TWENTY-FIVE YEARS SUPPORTING RERTR ACTIVITIES FROM CNEA MTR FUEL FABRICATION PLANT (ECRI)

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ABSTRACT

CNEA, the Atomic Energy National Commission of Argentina, has been participating in the RERTR Program effort since twenty-five years ago approximately. Most of this participation and support are related with fuel development and fuel manufacturing activities.

This paper describes the contributions from CNEA fuel related facilities. They comprise R&D and manufacturing activities. R&D started in the early eighties with the development and fabrication of miniplates for the international silicide fuel qualification effort. At present the R&D activities continue with the development of fabrication techniques and procedures suitable for the manufacturing of fuel plates using the U-Mo based alloys. The above mentioned facilities include also a fuel power production plant and a facility for fuel scrap treatment.

In the MTR fuel manufacturing field the contribution began with the fabrication of the fuel elements for the conversion of the Argentine RA-3 Reactor. LEU fuel elements were also produced for several reactors outside Argentina. Among them the core for the RP-0 facility in Peru, the conversion of the Iranian Reactor, the fuel for the Algerian Reactor and more recently the fuel for the MPR in Egypt. All these fuels use U_3O_8 as fissile material.

CNEA has qualified also as fuel manufacturer of fuels bearing silicide compounds. At present CNEA fuel fabrication plant is taking the manufacture of 64 fuel elements for the ANSTO Replacement Research Reactor in Australia.

As a result of the above mentioned activities more than 12000 fuel plates were fabricated and most of them have been successfully irradiated without any fuel failure reported.

CNEA contribution also covered the development and fabrication of targets for radio-isotope production. Argentina has converted the production of isotopes for medical applications to LEU in 2002. Up to present more than 600 targets bearing LEU aluminide have been fabricated irradiated and processed. Very recently CNEA has also become an international supplier of targets for Mo-99 production.

1 Introduction and Background

The Atomic Energy National Commission (CNEA) is an Argentine governmental organization created more than fifty years ago. Its main objective is the development and application of advanced technologies in the area of the peaceful uses of the nuclear energy. Due to its achievements CNEA has attained a positive national and international renown. Highly qualified personnel and very important facilities and laboratories are the most significant capital resources of CNEA's organization.

In the field of nuclear fuel technology CNEA has accumulated a wide experience in the development, calculation, design, fabrication and testing of both, power nuclear fuel and research reactor nuclear fuel. All required aspects of this technology are covered within CNEA facilities. From UF_6 conversion to U-oxide or U-metal at one end to the fabrication and control of finished fuel elements on the other end, all the activities related with fuel fabrication are carried out under a stringent institutional quality assurance program. The CNEA facilities also include a fuel powder production plant and a facility for fuel scrap treatment

2 CNEA and the RERTR Effort

The participation of CNEA in the RERTR effort started more than twenty-five years ago. Most of this participation and support is related with fuel development and fuel manufacturing activities.

CNEA's work has been quite significant at international level in the program of reducing uranium enrichment used in research reactors. Development of fuels, targets and other low-enriched elements for reactors and applications were the main evidence of this commitment. CNEA was involved also in the conversion of research reactors that were using highly enriched elements. In this field CNEA has participated in INFCE (IAEA) and later, from 1978, in the RERTR (Reduced Enrichment for Research and Test Reactors) program held by request of the United States Department of Energy and coordinated by the Argonne National Laboratory (ANL).

The main milestone of the Argentine participation in the RERTR program was the conversion of the RA3 reactor from high enrichment (HEU) to low enrichment (LEU). This process included the development of fabrication techniques to manufacture LEU fuel elements and the provision of the new fuels to the reactor.

3 Development of fuel technology for LEU utilization

As part of the RERTR effort, CNEA worked since the beginning in the fuel development field starting with aluminide lines and oxide dispersions in aluminum (U_3O_8-Al). In 1979, CNEA received uranium with 20% ^{235}U enrichment in small amounts in the form of U_3O_8 and metal U, which allowed making miniplates of different fuel types. When Argentina decided to manufacture fuel elements with 20% of ^{235}U, only UF_6 was available in the market. For this reason, alternative methods were developed to convert it to U_3O_8, This development was performed considering the special characteristics needed in the U_3O_8 powder in order to obtain fuel plates with sufficient high density (higher than 3 gU/cm^3).

