Environmental and Public Neutron Exposure from UF_6

By

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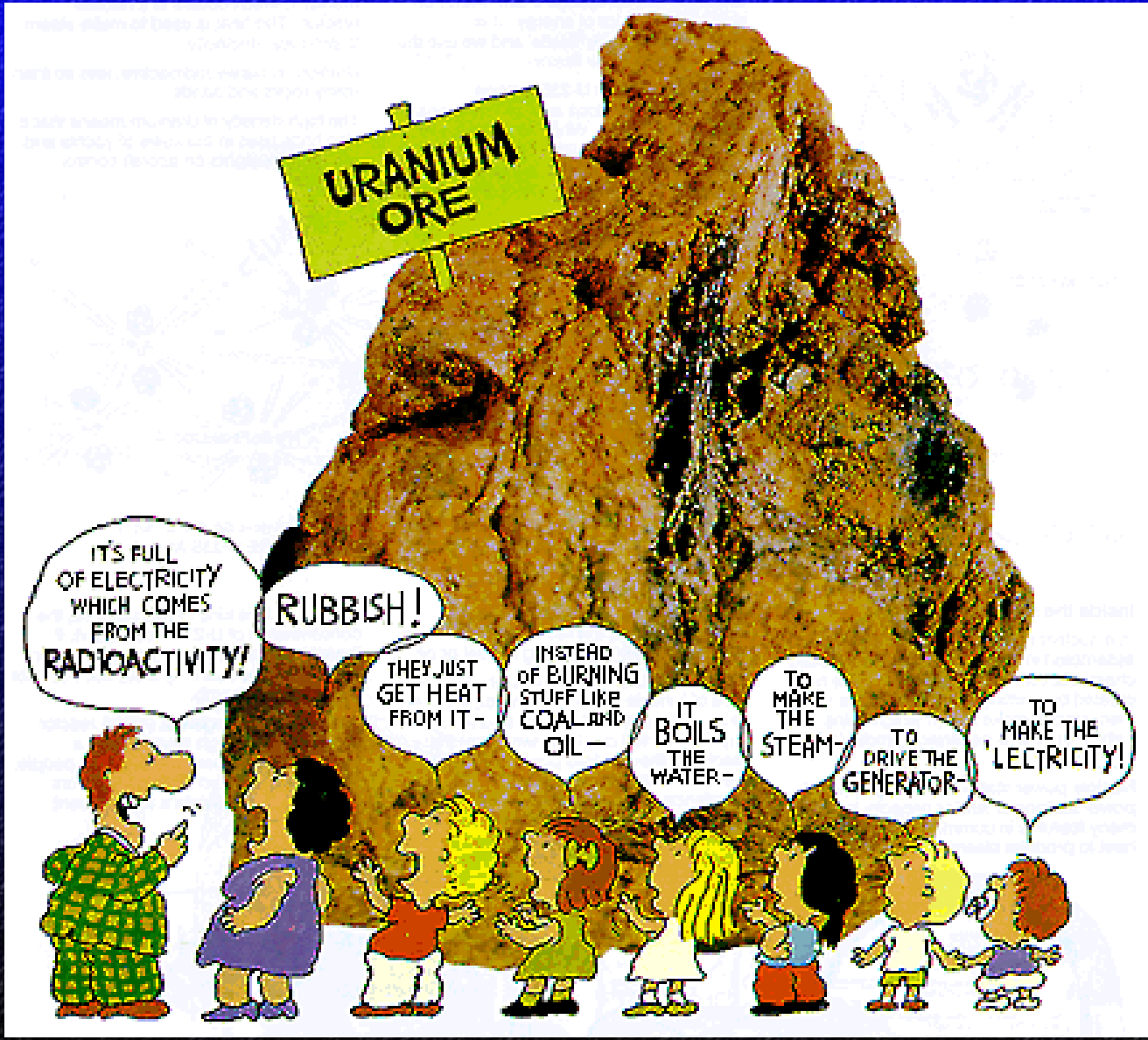
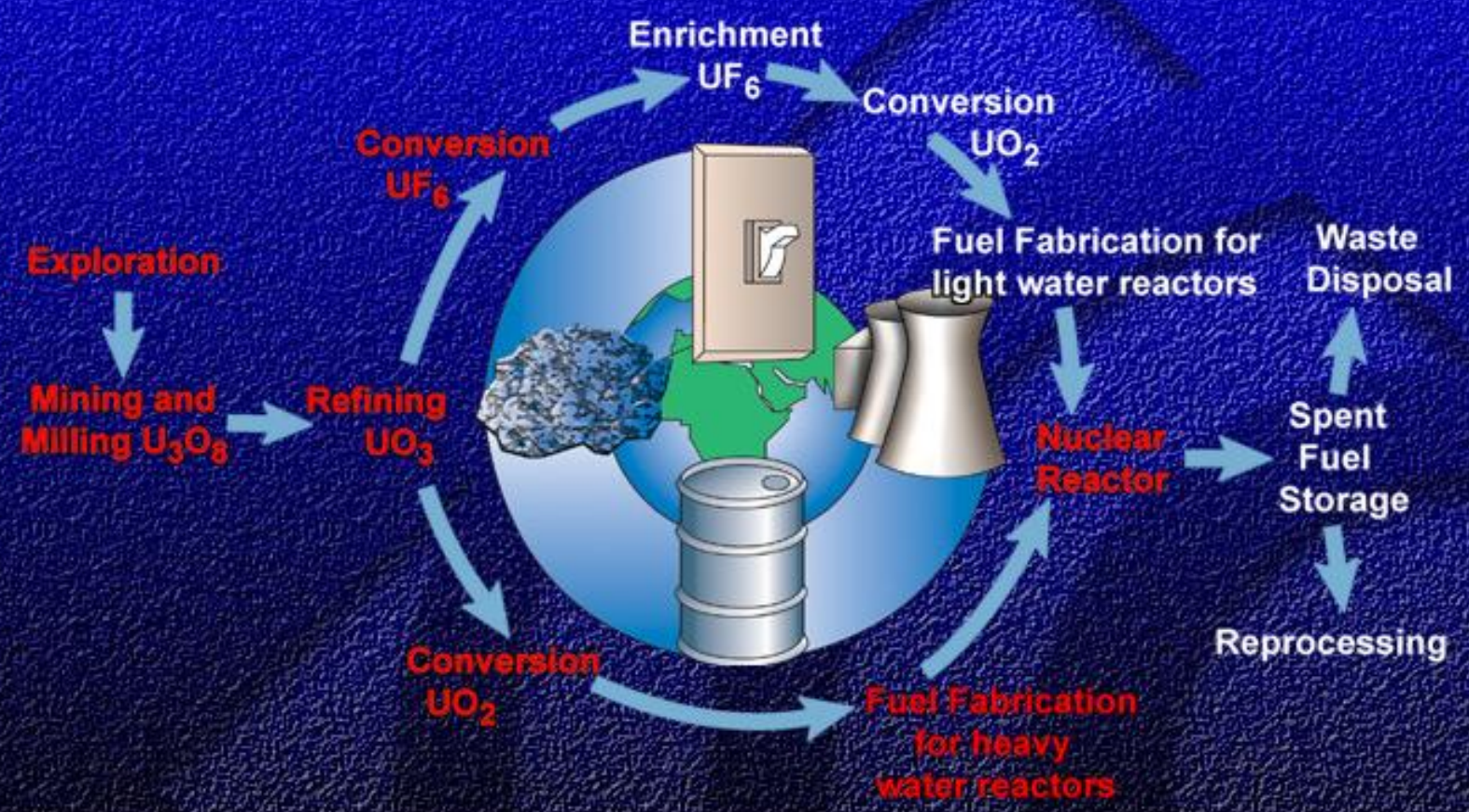
Fuel Cycle Safety – Past, Present and Future

