DECONTAMINATION AND REFURBISHING OF CELESTE-I INSTALLATION

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ABSTRACT

Envisaging the needs of the Chemical Engineering Department from IPEN/CNEN-SP with respect to decontamination and refurbishing of its installation named CELESTE -I, an organized R&D program was undertaken in Brazil. Under the IAEA Research Contract N° 7958/RB studies were initiated comprising chemical decontamination and the development of special devices to improve the remote servicing in the hot cells. This project consists of four major phases. Phase I started in 1991 as preparatory work by the construction of an intervention cell and planning of the overall decontamination operation. Phase two shows the laboratory runs to determine the best chemical decontamination solution. Phase III, the decontamination of the hot cells and Phase IV, the required special tools for remote servicing and the measures to installation refurbishing. The above identified concerns have now been solved except the last phase because the changing of the R&D program related to the installation.

I. INTRODUCTION

CELESTE I installation is a R&D hot lab designed to allow process chemistry for the treatment of spent fuel. It comprises two airtight stainless steel boxes, 4.5 x 1.25 x 1.35m and 3.5 x 1.25 x 1.35m lead shielded with five working places provided with lead glass windows and ten slave manipulators.

This miniature facility is allowed for R&D works in the treatment of low burned spent fuels, concerning basically with head-end and Purex first cycle process. The installation has run a basic high acid Purex first cycle flowsheet for the treatment of a simulated 500 Mwd/t burn-up PWR fuel type. Its design was started up in the middle of the seventies and it has been in operation since 1983.

CELESTE is part of the Hot Chemistry Division which is physically divided in cold and hot labs. The hot cells are located in the process room which is also provided with glove boxes, hoods for process and analytical preparations and analysis. Auxiliary services are available. Figure 1 shows the layout of CELESTE. The installation was shutdown in 1987 and has been submitted to a partial decontamination since 1991 in the boxes mentioned before.

The decontamination had its start up through a project and construction of an intervention cell [1] that was connected to the hot cells (Figure 2).

II. RISKS EVALUATION

An evaluation of radiological risks to run the intervention inside the hot cells was performed by the personnel from the Radioprotection. At this time the selection of intervention monitoring equipment was made.

The contamination limit promoted by an unknown mixture of radionuclides is 0.3 Bq cm^{-2} in restricted areas of CELESTE installation.

Characterization of the Contamination. The internal stainless-steel 304 surfaces from hot cells were contaminated. Swipe samplings were made and submitted to qualitative gamma spectrometry analysis have shown the presence of Am-241, Cs-137, Ce-144, U-238, Th-234, U-235, Ra-226 and Pu-239. Table 1 gives a relative idea from the activity of these elements.

An alpha spectrometry analysis was also performed after lixiviation of the swipe samples, aiming to establish the plutonium mass present in contaminated areas. The results can be observed in Table 2.