The development of this technology also allowed the export of a fuel fabrication plant with high added value. Progress in this field is given in successive stages, each one ending when the development is reasonably completed and qualified to be transferred to

the manufacturing stage. The methodologies applied in each stage are similar, including the training of human resources, basic and applied research, development and production.

The above mentioned activities conform the CNEA MTR Fuel Project whose main steps are:

3.1 First Research Reactor Fuel Generation -- Initial developments and fabrications

At the end of the 1950s, CNEA started the development and fabrication of fuel rods for the 40 kW RA-1 reactor. The rods comprised an extruded graphite-UO_2 in aluminum clad. The uranium used was 20% ^{235}U enriched.

From 1967 to 1987, new MTR-type fuels were developed with UAl_x-Al plates (90% ^{235}U) for the 5 MW RA-3 reactor and for the RA-2 critical facility. Some of them are still operating since 1982 in the RA-6 reactor.

Three development lines related with LEU fuels (less than 20% of ^{235}U) started in 1978. They were:

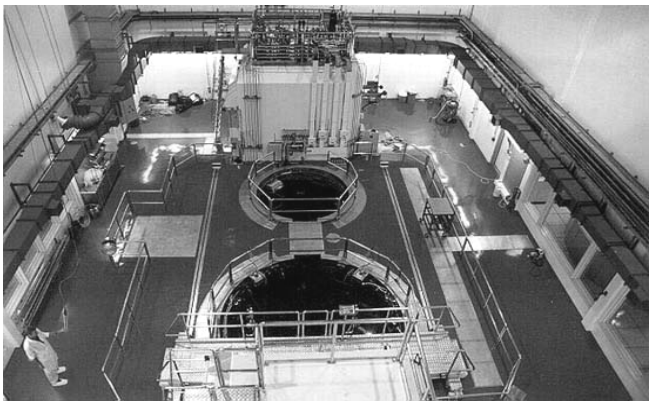
- U_3O_8-Al
- UAl_x-Al
- U_xSi_y-Al

In 1980 CNEA decided to use the U_3O_8-Al line as the standard process to manufacture the fuel elements for the domestic supply but the development of the other lines continued after that year in order to obtain experience with different fuel materials.

RA-1 and RA-3 Reactors

3.2 Second generation – CNEA industrial fuel supplier

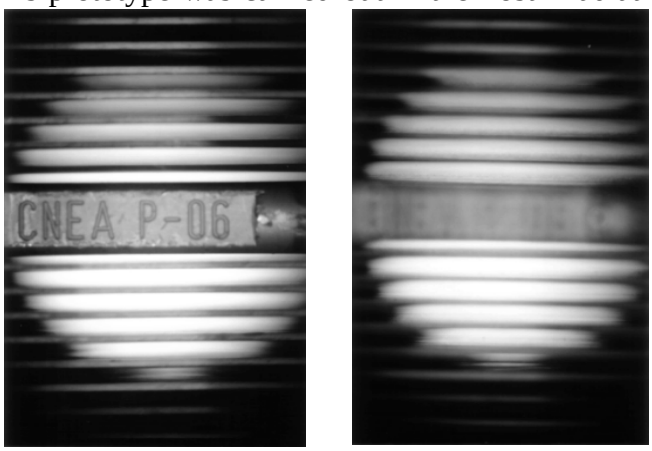
Based on the previous experience and knowledge, the second generation of fuels included fuel elements specially designed and fabricated in accordance with the requirements and characteristics of specific research reactors like the ETRR-2 in Egypt or the Peruvian RP-0. Most of the fabricated fuel elements are special designs, adapted to specific applications and customers.



ETRR-2 - Egypt

3.3 Third generation – Advanced fuels based on uranium silicide

This phase of the project consisted in the development and qualification of the technology related to uranium silicide (U_3Si_2). This step began with the preparation of a first experimental full-scale fuel element (P04), which was irradiated in the RA-3 reactor. The post-irradiation examination of this prototype was carried out in the Post-Irradiation Examinations Laboratory (LAPEP). This was the first time that an inspection in hot cells was completely performed in Argentina.



