DOCKET NO. 70-___ Supp. file cy.

SPENCER CHEMICAL COMPANY

PROCESS DEVELOPMENT DEPARTMENT

APPLICATION FOR

SPECIAL NUCLEAR MATERIAL LICENSE

September 15, 1957

UNCLASSIFIED

TABLE OF CONTENTS

<u>NOTE:</u> The Appendix comprises a separate document, parts A and B of which are considered by Spencer Chemical Com p any to be Confidential between Spencer and the Atomic Energy Commission, and part C of which is considered to be AEC classified as Confidential, Restricted Data.

I
INTRODUCTION AND APPLICATION

This application for a special nuclear material license is submitted by Spencer Chemical Company. The company is incorporated in the state of Missouri and has its principal office in the Dwight Building in Kansas City, Missouri. The principal officers of the Company are:

K. A. Spencer - President

C. Y. Thomas - General Vice President (Operations)

J. P. Miller - General Vice President (Finance)

J. E. Culpepper - General Vice President (Marketing)

E. V. Friedrich - Vice President, Administration, and Assistant Secretary

J. R. Brown, Jr. - Vice President, Research and Development Division

J. C. Denton - Vice President, Agricultural Chemical Division

H. R. Dinges - Vice President, Industrial Chemical Division

F. L. Pyle - Vice President, Plastics Division

E. W. Morgan - Treasurer

A. Mag - Secretary

W. L. Elleman - Administrative Assistant

All these officers have their offices in the Dwight Building except for Mr. Mag whose address is 9 West Tenth Street, Kansas City, Missouri. All are natural born citizens of the United States. The company is not controlled by any alien, foreign corporation or foreign government.

This license is requested for the processing of any enrichment of uranium up to highly enriched. The uranium in the form of UF_6 or scrap is to be converted to the nitrate or an oxide. The processing will be done at the Jayhawk Works of the Spencer Chemical Company located between Pittsburg, Kansas, and Joplin, Missouri, with a freight shipping designation of Military, Kansas.

The license is requested for 10 years.

Any enrichment of uranium up to highly enriched is to be processed. The uranium to be processed may be UF_6, a compound of uranium or a mixture of uranium and some metal such as might be generated in the fabrication of fuel elements. The product of the process will normally be finely divided UO_2 powder or pellets. When the nitrate is produced it will be in solution form. Oxides other than UO_2 may also be produced as finely divided powders or pellets.

The uranium will be processed for other licensees. Production is scheduled to begin December 1, 1957. The maximum design processing rate is 30 pounds of uranium per day. The actual processing rate will depend upon the exact nature of the feed material and upon customer demand. Inventory of U^{235} at the plant will not exceed 100 kg. Processing losses generally will be held to less than 1%, but may exceed this for small batches.

The Spencer Chemical Company is currently engaged in the manufacture of ammonia, nitric acid, N^{15}, polyethylene, nylon, urea, methanol and other similar products. It is accustomed to handling highly valuable materials on a commercial scale as exemplified by its current handling of a $200,000 inventory of platinum used as a catalyst. Also, the company has extensive experience in handling hydrogen and unstable compounds.

II
QUALIFICATIONS OF PERSONNEL

The processing of enriched uranium is the direct responsibility of L. H. Landrum, Director, Process Development. Mr. Landrum reports directly to Dr. John R. Brown, Jr., Vice President in charge of Research and Development for Spencer Chemical Company.

Dr. Brown holds a B.S. degree in chemistry from Oberlin College, an M.S. degree in chemistry from Ohio State and a Ph.D. degree in chemical engineering from Massachusetts Institute of Technology. From 1938 to 1946 Dr. Brown was employed by Esso Laboratories in Elizabeth, New Jersey, serving as assistant Director of the Chemical Division from 1941 through 1946. In 1946 he was made Director of Research for the Pro-phy-lac-tic Brush Company, a division of the Lambert Company in Florence, Massachusetts, and in 1949 transferred to the Lambert Pharmacal Company, a division of the Lambert Company, as Director of Research. In 1953 he became Vice President - Director of Research. Dr. Brown joined Spencer Chemical Company in August, 1953, as General Manager - Research and Development, and in February, 1957, became Vice President - Research and Development.

