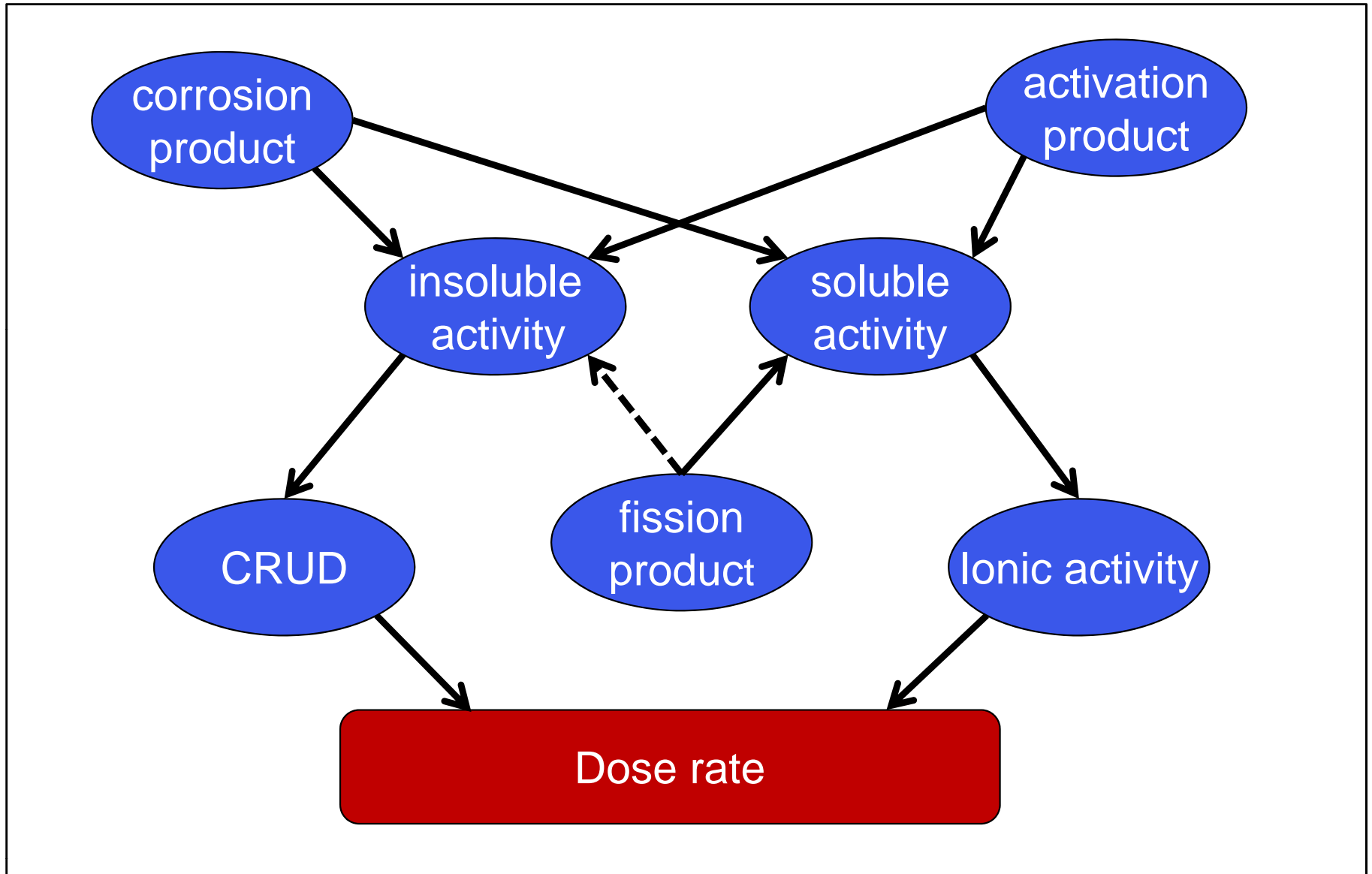


**TÜV SÜD Industrie Service GmbH**  
F. L. Karinda, C. Schauer, R. Scheuer

# Chemical decontamination in nuclear systems Radiation protection issues