KfK 4360
NUCLEBRAS/CDTN 594
April 1988

# Status Report on the Waste Management Cooperation Programme Jointly Undertaken by KfK/INE-NUCLEBRAS/CDTN

S. Teh Whei Miaw, H. Krause
Empresas Nucleares Brasileiras SA (NUCLEBRAS)
Centro de Desenvolvimento da Tecnologia Nuclear (CDTN)
Institut für Nukleare Entsorgungstechnik

Kernforschungszentrum Karlsruhe

K E R N F O R S C H U N G S Z E N T R U M   K A R L S R U H E

Institut für Nukleare Entsorgungstechnik
Empresas Nucleares Brasileiras SA (NUCLEBRAS)
Centro de Desenvolvimento da Tecnologia Nuclear (CDTN)

KfK 4360
NUCLEBRAS/CDTN 594

# STATUS REPORT ON THE WASTE MANAGEMENT COOPERATION PROGRAMME JOINTLY UNDERTAKEN BY KfK/INE - NUCLEBRAS/CDTN

Sophia Teh Whei Miaw (editor)
H. Krause

Kernforschungszentrum Karlsruhe GmbH, Karlsruhe

Kernforschungszentrum Karlsruhe GmbH
Postfach 3640, 7500 Karlsruhe 1

ISSN 0303-4003

**Statusbericht zum Kooperationsprogramm auf dem Gebiet der radioaktiven Abfälle zwischen KfK/INE und NUCLEBRAS/CDTN**


**Zusammenfassung**

Seit 1979 führt die Divisao de Tratamento de Rejeitos Radioativos (DITRR.CN) des Centro de Desenvolvimento da Tecnologia Nuclear (CDTN) in Belo-Horizonte, Brasilien in Zusammenarbeit mit dem Institut für Nukleare Entsorgungstechnik (INE) des Kernforschungszentrums Karlsruhe (KfK) ein Programm zur Behandlung radioaktiver Abfälle einschließlich der entsprechenden Forschungs- und Entwicklungsarbeiten durch. Dieser Bericht faßt die auf diesem Gebiet bisher erzielten Ergebnisse zusammen.

Das Hauptziel der ersten Phase dieses Programmes war die Entwicklung von Behandlungsverfahren für Abfälle, die im CDTN anfallen sowie die Charakterisierung der Abfallendprodukte im Hinblick auf ihre Endlagerfähigkeit.

Chemische Fällung und Verdampfung wurden als Hauptprozesse für die Behandlung der schwachaktiven, flüssigen Abfälle ausgewählt. In Laborversuchen wurden die Arbeitsbedingungen für die Fällung ausgearbeitet. Die Fällanlage ist bereits erfolgreich in Betrieb. Die Verdampfungsanlage nähert sich der Fertigstellung.

Zwei Pilotanlagen zur Zementierung wurden errichtet und getestet, eine mit einem in-Faß Mischer, die andere mit einem Mischerbehälter. In Laborversuchen wurden die Rezepturen für die Zementierung der ersten Konzentratchargen ermittelt. Laborversuche zur Bituminierung wurden in jüngster Zeit begonnen. Ein kleiner Extruder wird in Kürze in Betrieb gehen.

Weiterhin wurden Behälter und Abschirmbehälter für radioaktive Abfälle entwickelt, verbessert und getestet.

Die beschriebenen Arbeiten wurden in Zusammenarbeit mit dem INE ausgeführt und erlaubten der Abteilung DITTR.CN nicht nur, die im CDTN anfallenden eigenen radioaktiven Abfälle aufzubereiten, sondern auch anderen Tochterfirmen der NUCLEBRAS sowie Isotopenanwendern Hilfen zu geben.

**Abstract**

Since 1979 the Divisao de Tratamento de Rejeitos Radioativos (DITTR.CN) of the Centro de Desenvolvimento da Tecnologia Nuclear (CDTN) in Belo Horizonte, Brazil, in collaboration with the Institut für Nukleare Entsorgungstechnik (INE) of Kernforschungszentrum Karlsruhe (KfK), has carried out a programme on the management of radioactive waste including R & D-activities in this field. This report summarises the main results achieved so far.

The prime objective of the first phase of the programme was to develop processes for the treatment of the wastes arising at CDTN and to qualify waste forms for final disposal.

Chemical precipitation and evaporation have been selected as the main processes for the treatment of low-level liquid wastes. Operating conditions for flocculation have been specified in laboratory-scale experiments. The plant has already been operated successfully. The evaporator nears completion.

Two pilot plants for cementation have been erected and investigated, one with an in-drum mixer, the other with an in-tank mixer. Laboratory experiments on cementation have provided the basis for solidification of first batches of waste concentrates. Laboratory experiments on bituminization have started recently. A small-scale bitumen extruder will be put into operation soon.

There have also been activities on the development, improvement and test of drums, containers and shielding casks for radioactive wastes.

These activities which have been carried out in collaboration with INE, enabled DITRR.CN not only to manage the wastes arising at CDTN, but also to give assistance to other subsidiaries of NUCLEBRAS as well as to isotope users.

**Table of contents**

# 1. INTRODUCTION

Empresas Nucleares Brasileira S.A. - NUCLEBRAS, through the Centro de Desenvolvimento da Tecnologia Nuclear (CDTN), organized in 1974 a R&D-Programme Waste Management conducted by Divisao de Tratamento de Rejeitos Radioativos (DITRR). Since 1979, this programme has been supported by Kernforschungszentrum Karlsruhe (KfK) through the Institut für Nukleare Entsorgungstechnik (INE).

At its beginning the programme benefited from the advice of several German experts. In 1979, a close cooperation was started with KfK/INE. This cooperation was concentrated on areas of actual needs, i.e. mainly the fields of cementation, bituminization, evaporation, decontamination, and radioactive materials transport. Besides, short- and medium-term R&D-programmes and waste management concepts were established.

Within the frame work of this cooperation exchange of personnel took place which enabled CDTN to play an active role in radioactive waste management.

Different waste treatment flowsheets were investigated and developed. Some waste treatment facilities, based on R&D-work, are already available for CDTN waste treatment. The experience accumulated enabled CDTN also to provide assistance in waste management and radioactive material transport to other organizations.

For the period from March 1987 to March 1989, a new joint CDTN-INE working programme is proposed. The main tasks are: demonstration of the active operation of the pilot plants under development, R&D-work on the qualification of final waste products, development and testing of a prototype of hematite-concrete package, definition of a one-year corrosion programme, elaboration of conceptual and basic designs of the CDTN lowlewel waste treatment facility and exchange of personnel.

## 2. COOPERATION PROGRAMME

The cooperation between NUCLEBRAS and KfK in the field of radioactive waste management is laid down in the "Special Agreement" of October 1st, 1976. Since 1979 a Waste Management R&D-Programme at CDTN has been conducted by DITRR with the assistance by INE [1].

During that period there have been six Brazilian missions to Germany (Table 1), and several German delegations came to CDTN (Table 2). By this kind of personnel exchange it was possible

. to set up a group capable of dealing with problems related to waste management,

. to conduct various R&D-programmes for waste treatment processes,

. to operate treatment plants and treat real waste,

. to qualify final waste products,

. to qualify transport packages,

. to give support to NUCLEBRAS groups and other organisations working in these fields.

In 1984, CDTN promoted a 4 days seminar on cementation in collaboration with INE and with the participation of Comissao Nacional de Energia Nuclear, FURNAS Centrais Eletricas, NUCLEBRAS Engenharia, Instituto de Pesquisas Energeticas e Nucleares (IPEN). 30 persons attended that seminar in the course of which surveys were presented on the state of the art in cementation and on activities conducted in this field in the Federal Republic of Germany and in Brazil. Practical problems related to the cementation were discussed and analysed by the participants.

In 1987, CDTN received as donation from KfK/INE a small-scale extruder for use in the process of bituminisation. This equipment will enable CDTN to carry out research work in this field which is necessary for its own programme and that of other companies affiliated to NUCLEBRAS as well. The extruder will also allow to solidify on a small scale real wastes in routine operations. A joint research programme with KfK/INE on bituminization is being discussed.

## 3. WASTE MANAGEMENT PROGRAMME

The main objectives of the programme are:

. to investigate and develop processes and equipment for waste treatment,

. to qualify final waste products in accordance with Brazilian final disposal requests,

. to develop and qualify transport packages for conditioned radioactive wastes,

to treat waste generated by R&D-activities at CDTN,

. to give support in waste management including radioactive waste tansport packages to organizations in nuclear fuel cycle (NUCLEBRAS, its subsidiary companies, FURNAS, etc.) and to isotopes users.

### 3.1 R&D-activities

In the first phase, the R&D-activities pursue the primary objective to develop processes needed for the treatment of the radioactive wastes which arise at CDTN. Priority is given to these processes. Pilot plants are being constructed and operated for demonstration of the processes developed.

Two processes have been developed for liquid waste treatment: chemical precipitation/filtration and evaporation. The filter cake and evaporator concentrate, respectively, from each process will be solidified by cementation or bituminization. These two solidification processes are also being studied.

For the solid waste treatment, baling and crushing processes were already demonstrated. The relevant installations are in operation for CDTN wastes. All these installations will be integrated in the planned new facility for the treatment of LLW generated at CDTN (Figure 1).

