MONITORING OF RADIOACTIVITY IN THE ENVIRONMENT

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What is Environmental Monitoring?

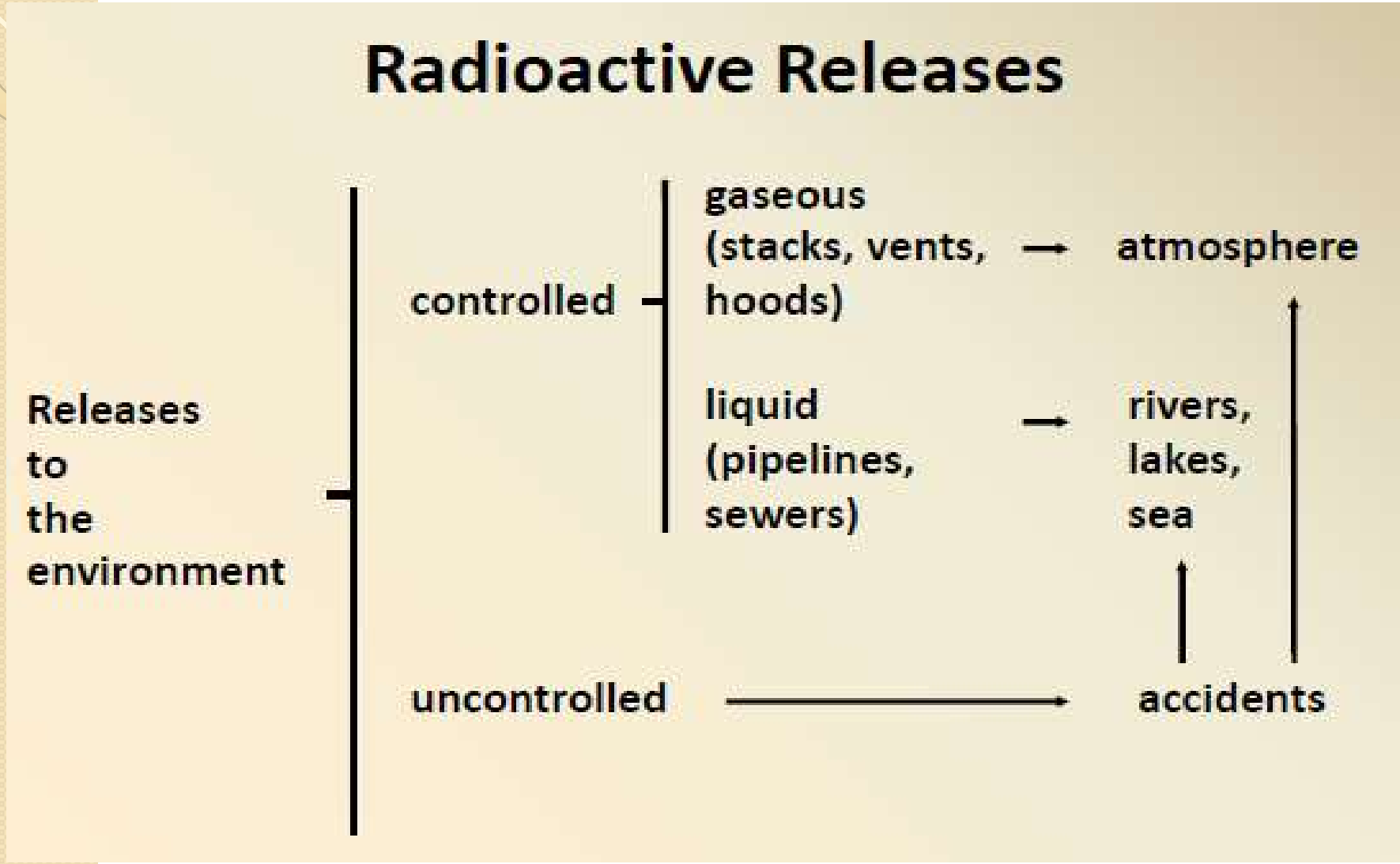
- Describes the processes and activities that need to take place to characterize and monitor the quality of the environment

- Used in the preparation if environmental impact assessments, as well as many circumstances in which human activities carry a risk of harmful effects on the natural environment.

Environmental Monitoring

- Air quality monitoring
- Soil monitoring
- Water quality monitoring
- Flora and Fauna monitoring

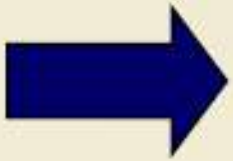
Monitoring

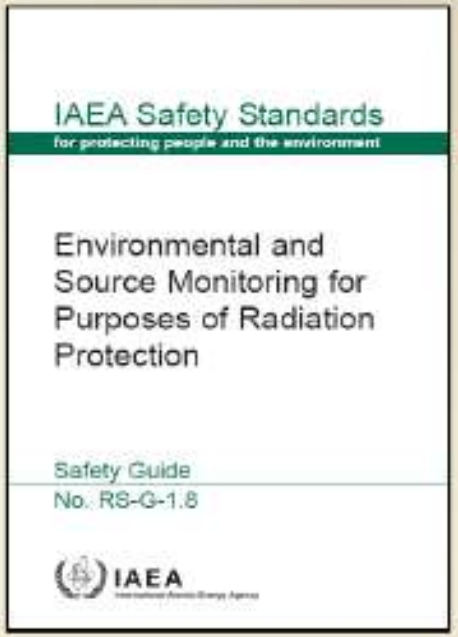

Radioactive Releases
Releases to the environment
controlled
gaseous (stacks, vents, hoods)
atmosphere
liquid (pipelines, sewers)
rivers, lakes, sea
uncontrolled
accidents

Monitoring

- Controlled releases
  - Monitoring (BOTH at the sources and in the environment) is an essential element in the control of the releases to assure protection of the public and the environment
- Uncontrolled releases
  - Monitoring (at the source and especially in the environment) is necessary for assessment and application of public protective actions and longer-term countermeasures. Individual monitoring could be used in some situations.

