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Design review of Belgian hot cells – Identification of design weaknesses

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Introduction

- Hot cells used for various purposes (radioisotopes, waste management, R&D)
- Most of hot cells designed and set up in the 70's
- Impact of refurbishment operations can be limited due to original design
- Nuclear safety is an important aspect during exploitation of hot cells because risks of
  - Internal and external exposure for the workers
  - Contamination spread on the site or in the environment

Identification of design weaknesses for Belgian hot cells

Shielding (1)

- Shielding to protect workers against irradiation risk
  - Lead used for hot cells with smaller dimensions
  - Concrete used for hot cells with bigger dimensions
  - Lead glass used for windows
- Shielding thickness ensure dose rate < 2,5 µSv/h at workstation

Shielding (2)

- Weaknesses identified

Location of ventilation ducts to minimize dose rate to the operators

- Additional shielding around ventilation ducts

→ Very few design weaknesses identified concerning shielding

Ventilation systems and filtration (1)

- To prevent the risks of contamination spread
- Various levels of static confinement (hot cell, laboratory, adjacent rooms)
- Dynamic confinement to complement static confinement
  - Negative pressure differentials from the low to the high contamination area
- Separate and redundant extraction networks
- Filtration to reduce radioactive releases
  - Charchoal filters for iodine gases
  - HEPA filters for aerosols

Ventilation systems and filtration (2)

- Weaknesses identified

Difficulties to comply with recommanded underpressure values

- In-depth study of the underpressure's dynamic systems
- Installation of airlocks and improvement of the leak tightness
- Underpressure measurements and daily walkdowns

Lack of physical separation between ventilators

- Redundancy in the design
- Fire barrier between redundant ventilators

Ventilation systems and filtration (3)

- Weaknesses identified

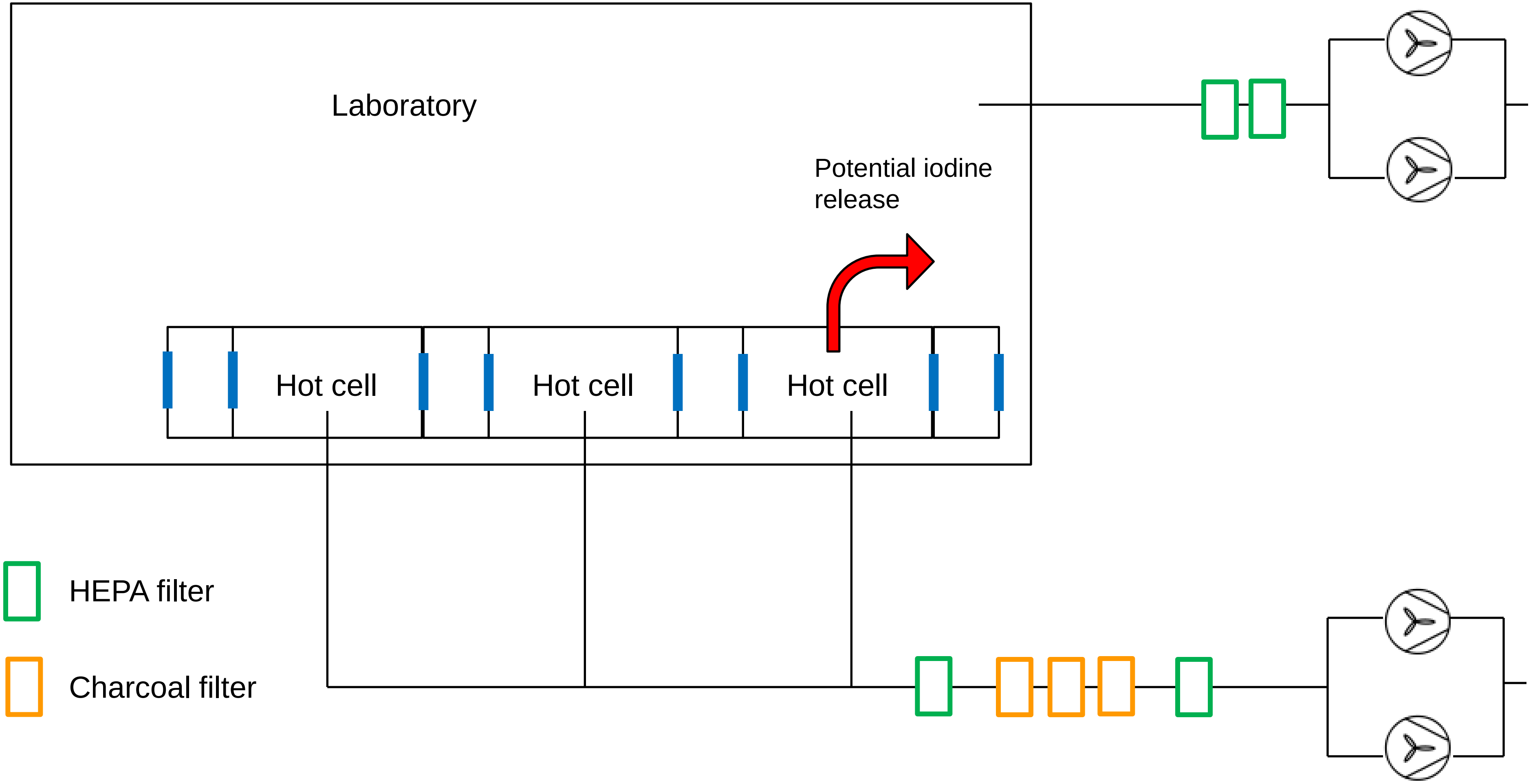
Insufficient iodine filtration because source of potential accidental release not correctly considered

