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Swiss Federal Nuclear Safety Inspectorate

Systematic Development of Radiation Protection in Nuclear Facilities

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Overview

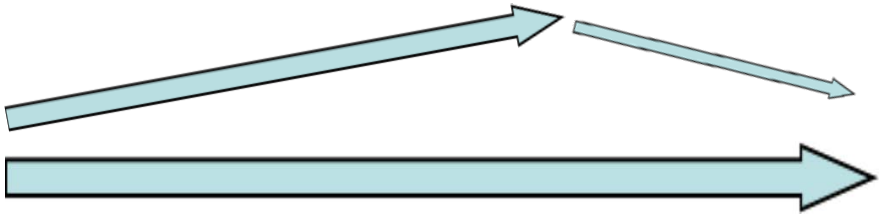
- RP as a multidimensional net of tasks (chaotic)
- RP main objectives and sub objectives (systematic)
- examples how to implement into practice

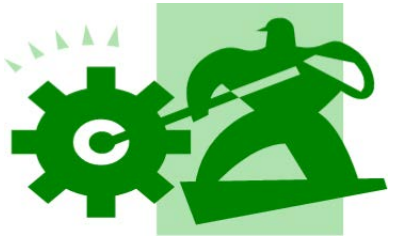
exposure situations in nuclear facilities

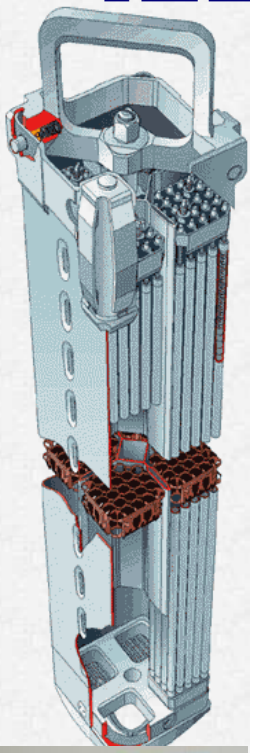
radiation sources

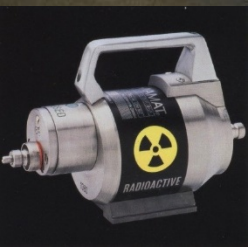
exposure pathways

persons and objects









source types

- new fuel elements
- fuel in reactor in operation
- spent fuel elements
- activated reactor incore fittings, vessel, cavity, instruments
- contamination and activation of coolant and its impurities
- contamination of primary cooling circuit
- radioactive gas/aerosol + water/soluble and unsoluble matter
- filters, ion exchange resins, rad. waste, contaminated tools
- radiography sources, X-ray equipment
- calibration and test sources
- thorium welding electrode, radon in air, other NORM sources
- accelerators, spallation sources, targets, beam dumps, activated beam equipment

states and conditions of sources

planned operation:

- commissioning
- power operation (incl. run up and down)
- outage
- post closure phase
- decommissioning
- storage

unplanned events:

- minor abbreviations from planned operation: leakages, …
- loss of control, incident, accident, emergency case

existing sources:

- existing waste deposits, contaminated areas (legacy from alumni)

practices with sources

handling (important to determine the possible path ways) :

- installation, modification, baring, stripping, milling, welding, …
- maintenance, non-destructive test, repairing…
- dismounting, separation, decontamination, conditioning, …

storage:

- temporary or long term,
- on-site, interim, deep geological

transportation:

- external (street, rail,…),
- company internal,
- reception and dispatch of radioactive goods

exposure pathways

pathways of radioactivity:

- spreading within systems and buildings
- aqueous and airborne release controlled via stack or uncontrolled via gaps
- distribution in air and water depending on weather a.s.o.
- transfer within biosphere and food chain

external exposure via direct and scattered radiation by:

- distant sources: point, surface, complex geometry
- airborne radioactivity: submersion, immersion
- contamination of skin

internal exposure by:

- inhalation
- ingestion
- incorporation via wound or skin

persons and objects to be protected

occupational exposed staff (which may accumulate >1mSv/y:

- permanent staff, outside workers, pregnant woman, young workers
- whole body, skin, extremities, eyes, other organs and tissue

persons on the facility site < 1mSv/y:

- staff not working in radiological controlled area (rca), young workers 16-18 a, visitors inside rca

population:

