SnT 2023
CTBT: SCIENCE AND TECHNOLOGY CONFERENCE
HOFBURG PALACE - Vienna and Online
19 TO 23 JUNE

Devices to reduce the emission of radioactive noble gases from fission radioisotopes production plants

Argentina

Eduardo Carlos Carranza
Argentina

INTRODUCTION

METHODS/DATA

START

RESULTS

CONCLUSION

The poster describes the history of molybdenum production in Argentina and the conversion from HEU targets to LEU targets. The Medical Isotope Production (MIP) by Fission release radioactive noble gases into the environment. Methods to reduce the emissions are presented, analysing their advantages and disadvantages

Methods:

Evacuated Tanks

Active Charcoal

Copper Oxide Regeneration

Porous devices

Hydrogen capturing devices

A fission MIP producing 400 six days Ci of ^{99}Mo, manipulates at Plant 1x10^{14} Bq of ^{133}Xe. The Decontamination Factor (DF) is the relationship between this activity of ^{133}Xe and the release into the environment. More storage time of ^{133}Xe in the plant implies a higher DF. Depending on their characteristics and applications, the DF of different retention methods can vary from tens to thousands.

The last slide presents a comparative table with the advantages and disadvantages of different retention methods. The designer of a Fission MIP should analyse the optimal option, according to their needs and possibilities.

Please do not use this space, a QR code will be automatically overlayed

P2.4-063

Devices to reduce the emission of radioactive noble gases from fission radioisotopes production plants
Introduction

History of Fission Radioisotopes Production in Argentina

1967 RA-3 Reactor - HEU fuel elements

1977 α, β, γ Hot Cells construction

1978 Fission ^{99}Mo radiochemical process first experiences

1980 Target development

1985 First commercial production of ^{99}Mo – HEU targets

1985 Enlargement of the building

1994 New hot cells

2000 RA-3 Reactor increases power - LEU fuel elements

2002 First commercial production of ^{99}Mo – LEU targets

2005 First commercial production of ^{131}I

Argentina was the first country in the world to change the Molybdenum-99 (^{99} Mo) production process from HEU (high enrichment Uranium) to LEU (low enrichment Uranium), taking into account the Treaty on Non-Proliferation of Nuclear Weapons (NPT) and world initiatives for stricter control of nuclear materials.

Fission ^{99}Mo is being produced in Argentina, at the Ezeiza Atomic Center, since 1985. The procedure involved the irradiation of HEU targets with an Uranium-Aluminum alloy “meat” cladded with aluminum.

In the late 90's the Atomic Energy National Commission of Argentina (CNEA) started the development of LEU targets for its ^{99}Mo production, in order to replace the HEU targets. In 2002, CNEA started to commercialize ^{99}Mo from LEU targets and in 2005 Iodine-131 (^{131}I).

INTRODUCTION
OBJECTIVES
METHODS/DATA
RESULTS
CONCLUSION

The **Medical Isotope Production (MIP)** by Fission release radioactive noble gases into the environment.

These emissions increase the environmental background and could hinder the mission of the **International Monitoring System (IMS)** to detect early **a nuclear explosion**.

The dissolution of plates with aluminium in a basic medium generates hydrogen.
The air is a consequence of the vacuum that must be made in the tanks to move the fluids in the purification stages. The circuits used for H and Air are different as their contents cannot be combined because an explosive mixture could be generated.

Hydrogen is produced by Al during targets dissolution.

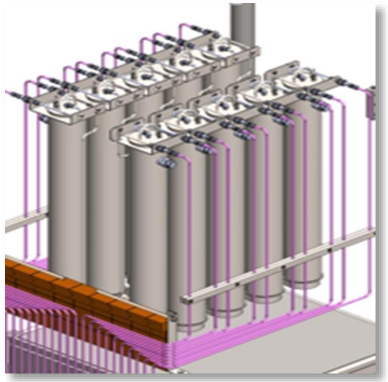
$$Al + NaOH + H_2O \rightarrow NaAlO_2 + 3/2 H_2$$

Air	Hydrogen
80%	20%

Relative ^{133}Xe activity between Air and Hydrogen

Devices to reduce the emission of radioactive noble gases from fission radioisotopes production plants
Objectives

