RADIATION PROTECTION IN NUCLEAR POWER PLANTS

Celso Osimani

6th International Summer School: Operational issues in Radioactive Waste Management and Nuclear decommissioning

JRC-Ispira, Italy, 8-12 September 2014
Contents

• The principles of radiological protection: optimization, justification and limitation
• Objectives of the radiological protection in NPP
• Radiation protection aspects in design
• Radiation protection of site personnel in operational states
• Protection of the public during plant operation
The principles of radiological protection: justification, optimization and limitation

• **Justification** of a practice: “No practice involving exposures to radiation should be adopted unless it produces sufficient benefit to the exposed individuals or to society to offset the radiation detriment it causes”

• **Optimization** of a practice: “The magnitude of individual doses, the number of people exposed, and the likelihood of incurring exposures where these are not certain to be received should all be kept as low as reasonably achievable, economic and social factors being taken into account”.

• **Limitation** of doses: “The exposure of individuals resulting from the combination of all the relevant practices should be subject to dose limits, or to some control of risk in the case of potential exposures”.

6th International Summer School, JRC-Ispra, Italy, 8-12 September 2014
Objectives of the radiological protection in NPP

Effective radiation protection is a combination of:

✓ *good design*,
✓ *high quality construction and*
✓ *proper operation*

«to ensure that in all operational states radiation exposure within the installation or due to any planned release of radioactive material from the installation is kept below prescribed limits and as low as reasonably achievable, and to ensure mitigation of the radiological consequences of any accidents»
Objectives of the radiological protection in NPP

Authorized dose limits and dose constraints for operational states

• The design of the nuclear power plant should ensure that authorized dose limits and dose constraints for site personnel and the public will not be exceeded over specified periods (e.g. monthly, quarterly or annually) in operational states (normal operation and anticipated operational occurrences) and also in decommissioning.

• The authorized annual dose constraints for members of the public apply to the average dose to the critical groups of the population.

AN AUTHORIZED DOSE LIMIT OR DOSE CONSTRAINT IS ONE THAT HAS BEEN ESTABLISHED OR FORMALLY ACCEPTED BY A REGULATORY BODY.
Radiation protection aspects in design

Source of radiation

• The magnitudes and locations of the sources of radiation in operational states should be determined in the design phase.

• The main sources that cause radiation exposure in normal operation are:
  – the reactor core and vessel;
  – the reactor coolant and fluid moderator system;
  – the steam and turbine system;
  – the waste treatment systems;
  – irradiated fuel;
  – the storage of new fuel; decontamination facilities;
  – miscellaneous sources such as sealed sources used for non-destructive testing.
Radiation protection aspects in design

Source of radiation

• The largest sources are:
  – the reactor core
  – irradiated fuel and
  – spent resins

• The magnitudes, locations, possible transport mechanisms and transport routes of the sources of potential radiation exposure under accident conditions should also be determined in the design phase of the plant

Design should ensure that personnel are not exposed to direct radiation from these sources
Radiation protection aspects in design

Human resource

Specialists in radiation protection should be closely involved in the design process because of their:

– Expertise in all areas that affect the production of radioactive material and its transport on the plant and its transport in the environment;

– Ability to evaluate the different sources of radiation in the plant and the resulting doses using the best available analytical methods and data from relevant operating experience;

– Familiarity with the relevant regulations, guidance and best practices;

– Familiarity with maintenance, in-service inspection and other work in high radiation areas that make a major contribution to the radiation exposure of site personnel.

– Because chemical parameters are very important in controlling the radioactive sources in the plant, specialists in radiochemistry should also be involved in the design process. Materials specialists should be involved in controlling the source term due to corrosion products.
Radiation protection aspects in design

Targets and strategy

• The targets are:

✓ Annual collective dose targets and individual dose targets for site personnel;
✓ Annual individual dose targets for members of the public.

