The Ninth International Symposium on Naturally Occurring Radioactive Material

Denver, Colorado | 23-27 September, 2019

"Cradle to Grave"

NORM Management Workshop

September 22, 2019

Worker Protection, Health Physics & Compliance

Overview

- Compliance with US/International Rules & Regulations
- Radiation Management Programs/Effective Work Plans/RWP/IH/PPE
- Worker/Public Monitoring (Radiation, Contamination, Air, Water)
- ALARA/Optimization Considerations
- Process Monitoring (Field Measurements for Project Progression)
- Records and Documentation/Operations/Close-out
- Q&A

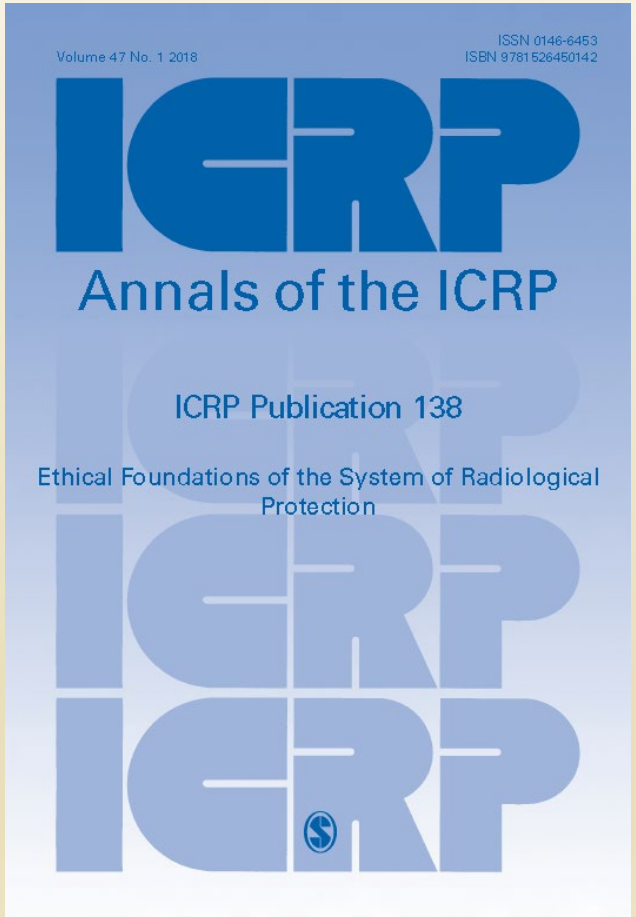
Compliance with US/International Rules & Regulations

- Could be a course unto itself.
- International:
  - UNSCEAR > ICRP > IAEA > Member States > Local
  - Nuclear Fuel Cycle/NORM both considered if non-exempt
  - ICRP 103 considers all controllable exposures

- US:
  - UNSCEAR > ICRP > NCRP > FEDS > States > Local
  - Nuclear Fuel Cycle - Federal
  - NORM/TENORM – Mostly States

ICRP Publication 138, Ethical Foundations of the System of Radiological Protection

- Describes the four core ethical values underpinning the present system of radiation protection:
  - Beneficence/ non-maleficence,
  - Prudence,
  - Justice, and
  - Dignity.
  - Great overview by Nicole Martinez:
    - https://www.oecd-nea.org/rp/workshops/science-values2018/sv5presentations/documents/2.2Ethics-RPchallengesinScienceandApplication-N.Martinez.pdf



ICRP 103 Principles

- ICRP 103 (2007) adopted a new paradigm for radiation protection based on the situation:
  - Planned
  - Existing
  - Emergency
- "*applies to all radiation exposures from any source, regardless of its size and origin.*" In particular, the Commission's recommendations cover exposures to both natural and man-made sources.
- Previous approach was based on practices and interventions
- Planned exposure situations subject to dose limits and optimization and justification

ICRP 103 Approach

- Existing situations NOT subject to dose limits, but rather exposures evaluated and optimized within bands (reference levels). Since it is existing when taken under consideration, justification may not be required.
- Emergency situations subject to optimization based on the situation.
  - In the US, we now have the revised PAGS manuals.
- The philosophy of *Publication 103* (ICRP, 2007a) compared to *Publication 60* (ICRP, 1991) is to recommend a **consistent approach for the management of all types of exposure situations**.
- This approach is mainly based on the application of the principle of optimisation using appropriate dose criteria. In existing exposure situations, the relevant dose criterion is the reference level.