Mr. Landrum received his B.S. and M.S. degrees in Chemical Engineering from Missouri University and Washington University respectively. Before entering the atomic energy program, he had some ten years of industrial experience in process and engineering development with Carbide and Carbon Chemicals Corporation in South Charleston, West Virginia, and with Titanium Division of National Lead Company in St. Louis and Sayreville, New Jersey. He entered the atomic energy program in July, 1951, when American Cyanamid sent him to Oak Ridge as part of that company's contract with the Atomic Energy Commission to operate the Idaho Chemical Processing Plant. At Oak Ridge he was associated with the pilot plant at the X-10 laboratory and participated in the design of some special recovery facilities. He was transferred to Idaho Falls in December, 1951, and was placed in charge of Cyanamid's process engineering section. His efforts were directed toward design of facilities for recovering uranium from spent fuel used in the submarine reactors, and in studies connected with the main chemical processing plant.

Mr. Landrum joined Nuclear Power Group in Chicago in 1953. Nuclear Power Group consisted of representatives of four utilities and a construction company, and Mr. Landrum represented Union Electric of Missouri. Studies made by NPG were directed toward industrial utilization of atomic energy. Since joining Spencer Chemical Company in July, 1955, Mr. Landrum has been Director of Process Development. As such, he has been in charge of Spencer's pilot plant activities. A portion of this has been in studies toward developing background for this license application.

Under Mr. Landrum's supervision are 21 other engineers and scientists, some of whom have been associated with the design of the uranium process. The process has been demonstrated in the laboratory with the use of depleted uranium obtained under source material license No. C-3571.

Mr. D. A. Young has been responsible for a major portion of the process design. Among the people who have participated in the design and who have applied previous experience to the design are Sinesio A. Zagnoli and R. B. Mesler. Two of the people who have participated in the laboratory demonstration of the process are L. G. Stevenson and David Rankin.

Mr. Young obtained a B.S. degree in Chemical Engineering from Pennsylvania State University in 1942. He spent 5 years with the Sun Oil Company at Marcus Hook, Pennsylvania, and then a year with the Warwick Wax Company at Chanute, Kansas. He has been with Spencer Chemical Company since 1947 and has been a group leader since 1954. He has been associated with many of the process development projects which have been responsible for Spencer's growth. Among these have been ammonia and methanol gas reforming, formaldehyde, polyethylene, nylon 6 and others.

Mr. Zagnoli received his B.S. in Chemical Engineering from Purdue University, and his M.S. in Chemical Engineering and M.S. in Gas Technology from Illinois Institute of Technology. He had some three years of industrial experience with petroleum and natural gas industry before his entry into atomic energy activities in 1952. He entered the atomic energy program with Nuclear Power Group and represented the Commonwealth Edison Company. He participated in several studies made by the Public Service Company of Northern Illinois and Commonwealth Edison Company before the latter joined Nuclear Power Group. With NPG, Mr. Zagnoli's work was with heat transfer, fuels processing and fuel element metallurgy. Mr. Zagnoli joined Spencer Chemical Company in October, 1955, and is a senior staff member in the Process Development Department, being assigned directly to Mr. Landrum. He is charged with planning experimental programs and designing experimental facilities, and with making economic analyses of various projects in the atomic energy field.

Mr. Stevenson was an Air Force officer during World War II, having completed the Air Force training program at the University of New Mexico and the California Institute of Technology. He was graduated with high honor from Kansas State College in 1947 with a B.S. in Chemical Engineering. After graduation, Mr. Stevenson was employed in the research and development laboratories of the Linde Air Products Company. In 1951 he joined the Spencer Chemical Company for process development work. He has been active in the nuclear fuel program since midsummer of 1956.