- adults, children, infant

environment:

- air, ground, water, plants, food

facility:

- inside & outside rca, inside main control room

exposure situations in nuclear facilities

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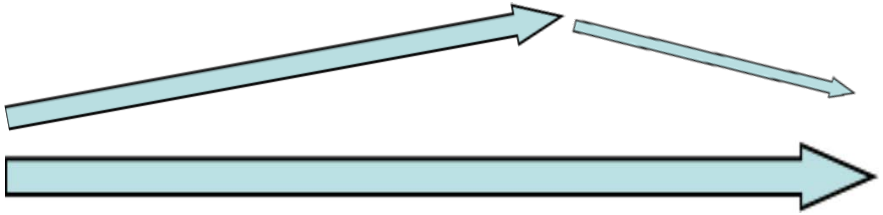
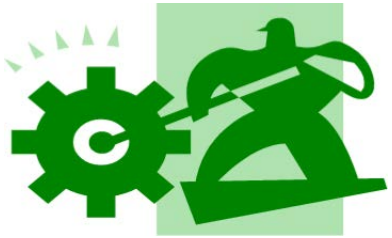




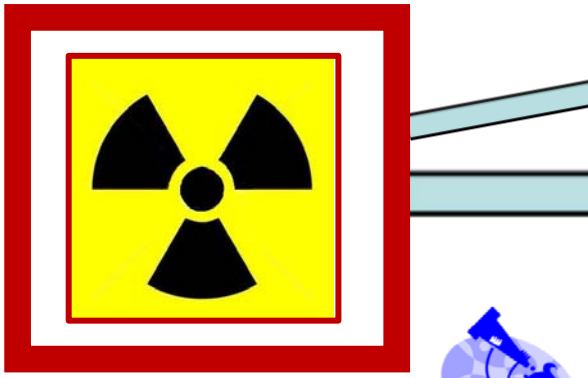
thausends of possible combinations

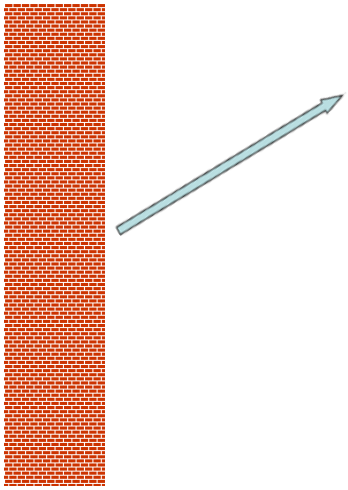
protection measures incl. monitoring

radiation sources

exposure pathways

persons and objects





thausends of different RP tasks

How to keep on the central theme without forgetting something when managing or supervising RP?

By using

Safety Objectives

fundamental safety objective
(IAEA Safety Standards Series No. SF-1)**:**

- protecting people and the environment from harmful effects of ionizing radiation

main safety objectives of nuclear safety :

(as determined in IAEA Safety Standard NS-R-1 / INSAG 10):

- control of criticality
- cooling of spent fuel
- enclosure of radioactivity
  (in spent fuel during power operation and emergency cases)

By using:

Safety Objectives

beside these standard objectives

following **Main Objectives of Radiation Protection** are:

1. **source term reduction**
2. **enclosure of radioactivity** (of all radioactive materials)
3. **avoiding internal exposure** (or limiting)
4. **control of external exposure** (limiting and optimization)