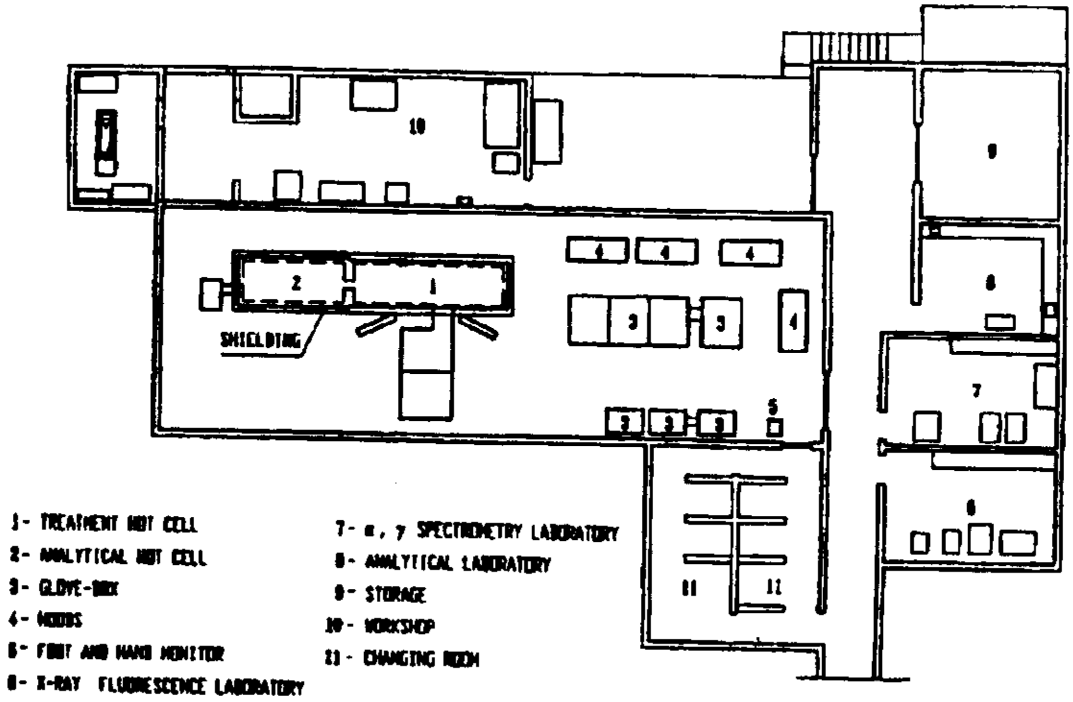

Figure 1. Layout of Celeste.

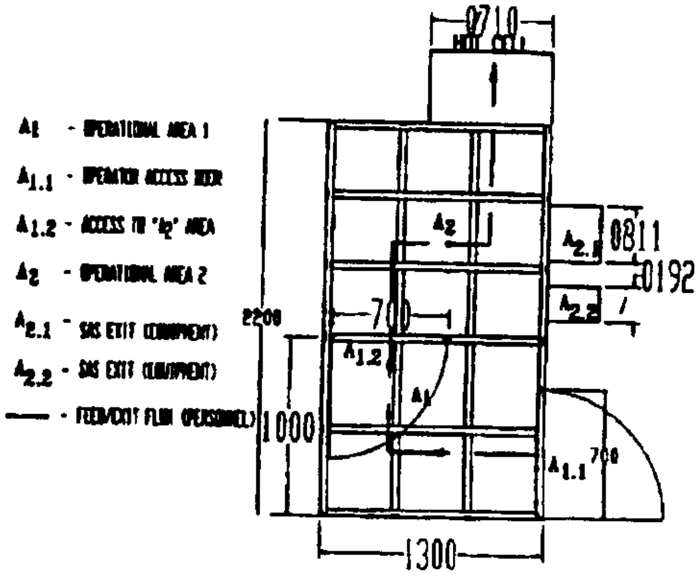

Figure 2. Intervention Cell.

TABLE 1. Gamma spectrometry analysis (2nd and 3rd windows).

Swipe Sample N°	Observed radionuclides on gamma spectrometry Time: 1000s							
	Am-241	**Cs-237**	**Ce-144**	**U-238**	**Th-234**	**U-235**	**Ra-226**	**Pu-239**
1	x	xxx	-	x	x	x	-	-
2	x	x	-	x	x	-	-	-
3	x	x	x	-	-	-	-	-
4	-	-	-	-	-	-	-	-
5	xxxx	xxxx	xx	-	-	-	-	x
6	xx	x	-	x	x	x	x	-
7	xxxxx	xxxxx	xxx	x	x	x	xx	xx
8	xxx	x	-	xxx	xxx	xx	x	xxx
9	xx	xx	x	x	x	x	-	-
10	xx	x	x	x	xx	x	-	-
11	x	x	-	-	-	x	-	-

- not observed
x observed (the x amount shows the radionuclide activity intensity)

TABLE 2. Alpha spectrometry analysis.

Swipe Sample	1	2	3	4	5	6	8*	9	10
Pu(μg)	0.08	0.01	0.01	0.01	0.41	0.23	0.09	0.13	0.26

* two extractions and two analyses

Decontamination Procedures [2]. Due to surface contamination level in the hot cells, a first remote chemical decontamination step was required in order to reduce the gross α, β, γ activities followed by a direct cleaning and decontamination operation.

In order to proceed the intervention/ decontamination, we have developed a work programme involving:

- Technical tasks
- Documentation
- Required tools
- Cleaning and decontamination process
- Materials
- Operators support
- Radiation protection
- Personal Training
- Entrance/Exit/Route
- Area decontamination
- Equipment removing
- Conditioning
- Storage
- Waste removing

Experiments on decontamination of alpha emitters contaminated surfaces were carried out. Research was conducted by the choice of the best methodology and reagents that must be used. In our case, as the stainless steel is the main construction material, we have concluded that HNO_3 and the complexing agent EDTA were the best reagents for hot cells cleaning or decontamination.

