



**IAEA**

International Atomic Energy Agency

# **LESSON 10: IODINE MONITORING**

# Need for Iodine Monitoring

Iodine has fairly good fission yield (nearly 3%) and dosimetrically significant isotope.

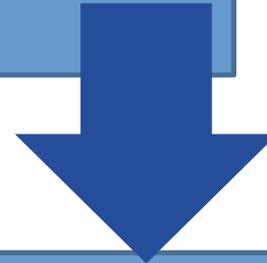
Under normal operating conditions of nuclear reactor radioiodine and other fission products are released from the fuel rods due to cladding failure.

It is retained in primary systems and subsequently released into the work atmosphere in case of breach.

Reprocessing plants likely to release  $^{129}\text{I}$  upon dissolution of spent fuel.

## Need for Iodine Monitoring

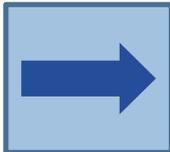
Hospitals and research institutions do use radio iodine. This is volatile in nature and in case of containment breach there is a probability of leak into working environment.



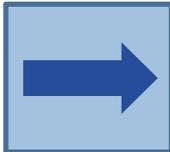
Depending on the facility, monitoring for one or more radio isotopes of iodine may be required.

- In non-nuclear facilities, typically one radioisotope used and evident which radioisotope is to be monitored

# Need for Iodine Monitoring

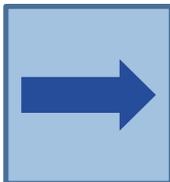


In nuclear plant, range of iodine radioisotopes may be produced with ranges of half life and emissions



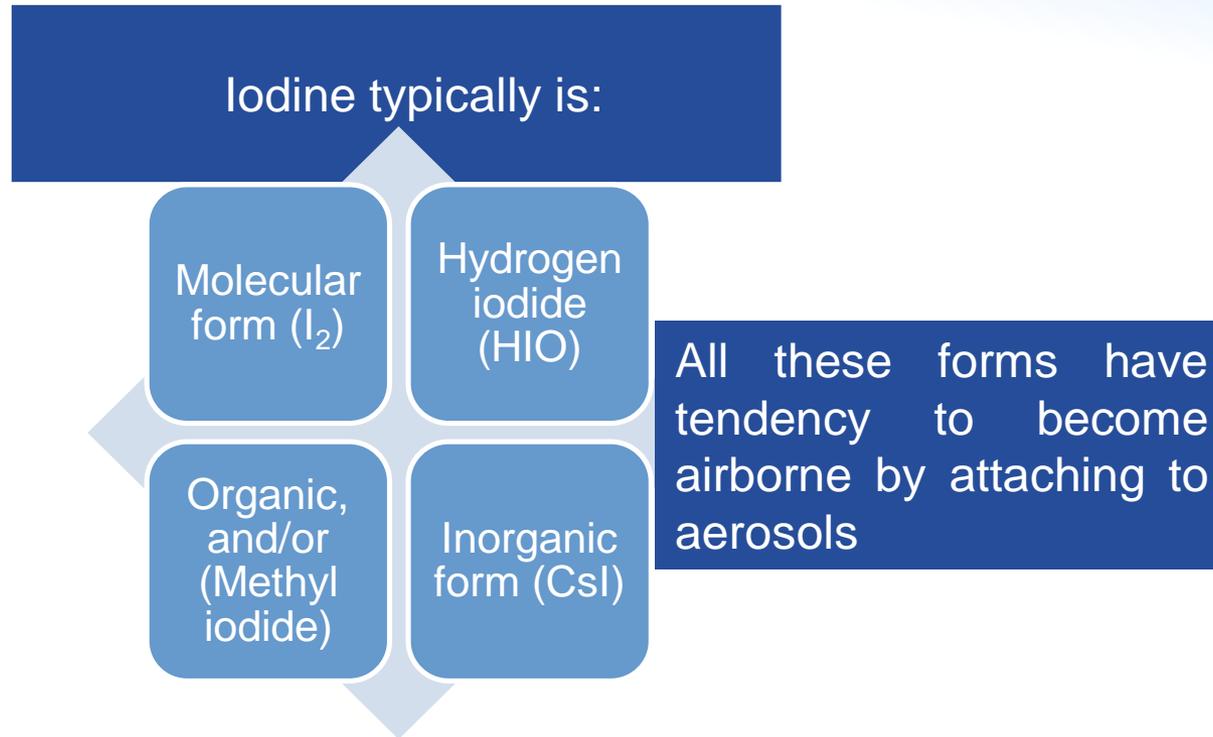
For nuclear industry, ratio between different iodine radionuclides is obtained from computer code

In workplace monitoring, typically measure I-131, I-125, I-129 and/or I-135 and ratio to other iodine quantities



Iodine gets concentrated in the thyroid gland of the person exposed to it and delivers radiation dose to the thyroid.