during planning and realization

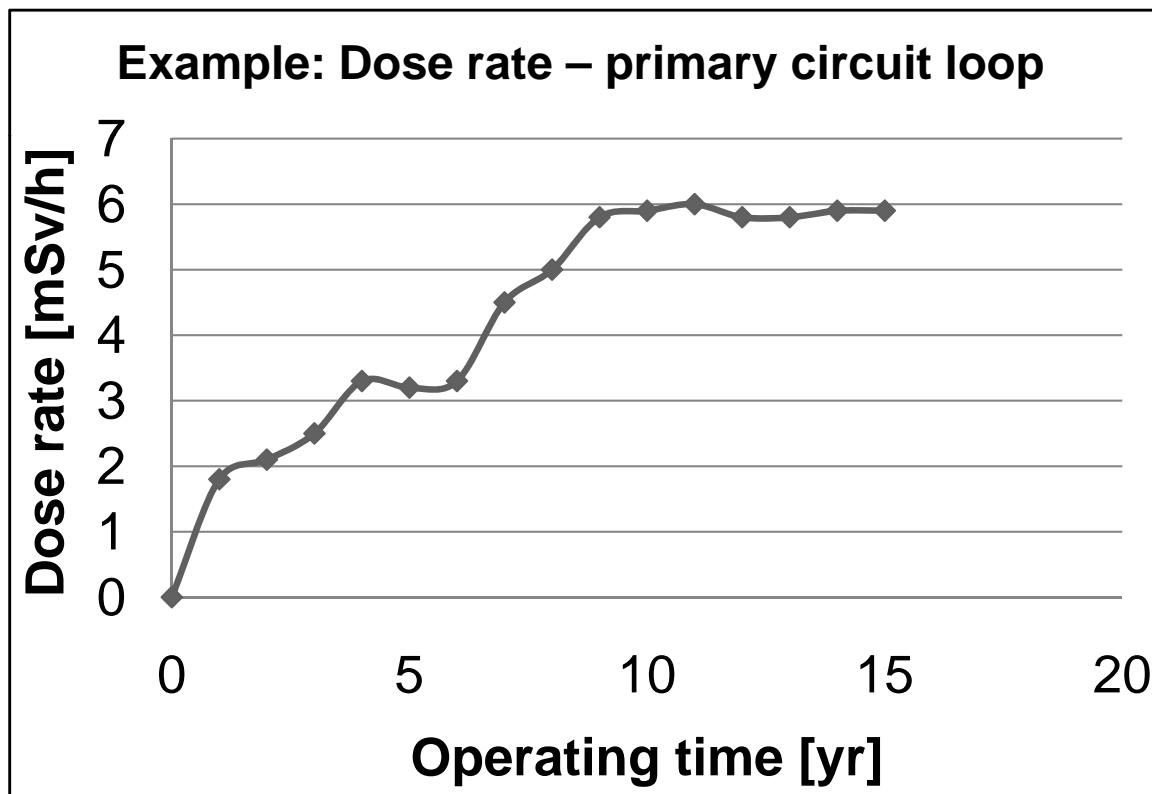
# Introduction



# Introduction

- Dose rate of systems and components rises with the operation of nuclear power plants