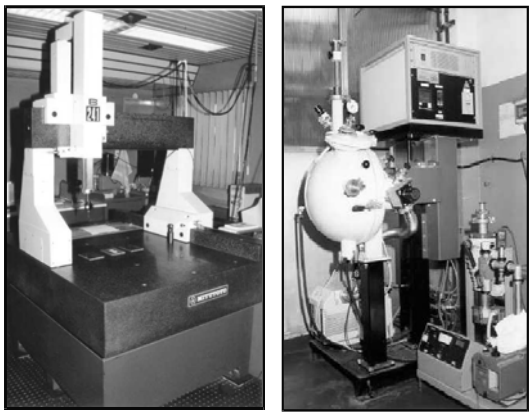
PIE of P-06 Fuel Element

After P-04 two full-scale prototypes, P-06 and P-07, were designed and fabricated. They were part of the CNEA qualification program as silicide high-density fuel manufacturer. The dimensions of the first fuel element (P06) were similar to the standard RA-3 fuel but with higher U density (4.8 g/cm^3). P-07 was designed with thinner fuel plates, like in the RRR or other operating reactors. Both prototypes reached the target burnup of 55 % and were inspected in the RA-3 poolside facility. P-06 was also submitted for destructive PIE in the Argentine Hot Cells. As a result of this program CNEA qualified satisfactorily as LEU silicide fuel manufacturer.

3.4 Fourth generation – Very high density fuels based on U-Mo alloy

The fourth step of the program is based completed all the capabilities required for the dev MTR fuels. The main facility is the fuel fabricat capacities are also covered from laboratory basic of the experimental prototypes and standard laboratory research in new nuclear materials, char preparation of nuclear raw materials and exper laboratory for post-irradiation examinations. It developed capabilities in neutronic and thermalh modeling, fuel engineering and quality assurance.

This stage of the project started in 1999. U-Mo alloys had been chosen as the more promissory candidates to study very high-density fuel materials. Considering the potential advantages of these alloys, regarding flexibility and safety, this phase of the project was initially focused on preparing and characterizing U-Mo alloys and assessing their comparative advantages as fuel for research reactors. An alternative processes to prepare U-Mo powder was also developed.



CNEA Fuel Fabrication Plant

In the last two years and after the results obtained by other organizations, the emphasis was put on the understanding of the interaction

between UMo and Al. Also on the fabrication of sound plates suitable for irradiation with the lowest interaction reaction in the as fabricated state. With the advance of these studies, the final step of this process will be the irradiation of miniplates and full-scale prototypes. The promising results reached up to now allow a continuous and very active participation of CNEA in the international effort for the qualification of this new fuel material. The UMo fuel is expectedly to be qualified by 2008. Simultaneously CNEA is pursuing to obtain its qualification as manufacturer of fuels bearing UMo alloys.

3.5 CNEA as Industrial HEU and LEU MTR Fuel Supplier

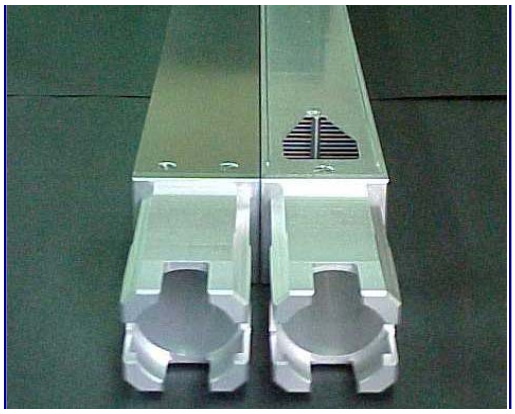
As was mentioned above, CNEA has reached a very high technological level in the production of Research Reactor Fuels and is considered as a qualified and reliable supplier of this kind of nuclear fuels. This can be easily corroborated by its experiences as domestic and international supplier.