What is Uranium?



Uranium Information Centre Ltd.

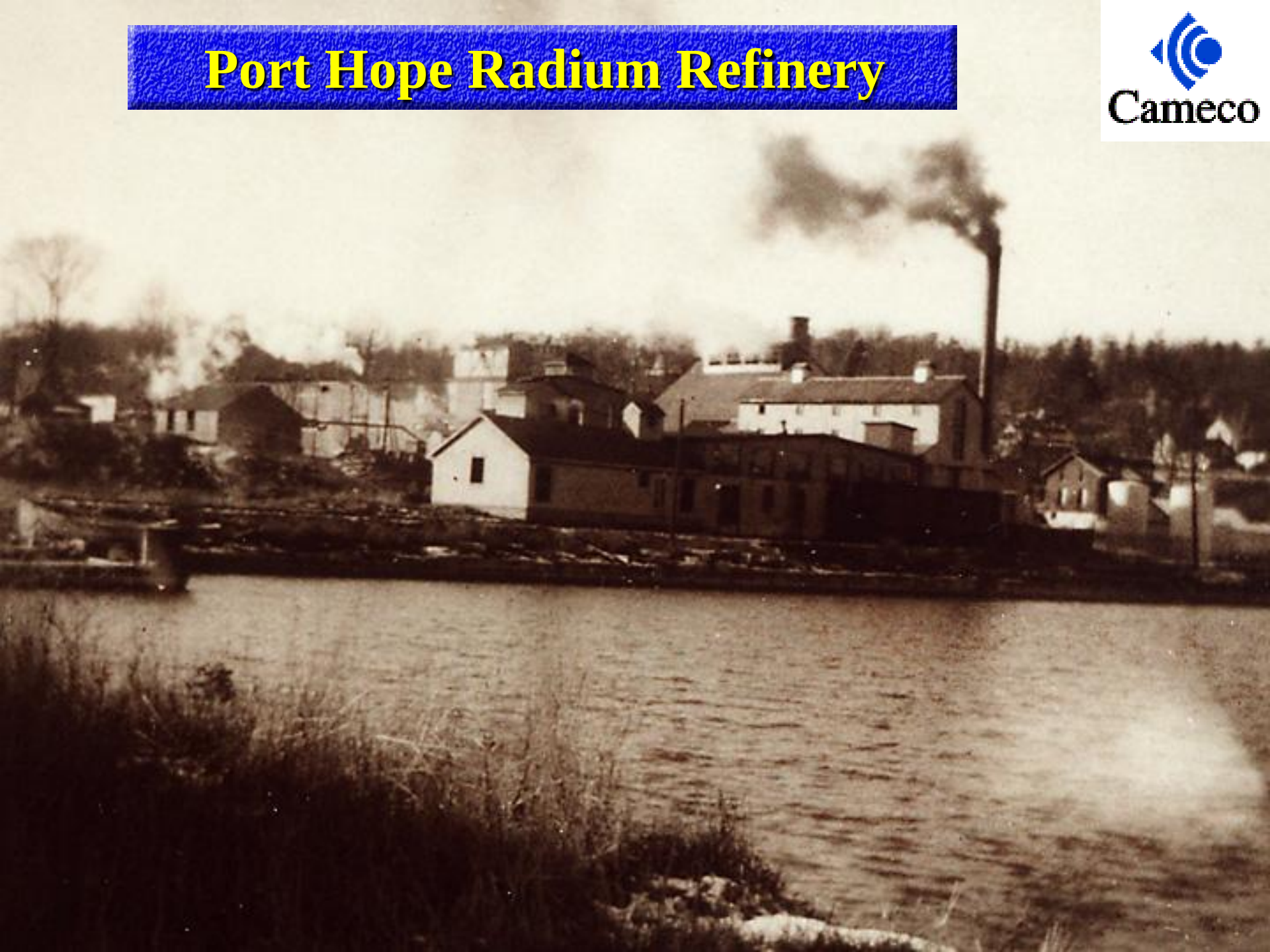
Nuclear Fuel Cycle



Carried on by Cameco and others

Carried on by others

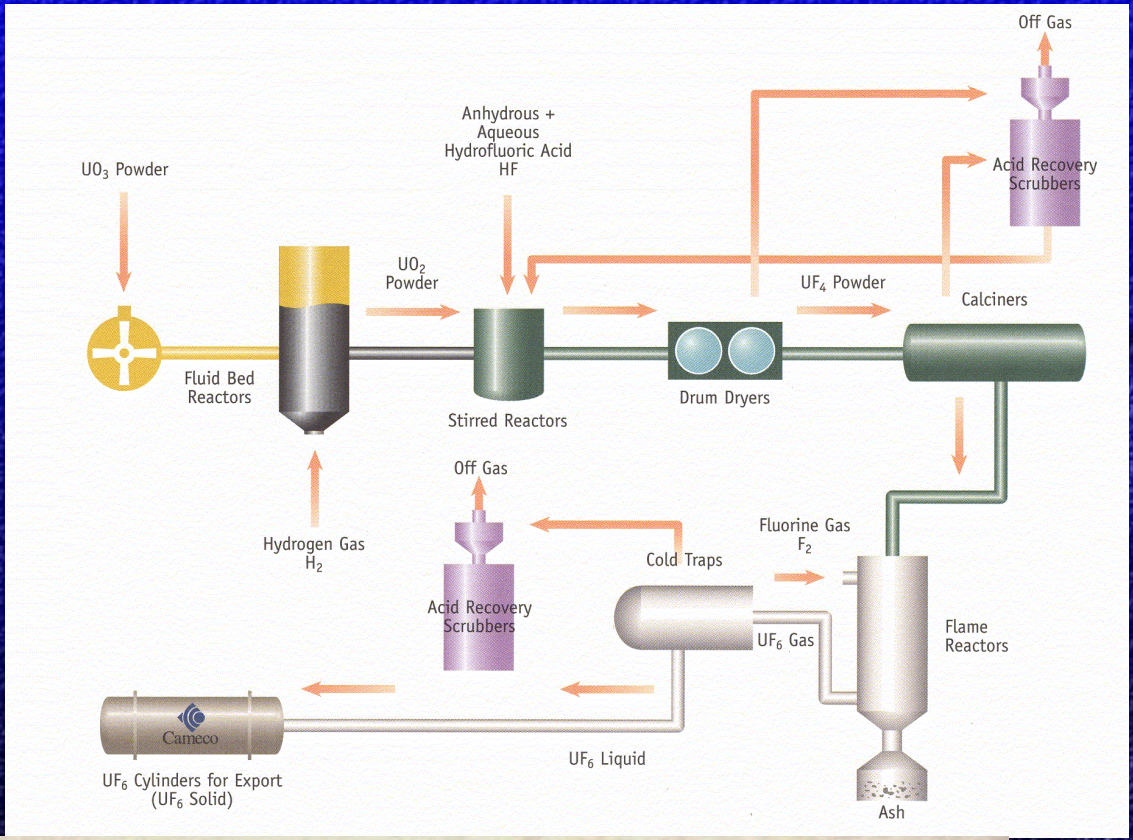
Port Hope Radium Refinery



Port Hope conversion facility

Cameco UF_6 conversion facility

UF_6 Conversion Process



Solid UF_6


1247

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UF_6 Cylinder Transport Canada to USA

Figure 1. Photograph of open trailer road truck loaded with 2 full 48X cylinders for transport to the U.S.A.

Neutron Measurements at PHCF

- Neutrons are generated at a low rate from spontaneous fission of uranium and at significantly higher rates from uranium-fluorine compounds through the reaction $^{19}F+\alpha \rightarrow n+^{22}Na$.

- Laboratory measurements and theoretical calculations indicate that the dose rate due to neutrons around UF_6 cylinders could be in the range of 0.5 to 2 µSv/h. These values suggest the doses to workers in the UF_6 plant should be less than 1 mSv/y because only a small fraction of a typical work year is spent in close proximity to UF_6 cylinders.

Neutron Measurements at PHCF

- To determine the validity of these studies, as they apply to the situation at Port Hope, measurements were conducted with a neutron survey meter.

- Neutron fields near large sources of UF_6 were easily measurable, but were less than 0.5 µSv/h in virtually every work area assessed.

- This means that doses to workers from neutrons are much less than 1 mSv/y.

Neutron Measurements at PHCF

- A neutron survey was conducted on December 14, 2000 with an ADM-300C Gamma/Neutron survey meter owned by Ontario Power Generation (OPG).