# Form of Iodine



In the nuclear industry, gaseous iodine is the most abundant of the forms

# Iodine Monitoring

Techniques

Equipment for Delayed Measurement

Equipment Used for Real Time  
Measurement

Examples of Iodine Monitors

Calibration and Verification

Factors Influencing Results

# TECHNIQUES

## Techniques

- The monitoring of radioactive iodine in the workplace may be accomplished both continuously by real time monitor or via sequential sampling and a delayed analysis in the laboratory.
- All radioactive iodine monitoring assemblies, whether these measurements are continuous or delayed, are accommodated in a sampling assembly and a measurement assembly to measure the sampled activity.
- The iodine is generally trapped in a collection medium like charcoal or zeolite contained in a cartridge.

## Techniques

- The activity of the iodine trapped is measured by gamma spectrometry either simultaneously (real time measurement) or in a laboratory after the sampling is completed
  - Delayed measurement to reduce interference due to radon daughters.
  - May also have interference from other gaseous radioisotopes.
- Usually the most common,  $^{131}\text{I}$  activity is measured with a single channel analyser, usually NaI (TI).
- A multichannel analyser with proper software should be used for measurement of multiple isotopes of iodine, and allows discrimination from other isotopes. Usually HPGe is used.

# **EQUIPMENT USED FOR DELAYED MEASUREMENT**

# Equipment used for Delayed Measurement

To perform delayed measurement the following equipment is required:

