THE MANUFACTURING OF DEPLETED URANIUM BIOLOGICAL SHIELD COMPONENTS.

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SUMMARY

The unique combination of the physical and mechanical properties of uranium made it possible to manufacture biological shield components of transport package container (TPC) for transportion nuclear power plant irradiated fuel and radionuclides of radiation diagnostic instruments.

Protective properties are substantially dependent on the nature and radionuclide composition of uranium, that why I recommend depleted uranium after radiation chemical processing.

Depleted uranium biological shield (DUBS) has improved specific mass-size characteristics compared to a shield made of lead, steel or tungsten.

Technological achievements in uranium casting and machining made it possible to manufacture DUBS components of TPC up to 3 tons of mass and up to 2 metres of the maximum size.

CONCLUSION

In Russia TPC with DUBS has been designed (its capacity is a factor of 1.5 larger than that of steel one) and components of DUBS have been manufactured.

REFERENCES

Metelkin and Birjukov 1983, Uranium and Its Alloys Melting and Casting, Energoatomizdat.

Metelkin et al. 1984, Theory and Practice of Radioactive Metall Casting, Energoatomizdat.

Metelkin and Orlov 1991, The Use of Uranium in National Economy, Journal "Conversion in Machinery, #1, pp.17-23.

Lecture Session Additional Papers

VITRIFIED WASTE TRANSPORT ON THE COGEMA LA HAGUE SITE

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SUMMARY

Thanks to reprocessing, non-reusable ultimate waste (fission products and minor actinides) are sorted out and incorporated into a glass matrix through the vitrification process. The vitrified residues are then conditioned stainless steel canisters stored in air cooled pits within the La Hague facilities before being sent back to its owner, one of the 33 utilities which have contracted with COGEMA for the reprocessing of their spent fuels.

The DRV - Vitrified Residues Destorage and Flask Loading Facility - units acts as the central post in charge of glass canisters handling and transport casks loading through its associated transport means (truck + shuttle). But, the DRV unit also performs a key mission which is the verification of the glass canisters (non-contamination and dose rate).

Carried out under the QA/QC system of COGEMA, the DRV mission ensures the industrial consistency of the glass production and transportation procedures implemented at La Hague. The reliability of the whole system has been proven by five shipments already performed to Japan and Germany.

INTRODUCTION

The spent fuel unloaded from nuclear reactor contains 96 % of uranium, 1 % of plutonium and 3 % of fission products and other actinides. Uranium and plutonium, once recovered, can be reused to make new fuels. Fission products and actinides are ultimate waste, or residues. They are highly radioactive and must be conditioned appropriately, for final storage in deep geological formations.

Commercial-scale high level waste vitrification in France is on line at the La Hague reprocessing plant with the R7 and T7 facilities. Each facility is made up of 3 lines implemented in individual cells and designed to produce 25 kg of glass per hour, corresponding to one canister filled every 16 hours. In addition, the R7/T7 glass specifications were also approved by the regulatory authorities of COGEMA's customers in Germany, Belgium, Netherlands, Switzerland and Japan.

The reprocessing contracts signed in the end of the 1970s between COGEMA Group and several utilities around the world specify that waste resulting from the reprocessing operation should be returned to their owner in a form suitable for transportation and final storage, i.e. in glass canisters. Four transports of vitrified residues were performed between 1995 to 1997 to Japan (by sea) and to Germany (by rail and road).

At the La Hague site, in order to prepare the shipment of the glass canisters, COGEMA Group uses the DRV - Vitrified Residues Destorage and Flask Loading Facility - which serves as the central flask acceptance and unloading station.

This paper aims at describing the role of the DRV in the preparation of vitrified residues transports from La Hague to customers.

VITRIFIED WASTE: LA HAGUE'S EXPERIENCE

The French vitrification process is based on the AVM (Atelier de Vitrification Marcoule) process which operates continuously and is the first successful industrial experience. The R7 and T7 vitrification facilities at La Hague are similar facilities. Their design is based on the experience gained in designing and operating the AVM facility. R7 was started-up in 1989 and T7 in 1992. The same French technology has also been used since 1990 to produce glass in UK (Sellafield).