➡ Increase of collective doses



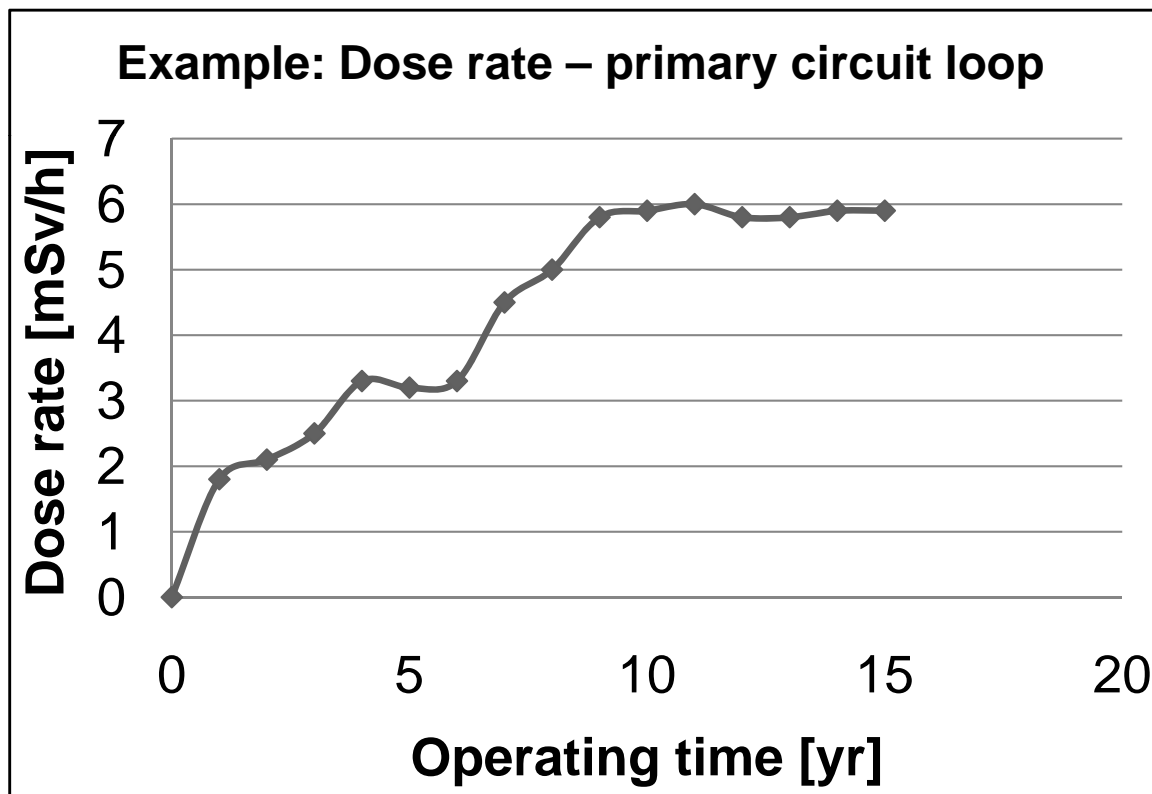
## Protection objective

Reduction of occupational exposure during maintenance

# Introduction

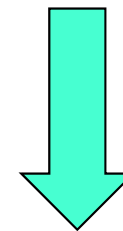
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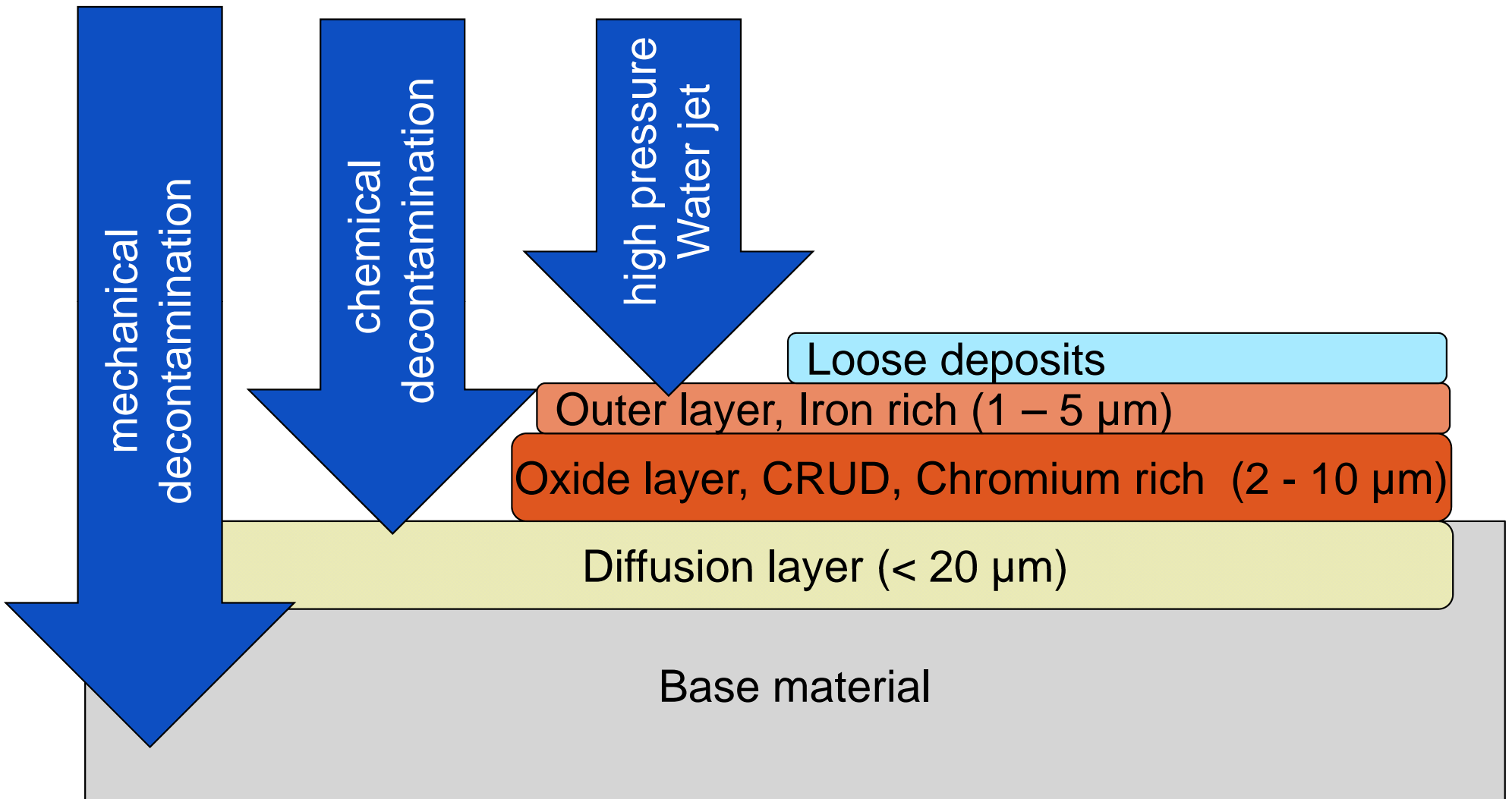
**Decontamination**

