 3\ \mu Sv/hr$$

Question:

If dose rate at a particular distance from 192Ir radioactive source is 1000 □Sv/hr, calculate the thickness of lead required to reduce the dose rate to 1 □Sv/hr. Given for 192Ir, TVL is 1.62 cm of lead.

Answer:

Using a formula: $$10^{n} = \frac{I_o}{I_x}$$

$$10^{n} = \frac{1000}{1} = 10^{3}, \quad \text{therefore}, \ n = 3$$

Given 1 TVL for Ir – 192 is 1.62 cm,

Therefore, 3 TVL is equal to 3 x 1.62 cm = 4.86 cm

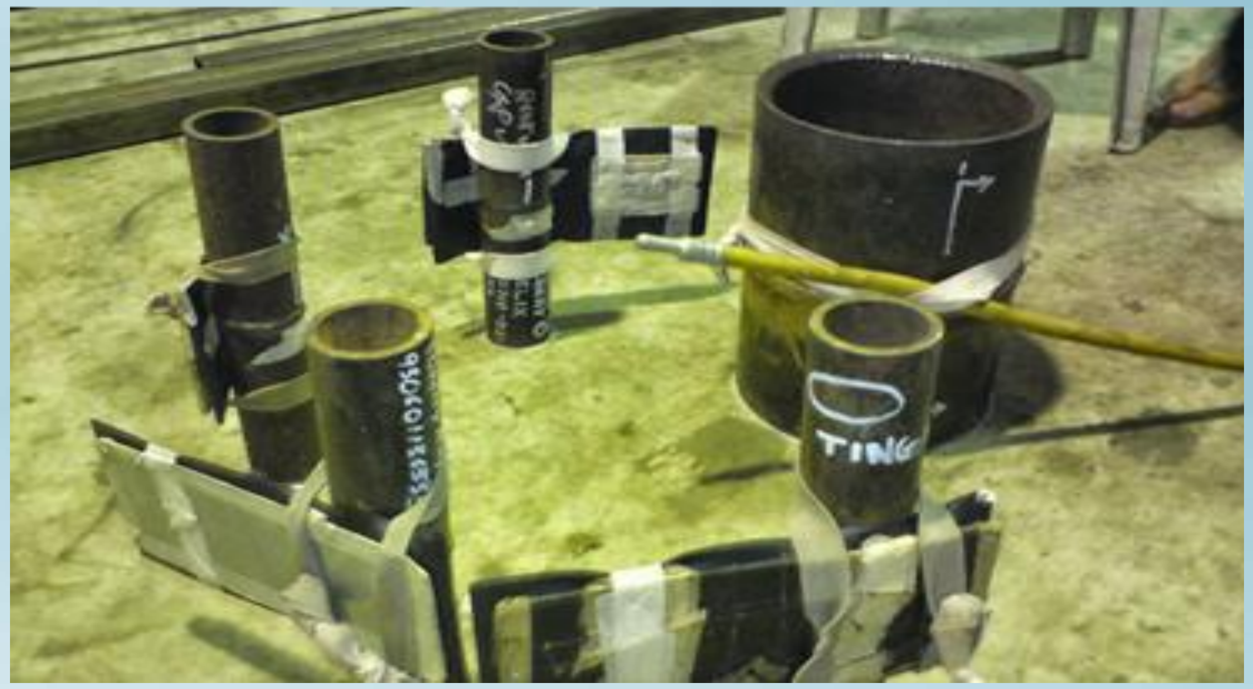
Question:

Any emergency involving radioactive must be planned to ensure that no single responder will received a radiation dose in excess of the recommendation limits.

What would be the maximum allowable "stay" for a responder to response at a distance 2 meter from unshielded sources??

- 30 Ci of Co-60
- 30 Ci Of Ir-192

Assume that the radiation intensity at 1 meter from 1Ci of Co-60 and 1Ci of Ir-192 to be 1.25R/hr and 0.5R/hr respectively?



Answer

- During the emergency, responder is allowed to received dose = 1000mR @ 10 mSv
- For Ir-192 RHM = 0.5R/hr/Ci at 1 meter

Dose rate for 30Ci of Ir-192 at 1 meter
= 30 x 0.5 x 1000 mR
= 15000 mR/hr

Using formula $I_1 d_1^{\ 2} = I_2 d_2^2$ to get dose rate at 2 meter

15000 mR/hr x (1 m x 1 m) = I_2 mR/hr x (2 m x 2 m)

I_2 = 15000 mR/hr / 4 m^2

I_2 = 3750 mR/hr

Therefore max allowable stay time = 1000 mR /(3750 mR/hr)
= 0.26 hr
= 0.26 hr (60 min/hr)
= 15.99 minutes.