Results accumulated so far at La Hague show that HLW vitrification in France fully meets criteria of a successful industrial process. Moreover, the resulting glass meets all required quality standards. Each facility R7 and T7 is made up of:

- receipt and adjustment units,
- liquid waste feeding, calcination and vitrification units,
- conditioning units,
- off gas treatment units.

Each facility R7 and T7 is designed to produce 600 canisters a year, corresponding to 800 tU reprocessed with reference solutions. It is worth emphasizing that these design figures correspond to the range of fuels that can be reprocessed, characterized from a reference fuel with a burn-up of 33,000 MWd/t with 3,5 % of U235 (3 year cooling period).

The process has proved to be highly flexible since fine particles from the dissolution step have been incorporated to the glass matrix.

From an industrial point of view, these facilities fully comply with production requirements. At the end of 1997, more than 5,100 canisters have been produced at R7 and T7. Since the active start-up of R7/T7 facilities, vitrified canister compliance with specifications relies upon a complete quality assurance/quality control program including process control. Last, by using well-developed process, the R7/T7 facilities can safely produce more than 80 % of the civilian vitrified HLW in the world.

THE DRV FACILITY: A PRESENTATION

The use of the DRV facility answers to the specificity of the La Hague site. The La Hague reprocessing plant is made of two facilities: UP2-800 devoted to reprocessing of French spent fuels (nominal capacity 800 t/year), and UP3 for the reprocessing of spent fuels used by european and Japanese utilities (nominal capacity 800 t/year). Each of these facilities has its own vitrification workshops: R7 for UP2-800, and T7 for UP3. Therefore. R7 and T7 have their own glass canisters interim storage facilities.

In order to ease the preparation of vitrified residue transports in terms of industrial practicability and schedule, it has been decided to design a single unit for the reception of glass canisters, their verification and the loading of the transport flasks. This sole equipment is the DRV, located in the NPH facility. The DRV was commissioned in 1994.

For transporting vitrified residues within La Hague site, the DRV relies on two tools: a shuttle and a dedicated truck.

The shuttle

(See figure 1)

The shuttle used in the DRV is a transport flask roughly similar to the one utilized during the operational transfer of vitrified residue from La Hague to Japan or Germany. The shuttle is shielded against neutron and gamma radiations. It contains seven glass canisters and weights 80 tons. According to the French regulatory framework, and since the shuttle is used only inside the La Hague site, it was designed to match with a type-A qualification.

The shuttle operating mode is completely automatic. No direct human intervention is necessary to handle the shuttle. This helps keeping low the exposure level of La Hague's operators (In 1996, the average worker exposure was 0.16 mSv, well below the regulatory level which is 50 mSv per year).

Today, the DRV uses three shuttles. The shuttles were designed by SGN and manufactured by Robatel, a specialized French company. It is noteworthy to add that the maintenance cycles of the shuttles and the transport flasks are equals and are performed at the AMEC facility at La Hague.

The truck

The shuttle is positioned on a dedicated truck (« MAFI » type), manned by a driver, then the driver transfers the truck and the shuttle between R7 and T7 interim storage and DRV facilities. Today, two trucks are in operation at the DRV. As for the shuttles, the trucks were designed by SGN, but they were built by MAFI.

