LOUISIANA ENERGY SERVICES
CLAIBORNE ENRICHMENT CENTER

DEPLETED UF_6 DISPOSITION STUDY

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& SERVICES, INC.

1.0 INTRODUCTION

The process of enriching uranium for nuclear reactor fuel results in the generation of depleted uranium tails (UF_6). At present, this depleted UF_6 is stored by DOE in cylinders at their enrichment facilities. The tails material is stored because it is viewed by DOE as a future resource too valuable to discard.

Local citizens living near the proposed LES facility are concerned over the issue of the tails material being stored at the facility. They view the tails as a "nuclear waste" and are concerned that the material could be left in their parish after LES closes the facility.

The purpose of this paper is to identify uses for the UF_6 tails material and also to identify means of ultimate disposal of the material, should that become necessary. This should assure the local citizens that LES does, and will, have the means to provide for ultimate use or disposal of the tails material.

2.0 SCOPE

The scope of this study is to identify potential uses of the depleted UF_6 as a resource and to identify means of conversion to forms suitable for either long term storage or ultimate disposal. Approximate costs for the conversion and disposal options are included.

3.0 CURRENT AND FUTURE USES

3.1 Fast Breeder Reactor Feedstock

The U-238 isotope in the UF_6 tails is placed in a fast breeder reactor core as a fertile material. The U-238 is irradiated and, after absorbing a neutron and then beta decaying, becomes Plutonium-239 (Pu-239). Pu-239 is a fissile material and can be used in either power reactors or military applications.

There is no current market for this application for commercial power reactors because reprocessing of the fuel is involved, and there are no commercial fuel reprocessing facilities in operation in the United States. There also is no current military application because the existing stock of Pu-239 is deemed sufficient.

3.2 Feedstock for Laser Enrichment

Developing laser technology would allow for further stripping of the U-235 isotope from the UF_6 tails. This would result in more complete utilization of the fissile U-235 isotope in the UF_6 feed.

There is no current market for this application because the technology has not been totally developed for commercial application. This technology will likely not be commercially available until sometime after the year 2000.

3.3 Uranium Metal

Depleted uranium metal is currently commercially manufactured from UF_6 tails material (see Section 4.0). Depleted uranium metal is approximately 1.7 times as dense as lead and exhibits high strength and mechanical properties. There are three principal uses of depleted uranium metal:

1) Armor-piercing projectiles for military ordnance
2) Radiation shielding
3) Aircraft counterweights

Military ordnance constitutes by far the largest single use of depleted uranium metal. In addition to high density, depleted uranium alloys offer high penetrator effectiveness and post penetration pyrophoricity. Current military needs (approximately 300 cylinders per year) do not constitute a large fraction of the generation rate of UF_6 tails at DOE facilities. This is, however, the same as the projected 300 tails cylinders per year at the LES facility.

Depleted uranium metal is used in numerous types of medical and industrial radiography equipment to shield the user and patients from high levels of radiation. Because of its high density, depleted uranium metal is considerably more effective than lead (per unit volume) for absorbing penetrating radiation. This use constitutes a very small fraction of the current generation rate of UF_6 tails.

Depleted uranium metal counterweights are used in airplanes, missiles and helicopters to maintain center of gravity when control surfaces are moved. High density is important in order to keep the counterweight small in confined spaces. Again, this use constitutes a very small fraction of the current generation rate of UF_6 tails.

4.0 CONVERSION AND DISPOSAL PROCESSES

4.1 Conversion to UF_4

UF_4 is produced by reacting depleted UF_6 with hydrogen at high temperature:

$$UF_6 + H_2 \text{ ----> } UF_4 + HF$$

The HF (hydrofluoric acid) can then be recycled back into the production of UF_6 or can be neutralized and dehydrated by reacting it with lime. The resultant calcium fluoride is then disposed of as a waste by-product:

$$HF + Ca(OH)_2 \text{ ----> } CaF_2 + H_2O$$

This process is currently in commercial operation in the United States.