Dr. Rankin graduated from Monmouth College in 1936 with a B.S. degree and a major in chemistry. He completed his M.S. and Ph.D. work at Purdue University in 1942 with a major in chemistry. He was employed at Penick and Ford, Ltd., Inc., as a research chemist during the years 1942-1943, and again in 1946-1947. In 1944-1945 he was naval officer in training activity. Dr. Rankin was employed as a research chemist and later as chief chemist of Lucidol Division, Wallace and Tiernan, Inc., whose principal products were peroxide catalysts and bleaching compounds. He joined Spencer Chemical Company in June, 1956, and was assigned to Process Development Department work on uranium scrap recovery and uranium dioxide production for the nuclear fuel cycles.

Dr. Mesler of the University of Kansas was consulted for criticality considerations. Dr. Mesler's background includes the Oak Ridge School of Reactor Technology, 1951-52, Ph.D., University of Michigan, 1955, Project Engineer for the Ford Nuclear Reactor and Assistant Professor of Nuclear Engineering, University of Michigan, 1955-1957. He is presently Associate Professor of Chemical Engineering at the University of Kansas.

III
PROCESSING AREA

The following equipment and facilities will be used to protect health and minimize danger to life and/or property.

The building used for uranium processing is a building formerly used as a high pressure laboratory. It is of frame construction containing 4 cells. These cells have a concrete roof and concrete walls on 3 sides, all a foot or more thick. One cell has been converted to a vault by adding a fourth concrete block wall. Another cell is used for the location of several storage vessels and a third cell for dissolving operations. The walls of these cells effectively isolate the contents criticalitywise, from anything outside.

The east end of the building has a partial second level. There is enough head room in the east end to accomodate the extraction columns and some other pieces of equipment. Lockers are provided at one end of the building for changing clothes. Film badges are provided for all personnel and ring film monitors are provided for those using the dry boxes. A Geiger counter survey meter with a range from 0.2 to 20 mr per hour is available for monitoring against contamination. Air sampling equipment and dust masks are available for monitoring building air. Film monitors will be mounted around the building to detect the occurrence of any spread of radioactivity.

A fence encompasses the entire Jayhawk plant works and entrance into the plant area is controlled by 24 hour guard force.

The concrete vault in the building is provided for storage of both raw materials and finished product. Another vault in a nearby building may also be used. Raw material will arrive in "always safe" geometry containers, packed in bird cages to maintain the necessary spacing between other containers. Watertight containers of "always safe" geometry along with their bird cages are provided for shipping out finished product.

IV
PRECAUTIONS FOR SAFETY

The following procedures are proposed to protect health and minimize danger to life and/or property.

All personnel working with uranium are required to pass a complete medical examination including chest x-ray before starting to work. Quarterly, or more frequently if justified, urine samples will be analyzed for uranium. Chest x-rays will be required annually. No smoking or eating will be allowed within the uranium processing building.

Good housekeeping will be exercised. Wet mopping will be performed in order to minimize air pollution.

Any minor spills (less than 20 grams) will be cleaned up immediately, both to recover the uranium and to avoid spread of contamination. Clean-up will be performed with rubber gloves and dust mask. Wash water will be collected and stored in safe containers awaiting return to process for recovery. Detergent may be useful for decontamination.

Major spills may necessitate orderly plant shutdown and reducing the inventory of uranium in the spill area to allow more freedom of movement. In handling cleanup solutions 1 liter graduates are to be used to transfer solution to safe storage, or transfer may be accomplished with small diameter tubing running to safe storage.

Clothing is to be monitored when leaving the building to prevent spread of contamination. The working areas will be continually surveyed for uranium on the floor and elsewhere.