Exposure Situations

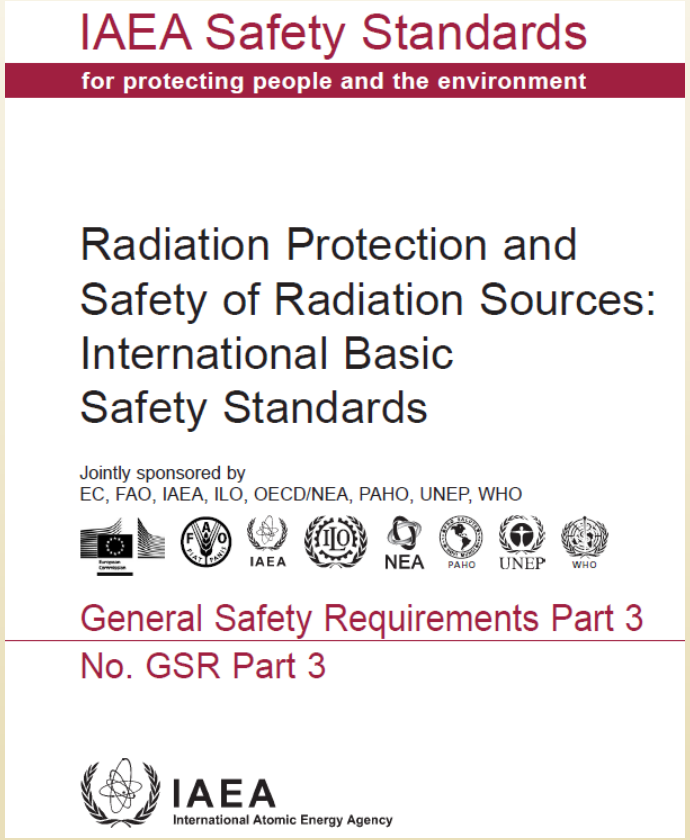
- ***Existing*** *exposure situations* are exposure situations resulting from sources that already exist when a decision to control the resulting exposure is taken. Characterisation of exposures is a prerequisite for their control;
- ***Planned*** *exposure situations* are situations resulting from the deliberate introduction and operation of sources. Exposures can be anticipated and fully controlled; and
- ***Emergency*** *exposure situations* are situations that may occur during the operation of a planned situation in case of loss of control of the source, or from any unexpected event involving an uncontrolled source. Urgent action is necessary in order to avoid or reduce undesirable exposures.
- The Commission considers human and environmental exposures resulting from NORM industries as an existing exposure situation.
  - The source is not deliberately introduced in the industrial process for its radioactive properties;
  - it already exists in material used in the process or industry, and
  - any protection decisions are made in that context to control the exposure.

Requirements 3 and 4 of GSR Part 1

- The **government** is required to **establish and maintain a regulatory body** that is effectively independent and has the authority and sufficient resources (staff and financial) to properly oversee the safety of facilities and activities. For regulatory bodies that historically have not been involved in regulating radiation sources, this is likely to require cooperation with other agencies or organizations with relevant radiation protection expertise.
- The **government** should coordinate the establishment of an appropriate **national inventory** of significant NORM residues arising from new and existing NORM activities. Where possible, residues identified from past practices (i.e. which need to be considered as part of the national strategy for residue management) should also be included in the inventory.
- The **government** should establish legislation that allows the regulatory body to maintain effective oversight of NORM activities, where such legislation does not already exist. Such legislation should address the relevant requirements of GSR Part 3, and should include provision for authorization of facilities and activities, and for establishing financial resources by the operating organization, where these are required.

BSS GSR-3 2014 – The Basic Safety Standards

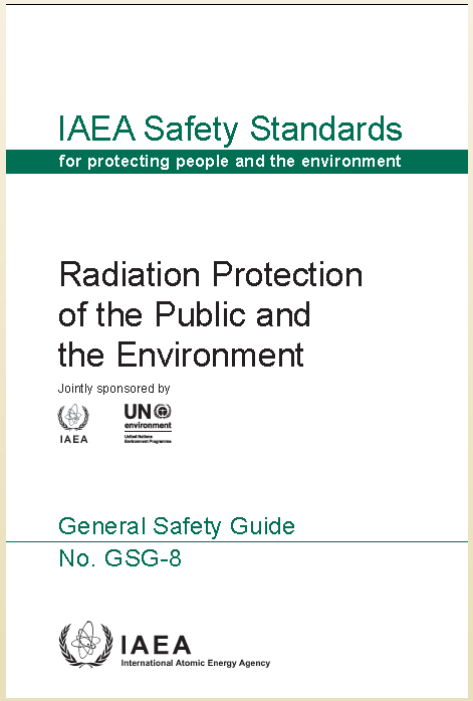
- https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1578_web-57265295.pdf
- Radiation Protection And Safety Of Radiation Sources: International Basic Safety Standards.
  - Follows ICRP 103 Recommendations
  - Applies to all facilities and activities
  - Planned, existing and emergency situations
  - Occupational, public and medical exposure categories
- 52 overarching requirements – for governments, regulatory bodies, industry, health and safety professionals, workers and the public.
- Nations can adopt the BSS directly, or with modification
  - The US follows its own path.