- Deviation of extraction duct
- Addition of charcoal filters on extraction systems of hot cells handling iodine
- Addition of charcoal filters even on extraction systems of adjacent rooms

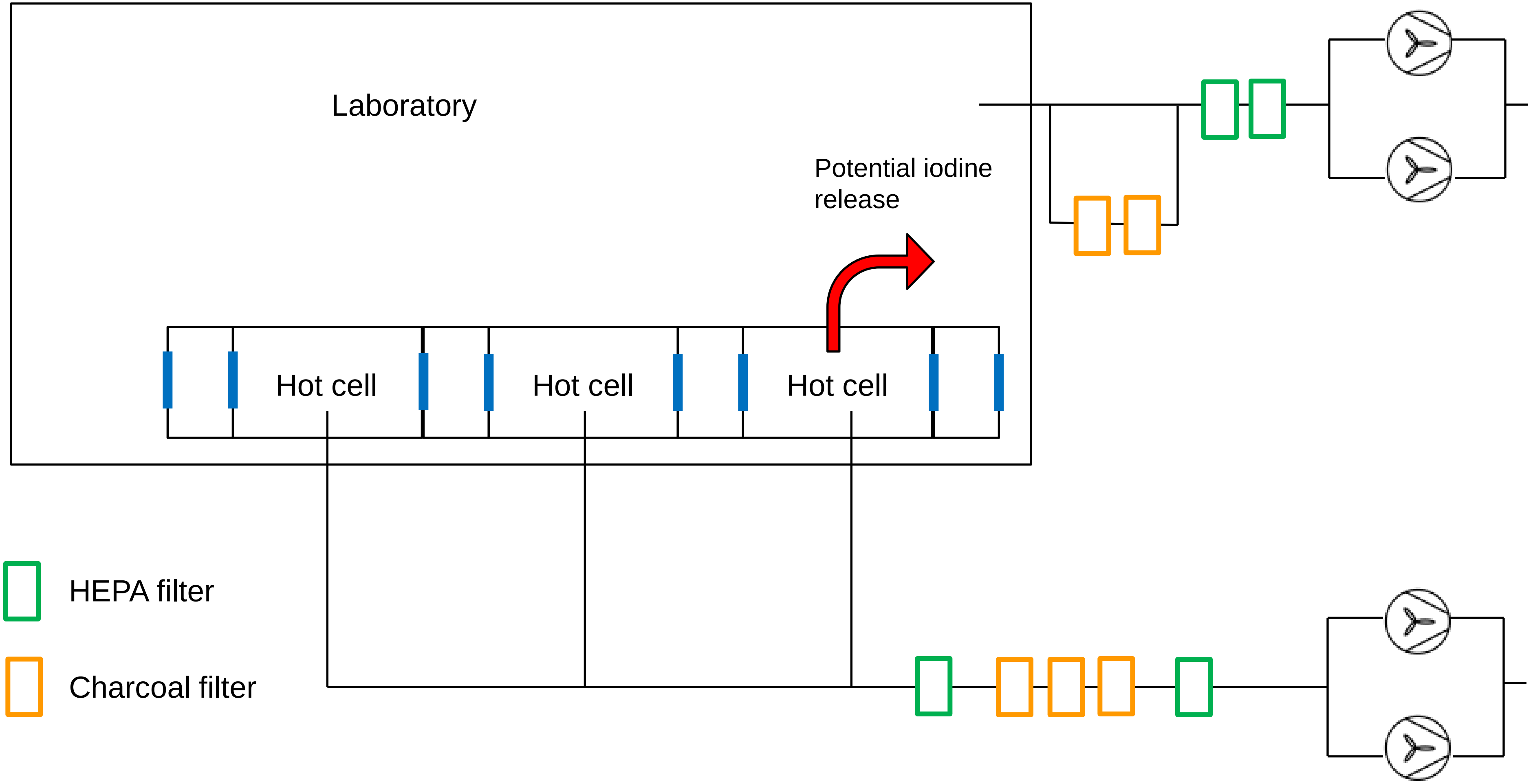
Testing methods

- Representativeness of the test

Addition of charcoal filters even on extraction systems of adjacent rooms



Addition of charcoal filters even on extraction systems of adjacent rooms



Ventilation systems and filtration (3)

- Weaknesses identified

Efficiency of iodine filtration

- Relative humidity measurements
- Installation of heaters
- Analysis of the airflow for chemical poisons
- Research to study the phenomenon of iodine released by a charcoal filter

Leak tightness and interfaces (1)

- High level of leak tightness to prevent the risks of contamination spread and to maintain underpressures
- Hot cells made up of stainless steel box
- Interfaces between hot cells to transfer products or materials
- Guillotine doors sealed by compressed air between the interface and the hot cell
- Separate extraction networks for all the interfaces

Leak tightness and interfaces (2)