Building and building exhaust air will be sampled to see that concentrations are below permissible limits of $5.0x10^{-11}$ and $1.7x10^{-12}$ microcuries per ml respectively.

Aqueous wastes will be discharged to the sanitary sewer which carries an average daily flow in excess of a million gallons away from the plant. The quantity of waste released to the sewer will be limited to that quantity which, if diluted by the average daily flow of sewage, will result in an average concentration less than $2x10^{-4}$ microcuries per ml. These conditions are set by Title 10, Part 20, Code of Federal Regulations.

Only one uranium container may be in motion at any one time and no uranium container may be moved unless all other uranium containers are in approved locations. No uranium container may enter the storage tank cell, the area behind the cells, or the main processing area. Chain guards prevent the movement of UF_6 cylinders, scrap containers, or finished material into these areas. A UF_6 cylinder and scrap may be safely moved by the processing area on the sidewalk outside the building.

Uranium containers are always to be in bird cages or in place in process except when removed and replaced one at a time.

Uranium shipments are to be shipped by Railway Express, Protective Signature. Shipment is to be made in bird cages with instructions to the carrier not to stack containers, but to secure them while in transit. No other enriched uranium shipment is to be handled in the same car. In the case of UF_6 cylinders, special additional instructions to the carrier will be as follows:

1. Avoid mechanical damage to container.
2. Protect from fire or excessive heat.
3. In case of leak as evidenced by a white fume, avoid exposure and notify shipper. Protect the public by prohibiting access to the general area.

The uranium processing building will be posted and uranium containers will be labeled according to Title 10, Part 20, Code of Federal Regulations. Outside shipping containers will be labeled according to ICC regulation.

Safe geometry storage is provided for all process streams. Before pumping any solution from safe storage to unsafe storage, it is to be sampled to assure that the uranium concentration is below 1 gram/liter. Unsafe vessels are to be inspected frequently for accumulation of uranium.

As much of the uranium inventory as possible will be kept in the vault where it is secure in the event of an emergency.

Fire in the frame constructed building presents three problems. First, the organic phase for extraction is inflammable. Second, the hydrogen is both inflammable and explosive. Third, water used in fighting a fire could mix with uranium and create a criticality condition. This is particularly true of the uranium in the dry box and furnaces. CO_2 will be used to control any fire in the uranium building and the plant fire department is instructed not to use water unless requested to do so by the uranium building supervisor. Care will be taken in handling UO_2 as it has been reported to burn. Explosion could occur as a result of the hydrogen, although precautions have been taken to prevent this. In the event of an explosion, the area will be surveyed for uranium containation.

Tornadoes are a possibility in Kansas. Material in the vault and in the vessel storage cell should be undisturbed by a tornado. Plant design is on the premise that a condition of criticality resulting from tornado damage would do negligible damage compared to that of the tornado.

The building site is 30 feet above any previous flood stage.

Loss of electrical power does not present any hazard except for loss of ventilation. Pumps, furnaces, vacuum system and dry box would be inoperative.

Criticality is avoided primarily by proper spacing of "always safe" geometry vessels. Concentration and mass control is exercised in handling dilute solutions. Mass and moderation control is exercised in handling dry UO_2 in the dry box, and in storing and shipping scrap uranium. A combination of mass, volume, and moderation control is used in specifying containers for shipping and storing UO_2 product. All safe parameters used are safe with a thick water reflector.

Process vessels are located so as to minimize interaction between vessels. In many instances advantage has been taken of the isolating effect of concrete walls thicker than 8". In other instances, spacing is used to minimize interaction.

A detailed process description, flow sheet and layout are presented in the Appendix with a discussion of the methods used for prevention of criticality.

V
INSURANCE COVERAGE

The company is negotiating for insurance to cover any possible loss of enriched uranium both while in process and in transit. Details of coverage will be supplied to the AEC when they are obtained.