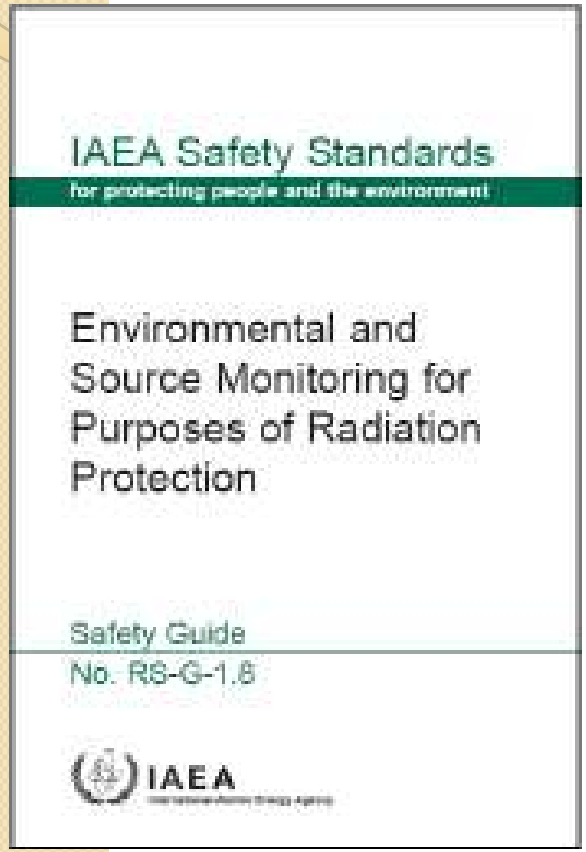
Monitoring





Book

RS-G-1.8- Contents



- Introduction
- Regulatory requirements
- Responsibilities
- Objective of monitoring
- Types of monitoring programs,
- Technical aspects of monitoring
- Interpretation of results
- Quality assurance, recording and training.

RS-G-1.8 – Scope

- Practices – from NPP to simples facilities (medical, research, educational, etc.)
- Emergencies
- Past practices, scenarios and commodities (foodstuffs, drinking water, etc.)

Monitoring – Generic Examples

- Hospitals or research institutes using short lived radionuclides – generally DON'T NEED environmental monitoring
- Small nuclear installations and nuclear medicine departments working with unsealed sources – may require routine monitoring at the source, but occasionally checks on environmental levels
- Nuclear installations; large nuclear medicine departments – BOTH source and environmental monitoring

Objective of Environmental Monitoring

- Objective:
  - To measure and assess the radiation and radioactivity outside the boundaries of facility/installations operating nuclear power plants, research reactors, fuel reprocessing plan, accelerators, handling radioactivity materials.

Objective of Environmental Monitoring (ICRP Publ. 43)

- To assess the actual or potential exposure of man to radioactive materials or radiation present in his environment, and further to estimate the probable upper limits of the such exposure
- To confirm that the above estimated exposure do not succeed the dose limits for general public
- To know the tendencies of accumulation of radioactive materials in the environment
- To detect the unexpected effluence of radioactive materials of radiation from facility at early time and influence evaluation dose to neighboring environmental area
- To make the operation system of environmental monitoring in the occurrence of abnormal or emergency

Subsidiary Objectives

- To provide information to the public
- To maintain a continuing record of the effect of the installation or practice on environmental radioactivity levels
- To distinguish the contribution from operator's installation or practice from the contribution of other sources
- To obtain data on the behavior of radionuclides in local environment that may be required in assessment of the consequences of accidents

Subsidiary Objectives

- To identify changes in the relative importance of transfer pathways and mechanisms including the emergency of new pathways, and therefore to enable environmental monitoring program to be revised in the light of experience and in response to changing conditions
- To verify or refine the predictions of environmental models, so as to improve the structure of the models and to reduce uncertainties in the parameters
- To conduct more general, scientific studies aimed improving knowledge of the transfer of radionuclides in the environment

Monitoring Programmes

- Depending on:
  - Characteristics of the release source (composition), medium (liquid, gaseous) and rate
  - Environmental parameters of area to be monitored
  - Control possibilities in practices and interventions
  - Techniques to be applied for source or environmental monitoring

Types of environmental monitoring design of the monitoring

1) Pre-operational surveys

2) Operational surveys

3) Emergency surveys

- Each phase of the monitoring programs should be design to fulfill specified objectives and should be reviewed from time to time.

1) Pre-operational survey

- Obtaining information on the critical nuclides, pathway and group, thus leading to the design of the operational survey and to the provision of the quantitative basis for interpreting the results in terms-of the actual or potential exposure to man
- Providing information on the pre-operational level of radiation and radioactivity in the environment, in case where this information is helpful in the interpreting operational surveys
- Testing and exercising operational survey method and procedure

1-1) Pre-operational investigation

- Estimating the dose from planned releases
- Determination of limits and conditions of radioactive releases from an installation/facility to the environment

2) Operational routine survey

- Factors affecting the design of the survey
  a) The types of facility/installation and the potential hazard associated with it
  b) The nuclides to be released, their activity, their physical and chemical form, and the method and route of release
  c) The existing of expected presence of these nuclides from source
  d) Natural features of the environment with effect the behavior of released nuclides, e.g, climate, topography, geology, hydrology and vegetative cover

2) Operational routine survey

- Factors affecting the design of the survey
  a) The behavior of the released nuclides in the environment
  b) Man-made features of the environment which affect the behavior of released nuclides, e.g: reservoirs, regulated streams or rivers, and harbor
  c) The utilization of the environment of agriculture, fisheries, water and food supplies, industry and recreation
  d) Population distribution and habits