Argentina

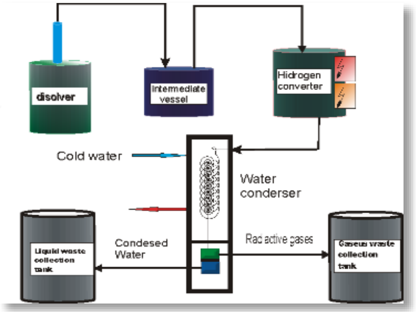


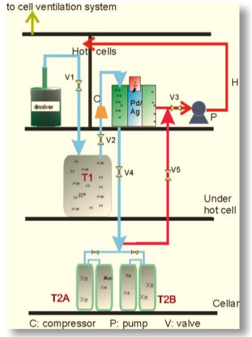
Air and Hydrogen

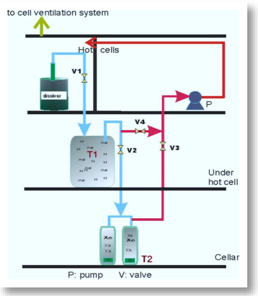
The objective is to show different alternatives to reduce the emission of noble radioactive gases into the environment from a Medical Isotopes Production (MIP) by Fission.

Some devices are applicable to Hydrogen and others to Air and Hydrogen.

A comparative analysis between them is carried out.







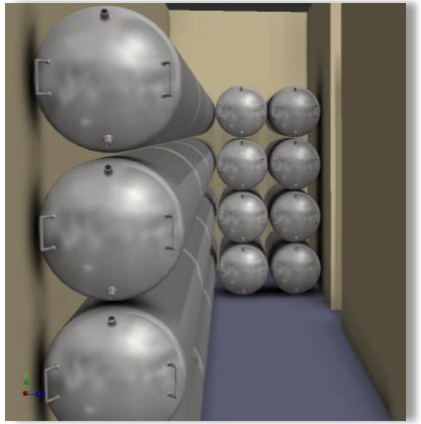
Hydrogen

INTRODUCTION
OBJECTIVES
METHODS/DATA
RESULTS
CONCLUSION

Devices to reduce the emission of radioactive noble gases from fission radioisotopes production plants
Retention Methods for Air and Hydrogen

Evacuated Tanks

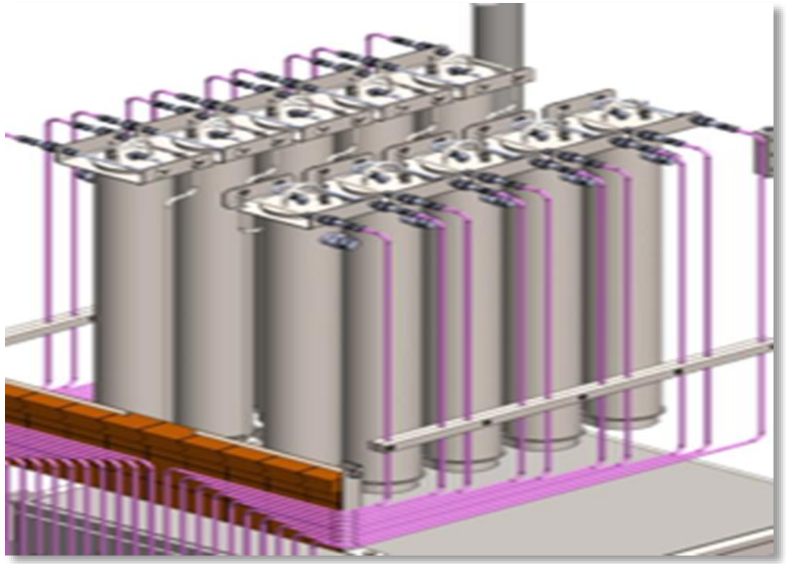




Evacuated tanks provide a large volume of storage. More storage represents more decay time and less radioactive noble gases emission to the environment. The gases are stored in tanks, previously evacuated, so that they decay as long as possible.