# Decontamination techniques

- High-pressure water jet decontamination
- Mechanical decontamination
- Chemical decontamination
  - Chemical process by means of oxidation and reduction
  - Multi cycle process
  - Example process: CORD (Areva)  
(Chemical, Oxidizing, Reduction, Decontamination )



# Decontamination techniques



# Decontamination techniques

closed systems:

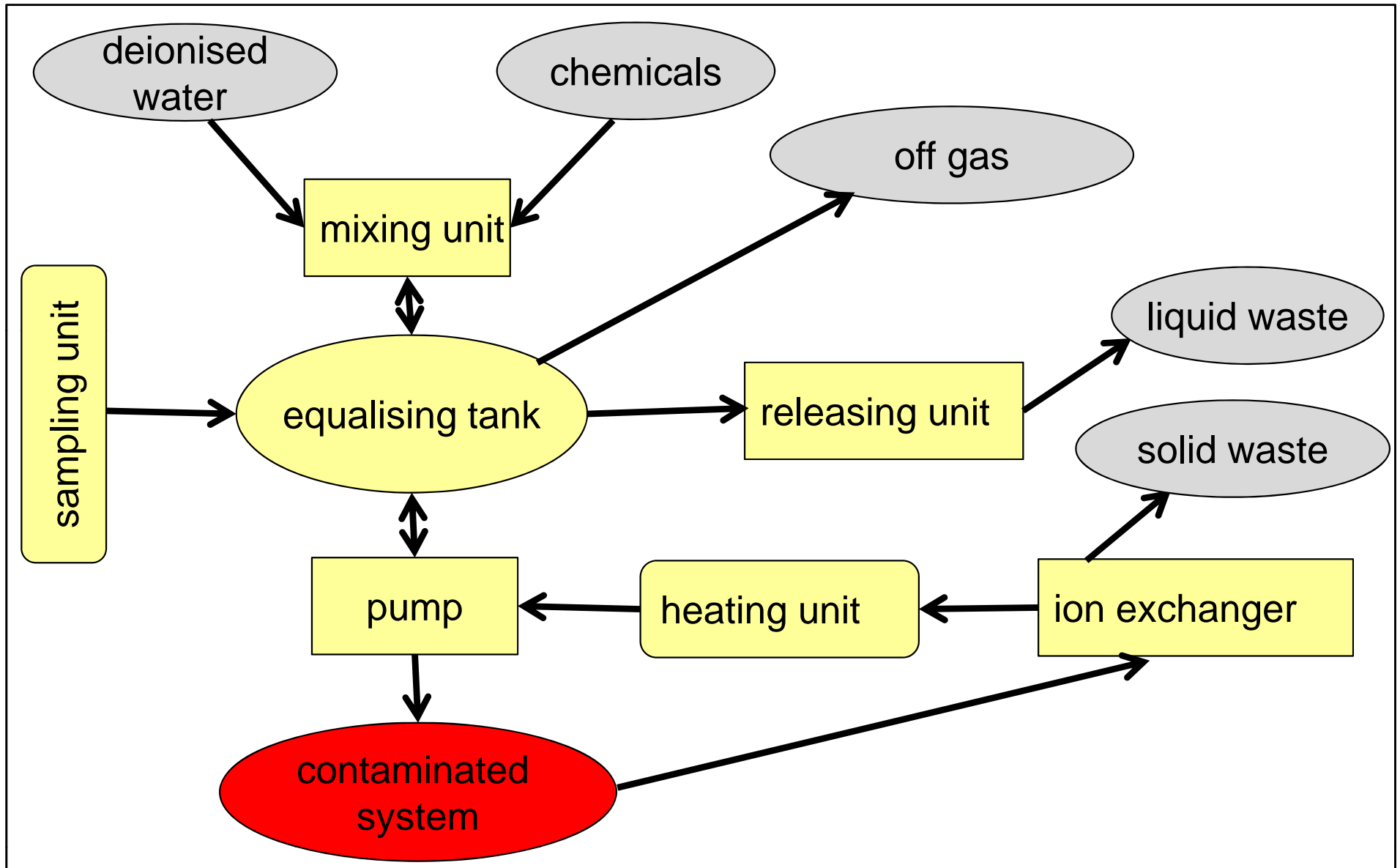
High-pressure water	Mechanical	Chemical
<p><b>Pros</b></p> <ul style="list-style-type: none"><li>● Fast</li><li>● Good decontamination results</li><li>● Water is compatible with most materials</li></ul> <p><b>Cons</b></p> <ul style="list-style-type: none"><li>● Access; Geometry</li><li>● Blasting unit can get stuck</li></ul>	<p><b>Pros</b></p> <ul style="list-style-type: none"><li>● Fast</li><li>● Well established</li><li>● Automation possible</li></ul> <p><b>Cons</b></p> <ul style="list-style-type: none"><li>● Destructive</li><li>● High particle production</li><li>● Waste</li></ul>	<p><b>Pros</b></p> <ul style="list-style-type: none"><li>● Good decontamination results</li><li>● Small waste volume</li><li>● Scalable</li><li>● Complex geometries</li></ul> <p><b>Cons</b></p> <ul style="list-style-type: none"><li>● Time consuming</li><li>● Material incompatibility</li><li>● Complex assembling / disassembling</li></ul>