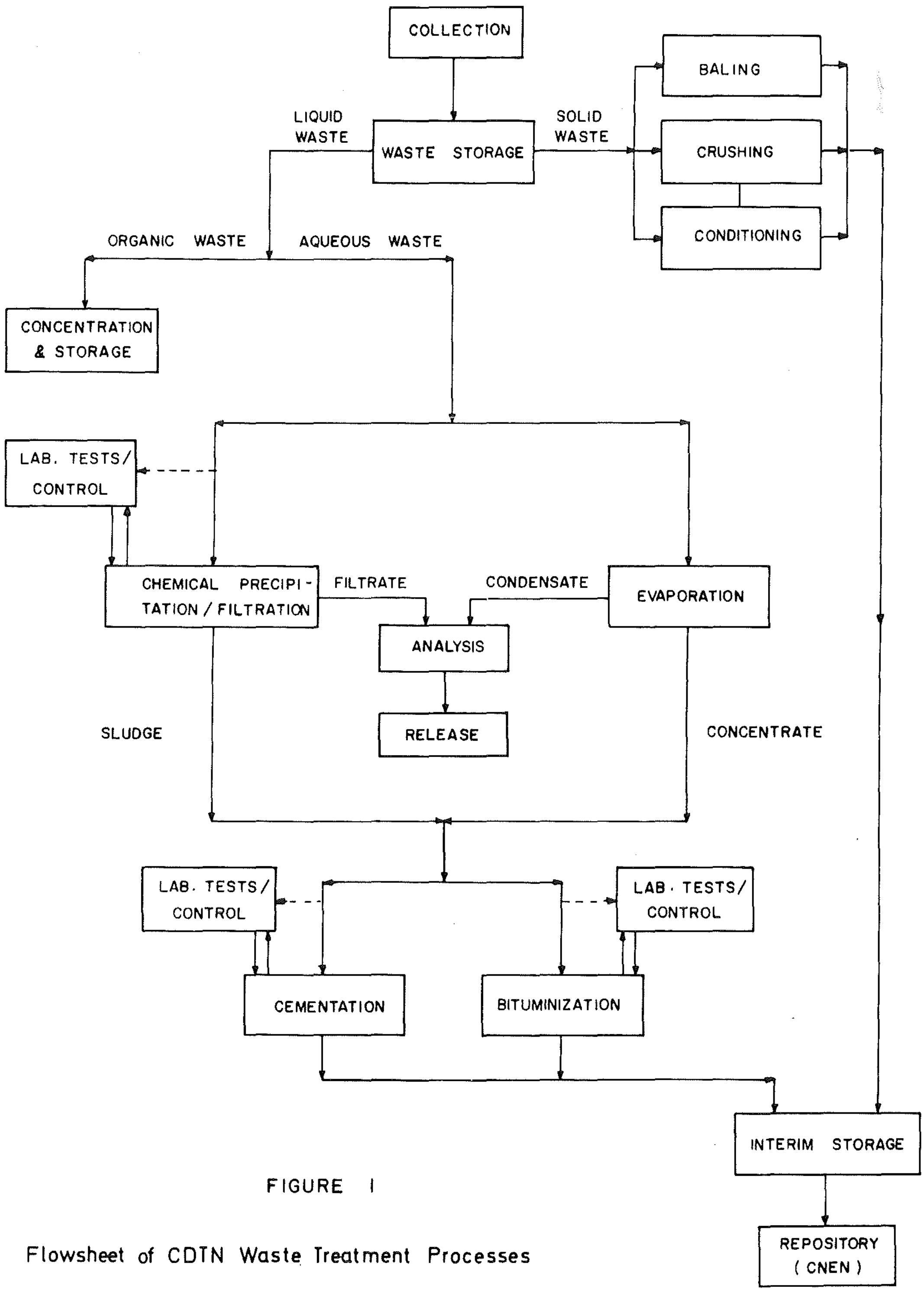



FIGURE I

Flowsheet of CDTN Waste Treatment Processes

There are also activities under way on the development, improvement and testing of drums and shielding casks for radioactive wastes.

### 3.1.1 **Chemical precipitation/filtration**

Laboratory-scale tests

Laboratory-scale tests were carried out with various CDTN waste samples to define the appropriate operating conditions for the pilot plant. Until now, precipitation processes have been developed for treatment of CDTN routine waste from uranium milling, uranium enrichment, and the fuel fabrication laboratory, under various operation conditions and using different chemical reagents [2-6]. Figure 2 gives an idea of the waste composition by the example of the spectrum of one kind of the liquid wastes generated at CDTN. Table 3 shows some results obtained from laboratory tests. For the definition of operation parameters of the pilot filter a small laboratory vacuum filter is available.

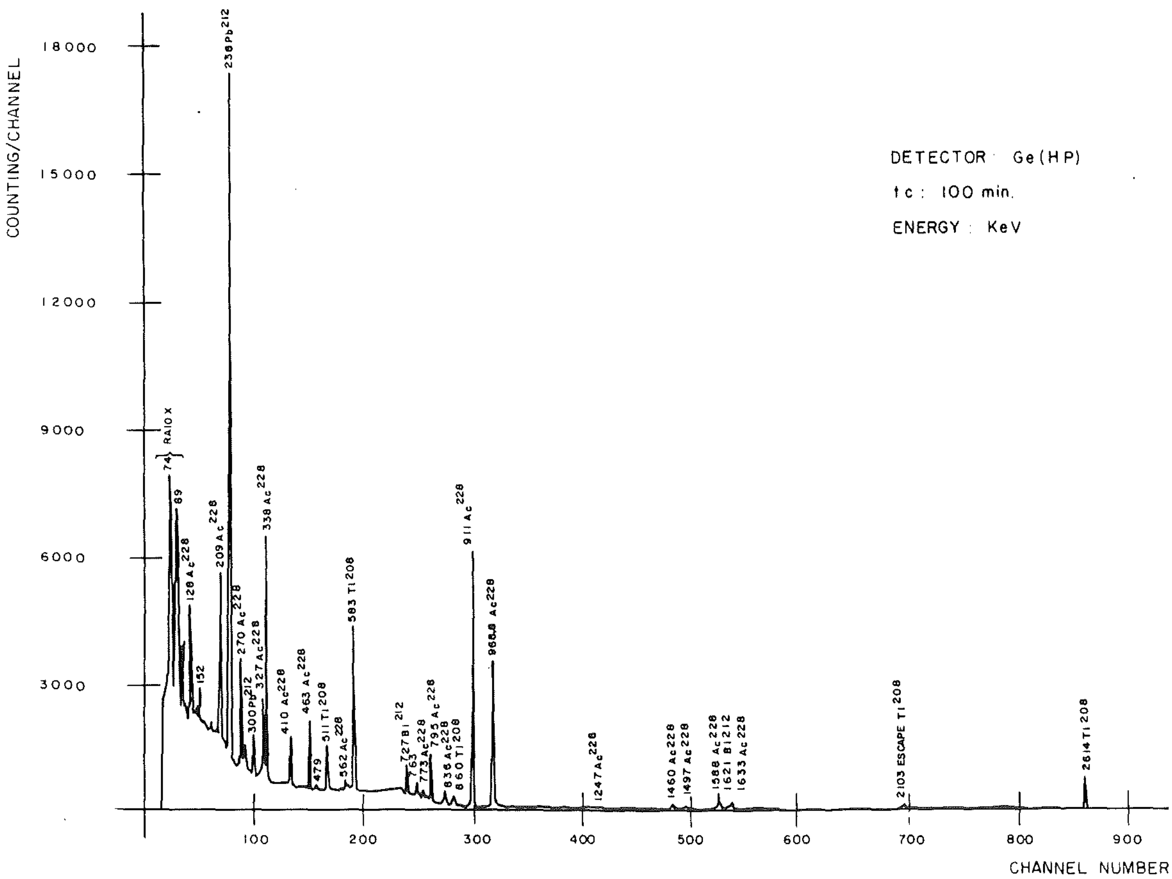



FIGURE 2-GAMA EMISSION SPECTRUM.WASTE FROM FUEL TECHNOLOGY DIVISION.

Future R&D-work will be extended to include all kinds of waste generated at CDTN, and to the optimization of the methods of treatment.

Chemical precipitation/filtration pilot plant

The correct functioning of the chemical precipitation/filtration pilot plant developed by CDTN was already demonstrated [7,8].

The installation is a 200-liter-batch plant connected to the cementation pilot plant. It consists basically of a mixing-decanting tank, a vacuum filter and tanks for filtrate monitoring and sludge storage. Two types of vacuum filter were developed. The first has a small filtration area (660 $cm^2$) of woven cotton canvas and is loaded with vermiculite (5 cm thick) as filter medium; it is designed as a bascule, easy to handle and to decontaminate. The other is used for solutions with low solid concentrations. Its throughput is higher than that of the first (filtration area 1.5 $m^2$); the filter medium is removed together with the slurry. Figures 3 and 4 show the simplified flowsheet and a general view of the pilot plant, respectively.