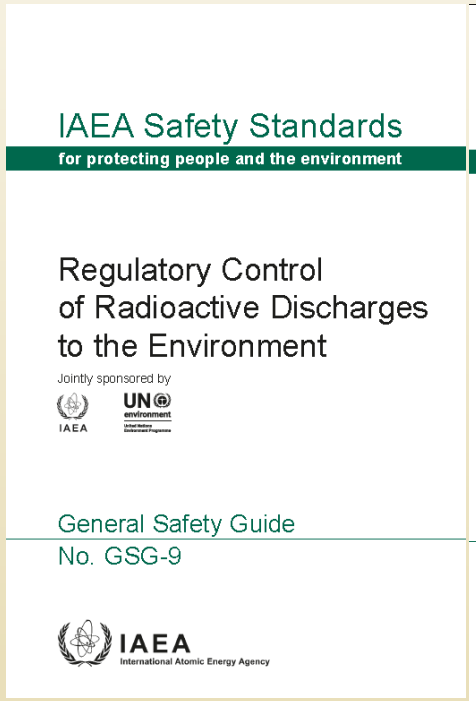


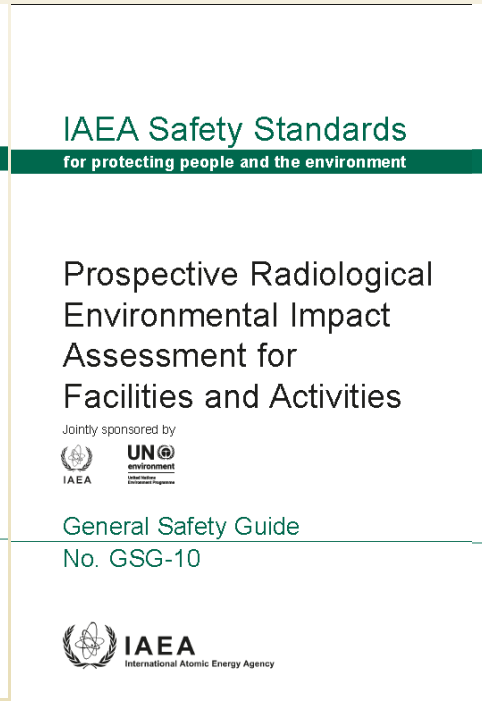
IAEA Existing vs Planned Situations

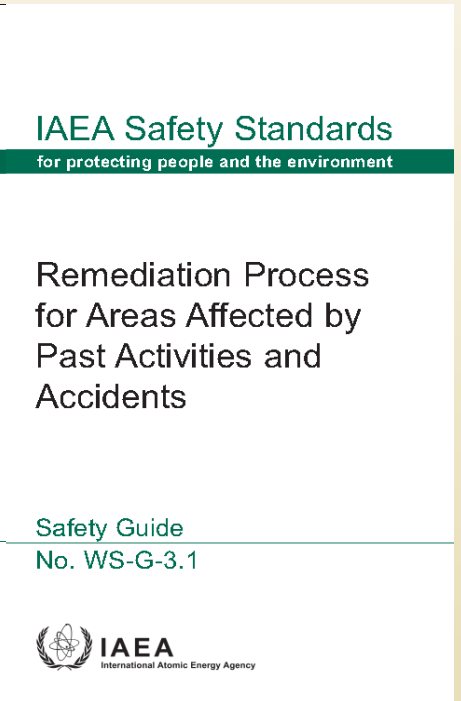
- (a) If, in any process material, the activity concentration of any radionuclide in the ^{238}U decay series or the ^{232}Th decay series **exceeds 1 Bq/g**, or if the activity concentration of ^{40}K exceeds 10 Bq/g, the industrial activity is regarded as **a practice and the requirements for planned exposure situations apply**.
- (b) If, in every process material, the activity concentrations of all radionuclides in the ^{238}U decay series and the ^{232}Th decay series are **1 Bq/g or less** and the activity concentration of ^{40}K is 10 Bq/g or less, the material is not regarded as naturally occurring radioactive material, the industrial activity is not regarded as a practice and the requirements for **existing exposure** situations apply.
- Exposure to cosmic radiation at ground level is regarded as unamenable to control and is therefore excluded from the scope of GSR Part 3
  - Control of occupational exposure to cosmic radiation above ground level is required to be considered for aircrew in terms of the requirements for existing exposure situations, and exposure is required to be controlled for individuals in space based activities.

Additional IAEA Guides









IAEA Training on Wednesday

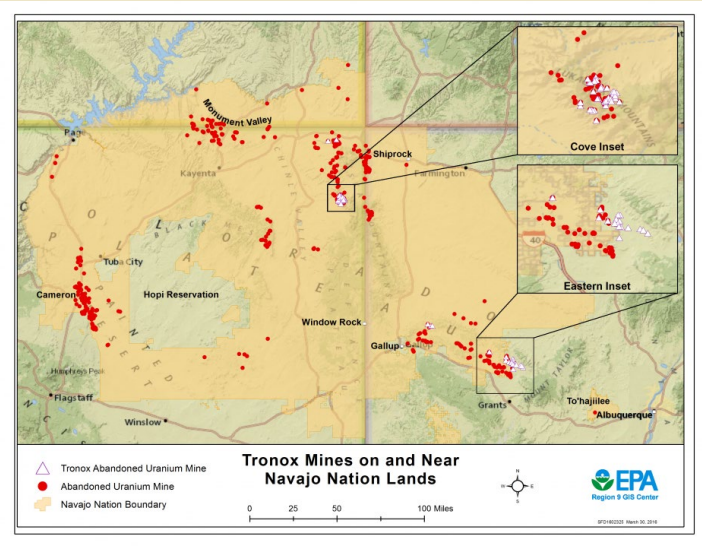
- Will focus on DS-459 and GSR-7.
- They will go into much more detail on these guides!
- Jim Hondros will be presenting on Radiation Protection Programs
- We will return to these in a few slides…

US Approach – A Little Different

- Constitution Article X
  - That which is not reserved to the federal government falls to the states and the people.
  - Therefore, it would take **legislation** to grant federal authority over NORM
  - We do not anticipate a “TENORM Control Act” any time soon in the US.
- Atomic Energy Act
  - Limited to the nuclear fuel cycle (including source and byproduct materials).
  - Kicks in “After removal from its place in nature.” i.e., when it gets to the mill.
  - Does not regulate diffuse NORM or machine-generated radiation
- Federal laws that have a nexus with NORM:
  - Clean Water Act
  - Safe Drinking Water Act
  - Clean Air Act
  - CERCLA
  - Resource Conservation and Recovery Act (RCRA)