- **Need** vacuum pumps
- very little maintenance
- large space

Activated Charcoal



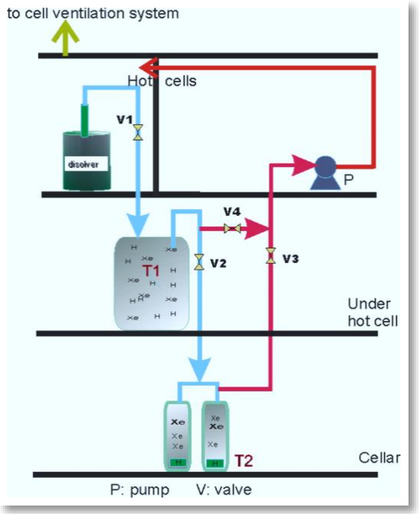
They are beds of activated carbon that dynamically adsorb Xenon.
Need change the charcoal periodically and dehumidification of the gas flow.
Its performance (DF) improves with:

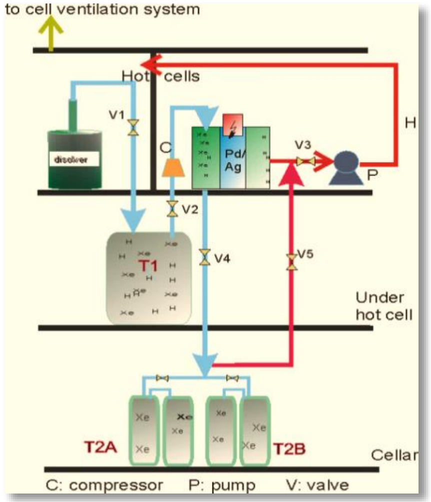
- lower humidity
- lower gas flow
- larger volume of coal
- lower gas temperature

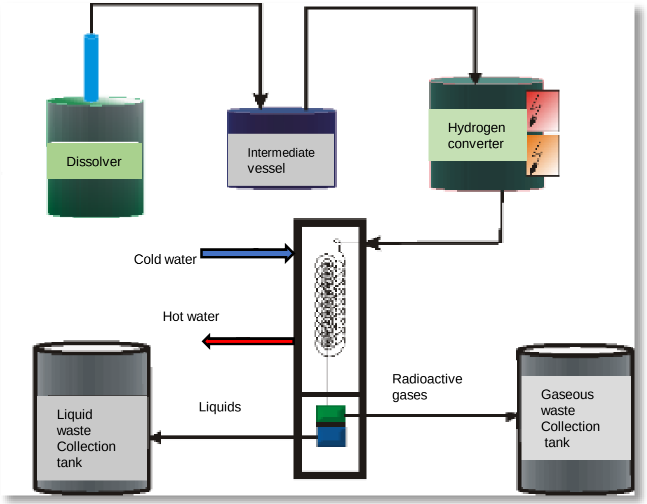
SnT 2023
CTBT: SCIENCE AND TECHNOLOGY CONFERENCE
HOFBURG PALACE - Vienna and Online
19 TO 23 JUNE

Devices to reduce the emission of radioactive noble gases from fission radioisotopes production plants
Retention Methods for Hydrogen

Argentina







HYDROGEN CAPTURING DEVICES

The characteristic of hydrogen capturing device is their ability to absorb hydrogen reversibly.

When these materials are in contact with hydrogen at a given pressure and temperature a reaction of phase change is produced.

A new compound is formed.

$M + X/2\ H_2 \leftrightarrow MH_x$

M=hydride forming materials, MHx=formed hydride

It is a reaction with heat exchange: exothermic when the hydride is formed and endothermic when releases hydrogen

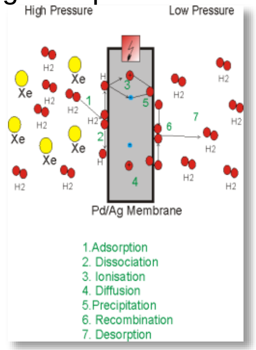
- **Need**: Heating
- Cooling
- Pump
- Small space

POROUS DEVICES

The hydrogen permeates through the membrane and the impurities (noble gases, nitrogen, etc.) are returned to the tank or are sent to another.

The operating conditions need high temperatures to increase hydrogen permeability.

It requires differential pressure on both sides of the membrane.



- **Need**: Heating
- Compressor
- Pump
- Small space

COPPER OXIDE REGENERATION :
Converts hydrogen to water

Temperature and Pressure of operating: 450 °C,101KPA

Need time for regeneration

The converter is more than 95% efficient in reducing the volume of H

- **Need**: Heating
- Cooling
- Shielding.

Manufactured and installed by Invap Argentina in Radioisotopes Production Plants of Ansto (Australia), Insha (Egypt) and ^{99}Mo Production Facility (Mumbay-India).

