RADIOLOGICAL PROTECTION PROCEDURES RELATED TO THE HANDLING OF DIFFERENT URANIUM COMPOUNDS ENRICHED 20% IN 235U

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The obtainment of U3O8 starting from UF6 comprises a wet stage consisting in the extraction of gaseous UF6 by heating at 60-80°C, its hydrolysis to uranyl fluoride and precipitation to ammonium diuranate, and a dry stage where conversion to U3O8 powder takes place through calcination at 800°C and further treatment until the attainment of the raw material for fabrication of fuel elements.

The treatment of these compounds upon the stated process involves a prevailing toxicological risk due to exposition to UF6, FH and UO2F2, and a radiological risk of fundamentally non-stochastic nature for the critical accident and stochastic nature for the dispersion of materials.

Exposition to UF6 constitutes an emergency because in a few minutes UF6, FH and F2UO2 incorporations can reach toxicological limits. On the other hand, these incorporations represent only 10^{-2} times of ALI.

Uranium (20% 235U) air concentration

-Toxicological risk (UF6, UO2F2)	
continuous exposure	200 μg m^{-3}
TLV-EE 10 min	3 mg m^{-3}
-Radiological risk (UF6, UO2F2)	
continuous exposure	53 μg m^{-3}
ALI	134 mg m^{-3}

For the other compounds, ALI can be reached in a few minutes in case of inhalation of dry material dispersion.

	ALI
ADU	3.10^4 Bq
U3O8	103 Bq

For continuous exposure derived uranium (20% 235U) air concentration is determined by the radiological risk.

Uranium (20% 235U) air concentration

Toxicological risk	200 μg m^{-3}
Radiological risk	
ADU	[illegible] μg m^{-3}
U3O8	1 μg m^{-3}

Adequate respiratory protection systems for the above risks are:

Fume hood ($1m^3\ s^{-1}$ air velocity)	Hazards involving UF6 escape have to be avoided, personal protection is necessary for emergencies.
Glove box with air extraction system	UF6 explosion has to be avoided for glove box integrity.

The protection system adopted for the Plant Production at the CNEA Constituyentes Atomic Center is glove box with 10-15 air renovations h^{-1}, 1m s^{-1} velocity for any opening. In view of the differences in the process, kind of materials and type of risk involved in case of internal contamination the wet stage and dry operations are performed in two different enclosures.

The main risks in handling these compounds are the probability of internal contamination with stochastic radiological effects and the probability of criticality with mainly non-stochastic radiological effects. The hazards involved in these risks are UF6 cylinder explosion, UF6 escape, dispersion of materials and critical excursion. The Plant was designed under the principle of totally avoiding the first and second hazards, and reducing to minimum the consequences of the last two.

Several events may lead to internal contamination if combined with gloves or bags rupture and glove box ventilation failure:

- the presence of HF or impurities in the UF6 cylinder may result in explosion while heating. Prevention consists in UF6 vapor pressure determination at room temperature before heating.
- failure in impurities detection would lead to an abrupt rise of pressure during heating for which the countermeasure consists in the automatic relief to a gas expansion system.
- heating at temperatures higher than 121°C would lead to hydraulic rupture of a full cylinder; redundant, independent controls of temperature linked to automatic stopping of heating for T above 110°C are needed.
- heating of an overfilled cylinder can lead to hydraulic rupture of the tube. Tube weight must be determined prior to heating.
- contact of UF6 with hydrocarbons generates explosive mixture. The use of hydrocarbons is forbidden in the plant and fluorinated oils must be used in pumps.
- cloggins in piping or valves and water vapor presence are events conducing to pressure rise in the gas transfer system with the probability of loss of primary confinement. Check of piping leakage and use of purge gas are necessary prior to gas transfer. In case of pressure rise, connection to the already mentioned gas expansion system favours the state of confinement of UF6 gas.

The prevention of criticality is given operatively by the mass control at the wet stage, and mass and moderator control at the dry stage. Always units of less than 2,4 kg of uranium are handled.

The most relevant hazard for criticality lies in an uncontrolled transfer of UF6 to the hydrolysis vessel. For its prevention hydrolysis takes place in a vessel with annular geometry embodying a cadmium sheet in its construction. No matter the amount of UF6 transferred, critical excursion cannot take place. Physical restraints avoid the inadvertent transference to unsafe geometry.