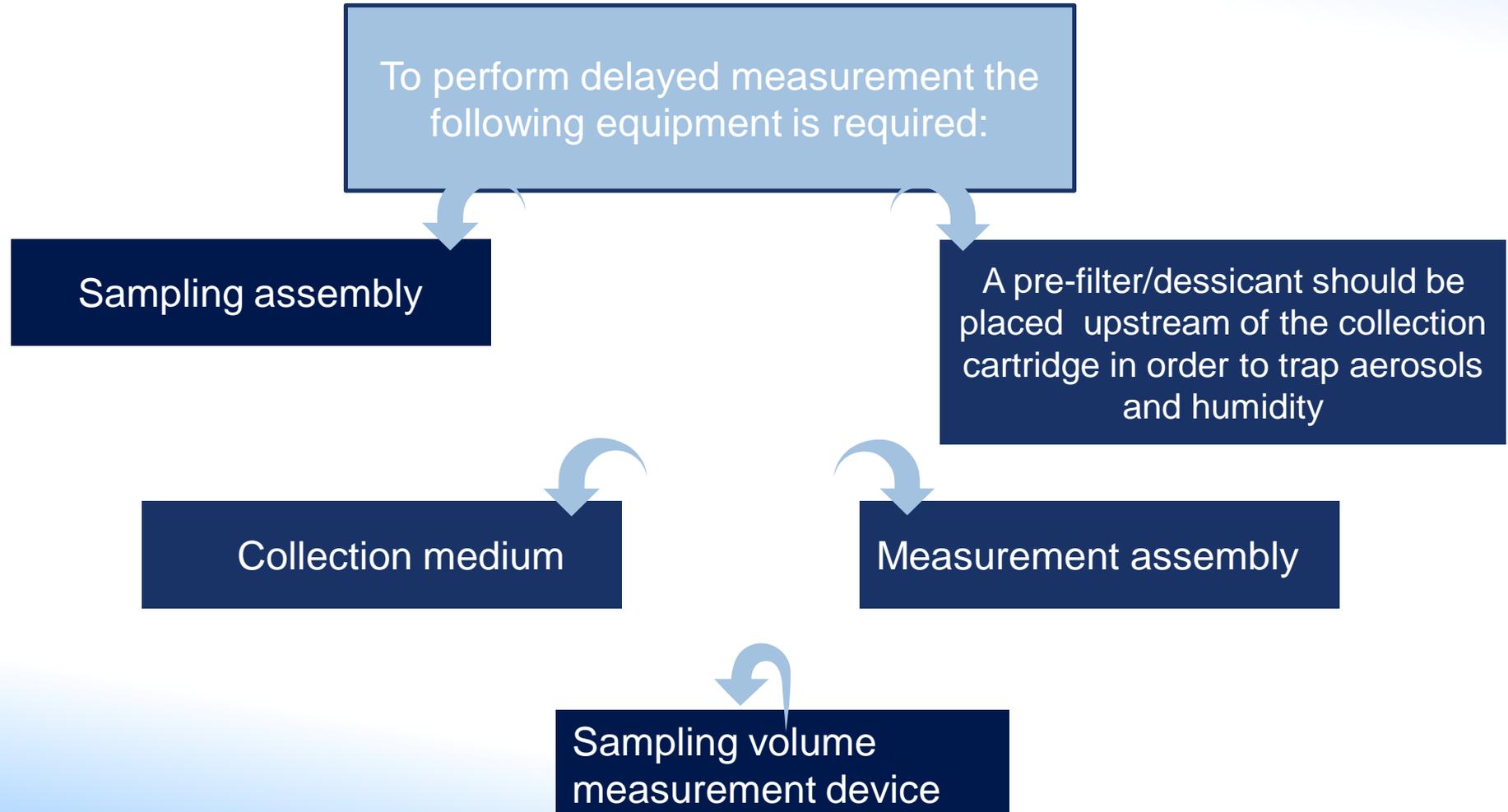
Sampling assembly

A pre-filter/dessicant should be placed upstream of the collection cartridge in order to trap aerosols and humidity

Collection medium

Measurement assembly

Sampling volume measurement device



# Equipment used for Delayed Measurement

- ❑ The sampling rate should be chosen to obtain an air velocity inside the cartridge lower than 50 cm/s or according to the manufacturer specification to avoid loss of absorption.

- Typical flow rates are between 1 and 6 m<sup>3</sup>/h.

- ❑ Sampling line (if added) should be carefully chosen

- Molecular iodine can become trapped on materials.
- Use anti-static material, such as stainless steel with electro-polished surfaces.
- Keep the internal surfaces dust free and dry.

## Collection Medium

- > The collection medium is generally made of a cartridge filled with charcoal or silver zeolite.
  - In order to improve the collection efficiency charcoal is generally impregnated with potassium iodide and tri-ethylene diamine (TEDA) to obtain collection efficiency close to 100%.
  - Use silver zeolite as it will absorb less noble gases than charcoal.
  - Cartridge must be stored to remain dry - be aware of storage and lifetime restrictions from manufacturer.
- > Iodine cartridges are intended for sampling of radioactive airborne iodine in either molecular ( $I_2$ ) or organic ( $CH_3I$ ) form.

## Collection Medium-Supplier Specifications

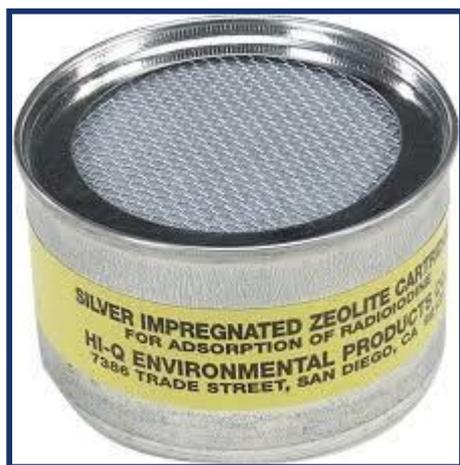
The medium is chosen in such a way that, the deposition of iodine is as uniform as possible (manufacturer defined).

The manufacturer shall state how the collection efficiency is influenced by the chemical form of iodine, atmospheric conditions and the presence of chemical products in sampled air.

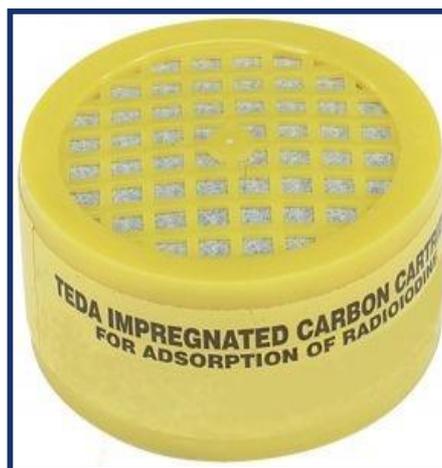
The manufacturer shall specify the storage conditions of the collection medium.

The user should not change the collection medium without consulting the manufacturer.