VI
FINANCIAL QUALIFICATIONS

A copy of the 1957 annual report of the Spencer Chemical Company is submitted with this application in support of the company's financial qualifications to undertake the processing of enriched uranium.

DOCKET NO. 70-146

SPENCER CHEMICAL COMPANY

PROCESS DEVELOPMENT DEPARTMENT

APPLICATION FOR SPECIAL NUCLEAR MATERIAL LICENSE

September 15, 1957

APPENDIX II

~~(This section is all confidential to the Spencer Chemical Company and should not be revealed to the general public.)~~

Enclosure to letter dated 10-7-57

TABLE OF CONTENTS

A. PROCESS DESCRIPTION

This process is designed to produce primarily UO_2 from either UF_6 or scrap. The steps in the process are uranium dissolution, extraction, precipitation, filtration, drying, calcining, reducing, screening and grinding. These steps are shown graphically on the flow sheet, Drawing 48-7. In turn, a material balance, showing expected flows of materials, is attached as Table I to this Appendix.

Starting with UF_6, a cylinder is first weighed and then placed in a heating chamber (EP-3) to liquify the UF_6. The chamber is steam heated and the temperature is controlled at 160° F. A vacuum pump preceded by a cold trap and a chemical trap permits evacuation and leak testing of the UF_6 piping.

A batch of UF_6 for hydrolysis is prepared by filling a small vessel (V-2) which holds 7 pounds of UF_6. Nitrogen is used to force UF_6 out of the UF_6 cylinder into V-2 and then to force UF_6 from V-2 into the hydrolyzer.

Before transferring UF_6 to the hydrolyzer, the hydrolyzer is first charged with an aqueous solution of $Al(NO_3)_3$ prepared in V-6. Nitric acid may also be added to adjust the acidity.

The product of the hydrolyzer is transferred to one of two rich acid storage tanks (T-1 and T-2) again with nitrogen pressure.

Starting with metallic scrap, a weighed quantity of the scrap is added to the empty dissolver. Acid is then added. The dissolver is fitted with a reflux condenser and with a jacket for heating and cooling the dissolver. After solution is developed, it is tranferred to one of the rich acid storage tanks using nitrogen pressure. This may result in a residue of solids in the dissolver which, for convenience, may be cleaned out periodically by prolonged dissolution treatment. Modification to the procedure may involve periodic addition of scrap and continuous addition of dissolving agents. In any event, the solution developed is tranferred to one of the rich acid storage tanks either by the pressure on the system maintained continuously or intermittently, or by a pump.

Only one of these two operations, hydrolysis of UF_6 or dissolution of scrap, will be in operation at any time.

Rich acid is pumped to the countercurrent extractor column (C-1) using metering pump (P-1). A solution TBP in kerosene is the solvent. The top part of the extractor serves as a scrub section in which acid is used to scrub the organic extract.

The flows of rich acid and solvent to the extractor are 1-1/2 gallons per hour. Scrub acid flows at about one-tenth this rate. Some variation in these stream ratios may be needed to accommodate other processes involving scrap recovery. The rich organic phase overflows from the extractor column into an intermediate storage tank. From this tank the rich organic is pumped to the stripper column. Raffinate from the extractor column exits through a jack leg to one of two lean acid storage tanks (T-3 and T-4). Here the lean acid is sampled and if the concentration of uranium is less than 1 gram/liter, it is then pumped to either the aqueous recycle tank (T-9) or the remote aqueous waste tank (T-14).

Water flowing at 1-1/2 gph is the solvent in the stripper column. The stripped organic phase overflows to a system which continually cleans the solvent for reuse. The rich aqueous phase exits through a jack leg to the rich aqueous storage tank (T-5).

Rich aqueous is pumped continuously to the precipitator where ammonia is also added continuously. Slurry from the precipitator overflows to one of two filters. The filters remove water to produce a more concentrated slurry.