• The methods used for calculating doses should be subject to the approval of the regulatory body.
Radiation protection aspects in design

Targets and strategy

The elements to take in account are:

• experience at relevant plants that have a good operating record in terms of radiation protection
• assessment of:
  o materials for the primary circuit
  o type of fuel
  o Burn-up
• accident conditions
• radiation protection aspect for members of the public
• radiation protection aspect for site personnel
Radiation protection aspects in design

Targets and strategy

Example of the strategy for the reduction of exposures in the (dashed of a PWR):

6th International Summer School, JRC-Ispra, Italy, 8-12 September 2014
Radiation protection of site personnel in operational states

• **Control of sources of radiation**
  – Corrosion products
  – Fission products
  – Activity in pond water

• **Plant layout**
  – Classification of areas and zones
  – Changing rooms, changing areas and related facilities
  – Control of access and occupancy
Corrosion products

- Corrosion products contained in the coolant are activated as a result of temporary deposition in the core and during the normal passage of the coolant through the core.
- Corrosion products are deposited in other parts of the primary circuit (i.e. external pipe work and heat exchangers).
- Corrosion products should be minimized by the following means:
  1. Reducing the corrosion and erosion rate of circuit materials by the proper selection of materials and the control of the coolant chemistry;
  2. Selection of materials to minimize the concentration of nuclides (particularly of cobalt in steel) that are known from experience to become major sources of radiation;
  3. Providing removal systems (such as particulate filters and ion exchange resins);
  4. Minimizing the concentration in feedwater nuclides that can be activated in the core.
Radiation protection of site personnel in operational states

Control Of Sources Of Radiation

**Corrosion products**

- Application of optimization principle reducing the presence of materials with high cobalt content (i.e. stellite)
- In water cooled reactors, corrosion products are removed by treating the water with ion exchange resins to remove soluble species and by the installation of particulate filters
- Systems to remove corrosion products, both radioactive and non-radioactive, should be provided for the primary coolant for both water cooled and gas cooled reactors (GCRs), especially for advanced gas reactor (AGR), where active corrosion products arise in the coolant circuit primarily from the oxidation of fuel cladding
Radiation protection of site personnel in operational states

Control Of Sources Of Radiation

Corrosion products

Flow chart of phenomena required to be considered in modelling the behaviour of corrosion products
Radiation protection of site personnel in operational states

Control Of Sources Of Radiation

Fission products

• Defects in the fuel cladding may result in the release of fission products to the coolant, which can add significantly to the activity of the coolant and contamination of the coolant circuit

• Defective fuel elements should be removed as soon as possible after a failure occurs to reduce the exposure of site personnel from this source

• Where refuelling is not on-load, means should be provided for detecting failed cladding, appropriate limits should be set for the coolant activity and the plant should be shut down within a prescribed time interval if these are exceeded
Radiation protection of site personnel in operational states

Control Of Sources Of Radiation

*Activity in pond water*

• Water in the fuel storage pond should be maintained at a low activity level by means of a cleanup system consisting of:
  – particulate filters
  – ion exchange resins

• Where modifications are made to the fuel storage pond of a reactor in which there have been major fuel failures, the design should provide a means for containing any radioactive material that might otherwise leak into the pond water by bottling the fuel or some equivalent handling.
Radiation protection of site personnel in operational states

Plant layout

Classification of areas and zones

• Any area in which specific protective measures are required for normal working conditions and for limiting potential exposures in relation to expected doses

• Definition of different zones depending on dose rates or levels of contamination:
  - Controlled areas
  - Supervised areas

• Demarcation of areas possibly through existing struuctural boundaries

• Appropriate information should be displayed at access point to controlled areas and specified zones:
  - Warning symbols (ISO)
  - Radiations levels
  - Zone category
  - Enter procedures or restrictions
Radiation protection of site personnel in operational states

Plant layout

Classification of areas and zones

• Each controlled area should have a minimum number of access and exit points for personnel and for materials and equipment

• Provision should be made for controlling the exit(s) from the controlled areas and for monitoring persons and equipment leaving the controlled areas

• Controlled areas should be divided into zones on the basis of
  – the anticipated radiation levels
  – radioactive contamination levels (i.e. dose rates and activity concentrations for surface or airborne radionuclides)

• The greater the radiation or contamination related risks of a zone, the greater is the need to control access to that zone for the purpose of ensuring compliance with individual annual dose limits and taking account of dose constraints
Radiation protection of site personnel in operational states

Plant layout

Classification of areas and zones

- In the plant design stage, all rooms should be classified into planning zones on the basis of their likely dos rates, surface contamination levels and concentrations of airborne radionuclides. These zones constitute the **controlled areas**.