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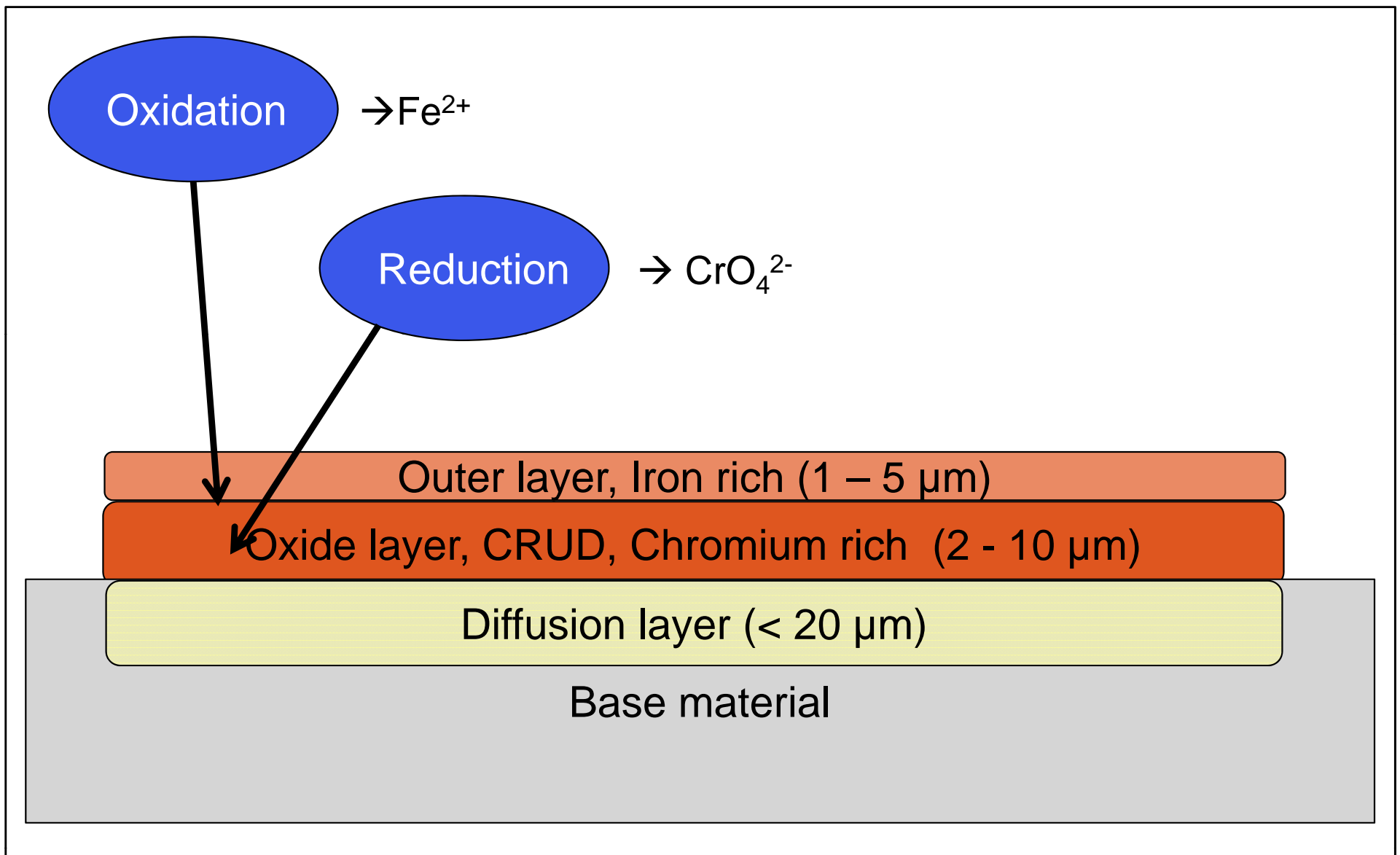
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# Chemical decontamination / Overview



