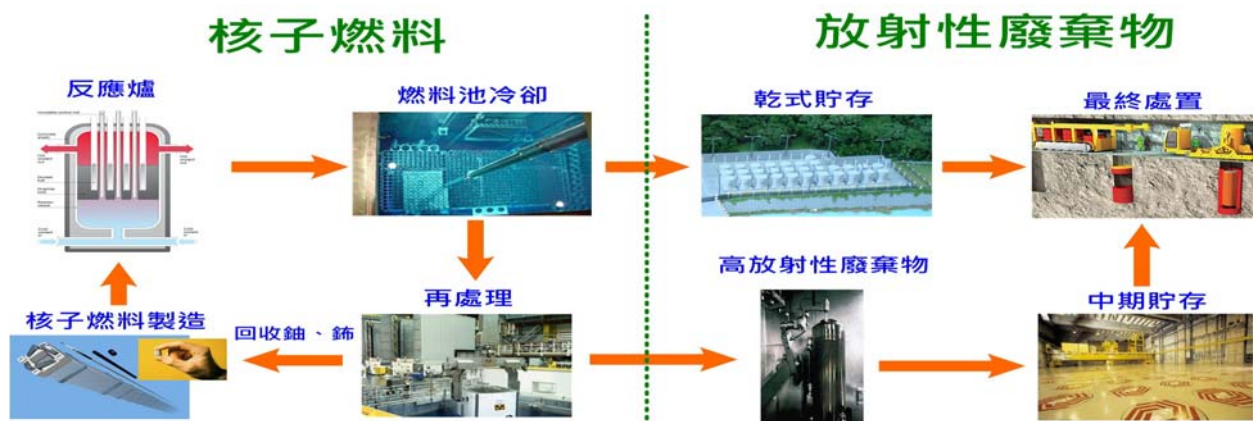


Safety Management of Abroad Reprocessing Spent Nuclear Fuels

Fuel Cycle and Materials Administration
Atomic Energy Council

1. Introduction

Nuclear fuels having been in the reactor of a nuclear power plant for certain time have to be replaced with fresh ones when their efficiency decreases to some extent. Nuclear fuels discharged from a reactor are called “spent nuclear fuels” which contain about 96.5% recyclable useful resources, uranium and plutonium (uranium 95.6%, plutonium 0.9%). Those useful resources can be recovered by reprocessing processes. The rest are 3.5% fission products and trace actinides which can be vitrified and safely put into storage. The spent nuclear fuel management strategies in Taiwan are: short-term – on site spent fuel pool storage; mid-term – on site dry storage; and long-term – carrying out final disposal with option of seeking the feasibility of abroad reprocessing.

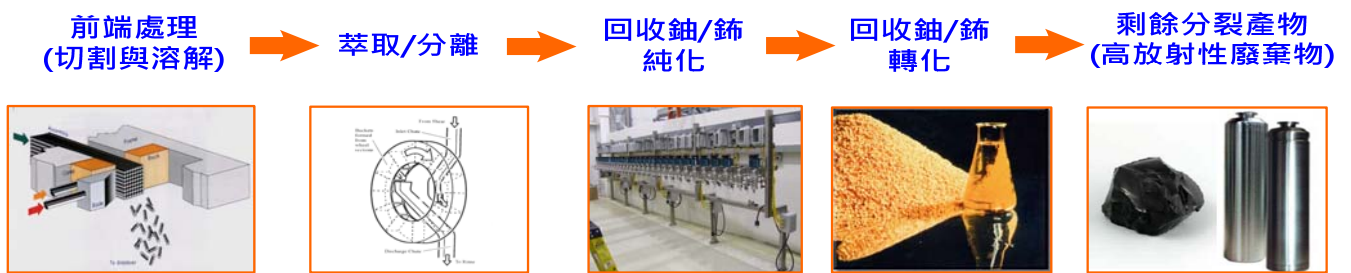


The flow chart of the spent nuclear fuel management

2. Reprocessing Processes

At present, the technology applied at an international commercial reprocessing plant is mainly the hydrometallurgical PUREX separation process in which elements, uranium and plutonium, are extracted from the solution separately and separated from the useless fission products. The separated uranium and plutonium elements can further be used in fabrication of nuclear fuels and re-utilized. The fission products after vitrification can be sealed in a stainless steel canister and regarded as high-level radioactive wastes (HLWs) which will safely be put into storage and

final disposal.



The flow chart of the PUREX reprocessing process

3. International Reprocessing Experiences

At present, the countries with the capability of the international commercial reprocessing technology are France (La Hauge Reprocessing Plant), the United Kingdom (UK) (Thorp Reprocessing Plant at Sellafield), Japan (Rokkasho-mura Reprocessing Plant), and Russia (Mayak Reprocessing Plant)

The reprocessing capacity of each country

Reprocessing plant	Reprocessing capacity (tonne U/yr)
France La Hauge Reprocessing Plant	1,700
UK Thorp Reprocessing Plant	900
Russia Mayak Reprocessing Plant	400
Japan Rokkasho-mura Reprocessing Plant	800

Germany, Belgium, the Netherlands, Switzerland, Spain, and Japan etc., had shipped their spent nuclear fuels to France for reprocessing. Finland, Germany, Hungary, Ukraine, and Bulgaria had carried out reprocessing in and with the help of Russia.