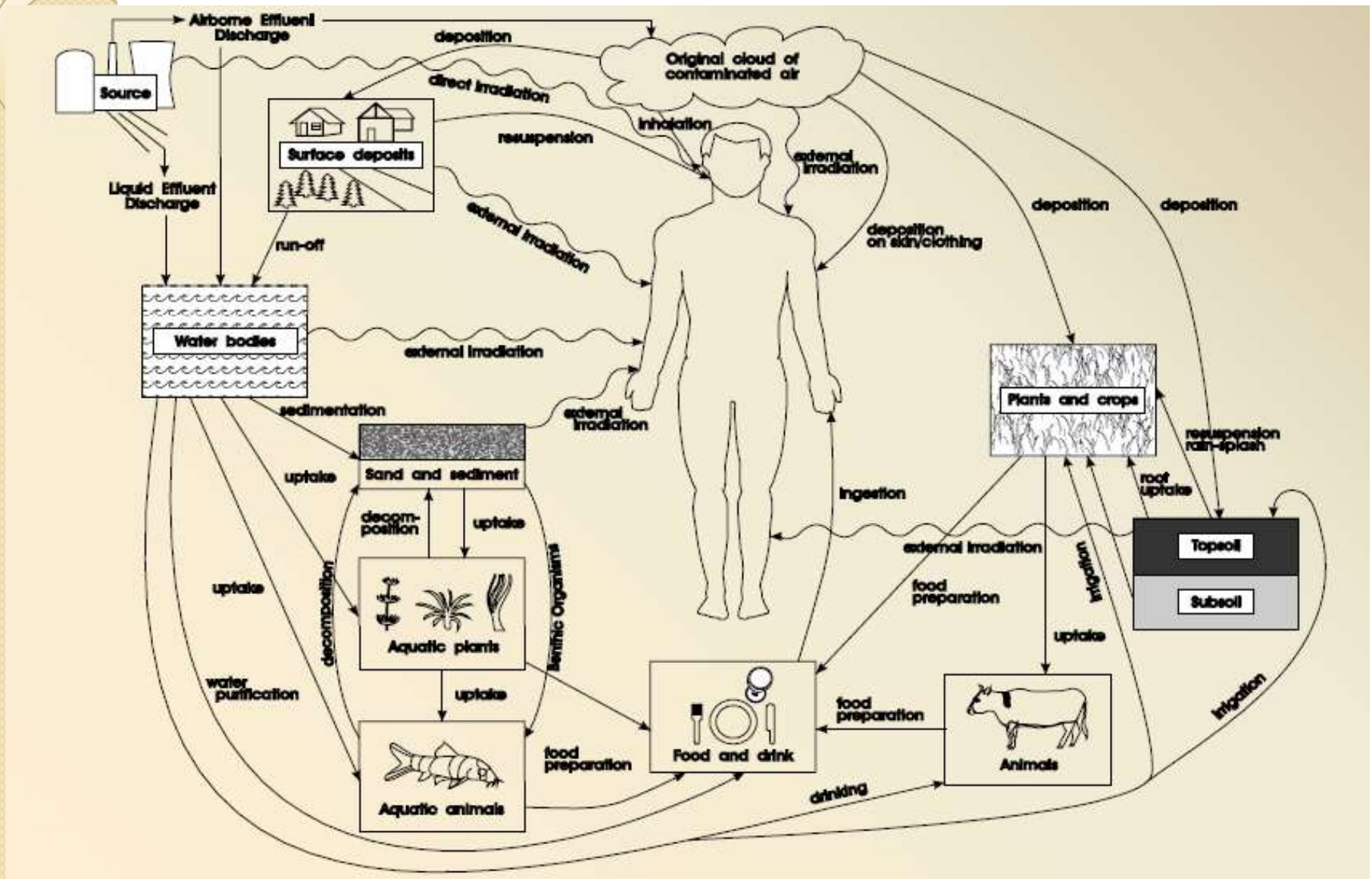
3) Emergency surveys

- To obtain a rapid information about the magnitude and location of immediate hazard to person so as to define the type and extent of any necessary emergency procedures and countermeasures
- To assess the effective dose actually incurred by the public taking into account any countermeasure have been applied
- To obtain scientific information on the results of the emergency and on the behavior of the released radioactive materials

Exposure Pathways

- It is important to understand the behavior of the radioactive materials released into the environment in viewpoint of public dose assessment
- Released gaseous, dust, and liquid radioactive wastes from nuclear facility transport through the various pathway, and cause the exposure to person finally
- These are called exposure pathway

Exposure Pathways



Exposure pathways

- Transfer Pathways
  - External exposure
    - Radiation from plume, ground surface contamination and contaminated water body
  - Internal exposure
    - Inhalation of contaminated air
    - Intake of contaminated water and foodstuffs

In some pathways, the transport time of radioactive materials from released point to the living environment is very short, while in the other, the time is extremely long

Exposure pathways

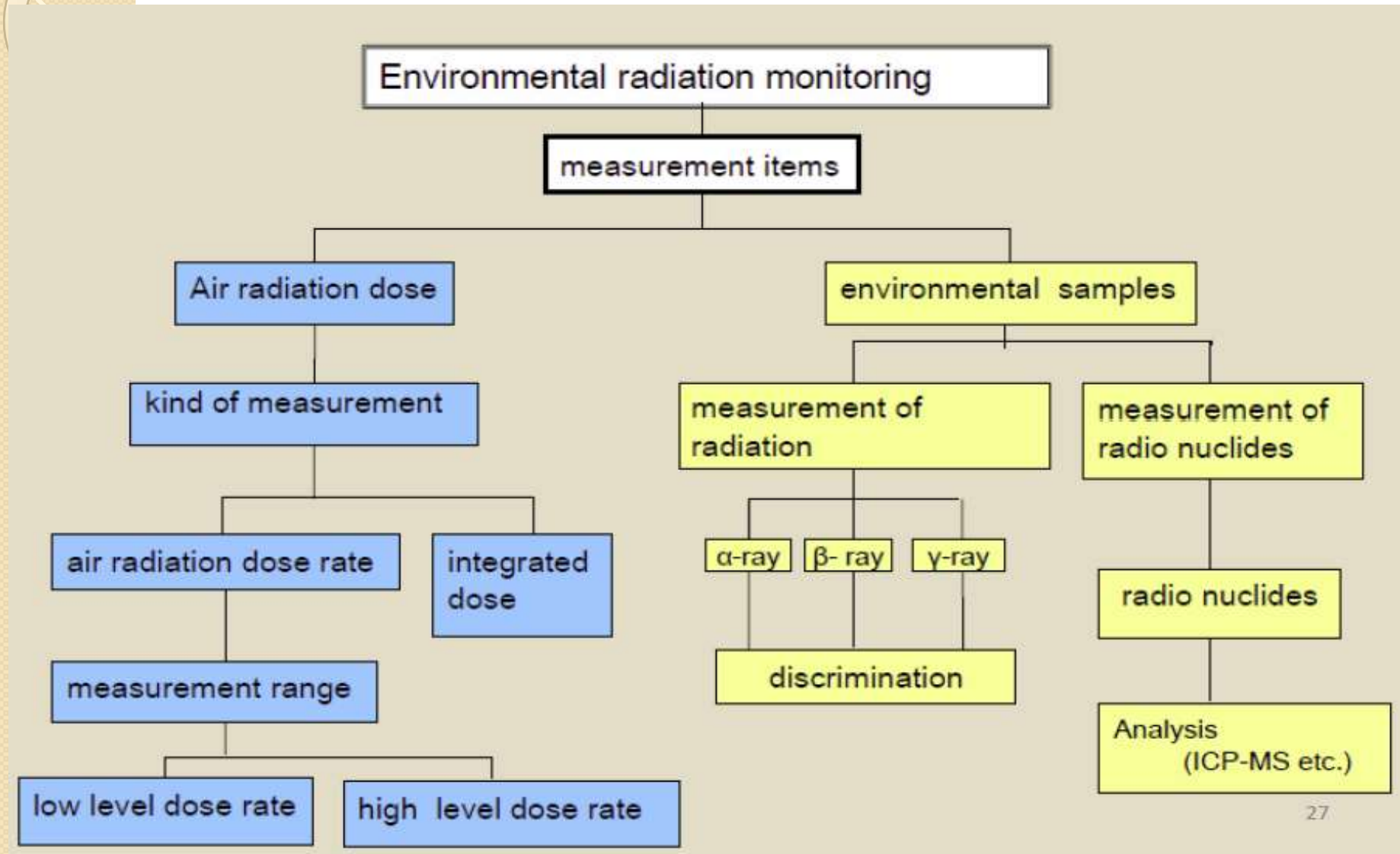
- The radioactive materials are diminished by their decay with time. The amount of radioactivity is so much decreased of the transport time to the human environment is long
- In case of short half-life nuclides
  - External and internal exposure are depended on their amount of release
- In case of long half-life nuclides
  - Internal exposure caused by the intake of contaminated water, foodstuffs such as eggs, meat, cereals, fruits, vegetables, and
  - External exposure caused by the contaminated ground surface are greatly influenced by the radioactivity level