- The general practice is to divide the controlled areas of a nuclear power plant into three or more radiation and contamination zones, including zones that may not be accessible during operation.
Radiation protection of site personnel in operational states

Plant layout

Classification of areas and zones – Example of restriction for the entrance to controlled area

FREE PERMANENCE

PUBLIC

WORKERS B

LIMITED PERMANENCE AREA

WORKERS A

RESTRICTED PERMANENCE AREA

WORKERS A + AUTHORIZATION DIRECTOR

PROHIBITED PERMANENCE AREA
Radiation protection of site personnel in operational states

Plant layout

Classification of areas and zones
A good example of zoning that addresses radiation, surface contamination and airborne contamination is given by the classification of zones within the controlled area in Swedish nuclear power plants:

<table>
<thead>
<tr>
<th>Access requirement</th>
<th>Design dose equivalent rate (μSv/h)</th>
<th>Mean</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uncontrolled areas on-site</td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Continuous (&gt; 10 person-hours per week)</td>
<td></td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>1–10 person-hours per week</td>
<td></td>
<td>10</td>
<td>50</td>
</tr>
<tr>
<td>&lt; 1 person-hours per week</td>
<td></td>
<td>100</td>
<td>500</td>
</tr>
<tr>
<td>1–10 person-hours per year</td>
<td></td>
<td>1000</td>
<td>10 000</td>
</tr>
<tr>
<td>&lt; 1 person-hours per year</td>
<td></td>
<td>10 000</td>
<td>*</td>
</tr>
</tbody>
</table>

* Dose rates in excess of 10 mSv/h are acceptable provided that the exposure time is correspondingly short.

<table>
<thead>
<tr>
<th>Zone identification</th>
<th>Blue zone</th>
<th>Yellow zone</th>
<th>Red zone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radiation zones</td>
<td>&lt; 25 μSv/h</td>
<td>25–1000 μSv/h</td>
<td>&gt; 1000 μSv/h</td>
</tr>
<tr>
<td>Surface contamination zones</td>
<td>For total β</td>
<td>40–1000 kBq/m²</td>
<td>&gt; 1000 kBq/m²</td>
</tr>
<tr>
<td></td>
<td>For total α</td>
<td>4–100 kBq/m²</td>
<td>&gt; 100 kBq/m²</td>
</tr>
<tr>
<td>Zones for airborne contamination</td>
<td>1 DAC *</td>
<td>1–10 DAC</td>
<td>&gt; 10 DAC</td>
</tr>
</tbody>
</table>

DAC: derived air concentration.
Radiation protection of site personnel in operational states

Plant layout

*Changing rooms, changing areas and related facilities*

- Within the controlled area, changing areas should be provided at selected places to prevent the spread of vc contamination during maintenance and normal operation.

- The facilities included in these areas should correspond to the requirements for access to the potentially more contaminated of the two areas and on the anticipated contamination levels.

- Where justified by the possible levels of air contamination, consideration should be given to the provision of permanent changing areas with decontamination facilities for personnel, monitoring instruments and storage areas for protective clothing.

- Within the changing rooms, a physical barrier should be provided to separate clearly the clean area from the potentially contaminated area. The changing rooms should be large enough to meet the needs during periods of maintenance work, and allowance should be made for temporary personnel employed as contractors.
Radiation protection of site personnel in operational states

**Plant layout**

*Control of access and occupancy*

- The access by personnel to areas of high dose rates or high levels of contamination should be controlled by the provision of lockable doors and, where appropriate, the use of interlocks.

- The routes for personnel through radiation zones and contamination zones should be minimized to reduce the time spent in transit through these zones.

- To minimize the radiation doses to personnel working in the controlled area and the spread of contamination, the layout of the controlled area should be so designed that personnel do not have to pass through areas of higher radiation zones to gain access to areas of lower radiation zones.

- The design should be such as to limit the possible spread of contamination and to facilitate the erection of temporary containments.
Radiation protection of site personnel in operational states

**Plant layout**

*Control of access and occupancy - Radiological passport and work permits*

<table>
<thead>
<tr>
<th>BEFORE</th>
<th>DURING</th>
<th>AFTER</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Updated dosimetric data</td>
<td>• Wear official external dosimeter (TLD)</td>
<td>• Control of external contamination</td>
</tr>
<tr>
<td>• Medical fitness</td>
<td>• Radiological Work Permit (RWP)</td>
<td>• Exit control of internal contamination (WBC)</td>
</tr>
<tr>
<td>• Training</td>
<td>• Wear protective clothes/respiratory equipment</td>
<td>• Fill in the Radiological Passport</td>
</tr>
<tr>
<td>• Entrance control of internal doses</td>
<td>• Observance on the transit zone</td>
<td>(Doses, specific training, internal dose control, facility data)</td>
</tr>
<tr>
<td></td>
<td>• Follow RP instruction in RWP</td>
<td></td>
</tr>
</tbody>
</table>
Radiation protection of the public during plant operation

The important contributors to doses to members of the public are typically:

- $^{14}\text{C}$, $^3\text{H}$ and $^{85}\text{Kr}$, because the best practicable means available for their removal by waste treatment systems are not efficient and because their half-lives are long;
- $^{41}\text{Ar}$ is an important contributor, although its half-life is short, because it is released in large volumes of air (in venting of the containment during operation for agrs and some PWRs);
- $^{133}\text{Xe}$ is a weak gamma emitter but it may be of importance when the reactor has been operating with a significant number of defects in the fuel cladding;
- Iodine, caesium and corrosion products
Radiation protection of the public during plant operation

- Discharge Criteria
- Source Reduction
- Effluent Treatment Systems
- Shielding
Radiation protection of the public during plant operation

**Discharge Criteria**

- Plant operators should ensure that:
  - doses to members of the public arising from radioactive substances in the effluents and from direct radiation due to the plant do not exceed the prescribed limits (specific discharge limits for the most significant radionuclides)
  - the optimization principle is applied

- A careful analysis should be made of the operational experience so as to take into account possible differences in the design of similar units, such as in the types of alloy in contact with the primary coolant.

- Three types of effluents should be considered: liquids (mainly aqueous), gases from process systems and ventilation air.
Radiation protection of the public during plant operation

Source Reduction

• Implementation of actions to eliminate unnecessary radioactive materials

• Build-up of radioactive residues: control over the selection of materials and chemical parameters for piping and components of the primary system

• Out-of-core radiation field: Transportation of corrosion and precursors of activation products in the primary system (welding rods, screws and nuts) $\rightarrow$ damaging of components

• Minimization of Co from neutron irradiation: removal during modification of piping systems or maintenance
Radiation protection of the public during plant operation

Effluent Treatment Systems

• The flows and the activity concentrations of liquid and gaseous effluents need to be monitored and controlled to ensure that the authorized discharge limits are not exceeded.

• The best practicable means should be provided for:
  • Liquid treatment systems
  • Gas treatment systems

Following recommendations and information on the calculation of the exposure of the public resulting from radioactive discharges

(IAEA Safety Standards Series NS-G-3.2)
Radiation protection of the public during plant operation
Effluent Treatment Systems

Liquid treatment systems
The major sources of contaminated water that require treatment include:
• primary coolant that is discharged for operational reasons;
• floor drains that collect water that has leaked from the active liquid systems and fluids from the decontamination of the plant and fuel flasks;
• water that is used to backflush
• filters and ion exchangers
• leaks of secondary coolant
• laundries and changing
• room showers; and chemistry laboratories
Radiation protection of the public during plant operation

**Effluent Treatment Systems**

*Liquid treatment systems*

• Proven methods of treating the radioactive waste water to reduce radioactive contamination use:
  - mechanical filtration
  - ion exchange
  - centrifuges
  - distillation or chemical precipitation.

• Radioactive water may be present in the secondary (turbine) circuit of a PWR as a result of operating with some primary circuit to secondary circuit leakage in the steam generator. Treatment of the water from the secondary circuit may be necessary to reduce the activity before the water is discharged.

• For water that cannot be recycled into the plant, provision should be made to reduce its radioactive contamination to such levels that the design target doses and discharge limits.
Gas treatment systems

• The management system for gaseous waste should be designed to collect all the radioactive gas that is produced in the plant and to provide the necessary treatment before it is discharged to the environment.

• In the case of noble gases, the discharge of radioactive gas should be delayed where there is a potential for the gas to contain short lived radionuclides such as $^{133}\text{Xe}$ using delay tanks or pipes or carbon delay beds.

• The removal of long lived noble gases, such as $^{85}\text{Kr}$, is often not justified but, if necessary, it can be achieved by using cryogenic devices of an appropriate design and choice of material.
Radiation protection of the public during plant operation

Effluent Treatment Systems

Gas treatment systems

• The isotopes of iodine, which usually have the greatest radiological impacts, are commonly removed by means of charcoal filters
• Particulate material from both the management system for gaseous waste and the ventilation systems should be removed using filters
• It is a good practice to ensure that all gas discharged from the plant that may be radioactive passes through high efficiency filters
• All radioactive gaseous effluents discharged to the atmosphere should be released from elevated points, with the topography of the site taken into account
Radiation protection of the public during plant operation

Shielding

The provision for shielding that is incorporated into the design to protect site personnel during plant operation and to protect the public under accident conditions from direct or scattered radiation should also be designed to ensure adequate protection of the public during plant operation.