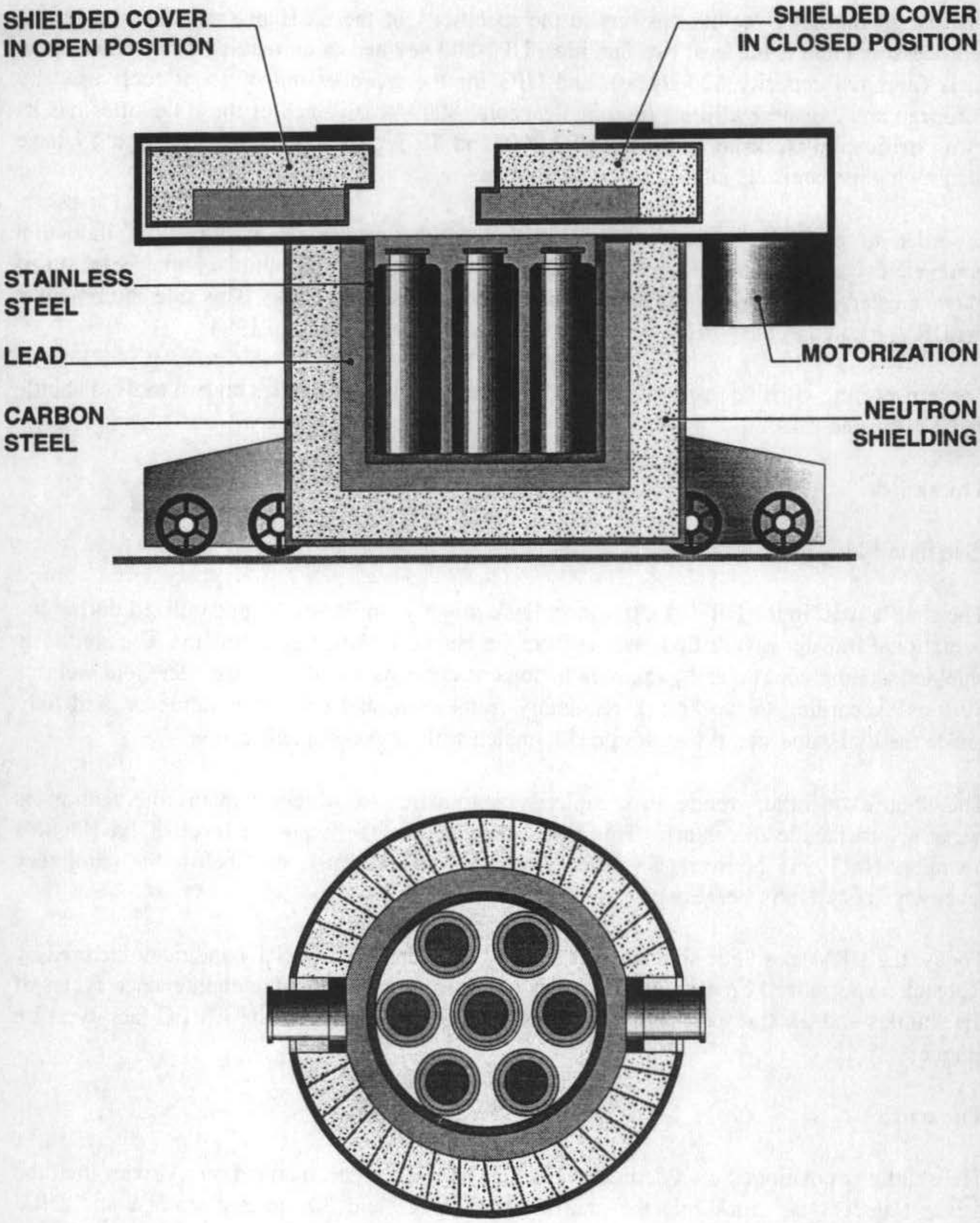

Figure 1: Principle of the vitrified waste shuttle cask

THE DRV FACILITY: ITS ROLE IN THE TRANSPORT PROCESS

As seen before, the DRV is used to destore vitrified residue and to load the shuttle flask prior to the effective loading of the transport flask. The glass canisters selected for shipment are transferred from the interim storage pits of R7 and T7 by the shuttle to DRV. Once the shuttle is arrived at DRV, the next steps are the following:

Reception of the shuttle: The shuttle flask containing 7 glass canisters is removed from the truck and transferred by a bridge crane to the DRV, set onto a movable platform inside a transfer cell. After the shuttle has been checked, the transfer cell is closed. Then the shuttle lid is removed by remote handling. After this, the shuttle flask is moved on the platform to the reloading position beneath the DRV destorage cell, ready for unloading.

Unloading of the glass canisters from the shuttle into the destorage cell: A lock at the bottom of the destorage cell is opened and the glass canisters is lifted one by one by the cell crane and stored into the destorage cell. Then the shuttle flask is removed after several checks aimed at controlling non-contamination and dose rate.

Reception and preparation of the flask for shipment: the empty flask is transferred to the reloading position of the DRV in the same way as it was done for the shuttle. Then the glass canisters are loaded in the destorage cell. After loading, the filled flask is disconnected from the destorage cell and closed by remote handling. Inner and outer tests ensure that the flask is ready for shipment.