- Weaknesses identified

Hot cell leak tightness

- Improvements and verification during refurbishment operations

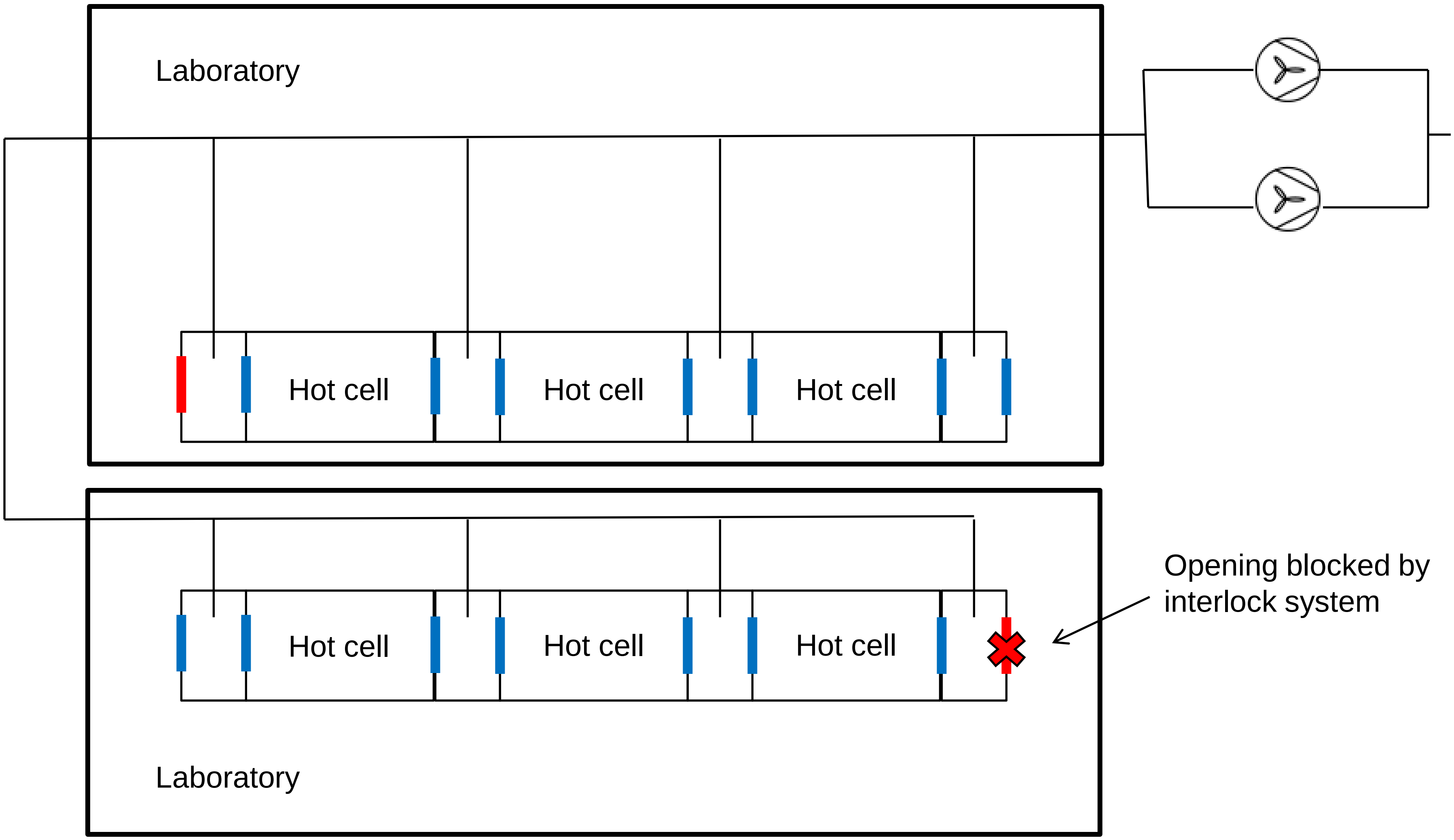
Underpressures during interfaces openings

- Interlock system to block the opening of all interface doors when one interface is already opened

Safety significance of compressed air

- Impact of malfunction of the compressed air system to be considered within safety analysis

Interlock system to block the opening of all interface doors when one interface is already opened



Monitoring (1)

- In normal conditions : to quantify the radioactive releases
- In accidental conditions
  - To rapidly identify the accident origin
  - To evaluate the needed protection measures for the population
- Two types of measurements