Answer

- During the emergency, Responder is allowed to received dose = 1000mR @ 10 mSv
- For Co-60 RHM = 1.25 R/hr/Ci at 1 meter

Dose rate for 30Ci of Co-60 at 1 meter
= 30 x 1.25 x 1000 mR
= 37500 mR/hr

Using formula $I_1 d_1^{\ 2} = I_2 d_2^{\ 2}$ to get dose rate at 2 meter

37500 mR/hr x (1 m x 1 m) = I_2 mR/hr x (2 m x 2 m)

I_2 = 37500 mR/hr / 4 m^2

I_2 = 9375 mR/hr

Therefore max allowable stay time = 1000 mR / (9375 mR/hr)
= 0.106 hr
= 0.106 hr (60 min/hr)
= 6.4 minutes.

Control Dose For Responder

Radionuclide	Activity (GBq)	Dose Rate at 1m (mSv/hr)	Allowable time (min)
Ir-192	37	4.8	120
	74	9.6	60
	185	24	25
	370	48	12
	740	96	6
	1850	240	2
	3700	480	1
Co-60	37	13.2	46
	185	66	9
	370	132	4.6
	740	264	2.3
	1850	660	0.9
	3700	1320	0.4

Derived from a dose of 10 mSv to the hand at 1 meter

Protection For Workers Undertaking Intervention

Regulations 76. (1) The licensee and employer shall ensure that no worker undertaking an intervention is exposed in excess of the maximum single year dose limit of 50 mSv, except—

- (a) for the purpose of saving a life or preventing serious injury;
- (b) when undertaking actions intended to avert a large collective dose; or
- (c) when undertaking actions to prevent the development of catastrophic conditions.

Protection For Workers Undertaking Intervention

NO	CONDITIONS OF WORKER	SITUATIONS	MAXIMUM DOSE
1.	Worker Undertaking An Intervention	Maximum Single Year Dose Limit Of 50 mSv	50 mSv
2.	Worker Undertaking Actions Intended To Avert A Large Collective Dose	Twice The Maximum Single Year Dose Limit @ 50 mSv	100 mSv
3.	Worker Undertaking Actions To Prevent The Development Of Catastrophic Conditions.	Twice The Maximum Single Year Dose Limit @ 50 mSv	100 mSv
4.	Worker Undertaking Actions For Life Saving Actions	Below Ten Times The Maximum Single Year Dose Limit @ 50 mSv	500 mSv
	"worker who acts as a volunteer"		

Any Question?

THANK YOU

"The important thing is not to stop questioning"

Albert Einstein

MMTC ASIA SDN BHD

TOPIC 12

ELEMENTS IN RADIOLOGICAL AND NUCLEAR EMERGENCY PLAN

MMTC ASIA SDN.BHD
1330199-X

Definitions

- "Emergency plan" means a set of procedures that must be implemented in the event of an accident.

- "Prevention" means action taken to prevent or stop an emergency from occurring.

- "Mitigation" means action taken to reduce the adverse effects of emergencies.

- "Recovery" means action taken to restore the situation to normal.

Legislative Requirements P.U.(A)46

Responsibilities of licensee and employer

- Regulations 15(4) - (4) The licensee shall establish and maintain a radiation protection programme and safety procedure, including emergency plans to ensure the protection of the health of workers and members of the public and to minimize the danger to life, property and the environment.

Emergency plans

- Regulations 68. (1) The licensee shall establish an emergency plan for responding to and correcting every reasonably foreseeable emergency situation involving a radiation source.