It may be necessary to consider ‘sky shine’, particularly if buildings have roofs of light construction, and to restrict public access to the site by providing barriers such as fences.
THANK YOU FOR ATTENTION
RECORD KEEPING

• The operating organization must:
  • collect and store records related to important safety matters;
  • Maintain up to date historical information (including RPP).
• Records should be readily retrievable and easily understood at a later stage
• The minimum period of retention should be specified by the regulatory body
• Record concerning important safety matters should be stored in at least two separated places
GUIDELINES FOR ESTIMATING RADIATION DOSE RATES DURING PLANT OPERATION

Calculation of dose rates should be to evaluate the source strength and its distribution.

1. Calculations concerning the transport of radionuclides and their redistribution when activated corrosion products or fission products are carried in the reactor coolant (liquid or gas) and deposited away from the point of origin.

2. Calculation of the fluence rate (flux) at the dose point as a result of radionuclide transport from the source to the dose point and to calculate the radiation dose rate by multiplying the flux by the appropriate conversion factors.
SOURCE AND PROPAGATION OF RADIATION

• Reactor core
• Reactor components
• Activity of the coolant
• Radiation propagation through shielding
Reactor core

Reactor core and the surrounding materials that are activated by neutrons that escape from the core, are the major source of radiation in an operational plant.

• The fundamental step in evaluating source strengths is to determine:
  ➢ the fission rate
  ➢ the neutron emission rate
  ➢ the spatial and energy distribution of the neutron flux within the core

• This may be achieved by using computer codes in which account is taken of
  ➢ the spatial distribution of materials in the core and changes in fuel composition
  ➢ the production of actinides and fission product poisons,
  ➢ the changes in control poisons (due to the positions of control rods, the heights of liquid moderators and poison concentrations) with fuel burnup
Reactor components
Depending upon the design, many of the components within the reactor vessel are regularly removed and become sources in locations outside the vessel:
- control rods
- spent fuel
- neutron sources,
- in-core instruments
- internals of the reactor.

- The source terms for all these components that are used for the design basis for the shielding should be based on the maximum activities that could occur over the lifetime of the plant.
- This is likely to be for the maximum rated fuel assembly and the end of life activity for the other components.
SOURCE AND PROPAGATION OF RADIATION

Activity of the coolant

- Corrosion products
- Fission products
- Activation products

For most types of reactor, corrosion products are the major contributors to radiation levels at the plant during shutdown and thus to the occupational exposure of personnel.

*In PWRs, for example, the activation of 10 g of $^{59}$Co and 5 kg of $^{58}$Ni in primary circuit components gives rise to 90% of the dose rates and occupational exposure at the plant*
SOURCE AND PROPAGATION OF RADIATION

Radiation propagation through the shielding

- Radiation propagation through the shielding calculations should be carried out for the propagation of radiation (mainly gamma rays) from the sources through simple, single material bulk shielding, or through shields of complicated geometry containing regions of low density (gases and voids) and low attenuation that present preferential transmission paths with scattering surfaces.
- In the design of shielding to achieve acceptable dose rates, the calculation for determining attenuation is begun for a design that is estimated on the basis of previous experience.
- The results should be evaluated in the light of the principle of the optimization of protection with regard to the site personnel and should then be compared with limiting values established for maintaining the integrity of materials, with any radiation effects taken into account.
- If necessary, the process should be repeated to achieve acceptable radiation levels.
THANK YOU FOR ATTENTION
Monitoring of individuals and workplace (1/4)

- **Routine monitoring:**
  - for continued operations;
  - No procedures reassessment needed.
- **Task-related monitoring:** for providing immediate information on the execution of the operation for a particular task.
- **Special monitoring:** abnormal operation conditions (incident or accident)
Monitoring of individuals and workplace (2/4)

Calibration service and Quality Assurance for monitoring instruments used in the RPP:
• Quality of equipment and instruments;
• Frequency of calibration;
• Frequency of maintenance;
• Traceability of usage

• Permanently installed instrumentations;
• Hand-held instrumentation
Monitoring of individuals and workplace (3/4)

External exposure

• Workplace monitoring:
  • Database of measurements.
  • Labeling and identifications.
  • Preliminary dose evaluation.

• Individual monitoring:
  • Passive dosimetry (TLD, Film-badge).
  • Electronic dosimetry.
Internal exposure

- Workplace monitoring:
  - Direct air measurement.
  - Indirect air sampling.
  - Personal air monitoring.