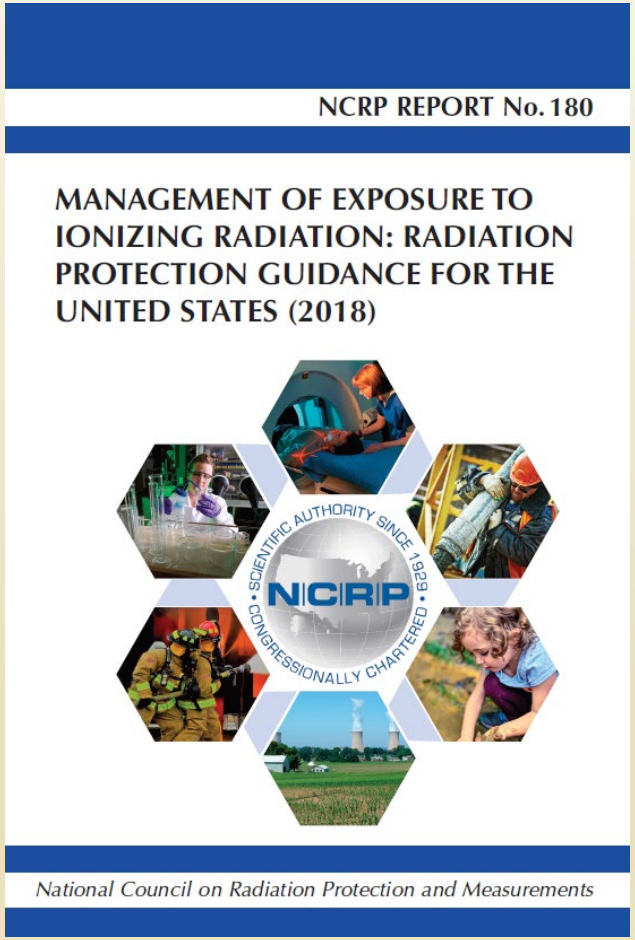
US Approach – A Little Different

- The US is still evaluating the ICRP situational approach, but recognizes it in its recent guidance (NCRP 180, 2018).
- Most NORM/TENORM is not subject to NRC or Agreement State Radiation Control Regulations
  - Not source, byproduct or SNM material.
- Over a dozen States have specific regulations for control and disposal of NORM/TENORM, most aimed at the oil and gas industry,
  - Part N of CRCPD Suggested State Regulations (under revision).
- Mining of ores also is not traditionally regulated by NRC, but rather by the Mine Safety Health Administration (MSHA) and State Land Management Agencies.
- Some legacy uranium mine sites are being cleaned up under the Superfund law (CERCLA)
  - https://www.epa.gov/navajo-nation-uranium-cleanup/tronox-abandoned-uranium-mines



NCRP Report 180. December 31, 2018

- Adopts the ICRP ethical principles
- Five categories of ionizing radiation exposure are: occupational, public, medical, emergency worker, and nonhuman biota.
- NCRP continues to recommend a **negligible individual dose of 0.01 mSv (1 mrem) annual effective dose** per source or practice as a guide for evaluating when efforts to reduce further the dose to an individual may not be warranted.
- Commercial airline crews, as well as pilots of cargo and corporate aircraft are occupationally exposed



Radiation Management Programs
Effective Work Plans/RWP/IH/PPE

Much of the following has been adopted from NCRP 116 (1993) Radiation Protection in the Mineral Extraction Industry, and

IAEA GSR-7 Radiation Protection Programs (2018)

IAEA GSR- 8 Radiation Protection of the Public and Environment

IAEA DS-459 (in press)

IAEA DS-459 In Press – Anticipated Scope

- **Management of Residues Containing Naturally Occurring Radioactive Material from Uranium Production and Other Activities**
  - *NOTE: This guide will be covered in detail in the Wednesday Morning IAEA special session.*
  - Provide recommendations on approaches for the safe management of NORM residues arising from uranium production and other NORM activities (e.g., rare earths,) in accordance with a graded approach.
  - Aimed at meeting the relevant requirements established in GSR Part 3 for the protection of people and the environment, both now and in the future.
  - Address strategy and protocols for the siting, design, construction, operation and closure of facilities.
  - Supersedes the Safety Guide on Management of Radioactive Waste from the Mining and Milling of Ores, IAEA Safety Standards Series No. WS-G-1.2, issued in 2002

Positive list industries - GSG-7

The following industrial activities are, or may be, subject to the requirements for planned exposure situations:

(a) Mining and processing of uranium ore;
(b) Extraction of rare earth elements;
(c) Production and use of thorium and its compounds;
(d) Production of niobium and ferro-niobium;
(e) Mining of ores other than uranium ore;
(f) Production of oil and gas;
(g) Manufacture of titanium dioxide pigments;
(h) Activities in the phosphate industry;
(i) Activities in the zircon and zirconia industries;
(j) Production of tin, copper, aluminium, zinc, lead, and iron and steel;
(k) Combustion of coal;
(l) Water treatment.

GSG-7

- Measures for preventing or reducing doses that might otherwise occur in an existing exposure situation may take the form of remedial actions or protective actions:

  (a) **Remedial actions** in an existing exposure situation involve removal of the source or reduction of its activity or amount. An example of a remedial action is the removal of residual radioactive material from a contaminated site.

  (b) **Protective actions** in an existing exposure situation involve measures that act on the exposure pathways rather than on the source itself. Examples of protective actions are the control of access to a contaminated site and restrictions on the use of contaminated water for drinking purposes.