CONCLUSION

The five transports already performed validated the DRV concept and showed that both shuttles and trucks are fully operational. The Quality Assurance/Quality Control system ensures the reliability of the whole glass production and transportation system, including the DRV. Inspections and audits are carried out Groups to check the proper application of this system.

TRANSPORT OF NUCLEAR MATERIALS: A MAJOR STAKE FOR THE REPROCESSING-CONDITIONING-RECYCLING STRATEGY

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SUMMARY

As the international reference in terms of fuel cycle services, the COGEMA Group has developed a wide range of industrialized products answering to its clients needs. But, as deregulation and competition are now expanding, utilities has to be perfectly aware of the cost level of their strategic choices, and to keep these costs down. This point is especially valid in the back-end of the fuel cycle. Several leading nuclear countries around the world have chosen the reprocessing-recycling option because it ensures a economically mastered vision.

In that respect, transportation reliability is consequently a basic requirement. It ensures a balanced and continuous flows of materials. Transportation system must be reliable in terms of schedule, safety or industrial aspects (i.e. dedicated packaging for road, rail, sea or air transports, maintenance aspects…). Any serious flaw in one of these three points could lead to delays, thus lessening the economic advantage for utilities.

But, one must not loose sight that transportation of nuclear materials is tied to extra-technical issues, such as environmental or regulatory factors, which are fundamental for a consistent understanding of this business.

The COGEMA Group, through its subsidiary Transnucléaire, possesses a dedicated transport system, widely praised for its constant commitment in terms of safety, quality and operability. This papers presents the overall back-end transportation framework and details the transport organisation as well as the main achievements of Transnucléaire when it comes to sea, road or rail back-end transports.

INTRODUCTION

Today, utilities relying on nuclear power can choose between several solutions and service suppliers for their back-end management. In this framework, industrial nuclear companies must offer a broad and attractive serie of flexible services in order to match with the utilities needs

Ranging from MOX production to appropriate waste conditioning in dedicated and standardized canisters, COGEMA Group has developed a client-first strategy giving utilities a real sense of priorities. More precisely, utilities select the industrial services they really need, and the associated schedule. Consequently, key factors such as long-term financial strategies can be assessed with a higher degree of accuracy. Industrial flexibility is a primary imperative for lower electricity generation cost which is, *in fine*, the ultimate rationale for utilities.

The COGEMA Group back-end strategy features a combined offer at the center of which lies the transport of nuclear materials. Within the COGEMA Group, the transport activity is performed with the same commitment to mastery and excellence than the RCR operations because it obeys to the same framework made of extra-industrial issues (environmental protection, relations with international agencies in charge of transport...) and technical challenges (transport cask design is different for vitrified residues or fresh MOX fuel assemblies ...).

This paper describes the global environment surrounding the nuclear materials transport business today and the way this activity is carried out by the COGEMA Group, including current status and future prospects.

TRANSPORT OF NUCLEAR MATERIALS: GLOBAL STAKES & GLOBAL ANSWERS

As seen, nuclear shipping business includes non-technical features as well. These aspects are of utmost importance for the nuclear community because they ensure the overall consistency of the transport activity. In that sense, transportation of nuclear materials is not different from running a nuclear facility. The public and regulatory constraints are quite similar. The only difference lies in the movable and transboundary aspect of transport operations. The COGEMA Group is fully aware of this situation and has integrated it in its daily transport operations. Three main stakes face the nuclear transportation community: environmental protection, relationships with national and international authorities and political relations. One cannot separate one from the other insofar as there is a constant interaction between them.

The environmental factor

Above all, nuclear transports have to be accomplished bearing in mind the extreme - and natural - sensitivity of public opinion regarding nuclear affairs and environmental protection. That is why the greatest care must be taken of environmental aspects during transport. For instance, non-nuclear states whose territory or territorial waters are crossed by a nuclear shipment are very much interested by the way environmental-friendly measures are implemented for such operation.

The regulatory factor

Transport of nuclear materials is maybe one of the most regulated business in the world. International and national regulations form a global regulatory framework covering the entire transport business. This mix of general principles and safety rules have been carefully established by international experts, published as recommendations by the IAEA and enforced worldwide through national legislation. The nuclear transportation community evidently abide by current regulations and support any regulatory initiatives that will lead to actual improvement in safety.