Exposure Groups

- Depending on radionuclide and exposure pathway
- Taking into account specific of each scenario (dietary habits, population, etc.);
- More conservative assumptions for normal discharges than for emergencies and chronic exposure situations

Environmental Radiation Monitoring

Flowchart of selection of instrument



Instrument used for environmental monitoring

Item	Objects of monitoring	Instruments used for measurement
Exposure	Dose rate	Monitoring posts, NaI (Tl) scintillation, High pressure ionization chamber
	Integral dose	TLD, Glass dosimeter
Dose	Accumulated dose	TLD, Glass dosimeter, FB
	Dose rate	Portable dose rate meter, Monitoring post, NaI(Tl), GM tube, High pressure ionization chamber
Environmental samples	Radioactivity in dust	Dust monitor, Dust sampler, Radiation counter
	Radioactivity in environmental samples	Sampling tool, Pre-processing apparatus of samples, Radiation counter

Example of typical monitoring in Japan

category		Investigation subject	Frequency of measurement	Note
Air radiation dose		Dose rate	Continuously	
		Integrated dose	quarterly	
Environmental samples	Radio activities in land samples	atmosphere	Continuously	Gas-monitor, dust monitor
			Continuously Every 1-3months	dust
		Land water	quarterly	Drinking water
		milk	On occasion	131I analysis
		soil	Every 6 months ~ 1 year	Surface soil
		Agricultural products	At the time of harvest	Green vegetable, edible roots, rice
		Index plants	Quarterly ~ 1 year	Mugwort, pine needle etc.
		Fallout, rain water	monthly	Basin method
	Radio activities in marine samples	Sea water	Every 6 months	Surface water
		Sea soil	Half year ~ 1 year	Surface soil in seabed
		Marine foods	At the time of fishing season	
		Index plant	quarterly	Gulfweed etc.

Response of Survey meter required at the survey

Type	Measuring range		Energy characteristic	Remark
	low	high		
Ionization chamber survey meter	1 μSv/h	10 ~ 300 mSv/h	30 keV ~ 3 MeV	Gamma (beta) ray
GM type survey meter	B.G (0.1 μSv/h)	300 μSv/h	50 keV ~ 3 MeV	Gamma (beta) ray
NaI(Tl) scintillation survey meter	B.G (few nSv/h)	30 μSv/h	50 keV ~ 3 MeV	Gamma ray
ZnS(Ag) scintillation survey meter	0 min^{-1}	10^5 min^{-1}	Over 2 MeV	Alpha ray (For Surface contamination)
Neutron survey meter	0.01 μSv/h	10 mSv/h	0.025eV~8 MeV	Neutron ray

Measurement of materials (normal and emergency)

Object		Identify nuclides	Instrument
α ray		No	ZnS(Ag)
		Yes*1	Si
β ray	Low energy region	Yes	Liquid scintillation counter
			β spectrometer
	High energy region	No	Low background β counting system(GM)
γ ray		Yes*2	NaI(Tl)
		Yes	Ge semiconductor

*1 : need to chemical separation sometime
*2 : low resolution

Accumulated Dose

Accumulated doses measurement for 3 months

Instrument: TLD or Glass Dosimeter, etc.

- These are most popular instruments for the measurement of the accumulated doses in the environment. Because TLD or GD has good linearity, low fading, good energy dependence, small size and so on.

TLD Dosimeter

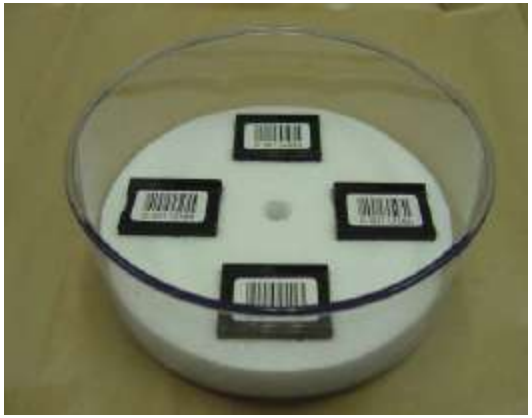
(CaSO4:Tm)