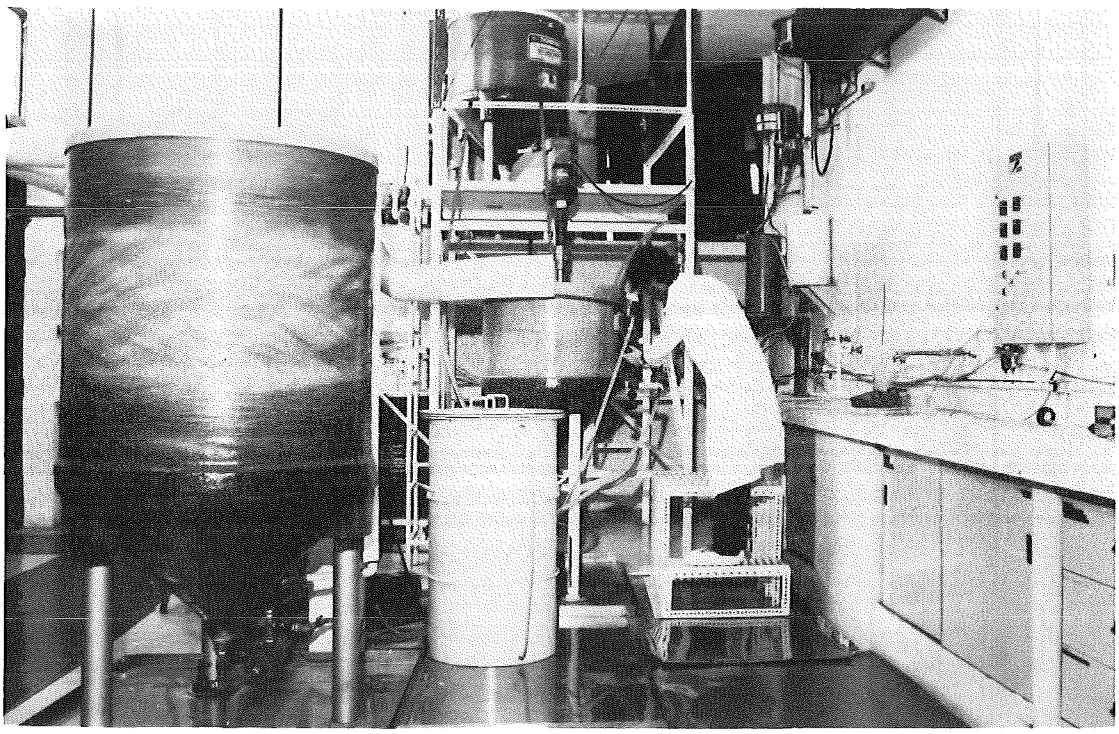
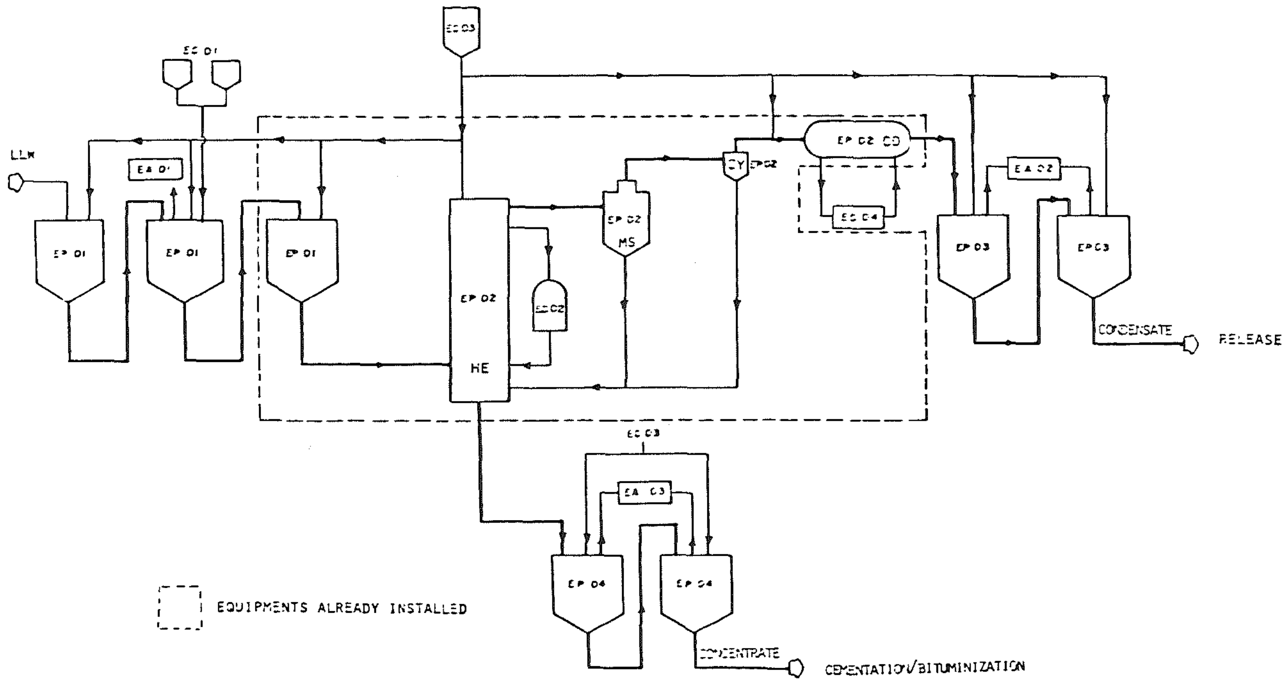


Fig. 3: Chemical Precipitation/Filtration Pilot Plant




LEGEND

EP 01 - Waste receiving, adjusting and feed tanks
EP 02 - Evaporation system
. HE - Heat exchange
. MS - Mist separator
. CY - Cyclone
. CO - Condenser

EP 03 - Condensate control tanks
EP 04 - Concentrate tanks

EC 01 - Reactant tanks
EC 02 - Steam generator
EC 03 - Decontamination solution tanks
EC 04 - Condenser cooling tower

EA 01 - Feed sample
EA 02 - Condensate sample
EA 03 - Concentrate sample

FIGURE 6 - SCHEMATIC FLOWSHEET OF EVAPORATION PILOT PLANT

### 3.1.2 **Evaporation pilot plant**

The pilot plant evaporator under development is a batch type with external heater. Its evaporation capacity is 48 kg/h [9]. It is composed mainly of three parts (Figure 5):

- process: waste receiving, adjusting and feed tanks, heat exchanger, mist separator, cyclone, condenser, concentrate and condensate tanks;

- auxiliary systems: pH adjusting tanks, steam generator, decontamination solution tank, condenser, cooling tower;

- sampling systems: feed, condensate and concentrate samples.