  - Off-line monitoring : accumulation of radioisotopes on filters and measurements in laboratory
  - On-line monitoring : direct measurements by various detectors
- General surveillance system and alarm system linked to the on-line monitoring

Monitoring (2)

- Weaknesses identified

On-line monitoring systems adapted to the radioisotopes mixture

- Replacement of the NaI detector by a pure Ge detector to distinguish iodine within a noble gas release

Complete accumulation of radioactivity within off-line monitoring systems

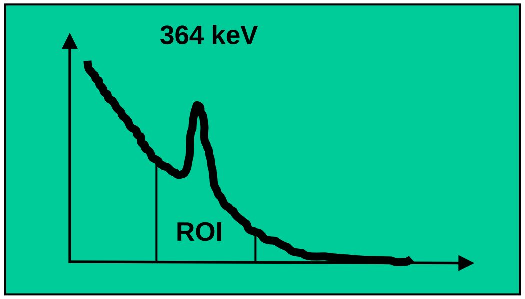
- Adding of several charcoal filters in series
- Daily replacement of the charcoal filters

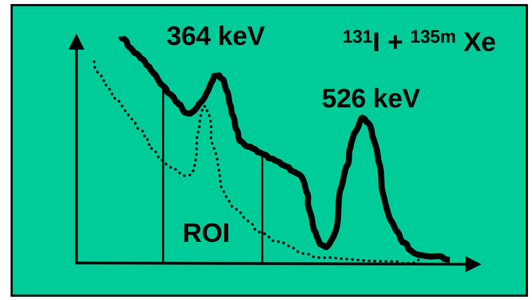
Safety significance of surveillance system