Reference levels instead of dose limits

- A reference level should be used in the optimization process. It represents a level of dose above which it is judged to be inappropriate to plan to allow exposures to occur. In considering the various possible remedial actions and protective actions, a reference level serves as an upper bound on the range of options considered; this will ensure that the optimized protection strategy will be aimed at reducing doses to some value below the reference level.
- A reference level for a particular existing exposure situation should be established by the government or by a regulatory body or other relevant authority acting on behalf of the government.

Radiation Management Programs

- So what is to be done to properly control and maintain safety in industries where the radioactive material is not wanted or planned?
- One does not have to reinvent the wheel.
- A Radiation Management *Program* can be developed that addresses the needs for environmental protection and worker and public safety.
  - In the form of a Radiation Management *Plan*.
- Since most facilities will exceed the exemption limits, the requirements for planned situations apply…
- The reader is referred to GSG-7 (and DS-459 when released)

Requirement 14 of GSR Part 3

- "**Registrants and licensees and employers shall conduct monitoring to verify compliance with the requirements for protection and safety**." Such monitoring should provide sufficient information to determine whether the levels of public exposures comply with the dose limits and to demonstrate that protection and safety is optimized.
- "The government or the regulatory body shall determine what additional restrictions, if any, are required to be complied with by registrants and licensees to ensure that the dose limits … are not exceeded owing to possible combinations of doses from exposures due to different authorized practices."

Take Precautions

- This can be complicated, particularly for existing facilities where inventories may have built up over time.
- New facilities can plan and design appropriately to minimize exposure to NORM/TENORM.
- Companies should consider taking a precautionary approach, which is, making reasonable and prudent assumptions when evaluating and managing environmental risks from their operations.
- “Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation”
  - Principle 15 of the 1992 Rio Declaration

Top down and bottom up

- “**The principal parties shall ensure that protection and safety are effectively integrated into the overall management system of the organizations for which they are responsible.**” (BSS GSR-3, 2013)
- A prerequisite is a commitment from management to quality and excellence.
  - Communication with the public
- Without management support, workers cannot be expected to commit to a quality program.
- It is the responsibility of all workers to ensure the Plan is put into practice by following procedures, etc.
- A review of ICRP Report 138 is recommended (Ethical Principles of Radiation Protection)

It's About Safety

- Workers should consider radiation safety as an inherent part of the safety program, and should be able to report to management unsafe conditions without fear of reprisal.
- The Plan should be well-documented; there should be control of documents or web sites where the plan resides.
- A graded approach should be taken commensurate with the facility conditions.
- There are two primary issues to be addressed:
  - worker and public exposure and
  - radionuclide concentrations in wastes.

Components

- The basic components of a radiation management program for NORM/TENORM are similar to those for licensed materials, and include:
  - Evaluation of the process and facility to determine where and when NORM/TENORM may accumulate,
  - An administrative and engineering controls program,
  - An exposure monitoring plan,
  - An effluent monitoring and environmental monitoring plan,
  - A waste management program,
  - Industry-specific or site-specific needs.

Facility Evaluation/Inventory

- Without a survey of the facility and wastes, one cannot determine if there is a NORM/TENORM exposure or waste issue at a facility.
- Adequately mapped and described, including natural geology and surface (and if appropriate- subsurface) hydrology, drainages, facility circuits, emission points, and waste collection and storage areas.
- Facility survey should be comprehensive enough for pathway analysis for risk or dose assessment purposes.
- A mass balance for solid and liquids may be needed, giving consideration to areas where radioactivity could be concentrated.

Scope of survey

1) Gamma exposure rate surveys of work areas, storage areas, process equipment, and waste areas,
2) Samples of raw materials, effluents and waste products to determine the concentrations of radioactivity,
3) Radon and radon progeny measurements,
4) Surface activity measurements on material and equipment,
5) Time studies of worker practices,
6) Background measurements and samples.

Evaluation

- Once the site is characterized, then it can be determined the level of effort needed for the radiation management program, or if there is a waste issue.
- Low-activity radioactive materials in wastes can often be handled as a solid waste rather than radioactive waste.
- If feed stocks or wastes contain uranium or thorium in source-material, or if there is a significant increase in radium concentrations, a specific radioactive materials license may be required.

Instrumentation

- It is recommended that facilities with the potential for NORM/TENORM contamination or exposures should have radiation detection instrumentation;
  - It is often the lack of data that leads to unnecessary exposure.
  - Having instrumentation also facilitates exposure monitoring and contamination control.

- See GSR-7, Appendix I
  - Methods And Systems For Individual Monitoring For Assessment Of External Exposure
- See MARSSIM also

RSO or not

- A Radiation Safety Officer may be needed, either as part of the industrial hygiene program, the safety program, or as a separate position, depending on the scope of the operation.
- The RSO must have adequate training commensurate with the program.
- Qualified experts may need to be retained until the nature and extent of the NORM/TENORM has been established and a program put in place.

SOPs

- Standard Operating Procedures (SOP) should be written for normal conditions and maintenance activities.
- Procedures should include, but not be limited to monitoring, ventilations systems, use of PPE/respirators, management of residuals, record keeping, and reporting.