The political factor

International transport of nuclear materials - because of its very nature (various countries and sensitive materials) - is intimately tied to political considerations. For instance, return from Europe to Japan of plutonium recovered during the reprocessing operation is covered by a multilateral agreement between Japanese, American and European authorities. Nurturing good political relationships with political authorities of various countries is therefore a basic objective for the nuclear transportation community.

TRANSPORT OF NUCLEAR MATERIALS: THE COGEMA WAY

As previously underlined, when nuclear materials are transported, the shipper may face a great diversity of regulatory or political situation. Each country - and each utilities - has its own specificity. This variety of situation did not prevent the COGEMA Group to develop its own industrial transportation strategy which is really tailored to each client needs while offering a world-class service.

This strategy lies on a combined offer: the reprocessor takes the spent fuel, ships it from the nuclear power plant to the reprocessing plant, reprocesses it and sends back fresh MOX fuels and vitrified residues according to a flexible planning established by both parties. In other words, utilities does not need to care about the ins and outs of their back-end strategies. The reprocessing company is then responsible for all the industrial aspects tied to the fuel cycle back-end management, including overseas transports. This is a global answer.

More precisely, to serve its clients, the COGEMA Group has developed a comprehensive back-end transport organization system covering various type of nuclear materials (vitrified residues, fresh MOX assemblies,...), transport modes (road, rail, sea, air).and relying on well-mastered procedures and capabilities in engineering of dedicated transport casks, shipping, carrying, and maintenance activities.

COGEMA Group: transport experience

COGEMA Group's experience in back-end materials transportation is extensive. Regarding spent fuel transportation experience, more than 17,000 MTU corresponding to more than 4,500 casks have been safely transported from the reactors to the La Hague reprocessing plant since 1966. For the year 1997 alone, more than 330 casks containing PWR and BWR fuels.

Regarding plutonium oxide powder transportation operations, these transports are performed by road within Europe (more than 120 transports of this type have been performed in 1996). COGEMA Group safely performs overseas vitrified residues transports as well. Three sea transport operations have been performed to Japan since 1995. Two vitrified residues transports have been carried out to Germany in 1996 and 1997. Belgium is the next country scheduled to receive vitrified residues casks.

COGEMA Group: transport organisation

The COGEMA Group transportation organisation relies on a very simple scheme. COGEMA Group acts as the transport's main contractor. However, the responsibility of organizing and realizing the shipment is generally handed over to specialized companies. Transnucléaire, a 100 % subsidiary of COGEMA Group, is the main operator in the back-end materials transportation in France. This specialized company designs and produces the packaging used for transportation of back-end radioactive materials like spent fuel assemblies, vitrified or compacted wastes, plutonium and MOX, etc... As of today, more than 150 different types of casks have been developed by Transnucléaire for the front-end and back-end of the fuel cycle.

COGEMA Group: industrial transportation aspects

Unlike those from the front-end sector, back-end transport activities requires specialized packaging and vehicles. The higher level of radioactivity of the materials transported implies that a very special attention must be paid to safe packaging and transport means. As a result only highly specialized companies are operating in this field.

Most of the materials belonging to the back-end of the fuel cycle are transported in high resistance type B packagings. All casks first go through an extensive engineering phase. Engineering works on the packaging include R&D on materials, design, tests, safety demonstration and approval as well as manufacturing follow-up. Next, Transnucléaire establishes the safety analysis reports that have to be approved by the Safety Authorities in order to get the transport license.

Sea transports

Overseas transports of spent fuel vitrified high level wastes, plutonium and MOX require special ships. COGEMA Group uses PNTL's ships, that comply with the class INF3 of the Irradiated Nuclear Fuel, Plutonium and High Level Radioactive Waste in Flasks on Board Ships, better know as the INF Code issued by the IMO (International Maritime Organization).

Road transports

For road transportation, Transnucléaire is relying on two specialized companies: CELESTIN and LEMARECHAL which altogether operate a fleet of more than 60 special vehicles for road transportation. The trucks used for radioactive materials transport are fully dedicated to that purpose. In other words, they are not allowed to carry radioactive matters on their way to and another non- radioactive matter on their way back.

Although this is not made compulsory by the French regulations, this aspect is of great importance for Transnucléaire which has committed itself to prevent any risk in all its activities. Trucks are fitted with an Inmarsat GPS satellite navigation system ensuring a precise tracking and real-time positioning.