Table 3 shows the experimental results obtained from contaminated stainless steel and other material samples, according to experiments accomplished before the intervention inside the process hot cell. During the tests, sample surfaces were contaminated with 50μl of alpha emitters aqueous and organic solutions.

From the table above we can conclude that EDTA and nitric acid have shown better decontamination efficiency for SS-304 (DF=943 for EDTA and 707.6 for HNO_3). Based on these facts it was decided to use both of them to proceed the cleaning and the partial decontamination inside the hot cells. In the case of rubber and acrylic, EDTA is better than nitric acid because this acid promotes attack over the surfaces as observed during former experiments.

TABLE 3. Experimental results on decontamination.

Reagent	**Surface**	**Aqueous**	**phase**	**DF**	**Organic**	**phase**	**DF**
		A_i (Bq)	**A_f (Bq)**		**A_i (Bq)**	**A_f (Bq)**	
EDTA	SS-304	62,242	66	943	6,740	73	92,3
	rubber	12,497	1,142	8.7	439	83	5.3
	acrylic	71,135	377	188.7	2,662	74	36
	PVC	70,361	1,399	50.3	2,299	455	4.9
HNO_3	SS-304	71,474	101	707.6	8,804	124	71
	rubber	20,327	1,123	18.1	1.824	293	6.2
	acrylic	59,603	399	149.4	3,104	31	100.1
	PVC	60,184	2,418	24.9	1,749	544	3.2
Ethanol	SS-304	-	-	-	7,949	367	21.7
	rubber	-	-	-	855	226	6.9
	acrylic	-	-	-	3,871	124	31.2
	PVC	-	-	-	1,539	687	2.2
n-dodecane	SS-304	-	-	-	8,121	156	52.1
	rubber	-	-	-	480	318	1.5
	acrylic	-	-	-	3,312	657	5.0
	PVC	-	-	-	1,783	1.033	1.7

III. DECONTAMINATION RESULTS

The results from these experiments are based on decontamination factors. The initial activity (A_i) was obtained by measuring the contaminated surface samples. After the decontamination using selected reagents (EDTA and nitric acid), the remaining activities on the samples were measured (A_f). The decontamination factor, defined by $DF = A_i . A_f^{-1}$, has been found in that way.

Based on DF's obtained from the mentioned experiments, HNO_3 and EDTA were used for the decontamination operation inside the hot cells. We are quite sure that the individual personal equipments have given the necessary protection for the operators during the intervention operation.

This technique was proved to be useful to minimize the contamination exposure to the workers. The intervention work has been well managed, because it was not our main objective to perform a full decontamination, as in the case of decommissioning. The decontamination factors after the intervention operation were not a critical data and, in this way, they were not determined.

IV. REMOTE SERVICING AND OPERATIONAL TESTS

After decontamination the installation was considered ready for servicing and refurbishing. The final phase follows the maintenance strategy to provide the facility with systems and equipments to substitute part of the required direct intervention. This aim was directed toward the following objectives:

Movable Crane. A movable crane design has been developed to improve the remote control inside the hot cells. The conception of this device provides displacement and transportation of equipments or materials.

Mixer Settlers Support. In order to simplify the exchange of mixer settlers when it is necessary, a specific support was designed (see Figure 3). The mixer settlers have a short life when submitted to radiation during the normal processes because part of its structure is made of acrylic. Former servicing was made only by intervention. The new support make possible to exchange it by remote control using the new crane mentioned before.

Sample Locating Device. The existing equipment was removed from analytical hot cell and submitted to decontamination. Afterwards, it was observed that the electronic control system must be replaced. This was made by using redundant inductive sensors, which give more operational safety during the chemical analysis, accomplished in the hot cell.

Fuel Elements Cutting Device. The system was totally decontaminated and dismantled. Damaged parts were replaced and the operational checking up has been made. This servicing was performed under intervention conditions.