- The meter has energy compensated response to neutrons that measures in units of µSv. The ADM meter can operate as either a rate meter or in a dose integration mode.

- The unit had to be used in dose integration mode and kept still for 4 minutes during the measurement period.

Neutron Measurements at PHCF

- Priority was given to locations with large UF_6 sources nearby because UF_6 is the strongest source of neutrons.

- Contact measurements were done on large uranium-fluorine sources (e.g., UF_6 cylinders) to determine the maximum neutron dose rates at the facility; these measurements were called engineering locations.

Neutron Measurements at PHCF

- High-occupancy work areas in the general vicinity of large UF_6 sources were also measured to give a realistic estimate of dose rates in these important locations; these measurements were called workplace locations.

- In addition, measurements were taken at some of the routine TLD stations along the fence line to determine if there is any measurable dose to the public; these measurements were called fence line locations.

Neutron Measurements at PHCF

Location Type	No.	Neutron Dose Rate µSv/h		
		Average	Minimum	Maximum
Engineering	7	1.51	0.05	3.00
Workplace	13	0.14	0.00	0.56
Fence line	8	0.03	0.00	0.05

Neutron Measurements at PHCF

- As anticipated, the engineering samples had the highest results and in the approximate range expected based on the literature review of the topic.

- Contact readings on UF_6 cylinders ranged between 1.5 to 3.0 µSv/h and one reading on top of the head of the primary filter in the second floor flame reactor area had a value of 0.2 µSv/h.