- Impact of failure surveillance system to be considered within safety analysis

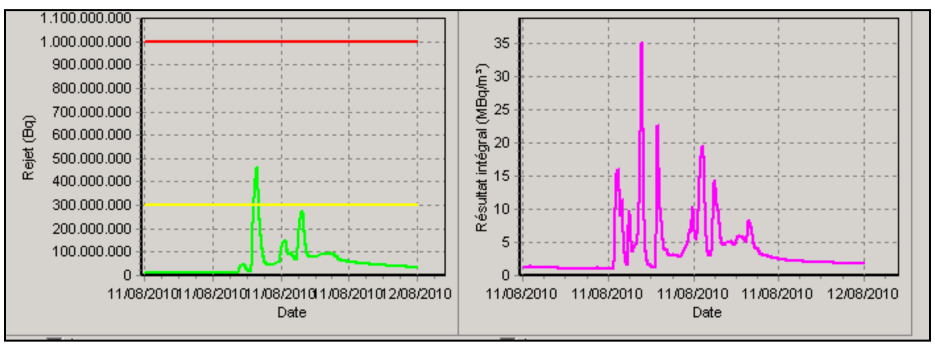
Replacement of the NaI detector by a pure Ge detector to distinguish iodine within a noble gas release

Xe interferences within the iodine channel



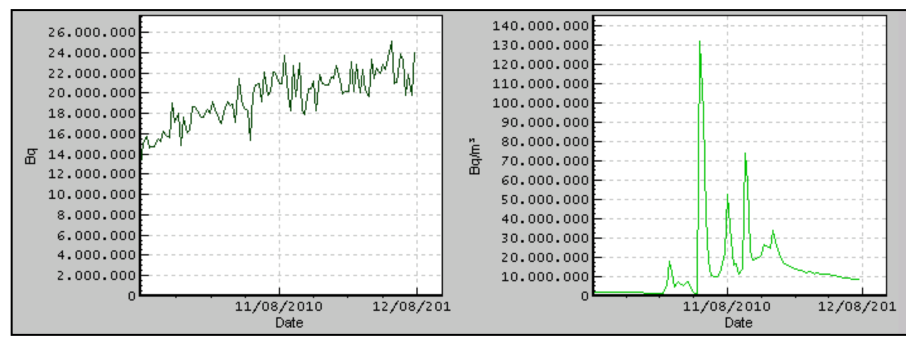


^{131}I ^{133}Xe eq



NaI detector

^{131}I ^{133}Xe eq



Ge detector

Fire protection (1)

- A fire can lead to the loss of integrity of the radioactive materials
- Principle of defence in depth applied to fire protection
  - Fire prevention
  - Fire detection and extinction
    - Detection system
    - Automatic suppression systems
    - Manual suppression capabilities
  - Prevent fire spreading

Ventilation systems and filtration (2)

- Weaknesses identified

Fire prevention

- Reduction of fire load
- Dedicated storage places and fire retardant cabinets
- Periodic verification of housekeeping

Fire detection for hot cells

- Fire detectors within the hot cells instead of in the ventilation ducts

Fire protection (2)

- Weaknesses identified

Adequacy of the automatic fire suppression systems

- Gaseous suppression systems replaced by water mist systems in laboratories
- Alternative solution for the gaseous suppression systems in the hot cells

Fire spreading

- Improvements of fire barriers

Lack of global Fire Hazard Analysis

- Study to be performed to demonstrate that safety functions are guaranteed in case of fire

Conclusions

- Design weaknesses identified during operating of hot cells
- Specific regulatory framework and international guidance limited for hot cells facilities
- Inspection and safety analyses of hot cells facilities = significant challenge for RB
- Currently, engineering judgement is used but may be expert-dependant
- Necessary to develop specific guidance about nuclear safety of hot cells facilities

Thank you for you attention