EXPERIENCE OF IEA-R1 RESEARCH REACTOR SPENT FUEL TRANSPORTATION BACK TO UNITED STATES

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ABSTRACT

IPEN/CNEN-SP is sending the IEA-R1 Research Reactor spent fuels from USA origin back to this country. This paper describes the experience in organizing the negociations, documents and activities to perform the transport. Subjects as cask licensing, transport licencing and fuel failure criteria for transportation are presented.

1. INTRODUCTION

IEA-R1 Research Reactor of Instituto de Pesquisas Energéticas e Nucleares (IPEN/CNEN-SP) is a pool type reactor of B&W design operating since 1957 at 2 MW of power. Irradiated fuels have been stored at the facility along the various years of operation. Nowadays there are 40 SFA´s at dry storage and 87 SFA´s U.S origin at wet storage. The oldest fuels are of USA origin, made with U-Al alloy of LEU and HEU MTR fuel type. Many of these fuel assemblies present corrosion pits along external fuel plates. This pits have their origin by galvanic corrosion between fuel plate and stainless steel storage rack although the excellent pool water characteristic would inhibit this occurrence of corrosion. Radiological analysis of pool water have been indicating low activity of ^{137}Cs. According to the decision to send back the old fuels to USA, sipping tests with SFA´s were performed in order to evaluate their ^{137}Cs leaking rate, if any. The ^{137}Cs leaking rate was determined in order to compare the results with the criteria established for canning spent fuel assemblies before shipment.

The first attempt concerning the returning of the SFA´s occured in 1996 but did not succeed because that there was not enough time to prepare the necessaries documents. In August, 1998 when every documents were ready and four transport casks were in IPEN the operation was postponed due to the difference in the criteria adopted by DOE and DOT for failed fuel assemblies.

2. EXPERIENCE OF IEA SFA´S TO USA DESCRIPTION

In August 25, 1995 the Superintendent of the Instituto de Pesquisas Energéticas e Nucleares (IPEN-CNEN/SP) sent to Spent Fuel Management of the U.S Department of Energy Office a summary data on irradiated fuel elements stored in the IEA-R1 research reactor (pool and dry storage). According to this document, these informations were not a commitment with the Department of Energy of the United States (DOE) to ship to USA the spent nuclear fuel of USA origin and burned in IEA-R1 reactor. However, this document admit that since IPEN had plans to up grade the reactor power from 2 to 5 MW and, as the pool storage racks were already almost complete of spent fuel assemblies, it was necessary to decide what to do with the irradiated fuel. To send the irradiated fuel to the United States without any cost for IPEN and Brazil it was an attractive option.

At that moment, the situation of the fuel elements was summarized as follows:

NUMBER OF FUEL ELEMENTS	ENRICHMENT (W/O U-235)	FABRICATION	PRESENT LOCATION (08/95)
40 *	20	USA	dry storage
39	20	USA	pool storage
29	93	USA	pool storage
4	93	CERCA	pool storage
10	93	USA	reactor core
5	20	NUKEM	reactor core
15	20	BRAZIL	reactor core

* the first 40 fuel elements failed, due to corrosion, at the first reactor operation, and had no considerable burn up.

In April 6, 1996 IPEN received a fax from the Consulate General of the United States in São Paulo, informing the visit of a DOE/DOS Team to South American Research Reactors and Spent Nuclear Fuel Storage Facilities in late June. They hoped to ship research reactors spent nuclear fuel to USA in August 1996. As informed by this fax, on 13 of May,1996, DOE issued a "Record of Decision" (ROD) for a joint DOE-DOS environmental impact statement on foreign research reactor spent nuclear fuel. DOE would accept and manage in the USA facilities, all foreign research reactor spent nuclear fuel containing uranium enriched in the United States. This Program has been designed to minimize the amount of nuclear weapons grade high enriched uranium in worldwide circulation, and it is a key element of the administration´s nuclear nonproliferation policy. The ROD opened a 10 years window of opportunity during which the United States will accept eligible spent fuel. Countries considering to take advantage of this opportunity will have more time to develop local long-term disposal options for nuclear spent fuel. In the interest of nuclear nonproliferation policy, the USA offered this service free of charge to many countries including Brazil.