HEPA Filters. The internal filters of the hot cells were exchanged. The manipulating system used for filter

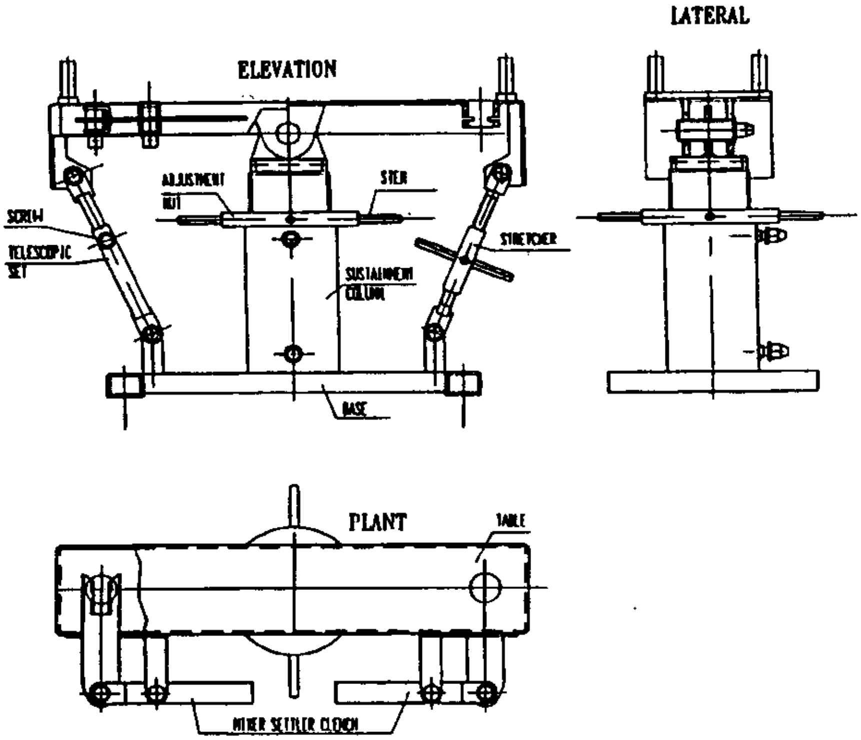

Figure 3. New Mixer-Settler Support.

servicing was also modified in order to improve the exchanges.

Washing and Concentrating Glove-boxes. The existing system was totally rebuilt in the following way:

- to separate the uranium and plutonium lines.
- to establish redundant liquid lines.
- to introduce a continuous reoxidation cell to plutonium.
- to introduce a more safe instrumentation in the glove-box for products evaporation (U,Pu).

Figures 4 and 5 show the new conception of these glove-boxes.

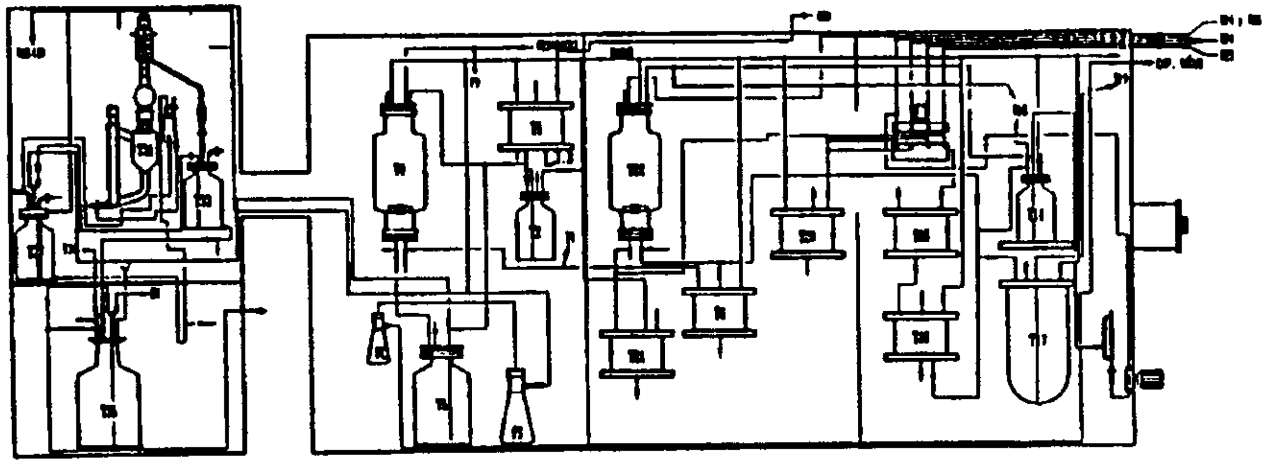

Figure 4. Solvent Washing and Uranium Concentration.