# Chemical process



## Activity: inventory, flow and enclosure

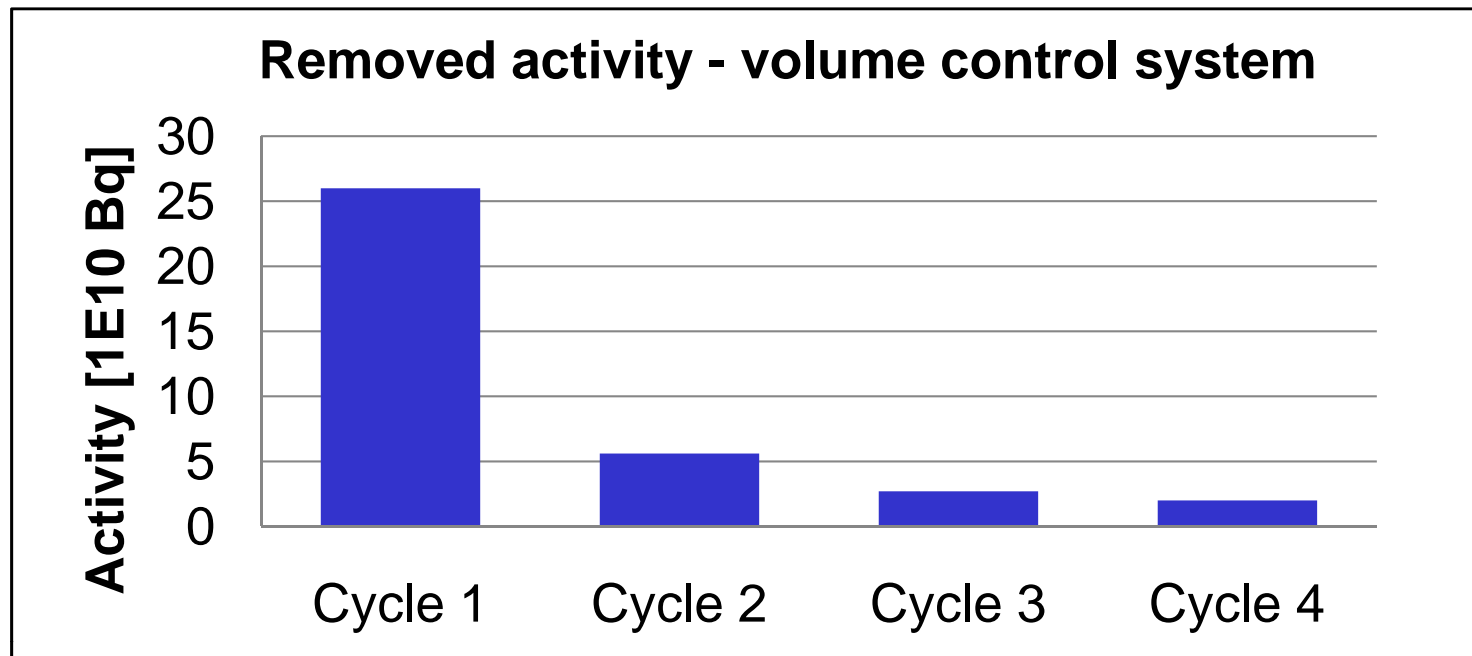
- Prior to decontamination the activity is fixed to the system/components
- During decontamination the activity
  - is dissolved
  - distributed through out the system and decontamination equipment
  - higher levels of mobile activity then before decontamination
- Activity removed by ion exchange resins in each decontamination cycle, or by discharge of process water

# Activity: inventory, flow and enclosure

## Example:

Activity inventories for part-system decontamination of

- volume control system after 30 years of operation
- volume: 4.0 m<sup>3</sup>; surface: 328 m<sup>2</sup>
- activity prior to decontamination: 1.7E 05 Bq / cm<sup>2</sup>