1. Source Term Reduction

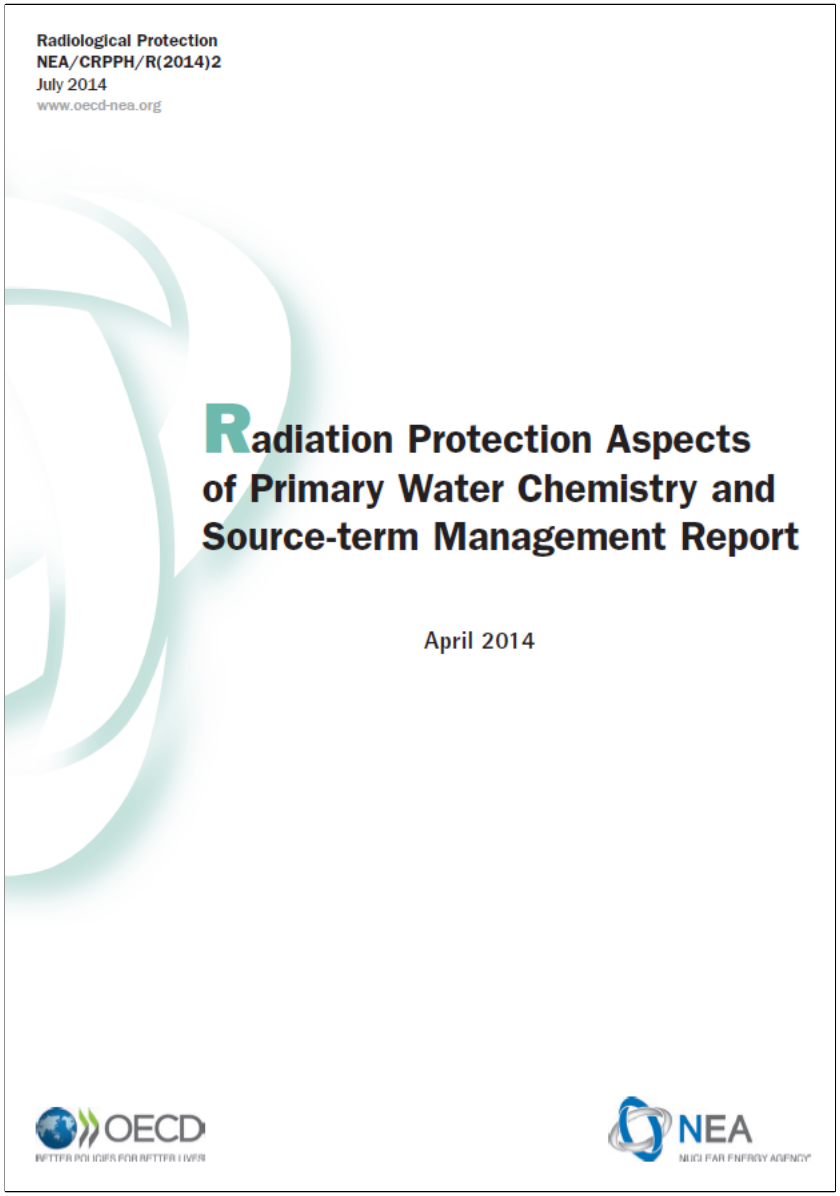
sub objectives:

1.1 avoiding of undesirable activation:

- exclusion of foreign material input in primary cooling circuit,
- using non activatable materials in contact with the coolant,
- elimination of impurities and corrosion products from coolant (water chemistry management)

1.2 removal of radioactive substances from coolant + PCC:

- design, operation and maintenance of reactor water clean up
- chemical operation modes for avoiding the deposition of activated material on PCC surface
- decontamination of PCC surface


Radiological Protection
NEA/CRPPH/R(2014)2
July 2014
www.oecd-nea.org
Radiation Protection Aspects of Primary Water Chemistry and Source-term Management Report
April 2014
OECD
NEA

1. Source Term Reduction

sub objectives:

1.3 limiting of contamination level in other systems, rooms and areas:

- ease of decontamination via design and construction (condition of surfaces, accessibility of surfaces and components)
- control of contamination by monitoring and decontamination

1.4 rad waste management:

- treatment of radioactive waste into heavily dispersible matrix, enclosed and shielded for safe storage as soon as possible
- transportation to interim or geological disposal

2. Enclosure of Radioactivity

(beside barriers as fuel matrix, fuel cladding, enclosure of primary cooling circuit, primary and secondary containment)
sub objectives :

2.1 integrity of external barriers of radiological controlled area to avoid uncontrolled releases (two-barrier-concept):

- external border of RCA by means of walls, locking doors, closed windows, gas and water tight joints, …
- underpressure system
- retention facilities as valve, air filters, gas decay channel, waste water treatment
- monitoring and control of releases via air and water pathway
- person contamination monitoring on the exit of rca with decontamination facilities (washbasin, shower,…)
- material clearance facilities on the exit of rca

2. Enclosure of Radioactivity

sub objectives (beside barriers as fuel matrix, cladding, primary cooling system, containment)**:**

2.2 integrity of internal barriers of radiological controlled area to avoid spreading radioactivity within rca:

- fixed and mobile internal barriers between rooms and areas by means of walls, trays, foils, …
- closed systems which contain or may contain radioactivity (example: circuits, tanks, hot cells, glove boxes, …) incl. isolation equipment (valves, plugs, taps) (two-barrier-concept: if the system has contact with a system which is open to the environment)
- underpressure system
- monitoring and control of person and material transfer
- water coverage

2. Enclosure of Radioactivity

sub objectives :

2.3 integrity of storage casks:

- depending on the risk as consequence of leakage: spend fuel storage casks, multilayer steel drum … plastic can with or without certification
- waste packages designed for deep geological repository

2.4 enclosure of radioactive sources:

- integrity certified and specified as ISO-classification number
- radioactive nuclide have to be enclosed by cladding or at least fixed in a solid matrix
- regular testing the contamination and condition of the cladding

2. Enclosure of Radioactivity

sub objectives:

2.5 integrity of transportation casks
(UN ADR, USA Orange Book, …):

- for external transportation on streets, rail, water or in air
  - indestructible against accidents
  - or limited activity inventory

- for internal transportation
  - on site outside rca
  - inside rca

3. Avoiding Internal Exposure

sub objectives:

3.1 classification and separation of rooms and areas inside rca depending on the contamination level of air and surfaces

3.2 rules about wearing personal protective equipment and about behaviour in RCA:

- avoiding incorporation via nose and mouth
- avoiding contamination of skin and hair

3.3 limiting internal exposure after suspicion of intake:

- triage and monitoring
- treatment: skin decontamination, prophylactic and therapeutic agents (like potassium-iodine)

4. Control & Optimization of Ext. Exposure

sub objectives:

4.1 categorization of rooms and areas and ruling/controlling the access

- categorization by highest dose rate at normal operation including extraordinary situations which may occur within the lifetime of facility taken from dose rate estimation by computer code and dose rate mappings

4.2 realisation of fixed and mobile shielding

4.3 concept for exclusion zones and lock up rooms

4.4 maximize distance source – person

4.5 minimize time of stay within radiation field

Defence in Depths Levels

beside of safety objectives for each combination of sources/pathway/person following levels have to be considered when determining protection measures

Level	Description	Example in RP: Handling radioactive liquids
1	avoiding abbreviations from planned operation	transportation and storage of radioactive liquids in break-proof casks, handling within a tray, using gloves and other protection
2	control of abbreviation from planned operation	periodical monitoring floors, equipment, hands and foot about contamination and if necessary decontamination
3	control of design basis accident	design specification: tight enclosure of RCA floor (liner in concrete, dense and decontaminable floor surface, sump …)
4	control of accidents beyond design	fixation/absorption of spilled liquid
5	mitigation of severe accidents	stop of taking drinking water from groundwater which may be affected

The checklist of safety objectives (incl. sub sub items) and levels could be helpful for following actions:

- developing RP program (by RPM), giving advise (by RPE) and/or establishing legislation/guidelines (by regulatory body)
- educating and training radiation worker, RPO and RPE
- planning a project or work and asking for license or permission
- permitting (by RPM) and/or licensing or authorizing (by regulatory body)
- preparing the planned operation
- instructing and briefing the involved persons
- managing, monitoring and controlling during performance
- preparing for and responding to emergency situations
- assessing and benchmarking (and giving feedback)
- inspecting, supervising, checking (by regulatory body or RPE)

Systematical Approach of Safety Objectives and Defence in Depth Levels

Examples for using in practice:

- planning and appraising a project for the nuclear safety during the operational phase of a deep geological repository
- checklist as an auxiliary device in the emergency preparedness program of NPP
- determining the training curriculum of the E&T course for RP technicians
- planning of inspections and assignment of findings to a matrix of objectives and levels

- Merci, für`s Zuelose
- thank you, for your attention

for more information please visit:

www.ensi.ch

www.ifsn.ch

http://twitter.com/#!/ENSI_CH

Further Detailed Information on RP Objectives, Measures and Monitoring

1.1:
1.2:
1.3:
1.4:
2.1:
2.2:
2.3:
2.4:
2.5:
3.1:
3.2:
3.3: limiting internal exposure

TMT-Handbook from NRPA (www.nrpa.org)

4.1:
4.2:
4.3