According to the ROD document, in the first phase of the Program two shipments were required to occur before September 96. One from Europe, and the other from South America. The destination of both were assumed to be CharIeston, in South Caroline. In order to implement this schedule a DOE/State assessment Team should evaluated the conditions at each eligible Country by mid-June and fuel loaded into casks at each site by mid-August.

During two days (June 24 and 25 , 1996) an U.S delegation visited the IEA-R1 Research Reactor to analyse the spent MTR-type fuel and the facilities available for shipping the spent fuel to USA. A checklist (some of the itens are presented below) was discussed at this time betweem the U.S delegation and IPEN- CNEN staff:

1. Identify key personnel to provide contact;
2. Describe the status of any licensing or institutinal approvals within the country to ship the SFA´s;
3. Establish a contact with the U.S. Embassy in the country in which the reactor is located;
4. Provide a short description of the reactor, its utilization, its operating schedule and amount of SFA that it generates per year;
5. Identify the current fuel inventory (number of assemblies, enrichment and etc..);
6. If the reactor currently uses HEU fuel, identify the plans and status of convertion to LEU;
7. Identify any fuel corrosion or other potential of ongoing releases of fission products from the stored fuel. Estimate the quantity of fuel requiring stabilization before shipment. Describe the water quality and other related informations;
8. Identify the preferred and latest possible schedules for the shipment of SFA´s;
9. Provide a description about fuel irradiation history, discharge date, mass, radiation dose rates, heat loads, manufacturer, drawings and so on;
10. Describe the facilities that could be used to prepare and ship the SFA (physical description, maximum storage capacity, capacities of the crane, floor loading limits, dimensions of building access doors and so on;
11. Estimate the amount and type of assistance that the reactor organization may need to prepare its SFA´s for shipment.

After the visit, the proposal of DOE staff was to perform a sipping test inside the shipping cask with all fuels loaded. IPEN staff pointed out that this wouldn´t be a good solution because if any cesium release were detected, all fuel assemblies would be sent back to the pool storage and an investigation would have to be done in na individual basis to identify the leaking fuel assembly. Then, IPEN staff proposed to perform individual sipping test of each fuel assembly before transfering it to the shipping cask. As the schedule for shipment was very short, sipping test had to be done quickly. IPEN performed visual inspection and sipping test in 60 spent fuel assemblies in two weeks of working /1/.

The visual inspection of the spent fuel assemblies stored at the spent fuel pool showed that pitting corrosion is present in the external fuel plates of many fuel assemblies. The assemblies within the pool for almost 40 years show the worse pattern. The pitting corrosion observed is due to the galvanic pair existing between aluminum fuel plate cladding and the stainless steel spent fuel rack.

The sipping test methodology and equipment used by IPEN showed to be efficient in determining fission products leaking from fuel assemblies (Figure 1).

It was determined a ^{137}Cs leaking rate of **14 Bq/min** for the worse leaking fuel assembly. This value was far bellow the DOE-SRS criteria presented to IPEN later for canning leaking MTR fuel assemblies. Analysis of pitting corrosion nodule by gamma-ray spectrometry showed the occurrence of Cs, U and Eu isotopes. The ^{137}Cs activity was much higher than the sipping water activity and U and Eu isotopes were not detected in water. This confirmed that it was a thru-clad pit.