Considering Japan as an example, during the years from 1969 to 1990, it had carried out more than 160 shipments of spent nuclear fuels to the UK and France for reprocessing. The vitrified HLWs, total 1310 stainless steel canisters, started being shipped back to Japan in 1995. After 11 shipments, the shipping was completed in 2007.

法國La Hague再處理廠



英國THORP再處理廠



日本六個所村再處理廠



The shipping of spent nuclear fuels

Spent nuclear fuel reprocessing plants
abroad

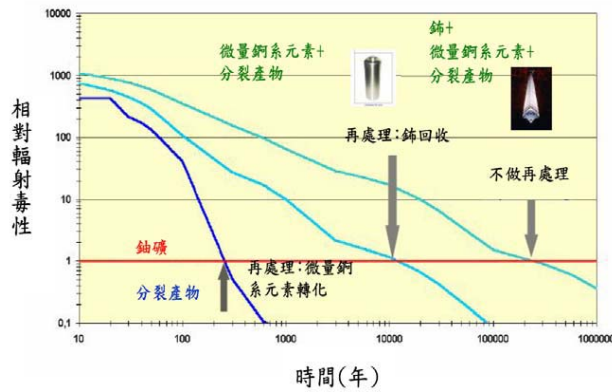
4. Benefits of Reprocessing

(1) Nuclear Waste Volume Reduction

The volume produced by a tonne of spent nuclear fuels being directly disposed is about 2 m³, while the volume of HLWs produced by a tonne of spent nuclear fuels reprocessed by the present available technology is about 0.4 m³, which is about one-fifth of that from direct disposal.

(2) Radiation Toxicity Level Decreases Faster with the Advanced Technology

The radiation toxicity level of spent nuclear fuels being directly disposed in a deep geological formation will reach the level of natural uranium ore in about 200 thousand years. The radiation toxicity level of vitrified HLWs produced by reprocessing spent nuclear fuels with the present available technology will reach the level of natural uranium ore in about ten thousand years. If the reprocessing residues are treated with group separation and nuclear transformation technologies, their radiation toxicity level will reach the level of natural uranium ore in about several hundred years.



The radiation toxicity level of HLWs decreases faster

(3) Nuclear Safeguards Supervision Lifted

Spent nuclear fuels are special nuclear materials which are under strict international nuclear safeguards supervision. The vitrified HLWs produced by reprocessing spent nuclear fuels, in which special nuclear materials, uranium and plutonium, are recovered and re-utilized, do not contain any special nuclear materials and have no obligation to nuclear safeguards supervision. The burden of long-term nuclear safeguards and physical protection will be lifted.

(4) Uniform Waste Form of HLWs

At present, the HLWs produced by the international commercial reprocessing are vitrified in stainless steel canisters, which are with unified dimension and uniform quality and will facilitate the following safe storage and final disposal.

5. Safety Management of Abroad Reprocessing

(1) National Policy

According to the management measures of the “Radioactive Waste Management Policy”, our country will seek the feasibility of reprocessing spent nuclear fuels abroad in compliance with the international nuclear safeguards agreements. Taiwan Power Company's reprocessing spent nuclear fuels abroad is in compliance with the “Radioactive Waste Management Policy”.

(2) Laws and Regulations

According to the legal provisions of the “Nuclear Materials and Radioactive Waste Management Act”, the “Regulations for the Nuclear Fuels Operational Safety Management”, and the “Ionizing Radiation

Protection Act”, operators shall file the application to the authorities for approval of exporting nuclear fuels, before they may engage. If Taiwan Power Company wants to ship its nuclear fuels abroad for reprocessing, in addition to having the approval of Atomic Energy Council, it also has to apply to the domestic transportation authorities for approval of the transport ship verification and vehicles with right of way in accordance with the related legal provisions, in order to assure the safety of transport operations.

(3) International Norms

Shipping spent nuclear fuels abroad for reprocessing involves cross-border transport operations and the related operations shall comply with the related provisions of International Atomic Energy Agency's (IAEA's) “Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management” and “Regulations for the Safe Transport of Radioactive Material”.

(4) Nuclear Safeguards

Spent nuclear fuels are special nuclear materials which are regulated by the IAEA and subject to strict supervision. Reprocessing-abroad-related operations are constrained by the “Agreement between the International Atomic Energy Agency, the Government of the Republic of China and the Government of the United States of America for the Application of Safeguards” and the “Agreement for Cooperation between the Taipei Economic and Cultural Representative Office in the United States and the American Institute in Taiwan Concerning Peaceful Uses of Nuclear Energy”.