- Individual monitoring:
  - In vivo analyses: WBC
  - In vitro analyses: excreta
  - Internal contamination evaluation through models.
Health surveillance programme

• *Who ensure the health surveillance? The operating organization in accordance with the rules and recommendations established by the Regulatory Authority*

1. Initial medical examination
2. Continuous surveillance during operation
3. Programme update according to changes in working conditions
4. Dose records for each worker.
Protective clothing and protective equipment

- After use protective clothing and respiratory equipment should be considered contaminated and should be handled accordingly.
- Training and qualification of personnel in the use of protective equipment is required!
Training

«The operating organisation shall ensure, for all workers engaged in activities that involve occupational exposure, that appropriate training in protection and safety be provided, as well as periodic retraining and updating»

(IAEA, NS-G-2.7)

When?
• Normal operation conditions
• Periodic emergency exercises

How?
• Manuals, written documents
• Lectures and discussions
• Operating procedures
• Demonstrations, training on mock-ups
• Job training and rehearsals

The regulatory body should provide guidance on qualification and requirements for plant personnel
Response to an emergency

• Definition of responsibilities: personnel designated to respond (on and off site)
• Criteria for executing emergency plans → emergency procedures
• Mitigation of impact
• Medical, fire fighting and police assistance
• Protection of people on off the site
• Information to members of the public
• Recovery, re-entry and post-accident operations

Use of reference levels, no longer of dose limits
Response to an emergency
International Nuclear Event Scale - INES

Basic Structure of the Scale

Criteria given in italics are broad indications only. Detailed definitions are provided in the INES User’s Manual.

<table>
<thead>
<tr>
<th>Criteria or Safety Attributes</th>
<th>Off-Site Impact</th>
<th>On-Site Impact</th>
<th>Defence in Depth Degradation</th>
</tr>
</thead>
<tbody>
<tr>
<td>7 MAJOR ACCIDENT</td>
<td>MAJOR RELEASE. WIDESPREAD HEALTH AND ENVIRONMENTAL EFFECTS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 SERIOUS ACCIDENT</td>
<td>SIGNIFICANT RELEASE. LIKELY TO REQUIRE FULL IMPLEMENTATION OF PLANNED COUNTERMEASURES</td>
<td></td>
<td>SEVERE DAMAGE TO REACTOR CORE/CEMENTOLOGY BARRIERS</td>
</tr>
<tr>
<td>5 ACCIDENT WITH OFF-SITE RISK</td>
<td>LIMITED RELEASE. LIKELY TO REQUIRE PARTIAL IMPLEMENTATION OF PLANNED COUNTERMEASURES</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 ACCIDENT WITHOUT SIGNIFICANT OFF-SITE RISK</td>
<td>MINOR RELEASE. PUBLIC EXPOSURE OF THE ORDER OF PRESCRIBED LIMITS</td>
<td></td>
<td>SIGNIFICANT DAMAGE TO REACTOR CORE/CEMENTOLOGY BARRIERS EXPOSURE OF A WORKER</td>
</tr>
<tr>
<td>3 SERIOUS INCIDENT</td>
<td>VERY SMALL RELEASE. PUBLIC EXPOSURE AT A FRACTION OF PRESCRIBED LIMITS</td>
<td></td>
<td>SEVERE SPREAD OF CONTAMINATION. MILD EXPOSURE TO WORKERS</td>
</tr>
<tr>
<td>2 INCIDENT</td>
<td>SIGNIFICANT SPREAD OF CONTAMINATION. OVEREXPOSURE OF A WORKER</td>
<td></td>
<td>INCIDENTS WITH SIGNIFICANT FAILURES IN SAFETY PROVISIONS</td>
</tr>
<tr>
<td>1 ANOMALY</td>
<td>ANOMALY BEYOND THE AUTHORIZED OPERATING REGIME</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 DEVIATION</td>
<td>NO SAFETY SIGNIFICANCE</td>
<td></td>
<td>NO SAFETY RELEVANCE</td>
</tr>
</tbody>
</table>

OUT OF SCALE EVENT

6th International Summer School, JRC-Ispra, Italy, 8-12 September 2014
Response to an emergency Communication with the public

• The public must be provided with transparent, timely, objective, accurate, clear and consistent information.

• The key is the effective preparedness for a radiological emergency:
  • Selection and training of spokespersons
  • Public perceptions and psychological impact must be taken into account
  • Monitoring news and media (misleading information might cause chaos!)

BUILDING PUBLIC’S TRUST ➔ ENGAGING WITH STAKEHOLDERS
THANK YOU FOR ATTENTION