Rail transports

Railway transportation of fuel assemblies or radioactive waste containers uses specific wagons which are the property of COGEMA. These rail wagons have a total weight of 160 tons, and are 25 m long. They could be inserted into the normal railway traffic without facing a special speed limitations. They will be also equipped with GPS tracking.

This industrial scheme is implemented on a full maintenance and Quality assurance framework. According to the IAEA Regulations, the COGEMA Group performs specific maintenance operations on its casks. Located in La Hague and Marcoule, these maintenance installations are operated by MMT, a COGEMA Group subsidiary. Both basic maintenance and main maintenance are performed at MMT facilities.

In addition, every activity in the nuclear materials transport is covered by a Quality Assurance system which meet either the ISO 9000 or the IAEA 50 CQA requirements. Generally speaking, quality is one of the most important factor for Transnucléaire when selecting a subcontractor. Adding to the audits made by the Quality Assurance certification bodies, regular external and internal audits and inspections are performed to check the proper application of the specifications over the all transportation system

CONCLUSION

The COGEMA Group transportation answer relies on an integrated commercial framework which encompasses spent fuel reprocessing, appropriate waste conditioning in dedicated and standardized canisters and MOX production. Thus, the RCR concept implemented by the COGEMA Group provides a cogent and complete solution for the back-end of the fuel cycle.

Regarding transport operations, the COGEMA Group - through its Transnucléaire subsidiary - has always paid a great attention to industrial as well as extra-technical issues. Because, successful transport mission participate in the global competitiveness and consistency of nuclear energy, the COGEMA Group feels that a proactive communication strategy based on openness and mutual trust is important. For instance, numerous Public Acceptance tools (films, booklets...) have been produced in order to explain why transports of vitrified residues were carried out. The COGEMA Group has also sent its representatives to several countries in the same goal.

The development of new casks by the COGEMA Group - for instance MOX transport casks called the MX family- and the implementation of new techniques, like satellite tracking of the trucks, as well as implementation of a comprehensive emergency plan, will give utilities new transport opportunities.

TRANSPORT OF RESEARCH REACTOR SPENT FUEL: ITALIAN EXPERIENCE

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SUMMARY

For 30 years the Italian Research Reactors and reprocessing plants have been involved in preparation and transportation of spent fuel assemblies. In the past, reprocessing services were offered by the ENEA pilot reprocessing plant « EUREX », located at Saluggia (Northern Italy) where about 500 fuel assemblies were reprocessed during the seventies. All research reactors, except two Triga's, have now been shut-down. Following phasing-out of nuclear generation in Italy and the subsequent redirection of ENEA programs, 150 MTR fuel assemblies from several origins, remained unprocessed.

Since 1987, ENEA has been negotiating with the U.S. Department of Energy (DOE), under the « Off-Site Fuels Policy » the return to the U.S. of these 150 MTR spent fuel assemblies stored at Saluggia. A contract was drafted early 1988 when the return policy was deferred. In 1996 the U.S. DOE issued a Record of Decision on Nuclear Weapons Non Proliferation Policy concerning Foreign Research Reactor Spent Fuel. Then a contract was signed between ENEA and DOE permitting the shipment to the U.S. of the remaining spent fuel assemblies.

After a long period of storage we were confronted to various problems related to fuel integrity, irradiation history, manufacturing specifications and drawings, cask licensing, transport operation, compliance to new regulations, specific U.S. DOE requirements, etc.

This paper will outline how we dealt with these various aspects to allow efficient transport operation involving organisations based in Italy, France and the United States.

INTRODUCTION

The EUREX pilot reprocessing plant of ENEA Research Centre at Saluggia (Italy), has been in operation from 1970 to 1983. During this period 504 irradiated MTR fuel elements and about 1.5 ton of irradiated CANDU bundles have been reprocessed and the fissile material recovered.