Glass Dosimeter

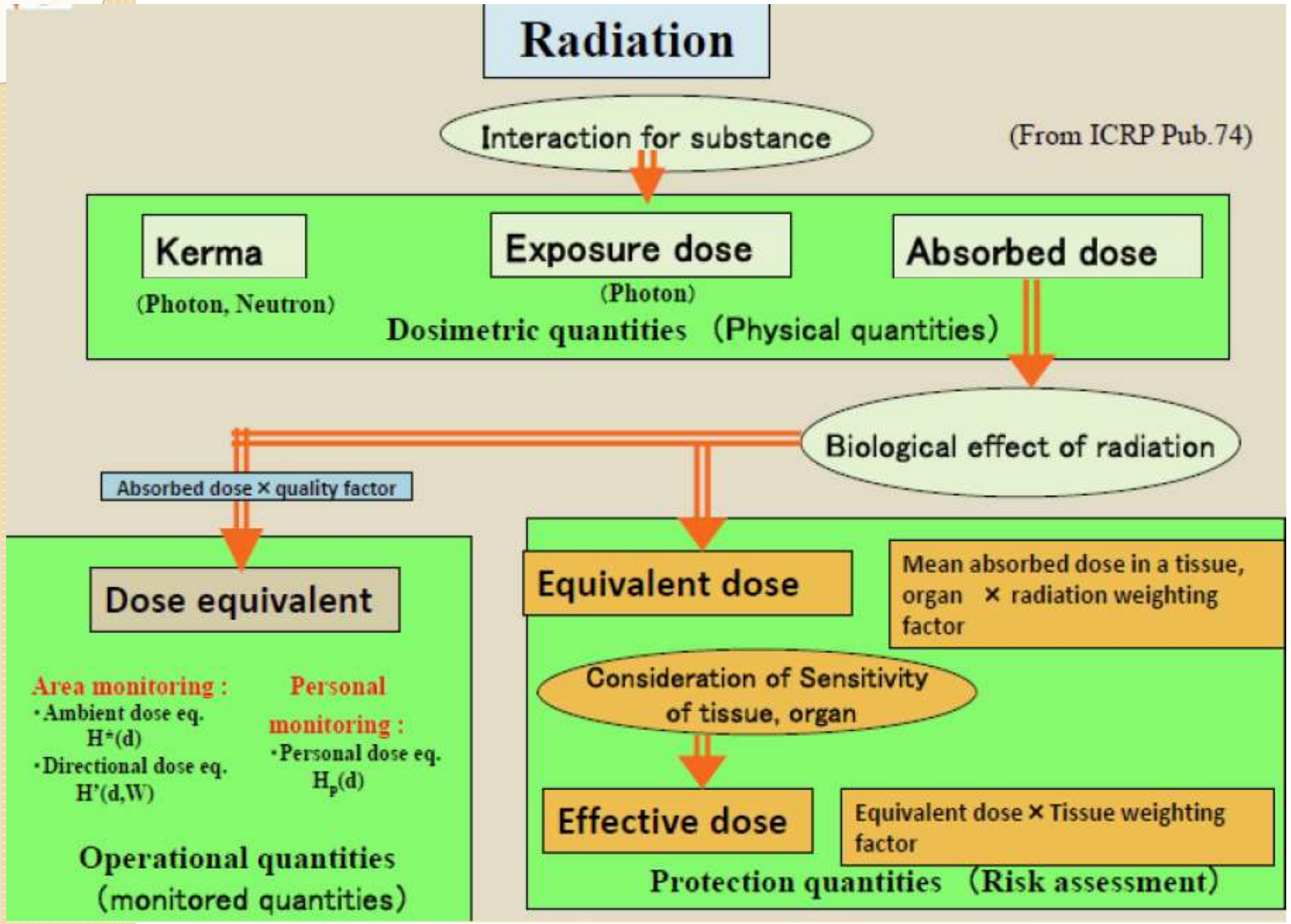
Glass element for environment

Measurement of accumulated dosimeters

- Accumulated dosimeters (measured the integrated dose due to a gamma ray) arranges by the concept of dose sensitivity and easy usage, etc.



Principle of the Dose Measurement


Radiation
Interaction for substance
(From ICRP Pub.74)
Kerma
(Photon, Neutron)
Exposure dose
(Photon)
Absorbed dose
Dosimetric quantities (Physical quantities)
Biological effect of radiation
Absorbed dose × quality factor
Dose equivalent
Area monitoring :
・Ambient dose eq.
H*(d)
・Directional dose eq.
H'(d,W)
Personal monitoring :
・Personal dose eq.
Hp(d)
Operational quantities
(monitored quantities)
Equivalent dose
Mean absorbed dose in a tissue, organ × radiation weighting factor
Consideration of Sensitivity of tissue, organ
Effective dose
Equivalent dose × Tissue weighting factor
Protection quantities (Risk assessment)

Recommended radiation weighting factors, W_R

Radiation type	Weighting factor, W_R
Photons	1
Electron and muons	1
Protons and charged ions	2
Alpha particles, fission fragments, heavy ions	20
Neutrons	A continuous function of neutron energy

All values relate to the radiation incident on the body, or, for internal radiation source, emitted from the incorporated radionuclide

ICRP Publ. 103 (2007)

Recommended tissue weighting factors

Effective dose (Sv) = $\sum$ (tissue equivalent dose (Sv) x tissue weighting factor)

Tissue or Organ	ICRP Publ. 60	ICRP Publ. 103
Gonads	0.20	0.08
Bone Marrow (red)	0.12	0.12
Colon	0.12	0.12
Lung	0.12	0.12
Stomach	0.12	0.12
Bladder	0.05	0.04
Breast	0.05	0.12
Liver	0.05	0.04
Esophagus	0.05	0.04
Thyroid	0.05	0.04
Skin	0.01	0.01
Bone surface	0.01	0.01
Remainder	0.05	0.12
Brain, Salivary Glands	-	0.01

Measurement of Dose

Measurement of Radiation dose

- It measures the radiation dose to use the estimation and evaluation of external exposure dose proceeded from facilities
- Subject of measurement is gamma ray
- When it is possible to release the neutron ray, prepares the neutron survey meter at emergency
- It arranges apparatus of continuance monitoring (monitoring post etc.) in near site and population concentration area
- It arranges the accumulated dosimeter at a lot of monitoring point uniformly

Measurement of radiation dose

- It arranges the same dosimeter for background in area no influence from facility
- The aim is to grasp the dose exactly and no bias of data for select of monitoring points and structure of system (arrangement)
- Monitoring apparatus arrange at same height from the ground (usually 1 meter)
- It arranges the continues meteorological installation in typical point of regional point for the exposure estimation

Continuous measurement of radiation dose

- Continuous measurement by monitoring post is possible to measure the short time fluctuation of dose rate

- It can be use as early finding of abnormal situation and utilizes for the investigation of the cause

Radiation measuring instruments in monitoring post

Detector	Method	Measuring Range
NaI (Tl)	Energy compensation type to flatten energy response	~ 50 μGy/h
Ionization chamber	Argon gas pressured type	~ 100 mGy/h
GM counter	-	~ 1 mGy/h
NaI(Tl) + Si semiconductor	Energy compensation type to flatten energy response	~ 10 μGy/h 10 μGy/h ~ 100 mGy/h
NaI (Tl)*	Energy compensation type to flatten energy response + current measuring method	~ 100 μGy/h 100 μGy/h ~ 100 mGy/h