Almost 70% of the plant is already completed. Figure 6 shows the plant in

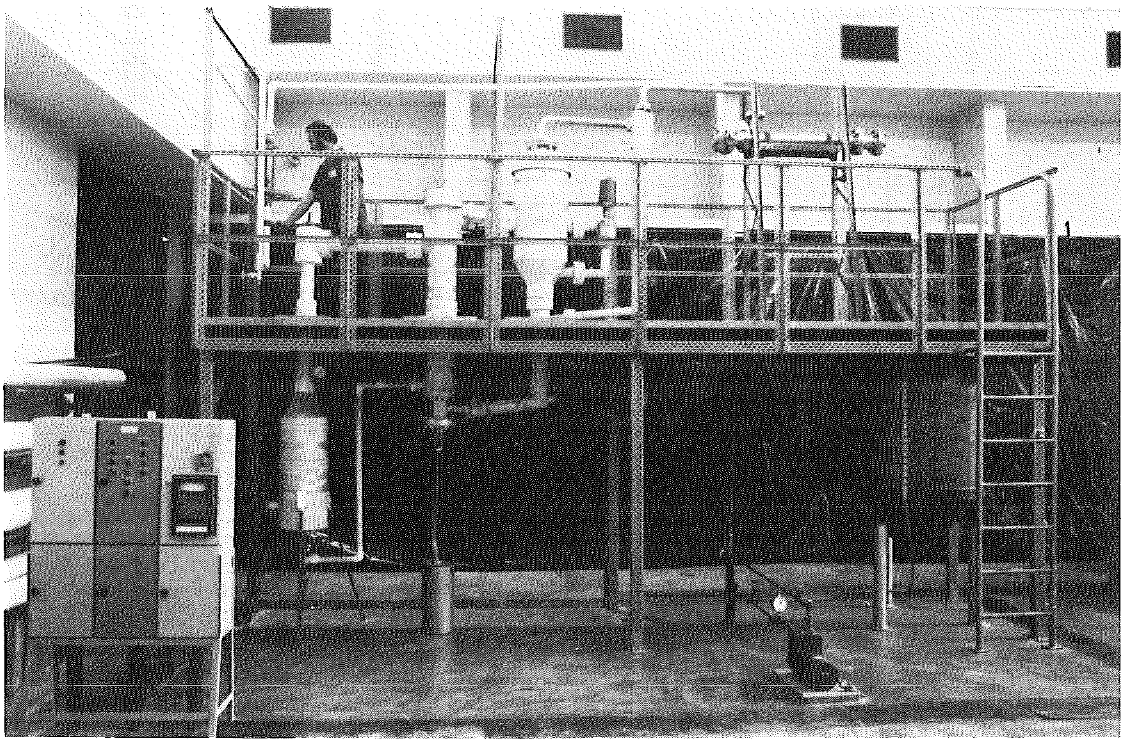


Fig. 5: Evaporation Pilot Plant

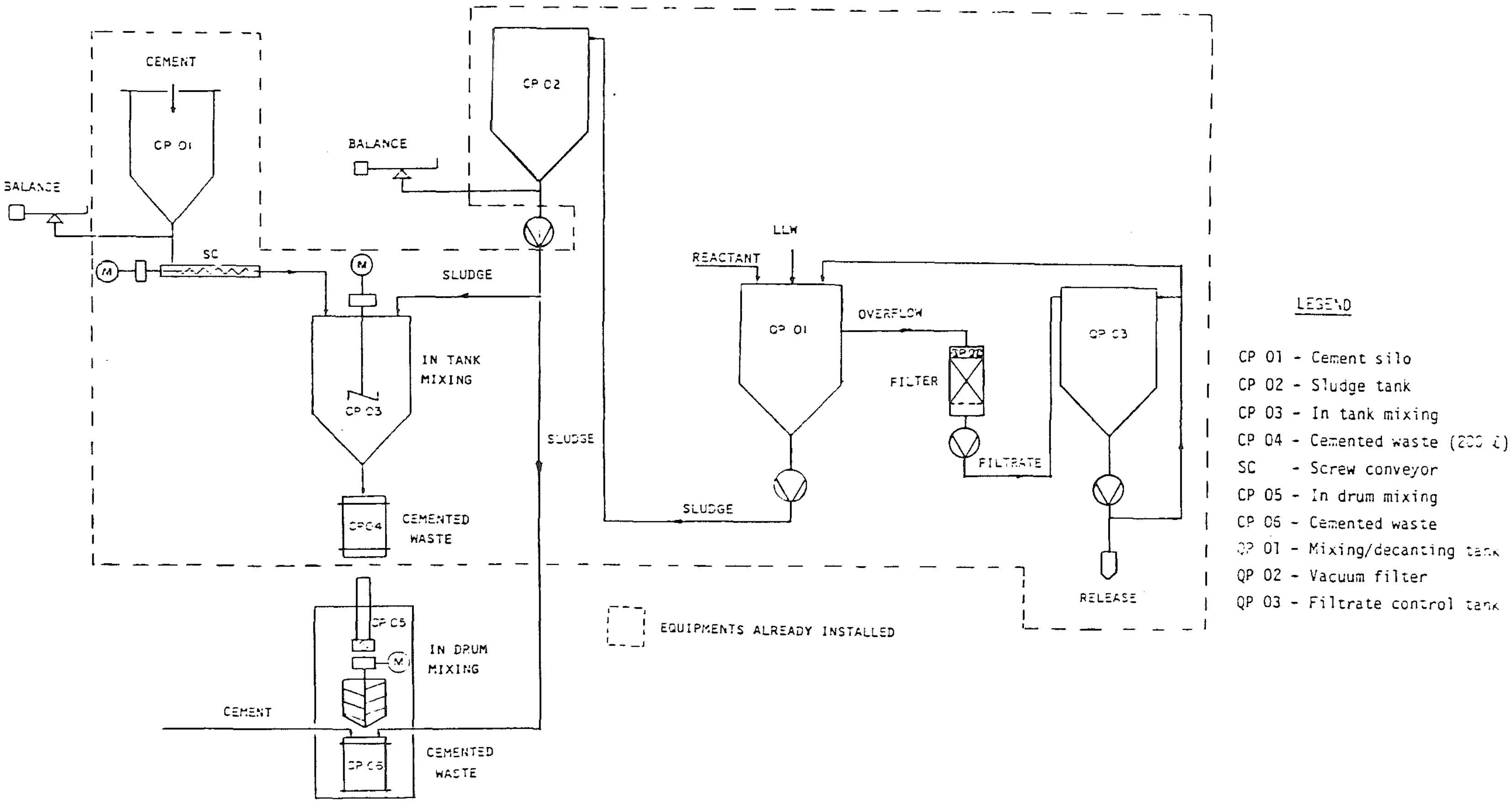



FIGURE 4 - SCHEMATIC FLOWSHEET OF CHEMICAL PRECIPITATION/FILTRATION AND CEMENTATION PILOT PLANTS (IN-DRUM AND IN-TANK MIXING PROCESSES)

its present state. When testing has been brought to an end and operation problems have been solved, the plant will be used to treat low-level liquid waste from CDTN.

### 3.1.3 **Cementation**

Laboratory-scale experiments

In laboratory-scale experiments the main operation parameters and product characteristics are investigated with a slurry produced in chemical precipitation tests.

The main parameters investigated are

- the viscosity of the cement mixtures,
- the setting time of the cement mixtures (Vicat-Test),
- the time dependence of the evaluation of hydration heat (hydration kinetics),
- the density and the compressive strength of the cured samples (after 28 d curing).

In parallel to these investigations, R&D-work is underway to select Brazilian minerals, especially clays, to be used as additives in radioactive waste cementation [10-12]. The aim of this study is to investigate the capability of such additives to reduce the leachability of cesium and strontium from cement products. Inactive tests have begun at CDTN and active tests were concluded at INE.

Figures 7 to 10 show as examples some results of leach experiments performed on four kinds of bentonite, Portland cement (CP 320) and simulated waste. Figures 7 and 8 compare specimens containing different amounts of the same kind of bentonite, leached at room and high temperatures, respectively. Figure 9 compares specimens from the same batch leached at different temperatures. Figure 10 compares specimens prepared with the same amount of the four kinds of bentonite investigated.

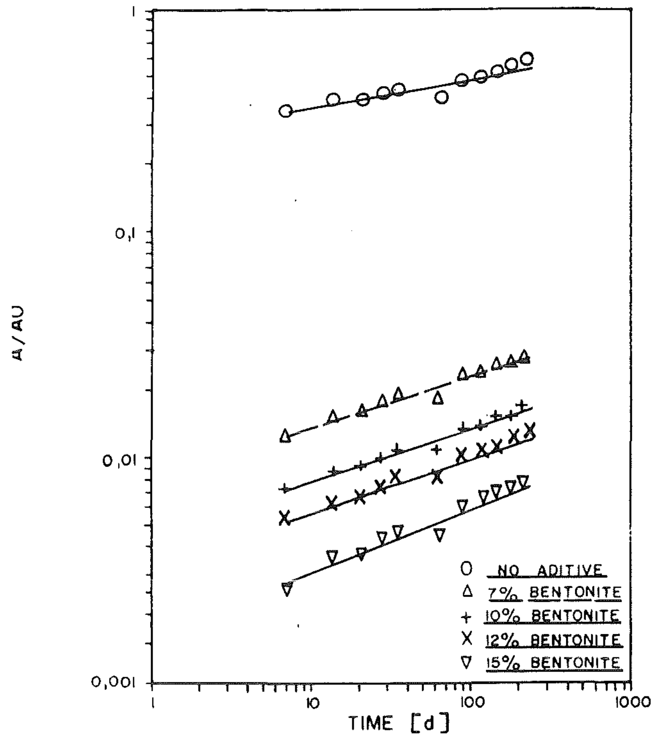



Fig. 7: Cs-leachability from cemented waste forms with different bentonite contents in dist. water at room temperature.

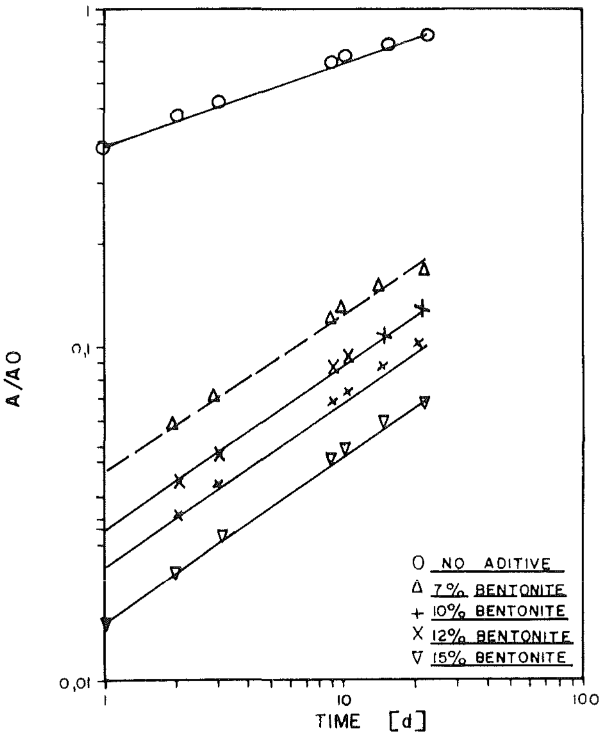



Fig. 8: Cs-leachability from cemented waste forms with different bentonite contents in dist. water at 70°C.

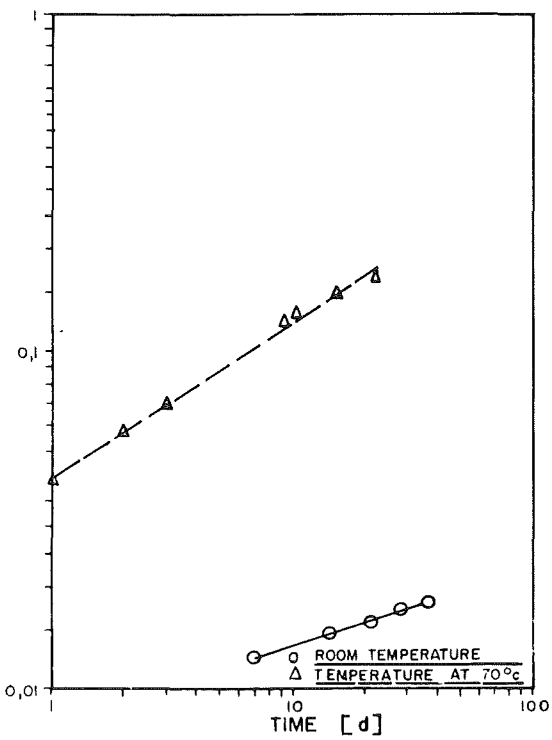



Fig. 9: Cs-leachability from cemented waste forms, both containing the same amount of bentonite, in dist. water at room temperature and 70°C.

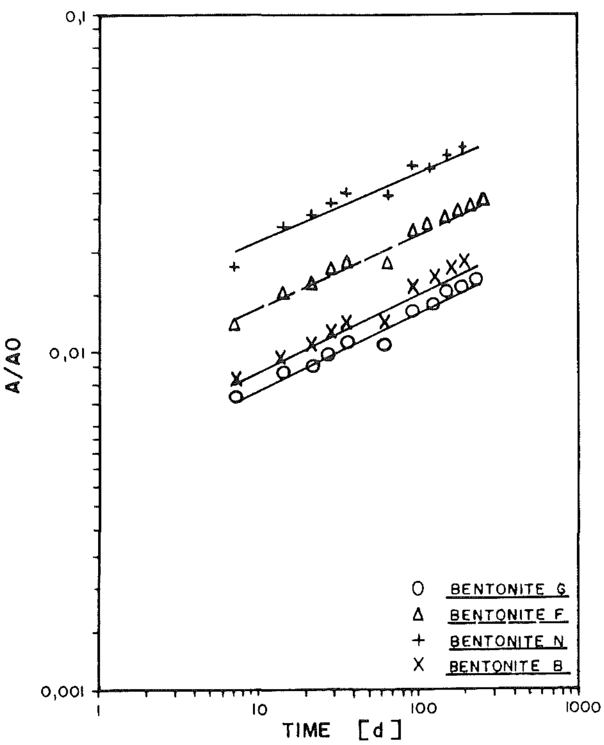



Fig.10: Cs-leachability from cemented waste forms containing the same amount of different bentonites in dist. water at room temperature.