Initial programs scheduled a further MTR reprocessing campaign, but the plant was shut-down in 1987 after the Italian governmental decision to abandon nuclear power generation and related activities. Due to this reason, 150 irradiated MTR fuel elements remained in storage in the EUREX pool at Saluggia.
Since 1987, ENEA has been negotiating with the U.S. Department of Energy (DOE), under the « Off-Site Fuels Policy » the return to the U.S. of these 150 MTR spent fuel assemblies stored at Saluggia. Early 1988 a contract was drafted with DOE for the acceptance of these spent fuel assemblies, and an other contract signed with Transnucléaire to prepare the administrative part of the transport operations including licensing authorisations and preliminary formalities. Unfortunately the return policy was deferred. In 1996, the US policy resumed and it was again possible to send spent fuel containing highly enriched Uranium from U. S. origin to the United States. After long discussions a contract was signed with the DOE, contract including more severe requirements concerning transport preparation.

From 1987, beginning of the discussions with DOE and Transnucléaire and 1997, date of the first shipment of Italian spent fuel to the U.S. several aspects changed, forcing us to solve numerous problems.

FUEL INTEGRITY

The acceptance criteria of the fuel by a nuclear facility are an important safety concern. This explains why DOE pays, as all nuclear operators, a particular attention to the possible deterioration of fuel assemblies stored for long periods of time, 15 to 20 years for Italian fuels. So, before the loading operations of the first batch of MTR fuel assemblies into transport casks, each fuel assembly was carefully checked in presence of Westinghouse representatives (acting on behalf of U.S. DOE Savannah), in order to see whether apparent fuel corrosion (clad damage) fulfilled, in particular, the requirements of the DOE Environmental Impact Statement (EIS). The EIS stated that fuel assemblies exhibiting corrosion, pitting, hairline cracks or other indication of damage should have to be canned prior to shipment from the origin facility.

Eleven out of the 72 fuel assemblies scheduled for this first shipment were rejected due to possible external corrosion. The fact that the fuel assemblies were satisfactory for transport in accordance with US and international transportation regulations was not the key issue.

Canning of MTR fuel assemblies is not usual, and technical standards have to be agreed upon in advance to satisfy the requirements of loading/unloading plants, as well as transport constraints: suitable casks with corresponding transport license.

Fortunately the availability of other acceptable fuels in the pool allowed us to find the 72 fuel elements needed to fill up the two casks of this first shipment, giving more time to solve this problem.

Immediately after the transport ENEA and DOE worked together on clear regulatory guidance to see under which criteria the remaining 78 fuel assemblies had to be transported taking also in consideration that only two licensed casks (IUO4) were available for this purpose. ENEA provided U.S DOE with a complete underwater video recording of the 78 assemblies.

Transnucléaire/Transnuclear Inc. also provided their expertise in participating to the Failed Fuel Task Team Recommendations. Finally new fuel acceptance criteria were defined authorizing shipment of all the Eurex fuel assemblies. The new criteria are effective since February 1998. The major distinction between old and new criteria, is that some fuel assemblies with minor surface corrosion will be authorised to be shipped without special canning, when permitted by the appropriate cask certificate.

IRRADIATION HISTORY, MANUFACTURING SPECIFICATIONS

After signature of the contract, and not less than 180 days in advance of a delivery date the contractor (usually the reactor operator) shall submit for approval an appendix A agreement spent nuclear fuel acceptance criteria, document describing the physical and chemical characteristics, approximate isotopic composition, dimensions and weight of a homogeneous batch of fuel assemblies for transport to DOE.

Filling out of these Annexes was more complicated than expected since ENEA was not the operator of the reactors. Uncertainties about number and position of fuelled and dummy plates in the assemblies were due to the very old technical data in the hands of Eurex plant, where some fuel assemblies had been transported in the early seventies from reactors shut-down a long time ago and from which records were no longer available.

DOE understood that much of the detailed information has long ago disappeared but they wanted to be sure that they will have the best information available. In addition, one DOE engineer had to go through many boxes of old information submitted to DOE over many years to try and gather details on the fuel for which no drawings or irradiation history are available. After several months of research, this aspect also has been solved to permit the shipments as scheduled.