A detailed list of CNEA fuel productions is presented in the following Table

Reactor or Facility	Country	Year	Type of Fuel	U Density	Type of End Box	Quantity supplied
RA2, RA3 and RA6	Argentina	1963 - 1987	MTR HEU	0,6 g/cm^3	welded	312 FE (5928 curved plates) 135 CFE (2025 curved plates)
RP0	Perú	1987	MTR LEU	3,1 g/cm^3	screwed	23 FE (368 flat plates) 5 CFE (70 flat plates)
NUR	Algeria	1989	MTR LEU	3,1 g/cm^3	welded	36 FE (684 flat plates) 9 CFE (126 flat plates)
RA3	Argentina	1990	MTR LEU	3,1 g/cm3	welded	27 FE (513 plates) 8 CFE (112 plates)
TRR-2	Irán	1992	MTR LEU	3,1 g/cm^3	welded	66 FE (1254 flat plates) 12 CFE (168 flat plates)
MPR	Egypt	1997	MTR LEU	3,1 g/cm^3	screwed	30 FE (570 flat plates)
RRR	Australia	2005 - 2006	MTR LEU	4,8 g/cm^3	screwed	64 FE (1344 flat plates)

Notes: FE: Fuel Element **CFE:** Control Fuel Element

Since the beginning of these MTR fuel fabrication activities more than 600 fuel elements of different types and more than 12000 fuel plates have been supplied to domestic and overseas customers. Most of them have been completely irradiated. The performance of these fuel elements has been excellent, within the expected parameters for their nuclear service and no fuel failures or any abnormalities have been reported.



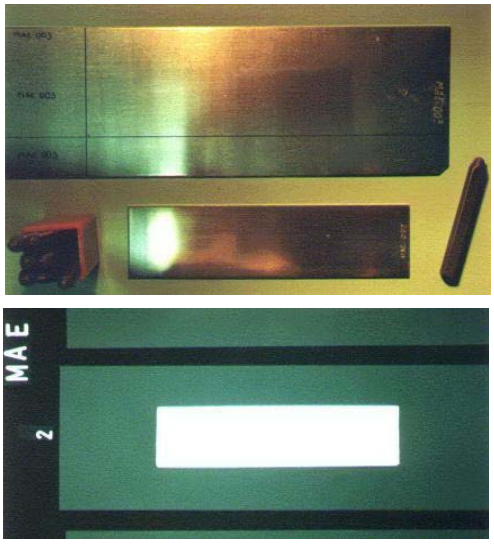
Fuel for the Australian RRR reactor

3.6 Fuel Targets for Mo-99 production

CNEA contribution to the RERTR effort also covered the development and fabrication of targets for radio-isotope production using LEU to replace the use of High Enriched Uranium (90% ^{235}U) for this purpose.

The development was based on the use of UAl2 dispersed in an aluminum phase.

Through this development it was possible to obtain targets with densities of 3 gU/cm^3. With this load of uranium the LEU targets are suitable to be used without geometric modifications and maintaining the current process of basic dissolution in the radiochemical process. The UAl_2 compound was selected due to its very convenient characteristics, among them its density of 6,42 g/cm^3.



LEU Targets

As a result of this development Argentina has converted the production of isotopes for medical applications to LEU in 2002. Up to present more than 600 targets bearing LEU aluminide have been fabricated, irradiated and processed. Very recently CNEA has also become an international supplier of targets for Mo-99 production.

4 Final Remarks

During the last 25 years CNEA has been actively participating in the RERTR effort. Four fuel generations of developments and fabrications, as part of the CNEA MTR Fuel Project, are proving these commitments. As a result of these largely sustained activities CNEA is in condition to supply to domestic and overseas customers different types of fuels. Up to now more than 600 FE (12000 fuel plates) have been supplied and satisfactorily used in the nuclear service without any report of fuel failures. Development activities are now focused on the qualification of the UMo compound as fuel material. Also in the qualification of CNEA as UMo fuel manufacturer.

Along with the fuel development activities CNEA also set up the technology for using LEU targets for the production of radioisotopes for medical use. Since year 2002 all the production of 99Mo from fission in Argentina is performed using LEU targets. CNEA is now in condition to provide this type of targets to different customers requiring this service.

5 References

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