In case of UF6 dispersion, liquids or material spreading, inherent safety is achieved by safe design of the air extraction system, safe geometry of the glove box floor and of collector bowls, and safe distribution of subcritical units.

As shown in Fig.1 interactions between subcritical units are only relevant after a chain of events of low probability has occurred. (B) identifies an interaction between dispersed solid UF6 and UO2F2 and spread water. (A) and (B) identifies the same situation as (B) but the interaction is with a spread UO2F2 saturated solution in safe geometry.

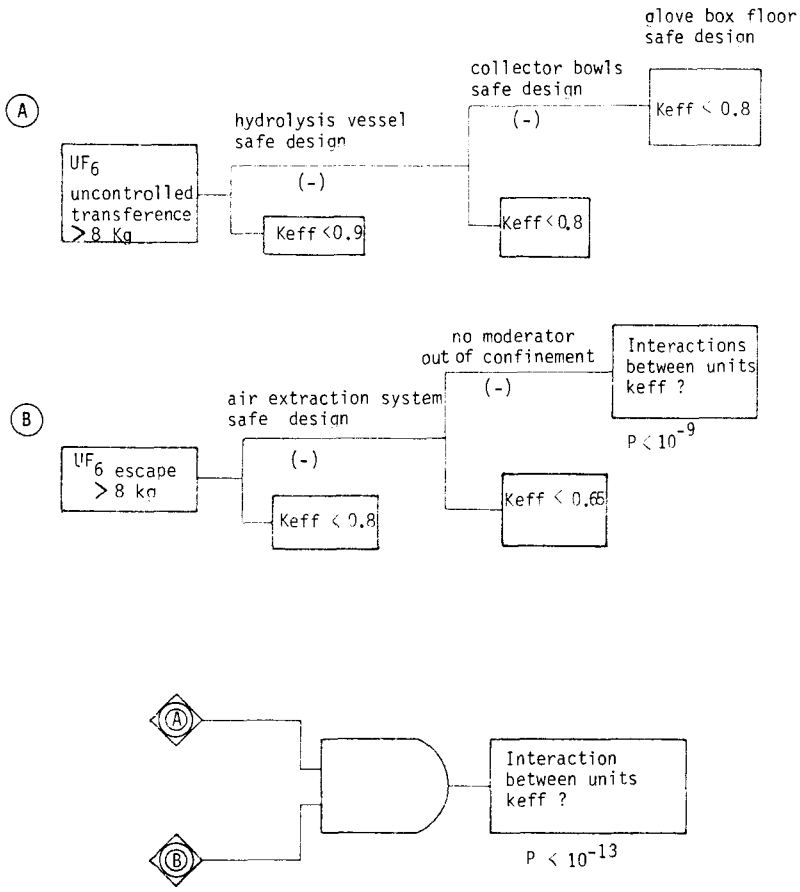

Figure 1

A simple administrative control of mass and moderation limits with wide margins of safety along the dry powder line was established. Ten kilograms of uranium are allowed, administrative mass control is aided by limiting the number and capacity of containers, so that operative control is reduced to respect the prohibition of moderator in excess of the minimum amounts allowed.

The operative experience showed that the principal hazards had been sufficiently taken into account. Incidents of UF_6 escape to the glove box occurres coming from UF_6 deposits in the connection pigtail to the transfer system and UF_6 deposits in the nozzle through which the gas enters to the hydrolysis vessel and the hydrolysis vessel cover. As expected, monitoring showed absence of contamination out of the glove box. After these incidents an outlet for the glove box air extraction was placed close to the cylinder valve. Admissible levels of contamination were detected in empty cylinders coming out of the glove box. Liquid and solid spreadings occurred as expected and without radiological consequences. There were no incidents involving internal contamination.

Intensive monitoring during the fabrication campaigns demonstrated that the risks had been adequately evaluated and safely handled.

BIBLIOGRAPHY

1. ICRP publication N° 30 (1979).

2. N.L. Spoor and N.T. Barrison. "Emergency Exposure Levels for Natural Uranium". NRPB-R 111 (Dec.1980).

3. Nuclear Safety Guide TID 7016 (Rev.2) (1978).

4. Guide de Criticité. Rapport CEA-R 3114 (1967).

5. Uranium hexafluoride handling procedures and container criteria. ORO 651 Rev.4.