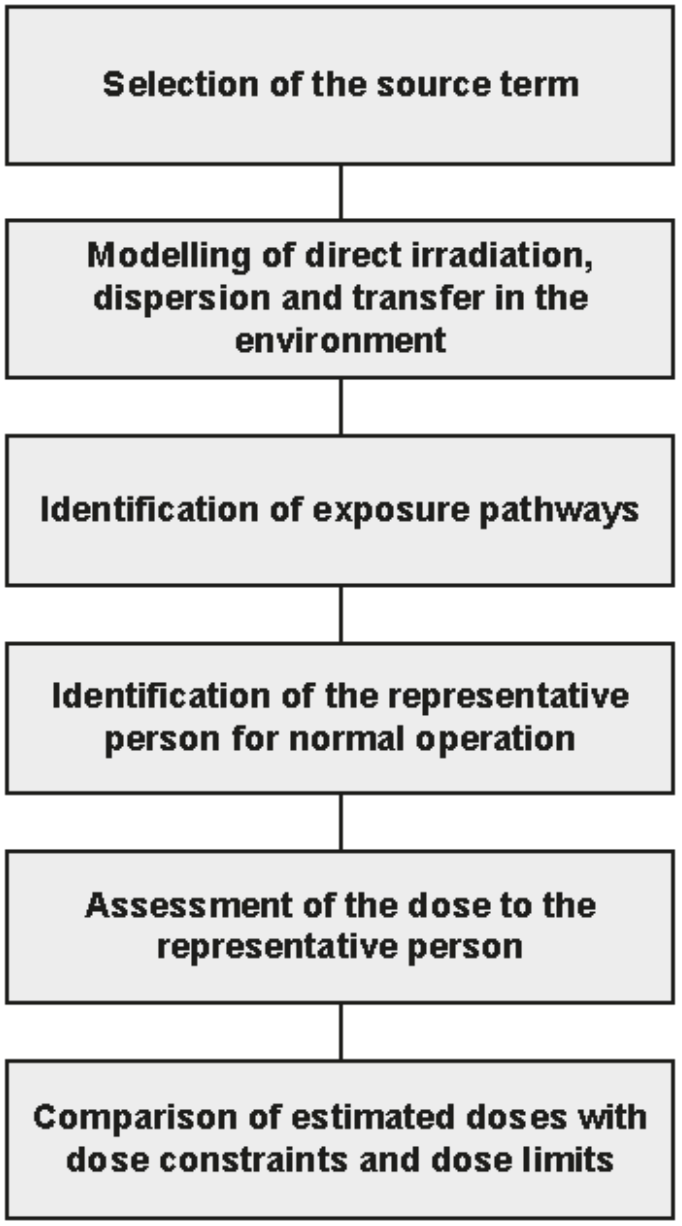
Worker/Public Monitoring (Radiation, Contamination, Air, Water)

Effluent Monitoring and Environmental Monitoring Plan

- Effluents from the facility, both to air and water should be evaluated for their TENORM content.
- In order to calculate doses to off-site receptors, and to provide information relative to environmental impacts.
- Facility operators need to know what the concentrations and exposure rates are in each processing unit, points within the circuits where TENORM can concentrate, points of potential release to the environment and the radionuclide concentrations in the effluents.

Environmental Monitoring

- An environmental monitoring program may be desirable (or required).
- The environmental monitoring should be for the isotopes in each major pathway that could contribute to an offsite dose.
- The baseline survey and environmental monitoring program should be as compatible with one another as practical.
  - Using the same sampling locations provides for direct comparison and trend analysis over time.



Contents

- The environmental monitoring program requirements are similar to those of the effluent monitoring plan:

1) airborne particulates, radon, and gamma radiation near site boundaries, and in the most likely wind directions,

2) airborne particulates, radon, and gamma radiation near the nearest resident and the nearest downwind resident,

3) if applicable airborne particulates, radon, and gamma radiation at the nearest population center,

4) water samples from the uppermost aquifer that is or could be used as a drinking source and is hydraulically down gradient from a major source of seepage, e.g., tailings ponds or impoundments,

More Contents

5) water samples from at least one downgradient surface water sampling point or from potentially affected surface water ponds,

6) food crops, fish, or livestock feed samples from locations where the highest airborne radionuclide concentrations are predicted,

7) soils samples from the areas of highest airborne deposition,

8) baseline or control samples for all parameters from upwind or upgradient areas.

- The analytical methods and isotopes chosen for analysis needs to correspond to the forms and isotopes being released from the site.
  - MARLAP is recommended
  - https://www.epa.gov/radiation/marlap-manual-and-supporting-documents
- Chemicals and metals associated with the facility process should also be evaluated on a rotating schedule.