* Portable monitoring post

Main apparatus used in normal or emergency monitoring

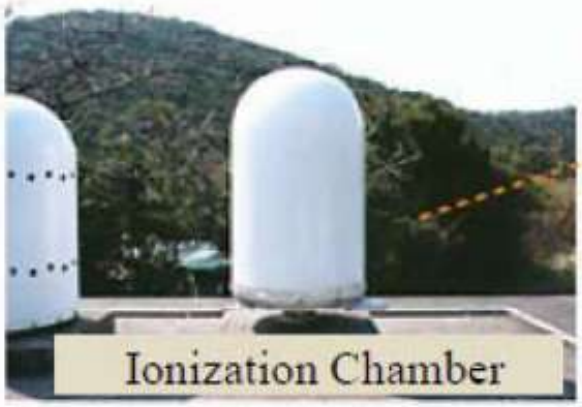
Air absorbed dose rate monitoring

① Monitoring post

② Monitoring station

Continuous measurement of dose rate

NaI scintillation detector

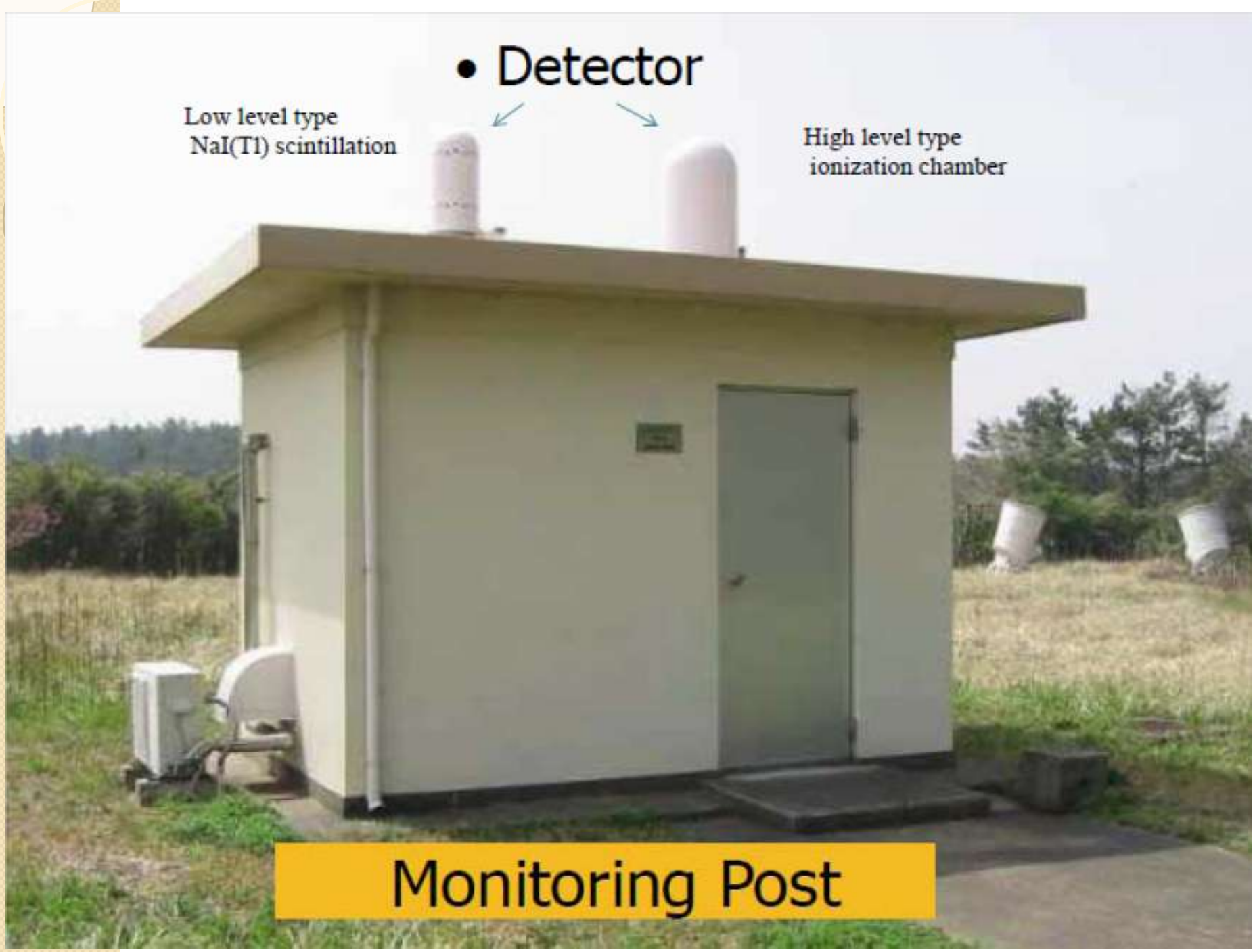


Ionization Chamber

Anemometer

Rain Gauge Rain Sensor

Monitoring Station


• Detector
Low level type
NaI(Tl) scintillation
High level type
ionization chamber
Monitoring Post

Main device in emergency monitoring

Air Absorbed dose rate Monitoring

Portable type Monitoring Post

Monitoring vehicle

NaI(Tl) Scintillation Survey Meter

- γ–sensitivity: high
- Energy dependence: inferior than ion chamber survey meter
- Dose rate range: 0.1~ 30μSv/hr

Ionization survey Meter

- Energy characteristic : 30keV~ 3MeV (±10%)
- Dose rate range : 1μSv/hr ~ 300mSv/hr
- Direction characteristic: Good

Monitoring programs in interventions

Monitoring interventions

- Generally constitutes the basis for decision making
- Depends on specificities of each scenario: sources involved, potential situations, possible exposure pathways

Interventions

- Emergency exposure situations;
- Chronic exposure situations

Monitoring interventions

Emergency exposures

- Depends on the severity of the situation
- Directed to early detection of exposures to the public and emergency workers
- Account of potential sources beyond national borders
- Finishes when the source is under control or decided based on prevailing circumstances

Monitoring interventions

Chronic exposure

- Depends on established by the national authorities intervention levels (generally when doses > 1mSv/year or as established nationally)

- Monitoring of foodstuffs and drinking water when radionuclide concentrations comprise a substantial fraction of generic action levels (BSS) or as established nationally

Emergency exposure situations

- All three types of monitoring – source, environmental and individual may be performed
- Overall strategy should be pre-planned as part of emergency preparedness actions
- There is a little time for making a monitoring plan after the accident occurred