COMPLIANCE TO NEW REGULATIONS

Early 1995, the International Maritime Dangerous Goods (IMDG) Code was supplemented by the INF (Irradiated Nuclear Fuel) Code laying down stringent requirements for ships transporting Irradiated Nuclear Fuel, Plutonium and High-Level Radioactive Waste. The INF code is not yet a mandatory instrument but is implemented in numerous countries where the IMDG Code is considered as the basic regulation for international transport by sea. Several amendments to this Code have been adopted and it was agreed at the 20th Assembly of IMO that the INF Code would be made mandatory and will enter into force in October 1999.
Depending upon total radioactivity of the transported products three classes are considered. The use of an INF 2 vessel is necessary when the activity of the consignment exceeds 4000 Tbq which is usually the case for the shipment of several casks coming from European countries. The Code covers principally matters of ship design, construction and equipment.

The INF code requirements and the decision made by DOE to utilize military ports in the US, exclude de facto the use of commercial liner services. To cover the needs of research reactor operators and other research facilities Transnucléaire decided to operate two INF 2-certified ships the « Beaulieu » and the « Bouguenais », under an exclusive contract with a French shipping company.

SPECIFIC U.S. DOE REQUIREMENTS

The finalization of the contract with U.S. DOE and Transnucléaire was also a difficult task due to the new aspects to be taken in consideration, particularly regarding operational aspects of the shipments. In addition to the applicable international and national laws and regulatory requirements governing shipments made under this contract, ENEA and Transnucléaire had to consider the requirements included in the EIS, ROD (Record Of Decision) and Mitigation Action Plan.

In addition to the technical matters, the main new requirements and constraints were :

- obligation to deliver only to Charleston Naval Weapons Station
- necessity to transport by rail between Charleston and Savannah
- fixed date of delivery at Charleston
- necessity to load a maximum number of casks (up to 8) from other shippers, on the same ship to limit the number of transports
- numerous meetings with all entities involved in Europe and in the U.S.

TRANSPORT OPERATION

The first shipment of 72 fuel assemblies loaded in two IU04 finally left the Eurex plant on the 18th and 19th February 1997 and were transported by truck to Agognate rail dock (Italy), then by railway to Cherbourg (France) to be loaded on the «Bouguenais » ship already loaded with an other IU04 containing the Spanish Ciemat fuel assemblies coming from Dounreay in U.K. We were requested by DOE to adjust loading and departure schedules in order for our ship to enter in Charleston at the same time as other ship transporting casks of spent fuel from other European countries. Due to similar problems encountered with « failed » fuel in the U.K., our ship was delayed and new difficulties occurred with the need to change again the transport schedule to arrange only one handling operation in Charleston and allow all the casks to be put on board the same train to Savannah.

The second half of 1997 was dedicated by EUREX management to obtain deeper information about the fuel, to agree upon how many fuel elements had to be canned or not before transport and what kind and how many transport casks would be available for the next transport(s). These actions also aimed at reducing total costs and finding accordance with EUREX policy to end the operations within the year.

The situation was furthermore complicated by the end of the cask transport certification in July 1997.

Fortunately an inspection with dose rate measurements showed that two elements were not irradiated, and then their transport to the U.S. was therefore not necessary (dry storage at EUREX plant option). This information reduced EUREX need to a single transport of two IU04 casks, with (40 + 36) 76 total places available, avoiding extra costs.

Contacts among ENEA, DOE and Transnucléaire and the progress of acceptance criteria revision, focused then on the hypothesis of a final transport of 76 elements, without canning. As the new cask transport agreement and DOE authorisation to ship have become available (27th November), the remaining MTR elements have been loaded in two IUO4 casks. The casks were ready to leave EUREX in December but again for several reasons the shipment was postponed to January 1998.
The two casks were also delivered to Cherbourg like for the first shipment to be loaded on the « Bouguenais ». The ship made a long trip from Cherbourg to Sweden to load R2 fuel assemblies from the R2 reactor, then Denmark to load casks with fuel assemblies coming from DR3 reactor and HMI fuel assemblies from Berlin reactor and finally to Greece to load one cask with fuel assemblies from the Demokritos reactor, before crossing the Atlantic to Charleston Harbour. The eight casks were safely unloaded in Charleston and transported by rail to Savannah River Site.

CONCLUSION

The process to plan and implement such shipments is long and difficult since it implies technical aspects, casks procurement and licensing, logistics and the involvement of numerous partners. ENEA has some other TRIGA fuel assemblies which will be ready to be shipped in 1999. Assuming that the conditions remain the same and taking in consideration the lessons learned we are confident that the next shipments will be made safely and successfully under good economic conditions.

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