Concentrated slurry from the filter overflows to a furnace where the precipitate is dried and calcined. Out of this furnace the material falls into the reducing furnace where reduction with hydrogen to UO_2 occurs. The reduced UO_2 from the second furnace is transferred to a dry box with a screw conveyor.

An inert helium atmosphere is maintained in the dry box so that the UO_2 can be screened and ground without oxidation.

TABLE I

MATERIAL BALANCE FOR URANIUM PROCESSING SYSTEM

HYDROLYZER

	1 Lb. UF_6		7.2 Lb. UF_6		30 Lb. U/Day		
	Pounds	Ft^3	Pounds	Ft^3	Pounds	Ft^3	Gal/Day
Inputs							
UF_6	1.0	0.00447	7.2	0.0321	43.2	0.192	1.44
$Al(NO_3)_3$	3.73	---	26.9	---	161.0	---	---
H_2O	7.03	0.113	50.5	0.812	304.0	4.87	36.4
Total	11.8		84.7		508		
Outputs							
$UO_2(NO_3)_2$	1.15	---	8.28	---	49.7	---	---
H_2O	6.90	0.110	49.7	0.797	298	4.77	35.6
HNO_3	0.736	---	5.29	---	31.7	---	---
Al_2F_6 complex	0.487	---	3.5	---	21.0	---	---
$Al(NO_3)_3$	2.49	---	17.9	---	107.0	---	---
Total	11.8		84.6		508		

TABLE I

MATERIAL BALANCE FOR URANIUM PROCESSING SYSTEM
(Continued)

EXTRACTOR

	Lbs./Hour	Ft^3/Hour	Gal./Day
Inputs			
Organic Phase			
TBP	2.94	0.0497	8.9
Kerosene	7.21	0.149	26.7
	10.15	0.199	35.6
Aqueous Phase			
$UO_2(NO_3)_2$	2.07	---	---
H_2O	12.40	0.199	35.6
HNO_3	1.32	---	---
Al_2F_6 complex	0.875	---	---
$Al(NO_3)_3$	4.47	---	---
	21.13		
Total	31.3		
Outputs			
Organic Phase			
TBP	2.94		
Kerosene	7.21		
$UO_2(NO_3)_2$	2.07		
	12.2		
Aqueous Phase			
H_2O	12.4		
HNO_3	1.32		
Al_2F_6 complex	0.875		
$Al(NO_3)_3$	4.47		
	19.06		
Total	31.3		

TABLE I

MATERIAL BALANCE FOR URANIUM PROCESSING SYSTEM
(Continued)

STRIPPER

	Lbs./Hour	Ft³/Hour	Gal./Day
Inputs			
Organic Phase			
TBP	2.94		
Kerosene	7.21		
$UO_2(NO_3)_2$	2.07		
	12.22		
Aqueous Phase			
H_2O	12.4		
Total	24.6		
Outputs			
Organic Phase			
TBP	2.94	0.0414	8.9
Kerosene	7.21	0.148	26.7
	10.15	0.189	35.6
Aqueous Phase			
H_2O	12.4		
$UO_2(NO_3)_2$	2.07		
	14.47		
Total	24.6		

TABLE I

MATERIAL BALANCE FOR URANIUM PROCESSING SYSTEM
(Continued)

PRECIPITATOR

	Basis - Continuous Lbs./Hour	Basis - Continuous Ft^3/Hour
Inputs		
Aqueous		
H_2O	12.4	0.196
$UO_2(NO_3)_2$	2.07	---
	14.47	
NH_3 Solution		
H_2O	0.76	0.0122
NH_4OH	0.76	
	1.52	
Total	15.99	
Outputs		
Solid		
$(NH_4)_2U_2O_7$	1.64	
Aqueous		
H_2O	13.3	0.213
NH_4OH	0.231	
NH_4NO_3	0.80	
	15.97	

TABLE I

MATERIAL BALANCE FOR URANIUM PROCESSING SYSTEM
(Continued)