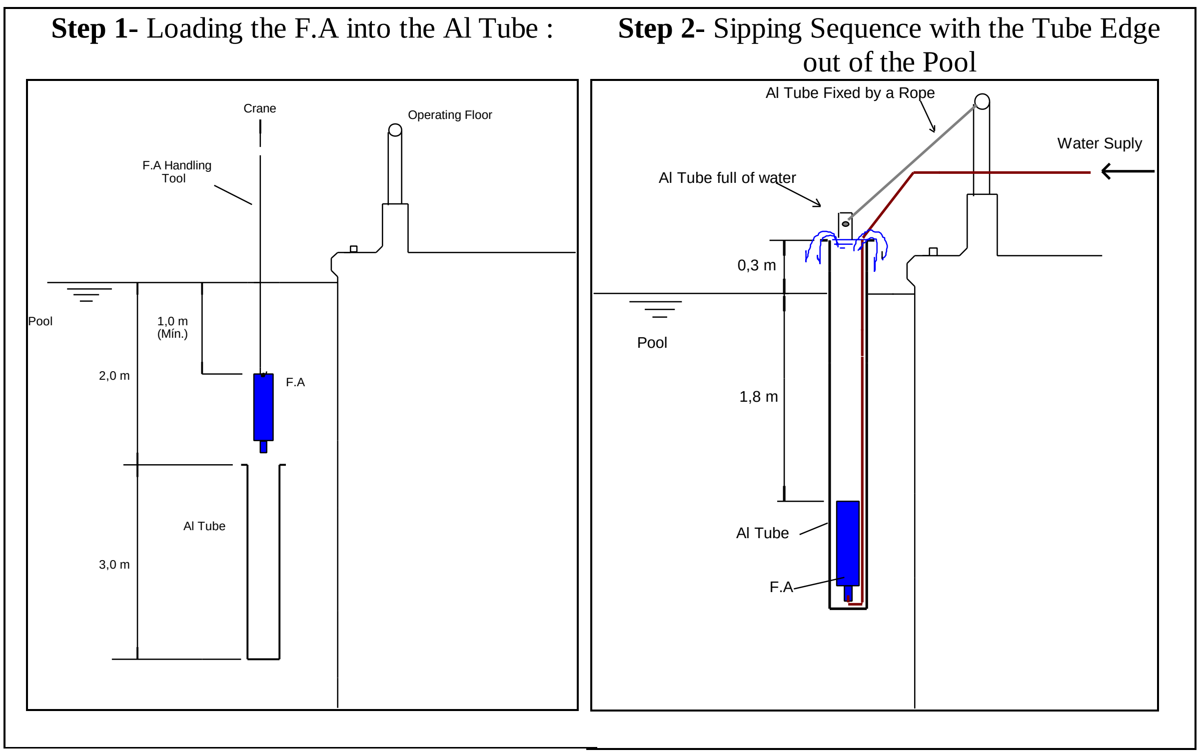

Figure 1 - Scheme of Sipping

Between 22 and 31 of July, 1996, a Team of personnel from DOE-Savannah River Site, WSRC (Westinghouse Savannah River Co.), SAIC (Scientific Applications International Corporation) and INEL came to IPEN to perform fuel assembly characterization and negotiations for fuel shipments to Savannah River Site. This group was supported by scientists, health physics and operations personnel from IPEN. Technical personnel from DOE-SRS participated in negotiations of the agreements with Brazilian Nuclear Commission (CNEN) for the release of the fuel and shipment to USA. They were supported in these negociations by DOE subcontractors and by an expert from SAIC. They also witnessed the characterization activities by WSRC and IPEN personnel, and provided the characterization team with interpretation of the FRREIS (Foreign Research Reactor Environmental Impact Statement) for acceptance of the fuel at SRS based on discussions he held with DOE-HQ during the trip.

The characterization of the wet-stored fuel assemblies involved an evaluation of corrosion and mechanical damage, and cesium release rate. It was performed by visually examining the assemblies, using an under water camera and by measuring the release of ^{137} Cs in sipping tests. A total of 66 high-enriched uranium (HEU) and low-enriched uranium (LEU) fuel assemblies were characterized. Table 3 and 4 contain, respectively, a listing of the condition of each of the 66 assemblies visually examined and the fuel element assemblies sipping resume. The results showed that 25 assemblies (HEU) did not contain corrosion pits into the fuel meat region. The ^{137} Cs release rates from all 66 of the assemblies were well-within the SRS interin criteria of 13.57 μCi/hr per cask shipment which is equivalent to 35.9 pCi/ml/hr based on the volume of water used in SIP tests. A maximum release rate of appoximately 0.32 pCi/ml/hr was recorded in SIP tests of the IEA-R1 fuels. There was no significant difference between the results before and after removal of the deposits over the corrosion pits which, for some pits, exposed fuel meat directy to the water.

The DOE provided interpretation of the FRREIS, DOE/EIS-0218F that the 41 assemblies that contain thru-clad pits may require canning for shipment and storage whereas, the remaining 25 SFA´s, could be shipped conventionally. But, they admited that was necessary to review the SRS criterion because even with some of the SFA´s of IEA-R1 presenting pits corrosion, the ^{137}Cs release rates was far below of SRS limits.