Objective

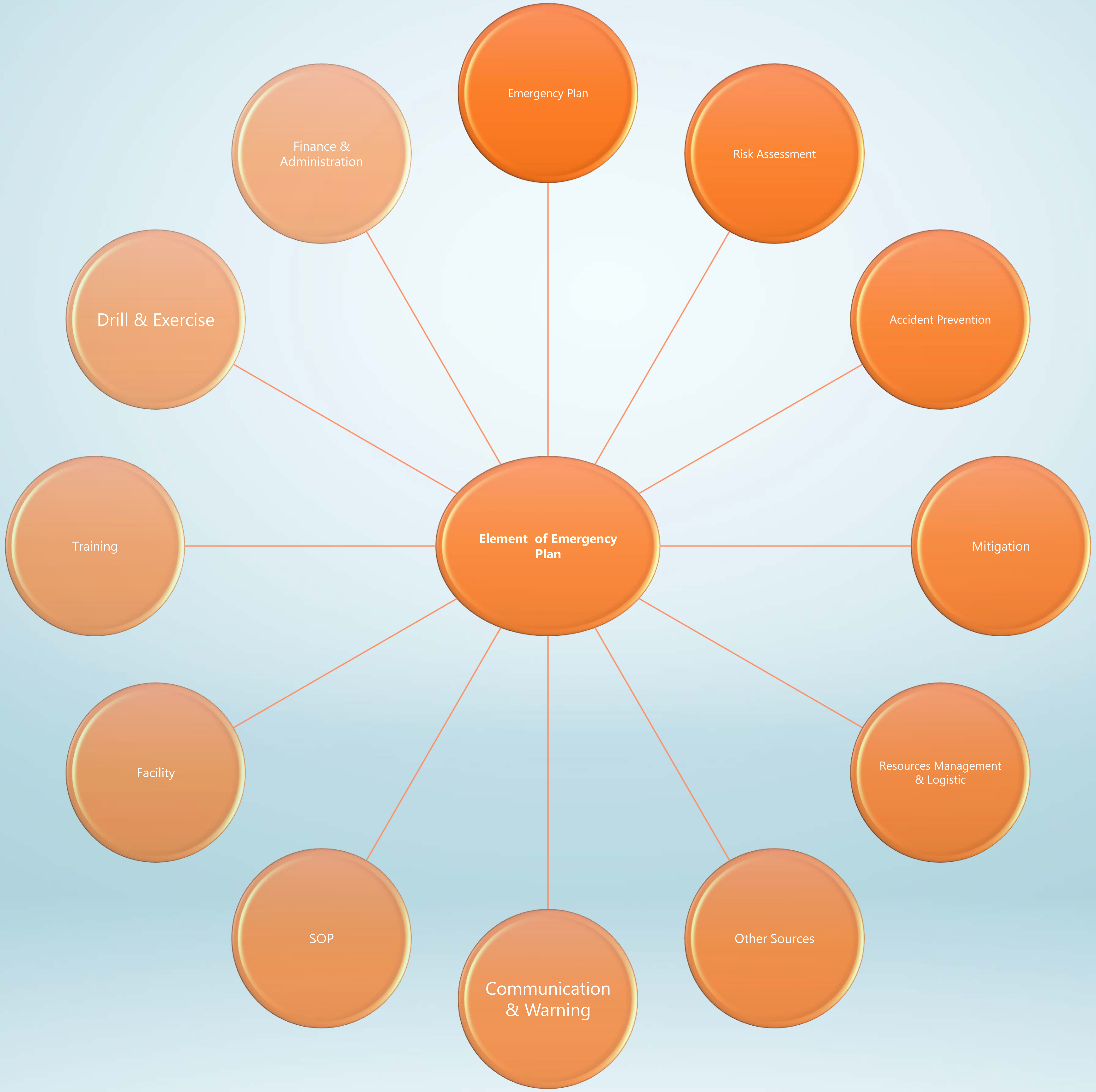
Protective Objective: to prevent the occurrence of deterministic effects on individuals by keeping dose exposure as low as possible and taking appropriate measures in reducing stochastic effects on current and future populations.

Safety Objectives: to protect individuals, communities and the environment from danger by creating and maintaining resistance to radiological hazards from radiation sources.