## □ Examples of Collection medium



Silver impregnated zeolite cartridge



TEDA impregnated carbon cartridge



Activated carbon

# EQUIPMENT USED FOR REAL TIME MEASUREMENT

# Equipment used for Real Time Measurement

A typical iodine monitor consists  
of:



An air sampling circuit.

A collection medium.

A gamma ray detector.

The associated electronics.

A data processing software.

Alarm device (based on volume of activity).

# Air Sampling Circuit

This circuit consists of the following:

A sampling head.

A pipe to transport iodine to the cartridge.

A device to measure the pressure drop of the cartridge.

A flow rate measurement device.

# Air Sampling Circuit

A sampling pump.



A pre-filter should be placed upstream of the collection medium in order to trap any aerosols.



The sampling flow rate is generally between 30 and 100 l/m. (refer to manufacturer of equipment for flow rate)  
This value may be compared to the breathing rate of 20 l/m of a man at work.

# Radiation Detector

- The monitors currently available are equipped with NaI(Tl) detectors.
- The detector should be placed on the side, rather than upstream or downstream of the cartridge because iodine is trapped in the medium by successive layers from upstream to downstream.
  - If the detector is placed at the side of the cartridge, the detection efficiency is quite independent of the location where the iodine is trapped.
- The manufacturer shall fully specify the detector characteristics, including the detector dimensions and transmission characteristics such as the effective surface area of detection.

## Associated Electronics and Alarms



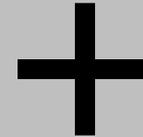
The data processing software is used essentially to calculate in real time the volumetric activity of iodine, to signal alarms and to archive values.



The audible and/or visual devices informs the user when an activity threshold is exceeded in the sampled air or when equipment malfunctions or fails.

# Nal Detectors

## Good points:



- Good detection efficiency.
- Low maintenance cost.

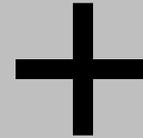
## Weaknesses:



- Sensitive to environmental temperature.
- Poor resolution of the gamma spectrum.

# HPGe Detectors

## Good points:



- Very good resolution of the gamma spectrum.

## Weaknesses:



- Lower detection efficiency than NaI detectors.
- Necessity to cool the detector.

# EXAMPLES OF IODINE MONITORS

# Examples of Modern Iodine Detectors



NaI based, Detection limit:  $3.7 \text{ Bq/m}^3$



NaI based Iodine monitor

# CALIBRATION AND TESTING

## Calibration and Testing

- The sampling flow rate of the sampling assembly should be verified at regular intervals
- The measurement assembly should be calibrated following the IEC 60761-4
  - The efficiency of the measurement assembly should be determined using simulated sources traceable to national standards for the specific sample media and geometry used.
  - Functional testing should be carried out according to manufacturer's instructions
    - Typically a standard source having energies close to I-131, e.g. Ba-133 or Cs-137 will be used

# Real Time Monitor Type Test Report and Certificate

Select a monitor whose characteristics and performances comply with the recommendations of the IEC standards 60761-1 and IEC 60761-4. These are confirmed during type testing conducted by the manufacturer. The manufacturer shall provide a certificate giving the following information:

- size, type and orientation (direction of flow) of the iodine retention device used (where applicable);
- characteristics of all sources used;
- delay time between sampling and measurement;
- limit of loading of the retention device in relation to iodine and its compounds;
- whether the equipment is selective and, if so, for what isotopes of iodine;
- response to noble gases and collection efficiencies for volatile iodine compounds.