MTR LEU fuel assemblies stored in dry storage were also visually examined. Some of them had leaked radionuclides in-reactor within months after initial service in 1957 due to corrosion attack at the brazed joints between the fuel plates and support plates of the assemblies. These assemblies had been in basin (wet) storage for an estimated 24 years followed by 15 years of dry stored at near room temperatures. The fuel assemblies were dry-stored in polyethylene bags that were taped shut and placed horizontally in carbon steel piping in a concrete vault. A sampling of 6 of the 40 assemblies was performed. Visual examination showed that corrosion attack at the brazed joints and pitting corrosion on the fuel plates had occurred. These conditions are attributed to corrosion mechanisms during water storage. No additinal degradation due to dry storage was apparent /2/.

IPEN authorities always made clear for DOE Team the wish of sending all 127 spent fuel assemblies in one trip to the United States. No solution could involve any partial shipment of the SFA´s to SRS.

Although the personnel of the Reactor Department of IPEN had started to write the Appendix A and discuss a "memorandum of understanting" and conclude the legal procedures regarding the shippment of the SFA´s, it was not possible to perform it because the preliminary proposed time schedule for shipment of the SFAs was extremely short. It was necessary to discuss a bilateral agreement between both goverments, in order to fulfill some requeriments such as safeguards, exportation control of sensitive materials, final use statement, liability including third part liability and others concerns regarding the retransfer of the title of the fuel assemblies which were acquired by CNEN from USAEC under the terms of the previous bilateral agreement.

Table 2 – Fuel element assemblies visual inspection resume

	F.A 20% Enrichment	F.A 93% Enrichment
Pits along outside fuel plate	42 43 48 49 53 55 58 61 62 64 66 69 70 78 79	103 106
Few pits at outside fuel plate	41 44 45 46 47 50 51 52 54 56 57 59 60 63 65 67 68 71 72	93 95 96 97 99 100 102 104 105 109
No visual remark	73	80 81 83 84 88 91 92 98 101 107 108 111 112

Table 3 – Fuel element assemblies sipping resume

	F.A 20% Enrichment	F.A 93% Enrichment
No indication of Cs-137	41 45 46 51 52 55 56 59 60 63 67	81 83 84 88 93 95 96 98 100 102 103 105 107 108 111 112
Low indication of Cs-137 (< 30 Bq/l)	42 43 44 47 48 49 50 57 62 64 65 66 68 69 73 79	80 91 92 97 99 101 104 106 109
Medium indication of Cs-137 (> 30 Bq/l: < 60 Bq/l)	54 61 70 71 72	----
High indication of Cs-137 (> 60 Bq/l)	53 58 78	----

Besides the requirements of the Brazilian Nuclear Energy Policy and related legislation concerned to exportation of sensitive material, equipment and technology (Law 9112/95 and Decree 1861 of 12/04/96) should be accomplished and, a detailed transport plan for the transportation of the spent fuel assemblies required more time to be done than previously estimate. It should be considered that it was the first time that this kind of material would be transportated in Brazil.

In August 14^{t}, 1996 the Acting Associate Deputy Assistant Secretary for Nuclear and Facility Stabilization Office of Environmental Management, sent a official letter from the DOE where he understood the problem of insufficient time to complete the needed contractual negotiations prior to the first South American shipment schedule. He mentioned that the next shipment from South American would happen until mid or late 1997. This schedule would allow sufficient time to complete negotiations and, also, to provide the opportunity for DOE to acquire the necessary materials and services required to “package” the fuels that may not be suitable for direct insertion into the shipping cask.

After that time, IPEN and CNEN authorities started to prepare all documents needed to export the SFA´s to USA.

In May 22, 1997 the head of the International Relations Officer of the Brazilian Nuclear Energy Commission, sent a fax to the Manager of the Spent Nuclear Fuel Program, with the purpose to restart the negociations concerning the return of the SFA´s from Brazil to the United States.

In Jun 12, 1997 the Manager of the Spent Nuclear Fuel Program answered to the head of the International Relations Officer of Brazil that the DOE was planning a shipment of SFA´s from South America in July, 1998 and the SFA´s from IEA-R1 reactor were expected to be a part of that shipment. He asked, also, in his letter to confirm that this tentative arrival date was acceptable and indicated how many SFA´s we desired to return at that time to USA once a third shipment from South America was sheduled for May, 1999. A draft contract between DOE and CNEN was also provided for IPEN conderation.

In July 26, 1997 Brazilian authorities answered to DOE indicating the wish to discuss and plan the shipment of the SFA´s from IPEN to SRS on July 98.