Specific objectives of environmental monitoring in emergency situation

- To provide accurate and timely data on radiation levels and environmental contamination
- To assist decision makers on the need to take interventions and protective actions
- To provide information for the protection of emergency workers
- To provide information for the public
- To provide information to identify those people warranting long term medical screening

General consideration (I)

- In emergency situation, nature of key data and requirements evolve with time

- Emergency time phase:
  - Pre-release and release phases
  - Post-release or intermediate phase
  - Recovery or remediation phase

General considerations (II)

- In emergency situations, monitoring resources are overtaxed

- Monitoring resources should focus on most contaminated areas as determined by meteorological observations and model predictions

General considerations (III)

- Monitoring data should be recorded and retained for use:
  - During the emergency
  - In post-emergency evaluations
  - For long term health monitoring of affected workers and members of the public

General considerations (IV)

- A radiological monitoring and assessment centre should be establish to:
  - Collect all monitoring results
  - Collect and /or produce interpretations and assessments
  - Produce formatted data needed to support decisions

Preparedness for emergency monitoring (I)

- Definition in advance of two zones:
  - The urgent protective action planning zone: need for arrangements to take urgent protective actions
  - The food and agricultural restriction zone: need to implement urgent protective actions is less likely

Preparedness for emergency monitoring (II)

- In the urgent protective action planning zone:
  - Arrangements to promptly assess any radioactive contamination (environmental monitoring)
  - Arrangements to promptly assess contamination of people (individual monitoring)
  - Arrangements include availability of instruments and trained personnel

Preparedness for emergency monitoring (III)

- In the urgent protective action planning zone
  - Arrangements should include on-line automatic measuring stations
  - Arrangements should include map of pre-selected easy-to-get-to sampling locations

Preparedness for emergency monitoring (IV)

- In the urgent protective action planning zone
  - Arrangements should include instruments to identify gamma-, beta- and alpha-emitting radionuclide, as they require different protective actions,
  - Arrangements should include instruments to monitor contamination levels of vehicles, personnel and goods moving out the contaminated areas

Preparedness for emergency monitoring (V)

- In the urgent protective action planning zone
  - Arrangements should include procedures and methods for promptly assessing environmental and individual monitoring results,
  - Arrangements should include default operational intervention levels (OIL): instrumental observations should automatically trigger intervention activities of OIL are exceeded

Source monitoring (I)

- Main objective is to determined the magnitude of release,
- Stacks and pipes should be instrumented with online system with sufficient dynamic range for accidental releases
- Local actual meteorological data should be available as well as prediction models to use source monitoring data for early preliminary dose estimates

Source monitoring (II)

- Possible unmonitored releases through building leaks or other non instrumented outlet should always be considered as long as no environmental monitoring results are available
- For accident events such as explosions, source monitoring may be meaningless or impossible

Environmental monitoring (I)

- Environmental monitoring is often the most informative source of data during emergency situations
- Main initial priority: determination of significantly contaminated areas (those which require intervention to avoid immediate population exposure)
- Early measurement should be made rapidly with sample instruments
- Early measurements near expected most contaminated locations (including those pre-defined in emergency-preparedness planning)
- Given an emergency-postulated nuclide mixture (defined in the emergency preparedness process), dose rate measurements are interpreted as likely integrated dose for members of the public and compared to operational intervention level (OIL)

Environmental monitoring (II)

Sampling priorities in early phases of a severe accident:

- External gamma dose rate in the air (rapidly, repeatedly at least every hour, at locations of possible intervention according to meteorological data and previous survey feedback)
- In-plume air sampling during the release (radionuclide concentration and composition, simultaneous external gamma dose rate to compare with)

Environmental monitoring (III)

Sampling priorities in early phases of a severe accident:

- Field-gamma spectrometry above ground deposition, after the release has stopped (simultaneous external gamma dose rate to provide data for determination of deposition densities with simple external gamma-dose rate measurements)
- Continuous recordings of external gamma-dose rate in air (useful in terms of projecting doses)

Environmental monitoring (IV)

Sampling priorities in early phases of a severe accident

- Radionuclide concentrations in soil sampling, after the release has stopped (Supplement the field-gamma spectrometry, detection of pure beta emitters and alpha emitters)
- Radionuclide concentrations in food, water and milk, after the release has stopped (input data to assess food restriction needs)

Environmental monitoring(V)

- Phases to take into account for environmental monitoring evolution near the release period:
  - Monitoring at the pre-release stage
  - Monitoring at the release stage
  - Monitoring at the immediate post release stage

Environmental monitoring (VI)

- Priorities for environmental monitoring at the stage pre-release
  - Access information on composition of radioactive material likely to be discharged
  - Get meteorological data (wind speed, wind direction, precipitation…)
  - Ensure adequate instruments and trained personnel are available
  - Request assistance from other organizations
  - Get instrumented aircraft in the air

Environmental monitoring (VII)

- Priorities for environmental monitoring at the release stage
  - Measure external gamma dose rate in the plume (instrumented aircraft, teams with usual beta-gamma survey meters, automatic recording beta-gamma survey meters)
  - Acquire samples of released aerosols and other radionuclides such as iodine (instrumented aircraft, teams with air samplers, automatic ground-based air samplers)

Environmental monitoring (VIII)

- Priorities for environmental monitoring at the immediate post-release stage
  - Determine radionuclide composition and deposition levels (field-gamma spectrometry, soil sampling)
  - Determine food and water contamination levels (in particular in milk in case of radioiodine release)

Individual monitoring (I)

- Individual monitoring required to determine if decontamination of medical follow-up of people within emergency zones is warranted
- Individual monitoring limited to selected part of exposed population because difficult to implement and follow effectively

Individual monitoring (II)

- Individual monitoring appropriate in emergency situations when individuals exposed at levels close to intervention levels (especially close to threshold of deterministic health effects)
- Individual monitoring may be undertaken for scientific purposes or public reassurance
- Individual monitoring includes
  - External dose measurements by dosemeters carried by individuals
  - Radionuclides activity in the body
  - Radionuclides activity in organs
  - Radionuclides activity in excreta

Individual monitoring (III)

- Combination of individual measurement data and modelling required for dose assessment
- External exposure
  - Individual dosimeters should be
    - Distributed when dose rate above background
    - Distributed to emergency workers
    - More exposed population group members (critical groups)
    - Worn during prescribed periods (consistent with the projected dose)
    - Used for validation of applied dosimetric models
  - Individual self-reading dosemeters should be distributed to the most exposed emergency workers