The addition of bentonite decreases from about 80% to 18% the amount of Cs leached in accelerated tests (70°C), and from about 60% to 16% at room temperature (leaching time 230 days). The amount of leached Cs in the accelerated test is much higher than that leached at room temperature (same period of time, same specimens, same batch). In both experiments the bentonites G and B have proved to be the most effective for Cs retention. The Sr-leachability is usually not affected by the addition of clays to the cemented waste form.

Fig. 11: In-Tank Mixing Cementation Pilot Plant

Cementation pilot plant

Two cementation pilot plants are under development in which in-drum (200 liter drum) mixing and an in-tank mixing process will be applied. Both systems will be coupled to the chemical precipitation/filtration process (Figure 3). With these two systems it will be possible to evaluate different cementation processes through the investigation of the final product quality and problems of operation. It will also be possible to compare the cementation and bituminization processes, and, therefore to select the most adequate one for the treatment of different kinds of waste.

The first cementation plant already being tested is the in-tank mixer (Figure 11) [13,14]. The system consists of a cement silo, a screw conveyor and a mixing vessel. In this process, the cement, the waste and any additives are fed simultaneously into the mixing vessel. After homogenisation, the mixture flows by gravity into a 200-liter drum. Some experiments on homogeneity, compressive strength and leaching behaviour of the final waste forms were already done. Additional investigations will be performed on the precision of dosing the different feeds and on the determination of the homogeneity of the waste forms produced.

A mobile in-drum mixing system is under design at CDTN. The cement, the additives, and the waste will be dosed directly into the 200-liter drum. At the same time, a planetary paddle mixer will be introduced into the drum to mix the content.

### 3.1.4 **Bituminization**

Laboratory-scale experiments

The bituminization laboratory is equipped to support process control, to investigate different kinds of Brazilian bitumen suitable for waste incorporation, and to investigate the final product properties.

As a result of these investigations, five types of commercially available bitumen were selected for further experiments (Table 4) [15].

Bituminization pilot plant

In March 1987, CDTN received as donation from KfK a small-scale bitumen extruder (1 kg/h evaporation capacity) with accessories (Figure 12). In this installation, incoporation experiments with different types of waste will be carried out; the operating conditions will be defined and final product properties investigated. This plant can also be used to demonstrate bituminization on a small scale.

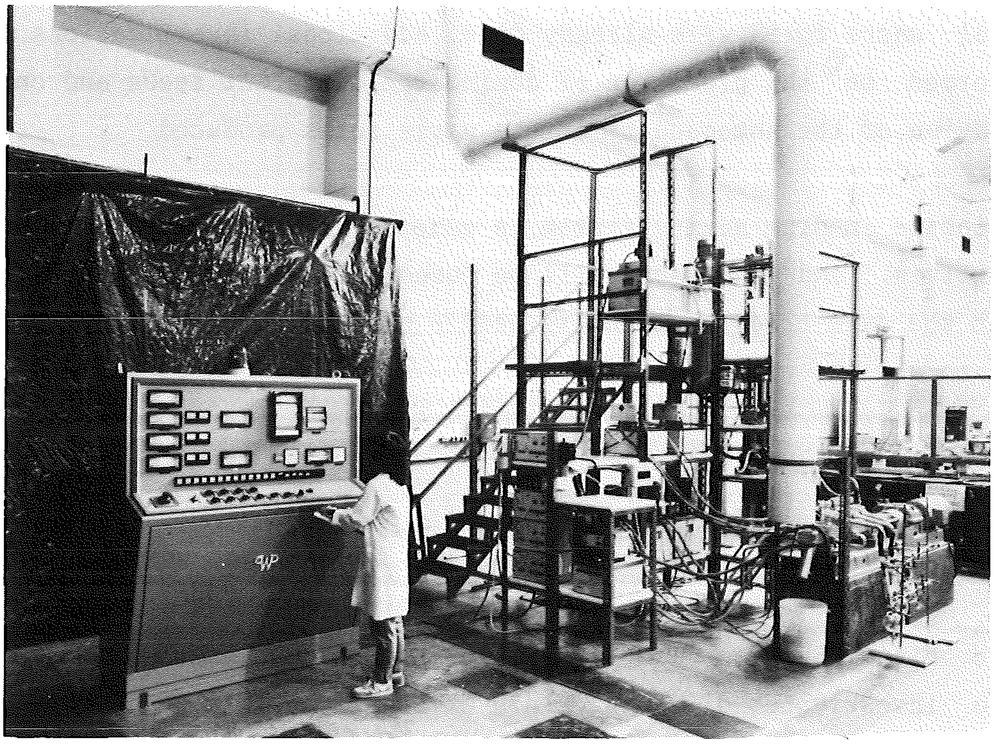


Fig. 12: Bituminization Pilot Plant

The R&D-programme on bituminization will include the following investigations:

- installation and testing of extruder operation,
- experiments on the selection of the best suitable kind of Brazilian bitumen,
- fixation of inactive simulated waste concentrates and ion-exchangers,
- improvement of certain waste form properties (e.g. precipitation of Cs-137 and Co-60 to reduce the leachability),
- fixation of simulated waste concentrates containing trace amounts of Cs-137 and Co-60,
- fixation of real low-level waste concentrates.

### 3.1.5 **Baling**

For the treatment of solid compactable waste, a 16 tonne press (Figure 13) was designed at CDTN and built by an industrial manufacturer. The press has been in operation since last year. During the pre-operational tests, a volume reduction factor of 5:1 to 7:1 was achieved depending on the waste composition. Information about the activity and size of dust particles released during operation are collected for enabling the selection of an adequate filtration system. If necessary, a glove box for waste segregation will be installed.

### 3.1.6 **Crushing**

For the treatment of crushable solid waste, a commercial shredder (80-130 kg/h throughput) was acquired. The equipment was tested and then put into operation for the treatment of CDTN wastes (Figure 14).

### 3.1.7 **Development and testing of transport packages**

In 1977 a group was set up to deal with the development, testing and qualification of transport packages.

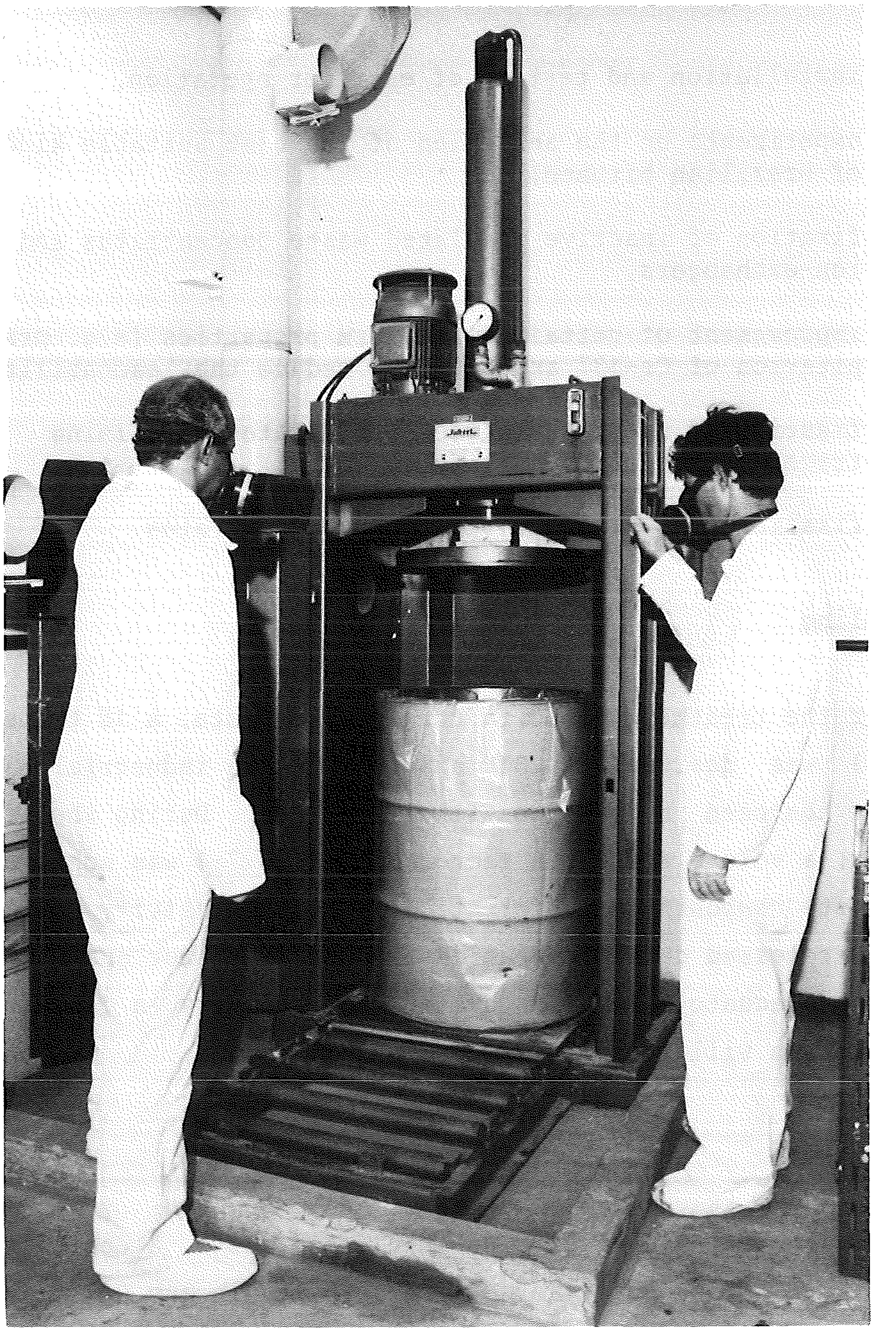


Fig. 13: Baling Press for Compactable Waste

Fig. 14: Shredder for Crushable Waste

The research work done includes as main topics:

- modifications of the closure/cover system of a commercial 200-liter drum. By these modifications it was possible to increase significantly the admissible weight of the transported material (yellow cake in this case) [16];

- type B hematite concrete container. The objective of the programme is to develop and qualify a hematite concrete cask for transportation and storage of radioactive waste, mainly waste generated in nuclear power plants. The proposed hematite concrete container has the advantage of low cost, high density and microscopic cross-section for neutrons which results in more compact packages. The use of such casks ensures the final product integrity for a long-term interim storage and also safe handling during transport to a waste repository. All relevant container properties will be checked under this R&D-programme [17,18].