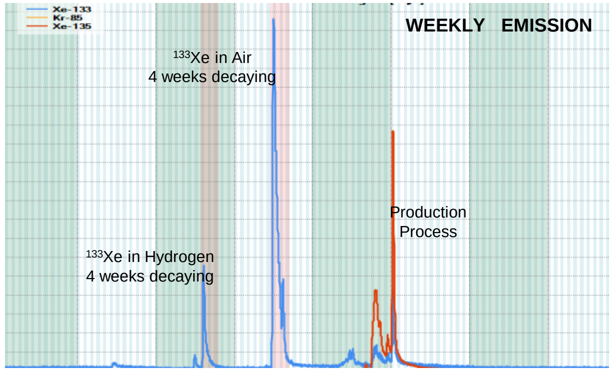
P2.4-063

Devices to reduce the emission of radioactive noble gases from fission radioisotopes production plants
Results

Argentina

Decontamination Factor

Fission MIP producing 400 six days Ci of ^{99}Mo, manipulates at Plant 1 10^{14} Bq of ^{133}Xe. The Decontamination Factor (DF) is the relationship between this activity of ^{133}Xe and the release of ^{133}Xe into the environment. More storage time of ^{133}Xe in the plant implies a higher DF. Depending on their characteristics and applications, the DF of different retention methods can vary from tens to thousands. (**half-life ($t_{1/2}$) ^{133}Xe : 5,247 days**)



DF: **Initial Activity of ^{133}Xe / Release Activity of ^{133}Xe**

weeks	DF
3	16
4	40
5	100
6	256
7	640
8	1600
9	4100
10	8200

DF value based on the weeks that the ^{133}Xe remains in the installation.

Methods	Dimensions	DF
Evacuated tanks (Air – H)	Volume: 6 m^3	40
	Volume: 9 m^3	250
Active Charcoal (Air – H)	Volume: 1m^3 Flow: 0.15 m^3/h	300
Copper Oxide Regeneration (H)	Volume: 0.2 m^3	250
Porous Devices (H)	Volume: 0.1 m^3	>1000
Hydrogen Capturing Devices (H)	Volume: 0.1 m^3	>1000

The table shows the volumes needed to contain the Xe with the different methods and an approximate value of DF for a production of 400 six days Ci of ^{99}Mo

INTRODUCTION
OBJECTIVES
METHODS/DATA
RESULTS
CONCLUSION

Devices to reduce the emission of radioactive noble gases from fission radioisotopes production plants
Conclusion

METHODS	ADVANTAGES	DISADVANTAGES
EVACUATED TANKS	Tested in production Simple, Few devices (vacuum pump) Air and Hydrogen Little Maintenance	Large volume of tanks Ned big space Big shield
ACTIVE CHARCOAL	Tested in production Air and Hydrogen Less volume and higher DF than Evacuated Tanks	Cooling and dehumidification Periodical change of charcoal Need Shield
COPPER OXIDE REGENERATION	Tested in production Low Volume Higher DF	Only Hydrogen. Heating and cooling Need Shield
HYDROGEN CAPTURING DEVICES	Low Volume Highest DF Little shield	Only Hydrogen. Heating ,cooling and compressor Developing-Tested whit ^{133}Xe
POROUS DEVICES	Low Volume Highest DF Little shield	Only Hydrogen. Heating. cooling and pump Developing-Tested with tracers

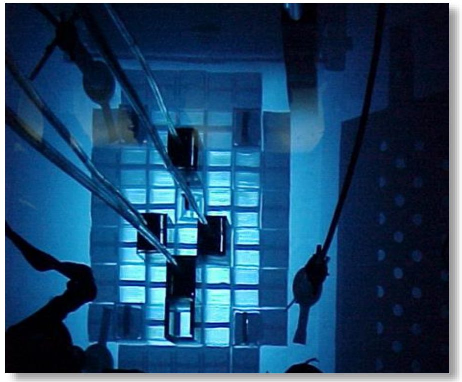
Comparative table with some advantages and disadvantages of the different retention methods.

The methods can be complementary. For example, use a Copper Oxide Regeneration for Hydrogen and Evacuated tanks or Active Charcoal for Air.

The designer of a Fission MIP should analyse the optimal option according to their needs and possibilities

Devices to reduce the emission of radioactive noble gases from fission radioisotopes production plants

Argentina



Thank you very much

edcarran2000@yahoo.com.ar
Eduardo Carranza

Acknowledgements: Daniel Amaya – Invap S.E. Argentina

Please do not use this space, a QR code will be automatically overlayed