# Residual radioactive materials and waste

Types of waste generated by chemical decontamination:

- Process water
- Off gases
- Ion exchange resins

Volume and activity depending on system

Example:

Waste generated by decontamination of volume control-system

Ion Exchange resins: 0,4 m<sup>3</sup>; 3E11 Bq



# Radiation protection issues

## During planning:

- Limitation of direct radiation during decontamination
  - 1) Separation of “high activity areas” and “low activity areas”
  - 2) Shielding
  - 3) Restriction of access
- Limitation of contamination / internal dose uptake
  - Prevent spread of contamination
- Limitation of impact of accidents (environment and operators)

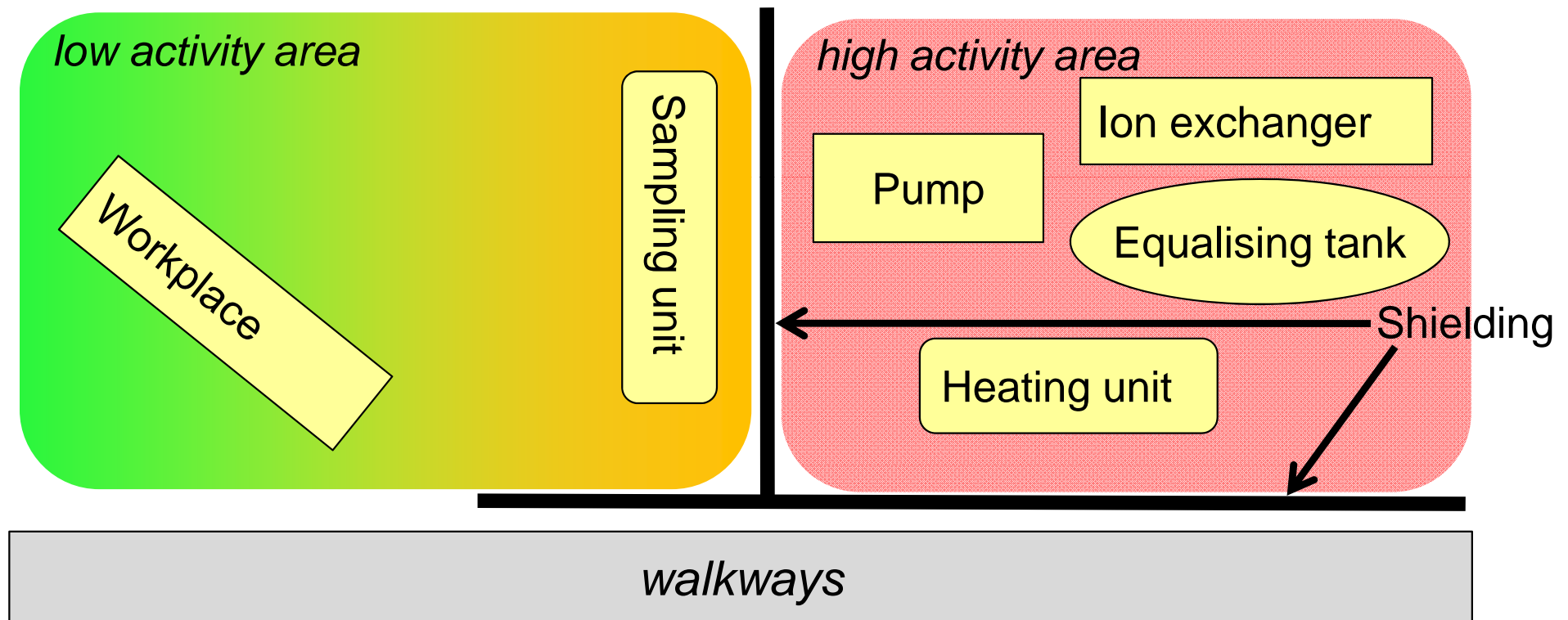
## During decontamination process:

- Monitoring of dose rates
- Monitoring of activity containment

# Limitation of radiation exposure

## Limitation of direct radiation during decontamination

1) Separation of “high activity areas” and “low activity areas”



Schematic display of installation of decontamination equipment, separated according to activity levels

# Limitation of radiation exposure

## Limitation of direct radiation during decontamination

### 2) Shielding

- Separation of “high activity”/ “low activity” areas
- Reduction of dose rates in workplaces and walkways ( $<10 \mu\text{Sv/h}$ )
- Reduction of dose rate at adjacent operations