Individual monitoring (IV)

- Internal exposure
  - Transportable and stationary whole body counters
    - Measurement of radionuclide content in the human body (due to inhalation and ingestion)
    - Measurement of radionuclide concentration in specific organs or tissue with collimated gamma-radiation detectors (I-131 in thyroid, low solubility radionuclides in lungs…)
    - Applications of simplified methods for wide-scale monitoring of I-131 in thyroid or Cs-134 and Cs-137 in whole body

Individual monitoring (V)

- Radiometric analyses of excreta:
  - Mainly in urine and faeces,
  - When accidental contamination with beta-emitting and alpha-emitting nuclide(and no significant gamma emitting nuclide)
  - Age also should be taken into account (because metabolic parameter variation with age)
  - Doses should be assessed with adequate models and results should be used for applied dosimetric model validation

Intervention: chronic exposure situation

- Sites with long lived radioactive residues
  - Off-site areas with increased levels of natural radionuclides as a result of past industrial activities, -TENORM, ARE
  - Off-site areas contaminated with human made radionuclides as result of radiation accidents and/or past radioactive releases
- Such sites are the subject of environmental monitoring and sometimes individual monitoring
- Ultimate goal of monitoring-to aid decisions concerning remedial actions (intervention)

Monitoring programs (I)

- Scale of monitoring programs determined primarily by the significance of doses to critical groups
- Monitoring programs usually include environmental monitoring and sometimes individual monitoring
- Monitoring programs should take into account:
  - Radionuclide composition of the contamination
  - Physical and chemical composition of radionuclides
  - Medium containing radionuclides (soil, water body)
  - Land and water use
  - Exposure pathways
  - Remedial actions

Monitoring programs (II)

- Monitoring programs usually include:
  - External radiation levels,
  - Radionuclide concentrations in environmental media (e.g. soils, surface water, ground water…)
  - Radionuclide concentrations in food products
- Monitoring is usually required 3 stages of remediation
  - Initial (screening) monitoring to decide whether and where intervention is justified (comparison to intervention and action levels, determine appropriate actions)
  - Monitoring during implementation of remedial actions to follow results and modify action plans according to feedback
  - Monitoring after remediation to ensure objectives have been met

Monitoring of external radiation fields

- Measurement of dose rate in the air
- Assessment of background to subtract of evaluation the contribution of contamination
- Measurement at locations accessible to the public
- For screening monitoring, dose rate measurement on undisturbed soils and dose assessment with simple models

Monitoring of internal exposure

- Assessment of internal doses due to intake via inhalation and/or ingestion through determinations of radionuclides content in environmental samples, drinking water and foodstuffs
- According to this sampling should include as appropriate: aerosols, soils and sediments, ground and surface waters and foodstuffs

Monitoring of internal exposure-aerosols sampling

- Frequent sampling at short term after an accident (maximum re-suspension because no penetration and fixation on soils deposition
- Less frequent sampling in the long term because radionuclide penetration and fixation on soils
- Long term periodic sampling in areas contaminated with plutonium and other actinides (inhalation critical pathway, very slow penetration)
- Indoor radon monitoring in areas with elevated radium levels

Monitoring internal exposure- soils sampling

- Long term periodic soils and sediment sampling to monitor vertical radionuclide penetration

- More frequent sampling for mobile radionuclide (e.g Cs, Sr, etc)

Monitoring internal exposure – foodstuffs sampling

- Monitoring programs should include, as appropriate
  - Agricultural vegetables and animal products
  - Natural foodstuff (fresh water fish, mushrooms, berries…)
- Priority to foodstuff
  - Consumed by population in larger amount
  - With elevated concentrations
- Special attention to plants from poor sandy or organic soils (woodland, artic areas, tropical areas) because of enhanced transfers from soil to plants

Monitoring internal exposure-drinking water sampling

- Monitoring programs should include, if appropriate, drinking water monitoring
- More frequent drinking water sampling required when contamination include mobile element (H3, Cs, Sr)

Supporting monitoring programs

- Monitoring programs should include other types if measurements and activities for data collection such as general monitoring of the environment as well as monitoring of characteristics of the population: climate, hydrology, population distribution and characteristics, etc.

Reporting Results

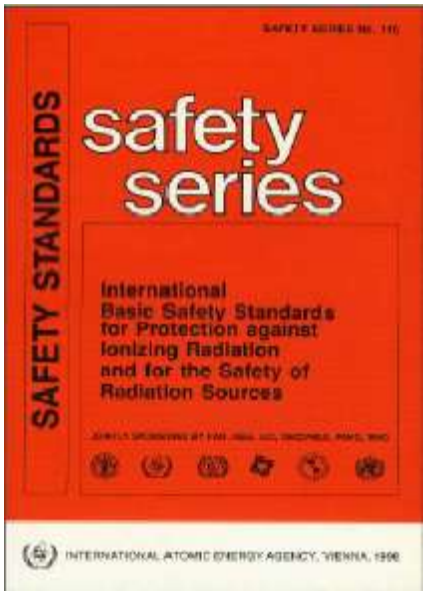
Reporting results (I)

BSS para. III.13

"Registrants and licensees shall, of appropriate:

(d) Report a summary of the monitoring results to the Regulatory Body at approved intervals

(e) Report promptly to Regulatory Body any significant increase in environmental radiation fields or contamination that could be attributed to the radiation or radioactive discharges emitted by sources under their responsibility…"



Reporting results (II)

- Additionally, any discharges exceeding the authorized limits on discharges should be reported to Regulatory Body
- Frequency of reporting- at least annually or as indicated by the Regulatory Authority. Reports on unexpected situations- promptly
- The Regulatory Body should make available to the public a summary information based on these reports

Periodic summary reports of monitoring results should include:

- Results of both source and environmental monitoring including
  - Verification of compliance with the authorized discharge limits
  - Performance according to objectives of monitoring
  - Dose assessments
- Interpretation of the results and explanation of their significance
- Other useful related information (weather condition, production, etc)

Report of unplanned or unexpected situations should include

- Description of the investigation carried out in this connection and results if available
- Actions taken in relation to discharges
- Foreseen actions for the immediate future

Summary

- Monitoring programmes in practices:
  - Pre-operational monitoring
  - Operational monitoring
- Monitoring programmes in intervention situations:
  - Monitoring in emergencies
  - Monitoring in chronic exposures scenarios


Thank You