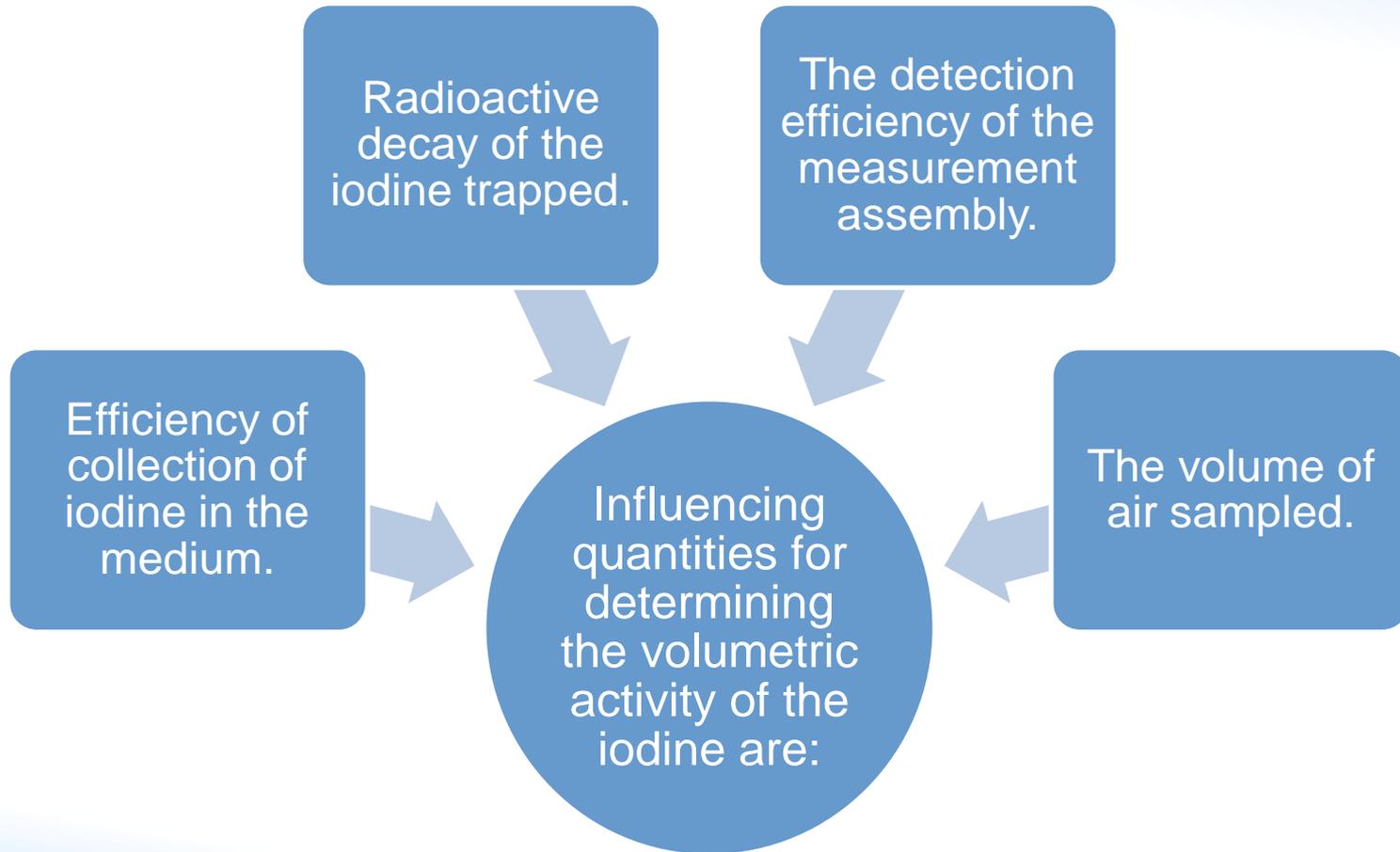
## Calibration and Testing Real Time Monitoring

❑ The sampling flow rate of the sampling assembly should be verified at regular intervals

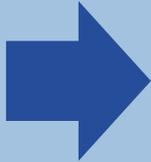
❑ Each air-monitoring instrument is required to have a valid calibration before using.

- Calibrations should be performed at least once a year.
- The manufacturer should state the calibration factor and the iodine isotopes for which it applies.
- Functional testing should be defined by the manufacturer and usually includes testing with a radioactive source
  - Ba-133 or Cs-137 are used in appropriate activity ratios and appropriate geometry to simulate a real sample
  - A calculated correction factor is then used

# Influencing Quantities



## Collection Efficiency of Iodine in the Medium



The chemical form of iodine and the air humidity or the presence of vapor in the air sampled may influence the collection efficiency of the medium chosen.



The manufacturer should give all necessary information about the collection efficiency of the collection medium chosen. The manufacturer should also give the impact of the influence quantities on the collection efficiency.

## Collection Efficiency of Iodine in the Medium



In case of delayed measurement with a long sampling time, for example, one week or in a damp atmosphere, it is recommended to use a second cartridge downstream of the first one. This second cartridge will trap the iodine passing through the first cartridge in case of overload of the first cartridge.



The two cartridges should be analyzed simultaneously and the total activity should be used for the determination of the volumetric activity in the air sampled.

## Radioactive Decay of Iodine Trapped

In case of delayed measurement with a long sampling time, the knowledge of the true volumetric activity of iodine in air sampled will be biased due to possible decay of I131 (half-life- 8 days).

To account for this, an appropriate decay correction should be applied to find true activity.