Practical Goals of Emergency Response

- Regain control of the situation
- Prevent or mitigate consequences at the scene
- Prevent the occurrence of deterministic effects in worker and public
- Render first aid and manage treatment of radiation injuries
- Prevent, to extent practicable, occurrence of stochastic health effects
- Prevent, to extent practicable, occurrence of non-radiological effects on individuals and the population
- Protect property and environmental
- Prepare for resumption of normal social and economic activity

Element of Emergency Plan



Emergency Plan

- 5 Main Planning
  - Strategic Plan
  - Operation / response plan
  - Prevention plan
  - Mitigation plans
  - Recovery plan
- Service continuity planning - as a recovery process
- Emergency plan re-evaluation
- Stakeholder involvement
- Self-developed / integrated

Risk Assessment

- Workplace Monitoring
- Regulations 21 (2) (c) P.U.(A)46 - radiation risk level assessment related to accident or emergency situation
- Identify and monitor possible hazards
- Hazards are assessed in terms of catastrophic events, events caused by technology and humans (fire, system damage, etc.)
- From this information, a risk assessment is performed
- It should be recorded and reviewed

Accident Prevention

- ❖ Accident Prevention
    - Regulations 67 (1) P.U.(A)46 - The licensee shall make appropriate arrangements to prevent as far as possible, any accident which may reasonably be expected of any radiation source in his possession or under his control, and to limit the consequences of any accidents that occur.
- ❖ Preventive measures are provided and updated based on risk assessment and current information.
- ❖ eg: housekeeping, safety culture, certified technology

Mitigation

- The purpose is to limit or control the effects, levels or severity of unavoidable accidents.
- Licensees need to take the necessary steps to reduce the consequences of an accident
- The respondent uses the basic principles: Distance, shield and time in response
- eg: access control, intervention level, action level, on-call advice
- Regulations 68(3)(e) P.U.(A)46 - Establish a different level of intervention for each emergency

Resource Management & Logistics

- Staff, emergency equipment, training, facilities, provisions, communication systems and others
- Processes involved in resource management
- Contingency plans for resource shortages
- Assessment to identify deficiencies and remedial measures
- Internal and external resource inventory updated

Other Resources

- Identify the assistance needed whether internal or external assistance as well as methods for obtaining assistance.
- eg: Fire Department (Bomba), Police, Hospital etc.

Communication & Warning

- Internal and external communication procedures need to be developed and tested
- Methods of warning staff while responding
- Accident warning system to employees and the public
- Notification procedure to AELB

Standard Operation Procedure

- Procedures for responding and taking remedial measures based on risk assessment
- Accident management system to coordinate response and recovery operations. Organizational duties, ranks and responsibilities are stated.
- Coordinate with other stakeholders in the accident management system
- Procedures to perform condition analysis
- eg Radiation mapping, plume direction

Facility

- ❖ Establish emergency operations centers at appropriate locations
  - for Emergency Preparedness Categories (EPC) I and EPC II
- ❖ Identify facilities that can support response and recovery operations
- ❖ eg .: Temporary shelter

Training

- The licensee must develop and implement a training curriculum for staff
- Training includes aspects of awareness and skill development required
- This exercise should be recorded
- Regulations 68(6) P.U.(A)46 - The licensee shall provide training for the staff involved or will be involved in implementing this emergency plan.

Exercise/Drill

- Aims to evaluate plans, procedures and capabilities for coping with radiological accidents
- Reassessment should also be based on analysis and reports of accidents that have occurred, teaching and performance appraisal
- Exercise is designed to test important elements in an emergency plan
- Regulations 68 (7) P.U.(A)46 - Training in respect of the emergency plan shall be held together with the relevant authorities at the appropriate time frame.

Crisis Communications

- Develop dissemination and response procedures before, during & after an accident
    - Distribution of emergency information to the public
    - Contact number
    - Preliminary information provided
    - Methods for coordinating and obtaining approval for information production
    - Etc.
- Public awareness programs should be implemented for activities that may endanger the public - eg. : Involvement in the community

Finance & Administration

- Licensees should develop financial and administrative procedures to support emergency plans for before, during and after an accident / disaster

Conclusion

- Risk assessment becomes a key prerequisite before preparing an emergency plan
- The effectiveness of the emergency plan can be proven through testing during the exercise / drill
- The understanding of the assessing officer in the field of emergency response helps in implementing the assessment process

Reference

- Peraturan-Peraturan Perlesenan Tenaga Atom (Perlindungan Sinaran Keselamatan Asas) 2010
- IAEA Safety Requirements GSR-2 Preparedness and Responses for a Nuclear or a Radiological Emergency
- LEM/TEK/66 Pind. 1 Panduan Penyediaan dan Pengujian Pelan Kecemasan Radiologikal dan Nuklear

Any Question?

THANK YOU

"The important thing is not to stop questioning"

Albert Einstein