Exposure Monitoring Plan

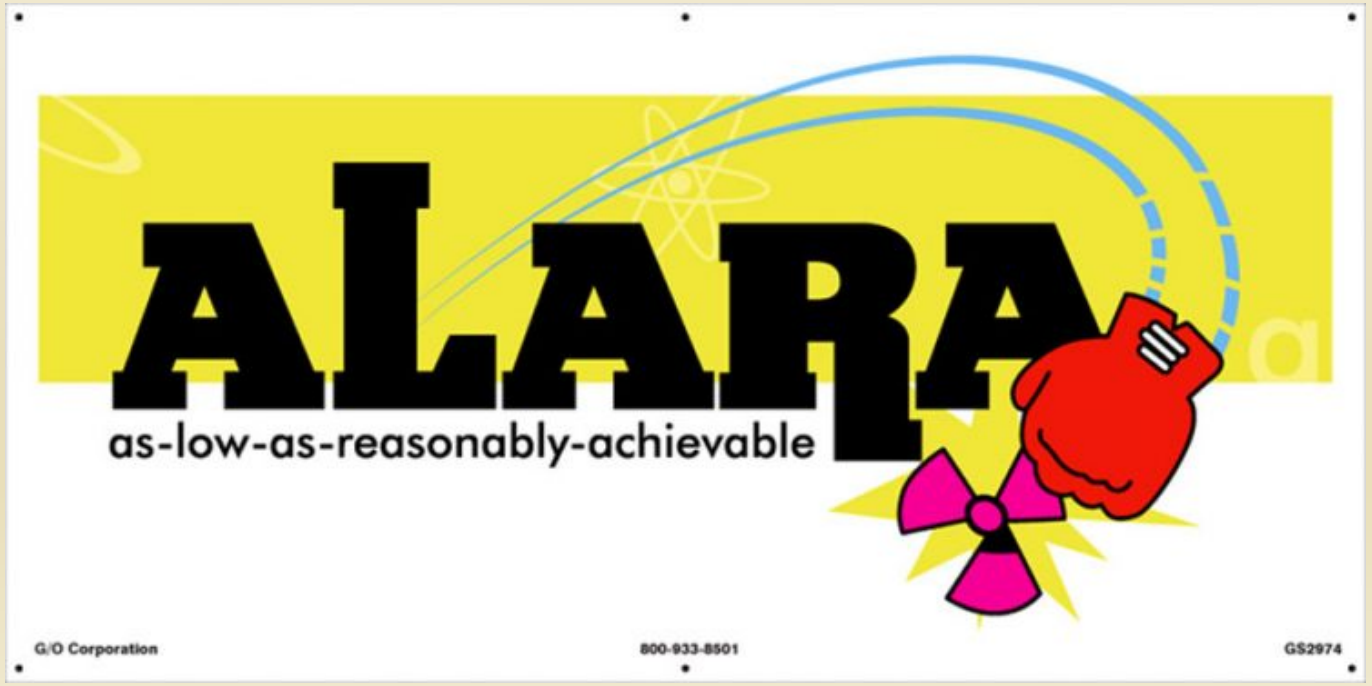
- The exposure monitoring plan should be commensurate with the risks.
- The plan should be based on the concepts of justification, limitation, and optimization.
- The facility should consider setting administrative action levels to ensure doses are kept ALARA.
- Facilities should consider monitoring the workplace for radon (and/or progeny) and establish separate administrative action levels.
  - It is difficult to recommend an action level for radon since the equilibrium fraction can vary from facility to facility.

Pathways

- The two primary pathways of exposure are direct gamma and inhalation.
  - Ingestion may be a viable pathway in some scenarios.
- The external dose rates may be monitored by passive area monitors (e.g., OSLs, TLDs), surveys with gamma detectors, or alarming ratemeters.
  - Depending on the layout of the facility, and the physical forms of the NORM/TENORM,
- Personal dosimetry may be worth the investment over trying to do time studies if:
  - Certain workers are likely to receive higher external doses than others, or
  - Workers frequent multiple areas during the course of their work.

Optimization (ALARA) Considerations

- Generators and Operators must always maintain the principals of As Low As Reasonably Achievable (ALARA)
- Mandated to make every reasonable effort to maintain exposures of ionizing radiation to workers and the public as far below the dose limits as practical.



Administrative and Engineering Controls Program

- Administrative classification of workers and support staff may help with monitoring programs.
- Administrative staff with little or no chance of exposure to NORM/TENORM will need less training and oversight than workers who may be exposed more through routine operations.
- The Plan should differentiate among visitors, workers who are members of the public (i.e., no exposure) and off-site potential receptors.
- Controlled areas
  - Workers frequenting controlled areas should be considered for individual dose monitoring.
  - Less restrictive than controlled areas, supervised areas can be created where exposure conditions are kept under review, but not to the stricter controls of a controlled area

Administrative controls

- Can include physical barriers, postings, signs, and radiation work permits for projects or situations not covered by SOPs.
- Controlled Areas (i.e., areas where preventive measures to limit exposure or contamination are in place) can consist of separate elevated areas from frequently occupied areas.
- There should be limitations on access to controlled areas by visitors and non-essential workers.
- Controlled areas should be posted and delineated.

Other controls

- Most industrial clothing (coveralls, gloves, goggles, boots) works well for protection from contamination by residuals and materials that can contain NORM/TENORM.
- Ventilation should be utilized rather than respirators.
- Time, distance and shielding are the keys to keeping dose rate exposures ALARA.

Engineering Controls

- Can include dust control, ventilation, shielding, conveyor covers, etc.
- If designing a new facility, incorporation of engineering controls can mitigate the need for respiratory protection and administrative controls.
- Adequate ventilation is crucial for maintaining particulate and radon levels ALARA.

Dose Constraints

TABLE 1. FRAMEWORK FOR SOURCE RELATED DOSE CONSTRAINTS AND REFERENCE LEVELS

Range in which the value for a dose constraint or reference level is set	Category of exposure and type of exposure situation
20 to 100 mSv [a,b,c]	• Reference level for public exposure in an emergency exposure situation
1 to 20 mSv per year	• Dose constraint for occupational exposure in a planned exposure situation • Dose constraint for medical exposure of carers and comforters in a planned exposure situation • Dose constraint for individuals undergoing non-medical human imaging that is conducted by medical personnel using medical radiological equipment in a planned exposure situation • Reference level for workers in an existing exposure situation • Reference level for public exposure in specific existing exposure situations, e.g. exposure due to radon in dwellings, areas with residual radioactive material
Not greater than 1 mSv per year	• Dose constraint for public exposure in planned exposure situations • Reference level for public exposure in specific existing exposure situations, e.g. exposure due to radionuclides in commodities such as food, drinking water or construction materials

[a] Acute dose or annual dose.
[b] In exceptional situations, informed volunteer workers may receive doses above this band of values to save lives, to prevent severe deterministic health effects or to prevent the development of catastrophic conditions.
[c] Situations in which the dose threshold for deterministic effects in relevant organs or tissues could be exceeded always require action.