- Lying on a full UF_6 cylinder would give a neutron dose rate of about 2 µSv/h, while the dose rate for a worker standing between two UF_6 cylinders, which one would hope to be a more realistic exposure scenario, would be about 1 µSv/h.

Neutron Measurements at PHCF

- In typical workplace locations the neutron dose rate ranged from non-detectable to about 0.6 µSv/h, with an average value of 0.1 µSv/h.

- Even close to UF_6 cylinders the dose rate was low; for example, 2 m from a row of 15 full cylinders the dose rate was only 0.4 µSv/h.

- None of the control rooms measured had any appreciable neutron fields. With maximum dose rates at 1 µSv/h and more typical locations having an average about 0.1 µSv/h, the survey shows that doses to workers from neutrons should be less than 1 mSv/y.

Neutron Measurements at PHCF

- The fence line monitoring detected a low-level neutron field around the UF_6 plant. Neutron fields are less than the gamma fields at these locations, but possibly a substantial fraction of the gamma dose rate.

- Neutron Bubble Detector manufactured by Bubble Technologies Industries (BTI) used for environmental monitoring of neutrons has been recommended by Cameco's Health Physicist .

BTI – Bubble Detectors

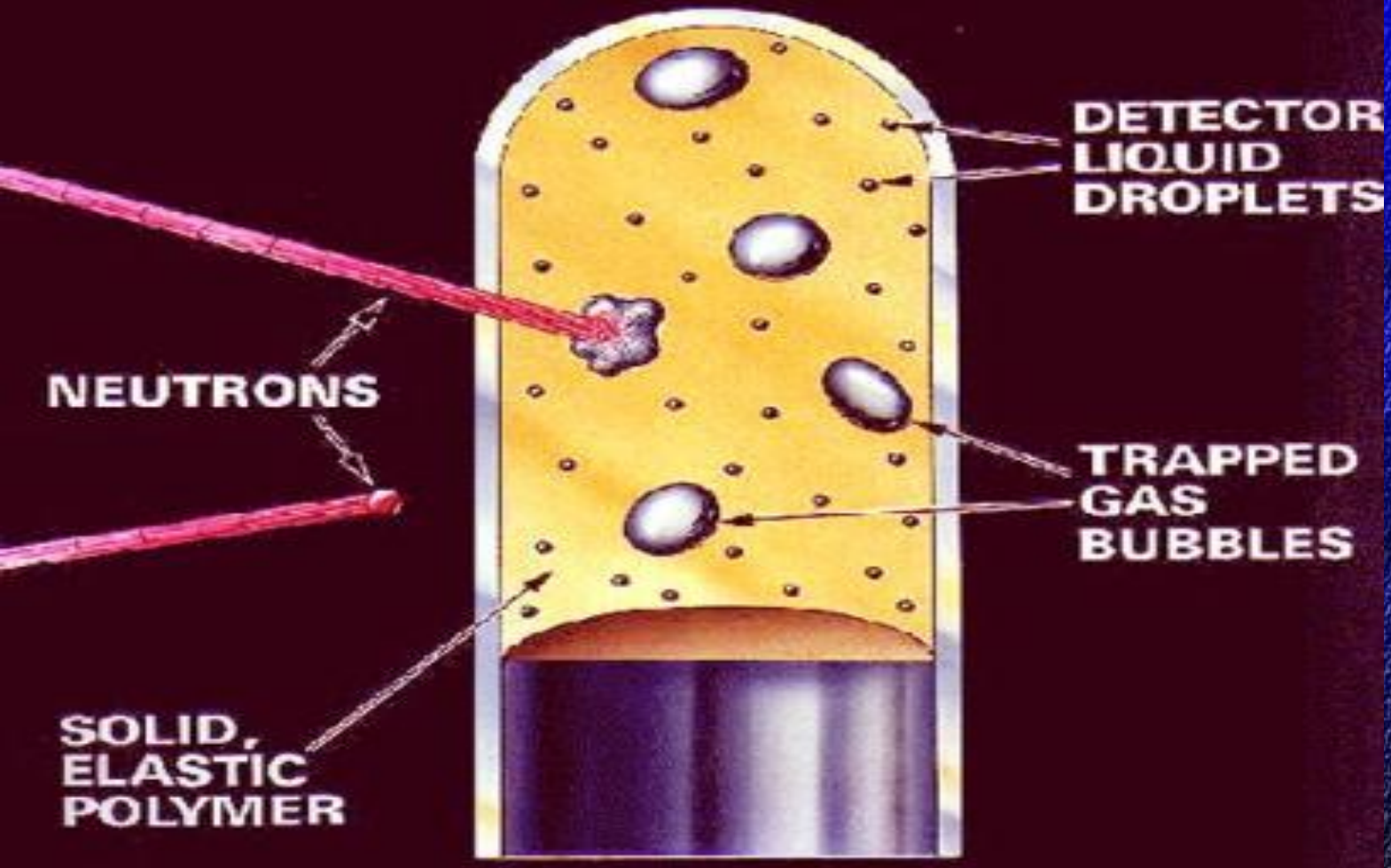
- Bubble tube dosimeters from (BTI) a dynamic company with world-renowned expertise in the field of radiation detection. These dosimeters have a detection limit of 0.01µSv.