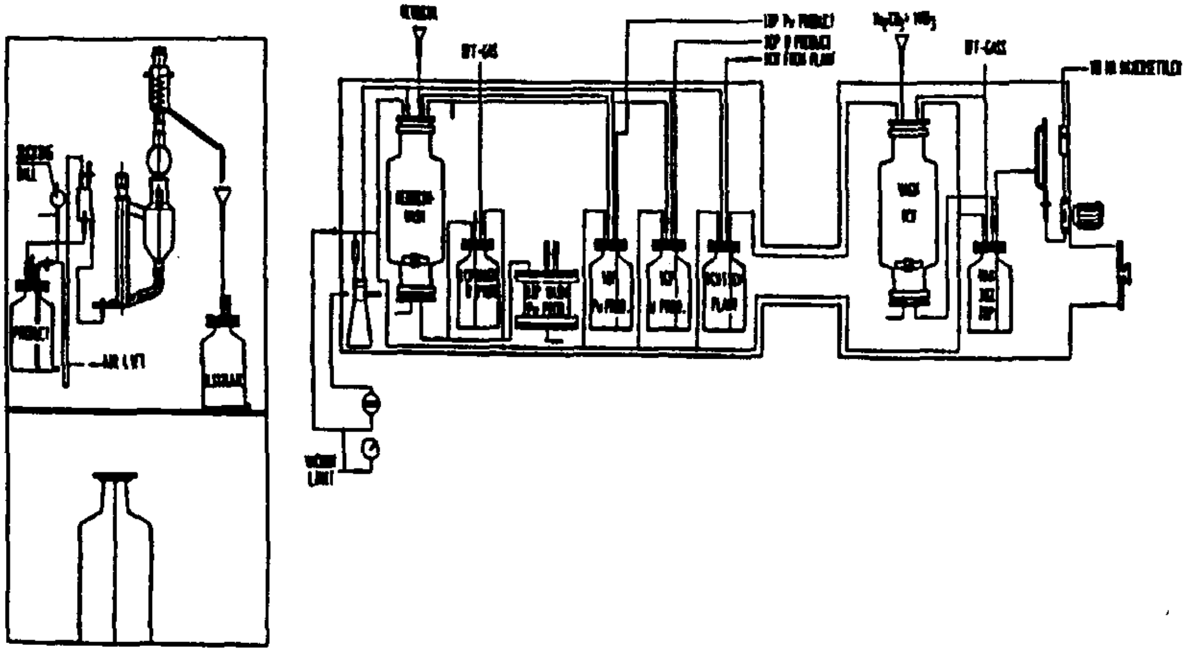

Figure 5. Solvent Washing and Plutonium Concentration.

V. CONCLUSIONS

The studies carried under IAEA Coordinated Programme were useful in identifying chemical formulation for partial decontamination of the CELESTE I installation. We would like to express gratitude for the IAEA collaboration, including financial resources.

This research was conducted by the choice of the best methodology and reagents that must be used. In our special case as stainless steel is the main construction material, we have concluded that nitric acid 1M and the complexing agent EDTA (aqueous solution 0,1M) were the best chemical solution reagents for cleaning or to provide appropriated descontamination of the hot cells.

This technique was proved to be useful to minimize the workers contamination exposure inside the hot cells. The intervention work has been well managed because our main objective was not to perform a full decontamination, as is the case of some decommissioning.

Unfortunately, by political decision from our National Nuclear Energy Commission we had to break up the research program. The last phase related with the operational tests was discontinued and the installation possibly will be used in another R&D program.

REFERENCES

[1] ARAUJO, J.A. et allii., **Descontaminação e Intervenção nas Células Quentes CELESTE I - IPEN-CNEN/SP**. Proceedings of the IV General Conference on Nuclear Energy, Rio de Janeiro, Brasil, vol. 1, p.257-259, 1992.

[2] ARAUJO, J.A et allii., **Descontaminação e Readaptação da Instalação CELESTE I do IPEN-CNEN/SP**. Proceedings of the VI General Conference on Nuclear Energy, Rio de Janeiro, 27 Oct.-01 Nov., 1996.