Process Monitoring (Field Measurements for Project Progression)

In-Process Material To Be Considered

- Materials that are still in-process (e.g., storage lagoons, settling impoundments, tanks, stilling basins, filters may not technically have been declared wastes, but if they pose an environmental or occupational risk, they should be considered in the WMP.
- Dust suppression may be important, consider use of surfactants or sprays to keep dusting under control.
- In effect, the WMP is a liquids and solids materials management plan.

Non-rad

- Most wastes will contain non-radioactive constituents, and the radiological components need to be evaluated in context with the chemical hazards and regulatory requirements of management of the non-radiological components (i.e., solid waste regulations, or perhaps hazardous waste regulations).
  - It is entirely possible that the chemical hazards of a waste are limiting when compared to the radiological components.

To waste or not to waste…

- An understanding of the regulatory status of a waste stream is crucial to economic and logistical options of disposition.
- Not all wastes are disposed, some may be candidates for beneficial reuse or recycling.
- The solids and liquids management approach should utilize technologies and equipment that minimize the release of radioactive materials into the environment.
- The facility processes should be evaluated at points where radioactive materials are handled, stored, treated, and discharged.

Aspects to Consider

1) flow description and mass balance of facility describing the processes responsible for concentration of radioactivity,
2) chemical, physical, and radiological properties of the waste streams, including quantities and rates of generation,
3) discharge points,
4) waste management options, treatment, and containerization, and
5) disposition options.

Disposition

- Once the waste streams have been characterized, waste disposition methods can be assessed.
- Cost and disposal options are often limited, particularly for liquid waste streams with elevated radioactivity, and for small facilities with limited resources.

Spill control

- Cleanup of spills should be undertaken as soon as practicable.
- There should be a written spill control procedure that addresses materials in transport and at the facility.
- While it may be the responsibility of the transporter to clean up spills in transit, it is good practice to have the resources to assist in the cleanup.

On-site disposal

- There are two primary options for disposal of wastes – on-site or off-site.
- On-site management and disposal may be the only viable options.
- Consideration must be given to the ultimate fate of the facility.
  - If wastes are managed on-site, there may be operational and post-closure issues. Impoundment or waste disposal cells must be designed to be robust and prevent escape of contaminants to the environment.

Down and out…

- Downhole disposal or treatment and discharge to ground or surface water bodies or local wastewater treatment plants are often difficult to permit if the effluent contains elevated NORM/TENORM.
- Interim treatment on site is often needed (e.g., evaporation, pre-treatment).
- Close consultation with the State agencies is recommended prior to making decisions that can impact closure of the site.

Records and Documentation/Operations/Close-out

Training

- A training program for employees and visitors (members of the public) should be considered, again commensurate with site conditions.
- The Plan should address new employee training, refresher training, and any emergency response or preparedness training.
- Records of training, and testing on the training should be maintained and available for review.

Training topics

- Topics can vary depending on the facility, but one should consider:
  1) the basics of radiation protection (ALARA),
  2) basic units and quantities,
  3) properties and hazards of NORM/TENORM at the facility,
  4) methods of dose monitoring,
  5) safe work practices,
  6) time, distance, shielding, and other methods to reduce dose,
  7) contact information in case of emergency,
  8) heath effects of radiation exposure,
  9) job-related specific training.

Audits

- Include an inspection and auditing program to ensure that correct work practices and procedures are being followed.
- Quality assurance is critical to ensure that instrumentation is properly calibrated, filtering and sampling equipment is operating properly,
  - therefore the RPP should have a companion Quality Assurance Plan.

Records

- Records management is important for liability purposes.
- Maintain records according to the retention requirements of your State.
- Records of calibrations and training should be maintained for at least 3 - 5 years.
- Dose records should be retained perpetually.

More Records

- Other records to be maintained include:
  - inventories of radioactive materials,
  - environmental and occupational sample and monitoring results,
  - site characterizations,
  - surface contamination surveys and release surveys for materials and equipment,
  - dose and risk assessments,
  - records and forms from implementation of the RPP.
- Dose records (or monitoring records if individual doses are not calculated) should be presented to employees annually, and at the end of employment.

Due Diligence

- The administrative and record keeping program will be graded to the scope of the NORM/TENORM program at a facility.
- The administrative program and record keeping program should demonstrate that the company has exercised due diligence in monitoring and controlling exposures to TENORM to ALARA levels.

Selected References

- ICRP 103
- ICRP TG-76 (in Press)
- ICRP Report 138 (Ethics)
- IAEA BSS GSR- Part 3 (2013)
- IAEA GSG-7 (Radiation Protection)
- IAEA GSG- 8 (Protection of the Public and Environment)
- IAEA GSG-9 (Discharges to the Environment)
- IAEA GSG-10 (Prospective Surveys)
- IAEA DS-459 (in press)
- NCRP Report 180
- MARLAP https://www.epa.gov/radiation/marlap-manual-and-supporting-documents