The most significant structural and radiological properties of the hematite concrete were investigated in the following tests:

a) compression tests of specimens,
b) shielding tests on plates with different thicknesses,
c) X-ray fluorescence analysis of hematite ore samples,
d) design of 200-liter drum overpack shielding.

For project implementation it is necessary to provide the CDTN infrastructure for container qualification tests in accordance with CNEN standards. It is also necessary to obtain financial support for the development and qualification of a type B package and the acquisition of test facilities.

### 3.1.8 Corrosion programme on painted drums

In order to study the corrosion process in drums during interim storage, a set of 16 drums were prepared in 1983 for simulation of the effects exerted by bailed as well as cemented wastes [19]. The quality control of these drums by visual inspection and metallurgical and chemical methods (adherence and coat thickness change, abrasion, resistance to NaOH and NaCl attack, resistance to dry and humid heat) is in progress. Starting 1988, the specimens will be opened, emptied, cut into samples and subjected to the same examinations as described above. The results will be compared in order to evaluate the corrosion effect in the drums.

## 3.2 **MANAGEMENT OF CDTN RADIOACTIVE WASTES** [20]

During the last six years, due to the growing technical activities at CDTN, the amount of radioactively contaminated material has also increased. For this reason, a waste management programme was established for the following purposes [21,22]:

- collecting, transporting and storing all liquid and solid wastes from the various laboratories for further treatment;

- removing any radioactive and chemical pollutants from liquid waste as specified by legal stipulations (CNEN Resolution No. 19/85, CDTN Radioprotection and Environmental Programme and Standards issued by the State Commission of Environmental Policy);

- converting liquid waste residues and solid wastes into mechanically and chemically stable forms suitable for final disposal.

Some treatment facilities (chemical precipitation/filtration, baling and crushing) are available for these purposes, and others (evaporation, cementation and bituminization) will be put in operation in the coming years. All these installations are based on research and development work conducted at CDTN.

The collected liquid wastes consist mainly of three types which contain Ra, natural U and Th. The measured maximum specific activity is about $10^4$ $Bq/m^3$. The solid waste is made up of papers, gloves, towels, irradiated flasks, glasses, polyethylene bottles, scraps, etc. and has a maximum exposure rate (measured at the surface) of about 0.5 μCi/kg·h. These wastes are classified as low level waste under the legal stipulations mentioned above.

The liquid waste from laboratories is collected in polyethylene or glass bottles, depending on its radiological and chemical characteristics, and stored for treatment. The solid waste is sorted in laboratories into compressible, non-compressible and crushable wastes. They are collected by DITRR.CN and appropriately stored.

All the wastes are received by the "Waste Control Guide", where they are identified according to the source, amount, specific radioactivity, chemical contaminants, etc.

After definition of the chemical precipitation process in laboratory experiments, liquid waste is treated in 200-liter batches in the pilot plant already described. This installation has been in operation since 1986. About 20 $m^3$ of waste have been treated so far. The filtrates are collected, analysed and released in accordance with legal stipulations. The slurry is transferred to an intermediate store for further treatment (cementation or bituminization).

Solid contaminated materials are separated in the generating laboratories according to the later treatment processes, packaged into plastic bags and stored for treatment.

In the baling plant the compressible waste is fed into a 200-liter drum and the content is compressed with a 16 tonne press. The procedure is repeated until the drum is full. The plant has been in operation since 1983. About 12 $m^3$ of waste have been treated so far. The volume reduction achieved has been about 7:1. The non-compactable waste is also conditioned in 200-liter drums and sent to the CDTN storage facility.

The volume of crushable waste (irradiated flasks, contaminated polyethylene bottles, etc.) is reduced by a commercial shredder. Since last year, about 25 $m^3$ of this kind of waste have been treated.

The treated waste is being stored in the interim storage facility according to the "Treated Waste Guide".

### 3.3 SUPPORT TO OTHER ORGANISATIONS

With the experience accumulated in research and development work, CDTN has been able to provide assistance in waste management and in radioactive material transport to other organisations.

#### 3.3.1 (NUCLEBRAS MONAZITA S.A. (NUCLEMON)

One of the activities of Usina Santo Amaro (USAM), Sao Paulo is the treatment of monazite ores with a view to obtaining rare earth chlorides as final product and uranium and thorium concentrates as secondary products. USAM processes also lithium ores which do not contain radioactive material.

As a result of the plant activities, liquid effluent is generated and must be controlled before it is released.

Since 1982 CDTN has conducted a "Liquid Effluent Characterisation Programme" for USAM. The first work done was the identification and characterization of the amounts of various contaminated effluents [23-25]. During this period some modifications were made of the plant and effluent flow to minimize contamination. In continuation of the programme [26] new samples will be collected (May 1987) and analysed in order to check the extent of contamination after these modifications.

A mixed cake from USAM monazite processing was classified for transport purposes [27].

#### 3.3.2 NUCLEBRAS ENRIQUECIMENTO ISOTOPICO S.A. (NUCLEI)

From the operation of the First Cascade of the Separation Nozzle Enrichment Plant, different kinds of radioactive waste will be generated and must be treated before release.

In laboratory experiments with simulated waste CDTN has defined a chemical precipitation method for the treatment of liquid wastes from aluminium components decontamination (composition: $UO_2F_2$, $NaHCO_3$, HF), steel components decontamination (composition: $UO_2F_2$, $HNO_3$, HF), and from facility decontamination after an accident (composition: $UO_2F_2$ + HF traces, neutralisation agents). The selected method uses a 15% lime stone slurry at controlled pH value. The decontamination factor achieved is around $10^2$-$10^4$. Also a filter medium was selected for the treatment of the slurry from chemical precipitation. The results still have to be checked with real waste to be generated at NUCLEI [28].

### 3.3.3 NUCLEBRAS ENGENHARIA S.A. (NUCLEN)

CDTN is involved in the first steps of a NUCLEBRAS/NUCLEN cooperation programme concerning "Off-site Irradiated Fuel Storage Technics". The group will study several irradiated fuel storage and transport options that can be applied under the conditions prevailing in Brazil. After that it will propose to the NUCLEBRAS Management the option that constitutes the optimum solution for Brazil.

### 3.3.4 Users of radioactive material transport packages

CDTN has tested several transport casks for NUCLEBRAS, isotope transport casks for IPEN, radioactive tracers transport packages for industries and research centers, packages for conditioned waste suitable for sea disposal developed by Pontificia Universidade Catolica do Rio de Janeiro, and also drums for conditioned waste accumulated during operation of Angra I. Table 5 shows a list of package qualification tests performed by the Waste Treatment Division.

Last year, CDTN tested two type-A concrete package prototypes of 3 tons each (Figure 15). During these tests problems were detected, and necessary improvements made. It is envisaged to continue the tests this year [29].