References: 1, 2

4.2 Conversion to Uranium Metal

Depleted uranium metal is produced by mixing UF_4 with magnesium metal. This mixture is packed inside a closed vessel and heated to approximately 1300 F whereupon an exothermic reaction produces depleted uranium metal and waste by-product magnesium fluoride:

$$UF_4 + Mg \text{ ----> } U + MgF_2$$

This process is also currently in commercial operation in the United States.

Reference: 1

4.3 Conversion to Uranium Oxide

There are two processes for converting UF_6 to oxide form. The first involves reacting the UF_6 with steam and hydrogen, forming uranium dioxide and hydrofluoric acid:

$$UF_6 + H_2O + H_2 \;\text{---->}\; UO_2 + HF$$

The other process involves reacting the UF_6 with steam to form uranyl fluoride and hydrofluoric acid:

$$UF_6 + H_2O \;\text{---->}\; UO_2F_2 + HF$$

The uranyl fluoride is then reacted with steam to form the oxide U_3O_8 plus hydrofluoric acid and oxygen:

$$UO_2F_2 + H_2O \;\text{---->}\; U_3O_8 + HF + O_2$$

As in the UF_6 to UF_4 conversion process above, the HF can either be recycled or disposed of as a waste by-product.

These oxide conversion processes are not commercially available in the United States at this time. COGEMA does currently operate an oxide conversion facility in France.

References: 1, 4, 5

4.4 Disposal of UF_4

- UF_4 could be disposed of (buried) at a low-level waste facility such as at Barnwell. The UF_4 would be disposed of in drums, each containing a 6-mil poly inner-liner bag. The poly bag prevents dispersion of the UF_4 in the event a drum is dropped and ruptures during handling. Reference: 3b

4.5 Disposal of Uranium Oxide

- Currently, uranium oxide generated by COGEMA becomes the property of COGEMA and is stored or disposed of by them. Reference: 4

5.0 <u>POTENTIAL CONVERTERS AND COSTS</u>

5.1 Bases of Costs

- The LES facility produces approximately 300 cylinders of UF_6 tails material per year.

- Each cylinder contains approximately 27,000 lb of UF_6.

- Each cylinder contains approximately 8,500 kg (18,700 lb) of uranium.

- Conversion of UF_6 to UF_4 results in the production of approximately .87 lb of UF_4 per pound of UF_6.

- Disposal (burial) cost by Chem Nuclear at Barnwell is $80.00 per cubic foot of material. Reference: 3c

- Each cylinder contains the equivalent of approximately 100 cubic feet of UF_4.

- All dollar numbers are based on today's costs.

5.2 Nuclear Metals, Inc.

Nuclear Metals, Inc. (Barnwell ,S.C.) both converts UF_6 to UF_4 and converts the UF_4 to uranium metal. They cannot, at this time, recycle HF. The cost for conversion to UF_4 of a one year supply of tails is approximately $12.5 million. The cost for converting a one year supply of tails to uranium metal is approximately $31 million. Shipping cost (one way) from the LES facility to Barnwell is approximately $0.15 per KgU - or approximately $380,000. Disposal cost of the UF_4 material at Barnwell is approximately $2.4 million.

Summary (annual cost):

1) Convert to UF_4 and bury UF_4 at Barnwell	$12,500,000
	380,000
	2,400,000
	$15,280,000
2) Convert to uranium metal	$31,000,000
	380,000
	$31,380,000

Reference: 1

5.3 Sequoyah Fuels Corporation

Sequoyah Fuels (Gore, Okla.) converts UF_6 tails to UF_4 but they do not have the capability to convert to uranium metal. They do, however, recycle HF back into their UF_6 production facility. Their current conversion cost is approximately $1.50 per pound of UF_4 produced - or approximately $10.6 million for a one year tails supply. Shipping cost (one way) from the LES facility to Gore, Okla. is approximately $0.10 per KgU - or approximately $255,000. Shipping cost from Gore to Barnwell is approximately $0.15 per KgU - or approximately $380,000.