6. Issues of Concern to the Public

(1) Utilization of Recycled Materials from Reprocessing

About 96.5% recyclable nuclear materials in spent nuclear fuels, uranium and plutonium, can be separated by reprocessing from the rest, about 3.5% fission products and trace actinides. According to Taiwan Power Company's plan, the recovered plutonium elements which are special nuclear materials and subject to nuclear safeguards supervision will be handled by the reprocessing plant and will not be returned to our country. The recovered uranium will be sold to foreign countries for further utilization.

(2) Arrangement of HLWs Resulted from Reprocessing

Spent nuclear fuels after reprocessing and recovering useful elements, uranium and plutonium, produce about 3.5% fission products and trace actinides which will be vitrified, i.e., they are mixed with glass raw material and heated and melted with high temperature, then poured into a cylindrical stainless steel canister and tightly sealed as vitrified HLWs for storage.

The countries with international spent fuel reprocessing service providers will basically demand commissioning countries' commitment to shipping back the HLWs resulted from reprocessing. So the two sides must sign a guarantee agreement on shipping back HLWs. As for the international HLW storage methods, France, the Netherlands, and Japan use underground pits in a storage building, while Germany and Switzerland use dual purpose (transportation and storage) casks in a storage building. Atomic Energy Council demands Taiwan Power Company to submit additionally an HLW storage plan for the returning HLWs when it files its application for reprocessing abroad.



The Germany HLW storage cask



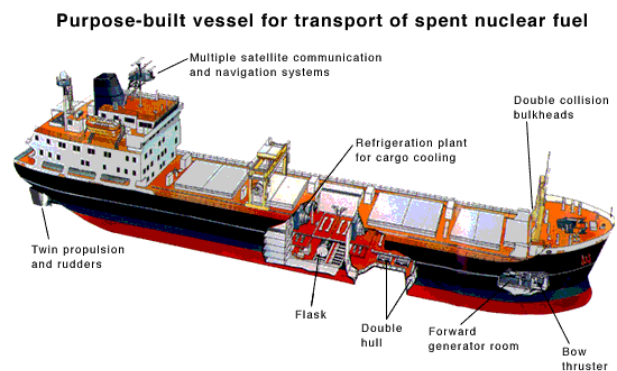
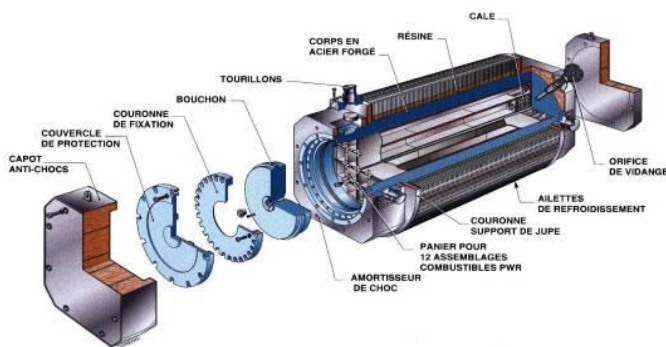
The France HLW storage facility

(3) Nuclear Damage Compensation

Nuclear damage compensation will be ensured according to Article 18 of “Regulations for the Nuclear Fuels Operational Safety Management”, which says “Where the operating of nuclear fuel involves transport or storage, the cosigner or operator shall, upon filing application, additionally submit the original guarantee of performing compensation liability for nuclear damage or financial guarantee, or its photocopy notarized by notary public.”

(4) Ships and Transport Vehicles

According to Article 30 of the “Law of Ships”, ships to which international conventions are applicable shall be checked in accordance with the provisions of the international conventions and with the provisions of the conventions on the certificate. The ships transporting Taiwan Power Company's spent nuclear fuels shall be subject to verification and in compliance with the Irradiated Nuclear Fuel (INF) code set by the International Maritime Organization (IMO). As for the transport vehicles loaded with spent nuclear fuels, they shall apply for permission in compliance with the provisions of “Traffic Regulations”.



The exterior of a shipping cask

The transport ship appearance

(5) Shipping Casks

According to “Regulations for the Safe Transport of Radioactive Material” and “Regulations for the Nuclear Fuels Operational Safety Management”, spent nuclear fuel shipping casks shall be approved by Atomic Energy Council. Atomic Energy Council demands that the spent nuclear fuel shipping casks used by Taiwan Power Company shall be approved by the safety authorities of the original design country, and shipping casks to be used for spent nuclear fuel transportation shall be the ones that have had international performance.

7. Conclusion

Our country's spent nuclear fuel management strategies are in compliance with the “Radioactive Waste Management Policy” approved by the Executive Yuan, and “short-term – on site spent fuel pool storage; mid-term – on site dry storage; and long-term – carrying out final disposal with

option of seeking the feasibility of reprocessing abroad while in compliance with international nuclear safeguards agreements”.

Shipping spent nuclear fuels abroad for reprocessing involves cross-border transport operations. Taiwan Power Company shall circumspectly be ready to meet our country's regulations and international norms. When Taiwan Power Company files the application, Atomic Energy Council will carry out critical review in order to assure the safety of related operations.