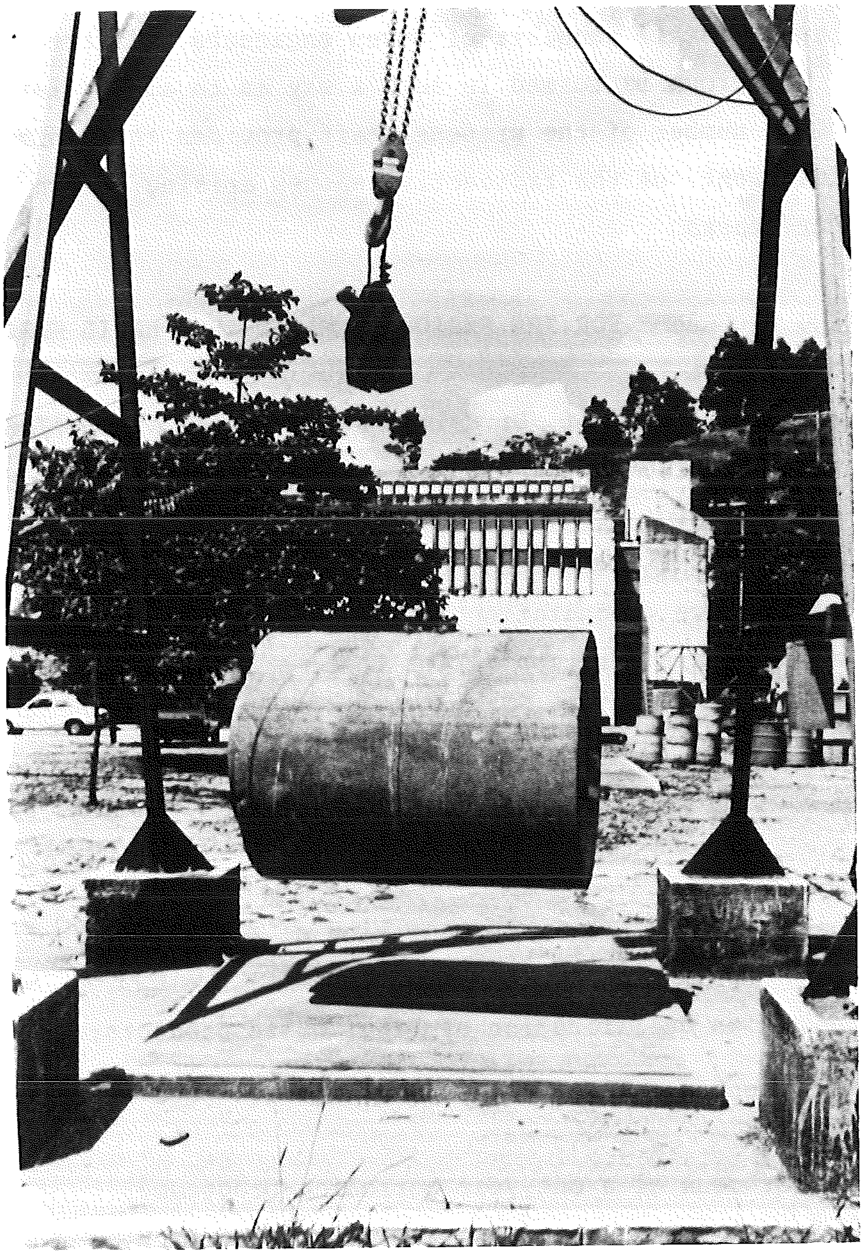


Fig. 15: Type A Concrete Package Prototype Test

## 4. PERSONNEL

The present staff consists of seven engineers and three technicians (Table 6). The group is formed in such a way as to allow flexible use of manpower. The number of the present staff provides the minimum required in the management of the radioactive wastes arising and in coping with R&D for future tasks.

## 5. WORKING PROGRAMME FOR THE PERIOD OF MARCH 1987 UNTIL MARCH 1989

During the visit of Dr.Helmut KRAUSE (head of KfK/INE) in March 1987, the further structure of the waste management programme was discussed. The proposals made are a compromise between the needs of CDTN on the one hand, and DITRR resources, on the other hand. They are based on a continuing intensive cooperation with KfK/INE. This waste programme is limited to two years duration. After that, a medium-term programme will be established.

Besides the routine management of CDTN waste, the main tasks proposed are:

- demonstration of the safe operation of all pilot plants developed; this task has the highest priority;
- R&D-work on qualification of final waste products;
- development and testing of a hematite concrete container prototype;
- establishment of a one-year corrosion programme;
- elaboration of the conceptual and basic designs of a CDTN low-level waste treatment facility;
- exchange of personnel.

Details of this two-years programme are given in Annex 1.

## 6. REFERENCES (unpublished, except [27]


[ 1] Krause, H.; Recommendations for establishing a R&D radioactive waste program at CDTN with the cooperation of KfK, NUCLEBRAS/CDTN, 1979.

[ 2] Gomes, H.; Campos, J.L.; Prado, M.A.S.; Proposicao de um sistema de gestao ded rejeitos radioativos, NUCLEBRAS/CDTN, 1980. (NT SUPED-002/80).

[ 3] Astolfi, S.D.; Relatorio de missao no INE, NUCLEBRAS/CDTN, 1981. (RM DETQ.PD-008/81).

[ 4] Astolfi, S.D.; Tello, C.C.O.; Avaliacao de materiais naturais na cimentacao de rejeitos radioativos (Parte I), NUCLEBRAS/CDTN, 1981. (NT DETQ.PD-016/81).

[ 5] Astolfi, S.D.; Avaliacao de cimento Portland para solidifica cao de rejeitos radioativos, NUCLEBRAS/CDTN, 1981. (NT DETQ.PD 018/81).

[ 6] Gabriel, J.L.; Tello, C.C.O.; Incineracao de rejeitos radioativos solidos (Parte I e II), NUCLEBRAS/CDTN, 1981. (NT DETQ.PD-019-020/81).

[ 7] Tello, C.C.O.; Avaliacao de materiais naturais na cimenta - cao de rejeitos radioativos - (Parte II), NUCLEBRAS/CDTN, 1982. (NT DETQ.PD-015/82).

[ 8] Astolfi, S.D.; Consideracoes teoricas sobre tecnicas de lixiviacao, NUCLEBRAS/CDTN, 1983. (NT DETQ.PD-010/83).

[ 9] Astolfi, S.D.; Gabriel, J.L.; Projeto conceitual da central de Tratamento de Rejeitos Radioativos do CDTN, NUCLEBRAS/CDTN, 1983. (NT DETQ.PD-014/83).

[10] Gabriel, J.L.; Projeto mecanico detalhado do sistema de cimentacao com mistura dentro do tambor, NUCLEBRAS/CDTN, 1983. (NT DETQ.PD-017/83).

[11] Santos, P.O.; Programa de controle de corrosao em tambores para acondicionamento de rejeitos radioativos - periodo 07/83 a 11/03, NUCLEBRAS/CDTN, 1983. (RP DETQ.PD-003/83).

[12] Gabriel, J.L.; Instalacao de tratamento de rejeitos liquido de baixo nivel do CDTN (filtracao/cimentacao), NUCLEBRAS/CDTN, 1984. (NT DETQ.PD-001/84).

[13] Prado, M.A.S.; Reis, L.A.C.; Gestao de rejeitos radioativos (solidos e liquidos) do CDTN, NUCLEBRAS/CDTN, 1984. (NT DETQ.PD-002/84).

[14] Miaw, S.T.W.; Sistema de evaporacao da Divisao de Tratamento de Rejeitos Radioativos, NUCLEBRAS, 1984. (NI DETQ.PD-005/84).

[15] Miaw, S.T.W.; Relatorio de missao da Enga. Sophia Teh Whei Miaw no INE/HDB - KfK - Republica Federal da Alemanha, NUCLEBRAS/CDTN, 1984. (RM DETQ.PD-001/84).

[16] Tello, C.C.O.; Avaliacao de Materiais naturais na cimentacao de rejeitos radioativos, Parte III - NUCLEBRAS/CDTN, 1984. (RP DETQ.PD-005/84).

[17] Guzella, M.F.R.; Desenvolvimento de processos de tratamento de rejeitos radioativos do CDTN. Rejeitos liquidos provenientes dos laboratorios da DITCO.PD, NUCLEBRAS/CDTN, 1984. (RP DETQ.PD-005/85).

[18] Silva, E.M.P.; Prado, M.A.S.; Avaliacao da amostragem de efluentes da USAM, NUCLEBRAS/CDTN, 1985. (NI DETQ.PD-010/85).

[19] Silva, E.M.P.; Miaw, S.T.W.; Prado, M.A.S.; Sistema de tratamento de rejeitos liquidos radioativos da NUCLEI - Resultados dos testes de laboratorio, NUCLEBRAS/CDTN, 1986. (NT DETQ.CN-001/86).

[20] Miaw, S.T.W.; Gerencia de rejeitos radioativos dos laboratorios quentes e de Tecnologia Quimica, NUCLEBRAS/CDTN, 1986. (NI DETQ.CN-001/86).

[21] Mourao, R.P.; Classificacao da torta de mesotorio da USAM para fins de transporte, NUCLEBRAS/CDTN, 1986. (NI DETQ.CN-003/86).

[22] Reis, L.C.; Miaw, S.T.W.; Projeto conceitual do sistema de coleta de residuos suspeitos do area controlada AC-1, NUCLEBRAS/CDTN, 1986. (NI DETQ.CN-007/86).

[23] Guzella, M.F.R.; Desenvolvimento de processos de tratamento dos rejeitos radioativos do CDTN - Rejeitos liquidos provenientes dos laboratorios da DITCO.CN e DIENR.CN, NUCLEBRAS/CDTN, 1986. (RP DETQ.CN-009/86).

[24] Miaw, S.T.W.; Relatorio de atividades desenvolvidas em 1986, NUCLEBRAS/CDTN, 1986. (RP DETQ.CN-003,008,012,014/86).

[25] Reis, L.C.A.; Silva, E.M.P.; Gerencia de rejeitos radioativos solidos e liquidos do CDTN, NUCLEBRAS/CDTN, 1986. (PD-008/86).

[26] NUCLEBRAS/CDTN - Relatorio de testes em recipientes de concreto tipo A - FURNAS. (RT DETQ.CN-001/86).

[27] Guzella, M.F.R.; Miaw, S.T.W.; Mourao, R.P.; Prado, M.A.S.; Reis, L.C.A.; Santos, P.O.; Silva, E.M.P.; Gestao de rejeitos radioativos liquidos e solidos do Centro de Desenvolvimento da Tecnologia Nuclear - NUCLEBRAS/CDTN - INIS - BR-537 (v. 2), 1986.

[28] Mourao, R.P.; Embalagem de concreto de hematita-NUCLEBRAS/CDTN, 1987. (NI DETQ.CN-001/87).

[29] Mourao, R.P.; Missao do Engenheiro Rogerio Pimenta Mourao, a Republica Federal da Alemanha, NUCLEBRAS/CDTN, 1987. (RM DETQ.CN-002/87).

[30] Reis, L.C.A.; Instalacao de tratamento quimico/filtracao de rejeitos radioativos de baixa atividade da DITRR.CN, NUCLEBRAS/CDTN, 1987. (TQ-003/87).