# Limitation of radiation exposure

## Limitation of direct radiation during decontamination

### 3) Restriction of access

- High dose rates near piping that contains decontamination materials
- Closing of walkways may be necessary
- Main components of decontamination equipment have to be installed in closed off areas



# Limitation of radiation exposure

## Limitation of contamination / internal dose uptake

- Prevent spread of contamination
- Inspection of leak tightness / minimize spread
  - Whole system:  
decontamination equipment & system to be decontaminated
  - Prior to start up (multiple checks)
  - During decontamination (periodic checks)
  - Compartment air monitoring

# Limitation of radiation exposure

## Analysis of the radiological impact of accidents in the environment and operators

Events usually to be considered:

- Leakages (e.g. from components containing the decontamination liquid)
- Failure of the circulation pump
- Malfunction of the heating
- Falling of components during transport (e.g. containers containing ion exchange resins)

# Monitoring of radiation exposure

## Monitoring of direct radiation

Dose rates have to be monitored for the duration of decontamination

Especially at:

- working places
- walkways
- waste containers



# Quantifying decontamination results

$$\text{Decontamination Factor} = \frac{\text{Dose rate before decontamination}}{\text{Dose rate after decontamination}}$$

Typical decontamination factors range from 5 to 50, depending on many factors such as geometry, material, surface characteristics ...

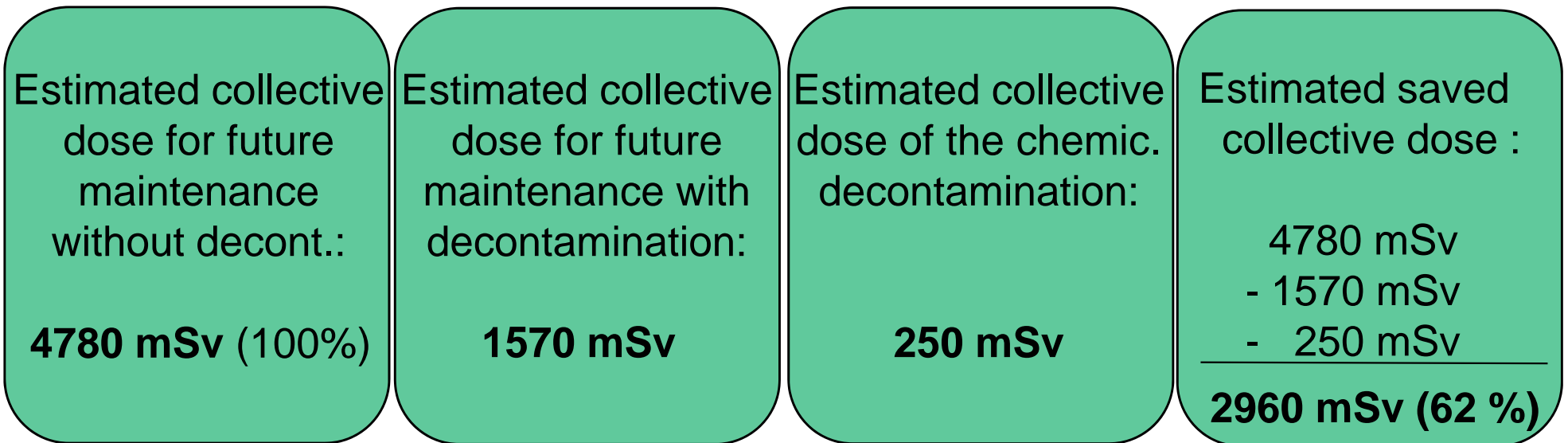
## Example:

Achieved decontamination factor after decontamination of the volume control system : 10

# Dose reduction

## Example:

Feasibility study to compare doses for the 2010 to 2014 planned shutdowns in a pressurized water reactor with and without full system decontamination (primary circuit):



# Role of the TSO during planning and realisation

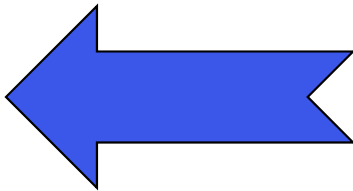
Technical support organisations are involved in each phase of the decontamination project

- Planning
- Installation
- Commissioning
- Operation
- Dismantling
- Waste treatment

# Role of the TSO during planning and realisation

Technical support organisations are involved in each phase of the decontamination project

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- consultation
- accompanying inspections

# Summary

## Chemical decontamination

- Rising number of applications
- Proven and tested method
- Wide range of radiation protection issues
- Very good decontamination results
- Large potential for reduced dose uptake to operators

Thank you for your attention