- Neutron Bubble Detectors are reusable, integrating, passive dosimeters that allow instant visible detection of neutron radiation.

- Bubble Detectors consist of minute droplets of a superheated liquid dispersed throughout an elastic polymer. When neutrons strike these droplets they form small gas bubbles that remain fixed in the polymer, providing a real time, immediate visual record of the dose.

BTI – Bubble Detectors

HOW A BUBBLE DETECTOR WORKS



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Neutron Measurements at PHCF

- Four fence line locations were selected for the Bubble technology trial in 2001.

Location	Number of trials	Highest results (µSv/h)
South of UF6 Plant	5	0.062
West of UF6 Plant	5	0.080
North of UF6 Plant	5	0.230
Critical Receptor at Mill Street	5	0.030

Neutron Measurements at PHCF

- Neutron radiation studies have been conducted at the PHCF in 2005 to confirm that this source of radiation does not pose a health risk to employees. For these trials Cameco have used two different devices to measure neutron radiation.

- Neutron dosimeters from Landauer Inc. These dosimeters have a minimum detection level of 100 µSv.

- Bubble tube dosimeters from (BTI). These dosimeters have a detection limit of 0.01µSv.

Neutron Measurements at PHCF

Personal monitoring

- **April and May 2005 - Employees from UF_6 plant, UO_2 plant and Materials handling wore a special Landauer CR-39 fast neutron dosimeter designed to neutron radiation exposure**

- **These three groups represent a broad cross section of employees at our site and will provide the data we need to assess the potential impact of neutron radiation on our entire work force.**

- **Results were below the detection level of 200 µSv.**

Neutron Measurements at PHCF

CR-39
Fast/Intermediate/
Thermal Neutron

Neutron Measurements at PHCF

- The Neutrak 144 detector is a CR-39 (allyl diglycol carbonate) based, solid-state nuclear track detector that is not sensitive to x, beta or gamma radiation, and can be packaged specifically for neutron detection only.

- The CR-39 is laser engraved for permanent identification, and wrapped with a 2-D bar code to assure efficient chain-of-custody.

Neutron Measurements at PHCF

- Track Etch Technology consists of etching the CR-39 for 15 hours in a chemical bath to enlarge exposure tracks.

- The fast neutron dose is measured by counting the tracks generated as a result of the proton recoil with the polyethylene radiator, while the thermal/intermediate dose is measured by counting the alpha tracks generated with the boron radiator.

Neutron Measurements at PHCF

- On April 1, 2005, thirty-three Landauer fast neutron dosimeters were deployed along Port Hope Conversion Facility fence line. After 30 days of exposure dosimeters show results below the minimum detection level of 100 µSv.

- A second trial has been initiated on December 1, 2006 and detectors are to be collected on December 1, 2007.

Landauer – Neutrak Detector

CR-39

Fast/Intermediate/

Thermal Neutron dosimeter

Landauer – Neutrak Detector

BTI – Bubble Detectors

- 2005-2006 - An extensive study of neutron radiation was conducted at the UF_6 operation plant using BTI neutron bubble detectors.
- The average neutron radiation dose inside the UF_6 plant was less than 0.3 µSv/h.
- The operators in the cylinder lay down area logged the highest dose rate at 0.12 µSv/h.
- All other operators showed lower dose rates.

BTI – Bubble Detectors

- The study also looked at neutron dose to the public and the environment. The maximum neutron dose along the fence line was 0.28 µSv/h.

- The studies concluded that neutron radiation at the PHCF represents a small fraction of the total whole body dose received by employees and therefore does not pose a risk to employees.

- Cameco will continue to use these devices to demonstrate that neutron radiation levels at the facility remain constant.

The End