[31] Mourao, R.P.; Inspecao visual para recebimento de tambores, NUCLEBRAS/CDTN, 1987. (TQ-004/87).

[32] Guzella, M.F.R.; Desenvolvimento de tratamento de rejeitos radioativos do CDTN - Rejeitos liquidos provenientes dos laboratorios da DITCO.CN, DIENR.CN e DIQUI.CN, NUCLEBRAS/CDTN, 1987. (RP DETQ.CN-004/87).

Table 1: Brazilian missions to Germany

| Name | Purpose | Period |
|---|---|---|
| 1. Sergio Daniel ASTOLFI | Incorporation into cement of radioactive waste and testing of the products obtained [30] | Oct.79 - Oct.80 |
| 2. Maria Augusta Silva do PRADO | General acquaintance with KfK procedures on radioactive waste [31] | Oct.79 - Nov.79 |
| 3. Sophia Teh Whei MIAW | Practical training in waste treatment processes [32] | Dec.81 - May 83 |
| | Bitumen extruder donated by KfK | Sept.85 -Oct.85 |
| 4. Rogerio Pimenta MOURAO | Radioactive material packages design and testing [33] | Sept.86 -Nov.86 |
| 5. Cledola Cassia Oliveria de TELLO | Cementation of waste and testing of the products obtained | Nov.85 -March87 |

Table 2: German missions to Brazil

| Name | Purpose | Period |
|---|---|---|
| 1. Dr.Helmut KRAUSE | Discussion about present status and future organisation of waste management programme | 19-23 Feb.79<br>8-11 Feb.82<br>31.3.-3.4.87 |
| | Cementation workshop | 6-10 Aug.84 |
| 2. DCh.J.WILHELM | Lectures on nuclear filter techniques | 11-15 Feb.80 |
| 3. Dr.Günter RUDOLPH | Technical assistance in cementation and leaching tests | 17-27 May.82 |
| | Cementation workshop | 6-10 Aug.84 |
| 4. Dr.Rainer KÖSTER | Cementation workshop | 6-10 Aug.84 |

Table 3: Decontamination factors achieved with different precipitation methods

| Waste Origin | Type | Initial concentration $\alpha_T$ (Bq/l) | Initial concentration $\beta_T$ (Bq/l) | Precipitation method | Decontamination factor ($\alpha_T$) | Decontamination factor ($\beta_T$) |
|---|---|---|---|---|---|---|
| Fuel Techn. Division | A | 98 | 900 | $H_2SO_4/BaCl_2$/ lime | 10 | 40 |
| Fuel Techn. Division | B | 5300 | 20 000 | caustic soda/ lime /$BaCl_2$ | > 1000 | > 2000 |
| Uranium Enrichment Division | C | 3000 | 3 300 | lime | > 600 | > 300 |

Table 4: Main specification of bitumen selected for the preliminary tests

| Specification | Type A | Type B | Type C | Type D | Type E |
|---|---|---|---|---|---|
| Penetration 25°C-100 g-5",mm/10 | 5/15 | 15/25 | 15/25 | 3/9 | 10/20 |
| Softening point (ring and ball) °C | 80/90 | 90/100 | 95/105 | 100/110 | 110/120 |
| Flashpoint (Cleveland) °C (minimum) | 250 | 200 | 230 | 250 | 230 |
| Density 25°C/25°C | 1.01/1.05 | 1.01/1.05 | 1.01/1.05 | 1.01/1.05 | 1.01/1.05 |
| Solubility in $CCl_4$ % (minimum) | 99 | 99 | 99 | 99 | 99 |
| Loss by heating (163°C-5 h) % (minimum) | 0.2 | 0.5 | 0.2 | 0.2 | 0.2 |

Table 5: Package qualification tests executed by DITRR.CN

| Document No. | Requested by | Description |
|---|---|---|
| TQ-01 | IPEN | Package for medical tracer (Tc-Mo) |
| TQ-02 | FURNAS | 1st. drum Shipment |
| TQ-03 | FURNAS | 2nd. drum Shipment |
| TQ-04 | FURNAS | Final report (drums) |
| TQ-05 | CIPC | Drum with internal polyethylene liner-visual inpection |
| TQ-06 | CIPC | Drum with internal polyethylene liner-tests |
| TQ-07 | FURNAS | Reinforced drum with epoxi painting |
| TQ-08 | FEC | Drum with internal polyethylene liner-visual inspection |
| TQ-09 | FEC | Drum with internal polyethylene liner-tests |
| TQ-10 | PUC | Drum for sea disposal |
| TQ-11 | IPEN | Package for medical tracer (Tc-Mo) |
| TQ-12 | IPEN | 200 l-drum for Ra-needles |
| TQ-13 | MALLINCKRODT | Package for medical tracer (Tc-Mo) |
| TQ-14 | FEC | Drum with internal phenolic painting-visual inspection |
| TQ-15 | FEC | Drum with internal phenolic painting-tests |
| TQ-16 | MALLINCKRODT | Drum for medical tracer (In) |
| TQ-17 | CIPC | Drum with reinforced closure |
| TQ-18 | IPEN | 20 l-drum for Ra-needles |
| TQ-19 | IPEN | 20 l-drum for Ra-needles |
| TQ-20 | FURNAS | Drum for LAW (trash) |
| TQ-21 | FURNAS | Drum for cemented LAW |
| TQ-22 | MALLINCKRODT | Package for medical tracer (Tc-Mo) |
| TQ-23 | CIPC | Drum for yellow-cake |
| TQ-24 | FURNAS | 1000 kg rectangular package for contaminated steel components |
| TQ-25 | FURNAS | Drum with concrete overpack |

IPEN - Instituto de Pesquisas Energeticas e Nucleares
FURNAS - Operator of the NPP Angra-I
CIPC - Complexo Industrial de Pocos de Caldas (NUCLEBRAS´ uranium mine)
FEC - Fabrica de Elemento Combustivel (NUCLEBRAS´ fuel assembly facility)
PUC - University-RJ
MALLINCKRODT - Medical Tracer Distributor

**ANNEX**

**WORKING PROGRAMME FOR THE PERIOD OF MARCH 1987 TO MARCH 1989**

During the visit of Dr. Helmut Krause (head of KfK/INE) in March 1987, the following waste management programme was worked out and submitted to the CDTN management.

1. Chemical precipitation
   - Investigations of the development of treatment methods not yet defined for CDTN waste;
   - Investigations of the separation of uranium and thorium by new processes.

2. Evaporation
   - Demonstration of the evaporator system.

3. Cementation
   - Termination of the present R&D-work on selecting Brazilian minerals;
   - Demonstration of the cementation pilot plant (in-tank mixing process);
   - Design of a mobile in-drum mixing cementation system;
   - Determination of final product properties;
   - Cementation of radioactive wastes.

4. Bituminization
   - Selection of the most appropriate Brazilian bitumen;
   - Start of extruder experiments;
   - Demonstration of the safe operation of the bituminization pilot plant;
   - Determination of final product properties;
   - Bituminization of real radioactive wastes.

5. Hematite concrete container

. Preparation of the test infrastructure (design of type-B test facility: free drop test, water immersion/containment test, compression test, thermal test);

. Construction of a prototype.

6. Corrosion programme

The objective of the programme is the investigation of the behaviour of metal drums for conditioned wastes, interim storage conditions, and in relation to the kind of waste confined.

The commerical 200 liter drums used by CDTN and other fuel cycle units will be investigated.

Drum specimens of different configurations will be submitted to different storage conditions and types of cemented waste (reactor waste, CDTN waste). This programme will last one year and be conducted in cooperation with the Materials Division - Divisao de Materiais (DIMAT/CDTN).

7. CDTN low-level waste treatment facility

The main purposes of the new low-lewel waste facility are to integrate all waste treatment operations in an appropriate building, to improve the existing pilot plants and to use them for the treatment of low-level waste generated at CDTN and delivered from outside (low-level waste from nuclear applications). The conceptual and basic design is planned to be carried out in the next two years.

- Conceptual design:
  . conceptual design criteria;
  . process flowsheets: definition and description;
  . preliminary specification of main equipment;

. preliminary location, safety and licence;
. master plan/general description of arrangement;
. description of preliminary layout;
. investment estimates;
. description calculus memorandum.

- Basic design:
  . basic design criteria;
  . master plan/general description of arrangement;
  . description of layout;
  . construction, architectural, electrical, hydraulic and ventilation projects;
  . equipment specification - data sheets;
  . acquisition of large items;
  . authorization for installation;
  . operational methodology/specific procedures;
  . description calculus memorandum.

## 8. Exchange of personnel

For continuation of the R&D-work conducted by DITRR it is important to maintain a continuous exchange of personnel for training in new areas and to get assistance by experts.

The following missions are proposed for the period of March 1987 to March 1989:

- short-term mission of a KfK technician (E.JOHN) for starting the bitumen extruder (February 1988): 4 weeks;
- short-term mission of a KfK expert (W.KLUGER) for the implementation of the bituminization programme (end of 1987): 3 weeks;
- short-term mission of a KfK expert in waste treatment facility design (beginning of 1988): 4 weeks;
- short-term mission of a KfK expert in scientific investigations of cementation and other areas (1988): 2 weeks;

- long-term mission of a DITRR chemical engineer for training in chemical precipitation (1988): 12 months;

- short-term mission of a DITRR mechanical engineer in cementation process (1988): 3 months;

- short-term mission of the DITRR division leader - updating knowledge and discussion of the waste management programme (1988): 4 weeks;

- Two weeks discussion of Dr. H.Krause with CDTN and NUCLEBRAS about the present status and future needs of the waste management programme.

The delegations for 1989 shall be discussed by mid 1988.