Summary (annual cost):

Convert to UF_4 and ship to	$10,600,000
Barnwell for burial	255,000
	380,000
	2,400,000
	$13,635,000

Reference: 2

5.4 COGEMA

COGEMA converts UF_6 tails to oxide form in their facility in France. Information obtained from URENCO, based on 1988 information to them from COGEMA, indicated a processing cost of approximately $3.00 per KgU with the oxide becoming the property of COGEMA. Shipping cost to France is approximately $1.00 per KgU. This results in an annual processing cost of approximately $7.7 million with a shipping cost of approximately $2.6 million.

Summary (annual cost):

Ship UF_6 tails to France for	\$7,700,000
conversion to oxide	2,600,000
	\$10,300,000

Reference: 4

6.0 CONCLUSIONS

The following items are results or conclusions reached in developing this study:

- Long-term contract storage of tails away from the LES facility is not currently available.

- The current market for uranium metal does not justify the cost for tails conversion to metal at this time. The future uranium metal market is uncertain.

- The technology and commercial process for converting tails to the more stable and disposable UF_4 form is available in the United States at this time. The cost of conversion is in the \$7.00 - \$8.50/SWU range and disposal adds approximately another \$1.60/SWU.

- Disposal of UF_4 by Chem Nuclear at Barnwell is technically and legally acceptable at this time.

- Discussions with Nuclear Metals and Sequoyah Fuels indicate that conversion costs could decrease significantly (20% - 50%) based on the availability of a long-term contract. Also, the rising cost of HF could drive down the conversion cost by making the recycled HF more valuable.

- The cost for conversion to an oxide at the COGEMA facility is not necessarily accurate. Also, it is not known if COGEMA legally could, or would, accept LES tails.

- The issue of permitting for tails shipping was not investigated. UF_6 tails are currently being shipped from DOE facilities to Nuclear Metals and Sequoyah Fuels, so permitting should not be a problem. Estimated shipping costs were obtained from Sequoyah Fuels.

Appendix 1

Technical Contacts/References

1) Nuclear Metals, Inc.

   a. Norman Weare - President
   b. Sherman Brady - Manager of Operations

2) Sequoyah Fuels Corporation

   a. Richard M. Cherry - Manager, Contract Administration
   b. James H. Mestepey - Senior Vice President
   c. Joseph E. Bohannon - Depleted UF_4 Area Manager

3) Chem Nuclear

   a. Vic Barnhardt - President
   b. Bill House - Manager of Regulatory Affairs
   c. Dave Pressley - Director of Marketing

4) URENCO - Washington, D.C.

   Maurice Lenders

5) CAMECO

   Peter Leney - Manager of Marketing

COGEMA, INC.

FRANK A. SHALLO
VICE PRESIDENT, MARKET DEVELOPMENT

October 16, 1991

Mr. W. Howard Arnold
President
Louisiana Energy Services
600 New Hampshire Avenue, N.W.
Suite 404
Washington, D.C. 20037

Dear Mr. Arnold:

This letter confirms COGEMA, Inc.'s willingness to consider providing, in the United States, conversion services for depleted uranium as UF6, which is produced from U.S. enrichment operations.

The experience gained by our parent company, COGEMA, in successfully operating a commercial-size defluorination facility in France, could be used as the basis for employing technology in the United States to convert depleted UF6 to a stable, solid form, namely U3O8.

Various cost estimates for such conversion services have been reported from several sources in the recent past. However, when one considers construction and operation in the U.S. under NRC standards, an appropriate fee for defluorination services may be estimated to be in the range of $ 3 - 5 per kilogram of uranium. In addition, transportation, long term storage and ultimate disposal of U3O8 product will have to be considered.

It is our belief, that prudent management of depleted UF6 should consider conversion to a U3O8 powder, which is insoluble in water, does not react with external chemical agents, is free of fluorine and is the most compact form for storage.

Very truly yours,

Frank A. Shallo

Frank A. Shallo

cc: Mr. Peter LeRoy
Louisiana Energy Services

FAS/ej