In September 18, 1997 an Engineer of the U.S. Department of Energy at the Savannah River Site sent a fax to the Reactor Department of IPEN informing that he would lead a U.S. DOE delegation to visit several South American countries in November 1997. The scope of the visit was to discuss the U.S program for SFA´s transportation to USA, contents of the contract, possible shipping dates, Appendix A comments, and so on. In November 18, 1997 IPEN received a DOE Assessment Team Members as mentioned.

In December 29, 1997 a fax from Edlow International Co. informed that the U.S DOE had awarded a contract to Edlow Team to transport the SFA´s from research reactors in Brazil, Uruguay and Venezuela. The Edlow Team consisted of Edlow International Co. (EIC), Nuclear Cargo + Services (NCS), Transnucleaire (TN) and Science Applications International Corp. (SAIC). In order to check the technical handling of the casks, two people from the consortium NCS/GNS were in IPEN between 16 and 19 of February, 1988. From this meeting it was decided that a Brazilian Company named TRION would provide the transport equipments, a saw tool design and construction to cut the control assemblies and all necessary customs documents for the SFA´s return to USA. The consortium would provide 4 transport casks (two GNS-11 and two GNS-16) and IPEN would provide the contract signature, exportation license, appendix A, Transport and Security Plans elaboration and salvaguard documents. It is necessary to mention that, at that time, the casks GNS-16 from NCS/GNS had no certificate in Germany or in the United States yet. It was delivered to the U.S. Department of Transportation and U.S. Regulatory Commission for appoval just in June 5, 1998 or, less than three months before the shipment date (8/27/98).

In April 27, 1998 the contract between CNEN and DOE was signed. In this contract, Appendix B showed the change of the criteria for failed fuel, incorporating the experience of IPEN SFA´s analysis. The loading operation was schedule to start on 20 of July.

In June 4 the Appendix A´s have been approved by DOE and at June 17, NCS/GNS sent a fax to IPEN where they asked about the existence of failed fuel assemblies since the U.S Department of Transport was questioning the capacity of GNS-16 to transport fail assemblies. IPEN answered this fax informing again all the previous work done on SFA´s visual inspection and sipping test, their results and the criteria adopted by Appendix B.

In the beginning of July Brazilian authorities had approved the export license, the Transport/ Security Plans and, validated GNS-11 and GNS-16 casks for SFA´s transportation in Brazilian territory.

In July 6, six containers arrived in Porto of Santos with four transport casks and equipments and in July 12, 4 technicals from the Germany Consortium arrived in São Paulo to prepare the SFA´s transport. In July 20, IPEN received a copy of the U.S. validation for the GNS-16 cask. According to this document, **known or suspected failed fuel assemblies and fuel with cladding defects greater than a pin holes and hairline cracks are not authorized**. Because of that, on July 24, IPEN received a official letter from DOE informing the temporary postponement of the shipment of SFA´s from Brazil. According to this letter, the postponement was necessary due to the inability to obtain transportation package certificates for all packages to be used in the shipment. Activities will continue to complete all coordination requeriments and conduct the shipment as soon as possible after resolution of transportation package certificates.

3. CONCLUSION

IPEN experts agree that the changes in criteria used in Appendix B for failed fuels are correct since they consider the physical condition of the assemblies and ^{137}Cs leaking rate. Our experience with visual inspection and sipping test performed in IEA-R1 SFA´s together with DOE Team in 1996 showed this. According the Appendix B, the SFA´s of IPEN are not failed and could be transported to USA in conformity with the schedule previously approved by DOE for August, 1998. The criteria of failed fuel for transport casks could be the same as the one in Appendix B for basin acceptance. This problem of stablishing a criteria for cask licensing was know by all US personnel involved in this operation. To have it not solved before the contract signature and shipment arrangements was a management decision with risk of failure.

IPEN hopes that all problems concerning criteria for failed fuel and cask licensing would be solved for the next transportation schedule.

4. REFERENCES

/1/ Perrotta,J.A; Terremoto, L.A.A.; Zeitune, C.A. “Experience on Wet Storage Spent Fuel Sipping at IEA-R1 Brazilian Research Reactor” – IPEN/CNEN-SP Technical Meeting in Budapest, Hungary (October/1996).

/2/ A Team of personnel from WSRC, DOE-SR, SAIC and INEL. “Characterization of IEA-R1 Spent Nuclear Fuels at the IPEN, São Paulo, Brazil, July 22 – July 31, 1996” – Internal report.