FILTER

	Basis - Continuous	
	Lbs./Hour	Ft^3/Hour
Inputs		
Aqueous Solution		
H_2O	13.3	0.213
NH_4OH	0.231	---
NH_4NO_3	0.80	---
	14.30	
Solid		
$(NH_4)_2U_2O_7$	1.64	
Total	16.0	
Outputs		
Aqueous Solution		
H_2O*	7.2	0.115
NH_4OH	0.12	---
NH_4NO_3	0.434	---
	7.75	
Cake		
H_2O*	6.1	0.0978
NH_4OH	0.106	---
$(NH_4)_2U_2O_7$	1.64	
NH_4NO_3	0.366	---
	8.21	
Total	16.0	

*Assumed 80% solution, 20% solids by weight in filter cake. No wash used.

TABLE I

MATERIAL BALANCE FOR URANIUM PROCESSING SYSTEM
(Continued)

DRYING AND DECOMPOSITION REACTION

	Basis - Continuous	
	Lbs./Hour	Ft^3/Hour
Inputs		
Cake		
H_2O	6.1	0.0978
NH_4OH	0.106	---
$(NH_4)_2U_2O_7$	1.64	
NH_4NO_3	0.366	
	8.21	
Air*	5.80	72 (STP)
Total	14.0	
Output		
Exit Gas		
N_2	4.59	58.8 (STP)
O_2	0.352	3.95 "
H_2O	6.59	131.0 "
NO_2	0.750	5.85 "
	12.28	200 "
Solid		
U_3O_8	1.48	---
	13.8	

* Assumed 25% excess air.

TABLE I

MATERIAL BALANCE FOR URANIUM PROCESSING SYSTEM
(Continued)

REDUCER

		Basis - Continuous	
		Lbs./Hour	Ft^3/Hour
Inputs			
U_3O_8		1.47	
H_2 *		0.014	2.51 (STP)
	Total	1.48	
Outputs			
UO_2		1.42	0.0061 (Solid)
H_2O		0.063	12.6 (STP)
H_2		0.007	1.25 "
	Total	1.49	

* Assumed 100% excess H_2.

B. PLANT LAYOUT AND EQUIPMENT DESCRIPTION

The building to house this facility is contained within the Jayhawk plant site. It is a two-level building with high equipment, pulse columns, furnaces, precipitator and filters in the two-story section; the dry box, wash room and storage vault are in the one-story section. It is constructed of steel framework and covered by wooden siding. It contains four concrete cells originally built for conducting high pressure research work. Attached Drawings 48-9, -12 and -13 show plot plans at two levels and an elevation view of the ground floor. Feed and product are stored in a vault in caged, safe containers. The flow of material is across a balance, around the building to the UF_6 heating chamber. Thence the uranium compounds flow through pipes and vessels as shown on flow sheet, Drawing No. 48-7. Movement of materials in other directions is hindered by chain guards.

Uranium scrap follows much the same path from the vault into the concrete cell containing the dissolver. Critically safe storage vessels (T-1, -2, -3, -4, -5, -6, -7 and V-16 and -20) are all located within another concrete cell.

Concrete trenches, lined with an acid-resistant coating are under these vessels. Accidental discharge of contents of any one of these vessels will be contained within trenches. The complete contents of more than 1 vessel would overflow into the cell. There is no connection to the sewer from this room. Similarly the pulse columns, precipitator and filters are equipped with such trenches.

Various storage tanks for chemical feed solutions are on the north side. They are conveniently placed for the process and will contain no uranium. All feed to the aqueous recycle and remote aqueous waste tanks will have been analyzed and be at a low uranium level before storage.

The second level of the building at 11' covers approximately one quarter of the building and is shown in Drawing 48-12. The floor consists of the tops of the concrete bays and access is obtained by stairway and walkway. Extending into this area are the pulse columns, precipitator, filters and furnaces.

Drawing 48-13 is an elevation view of the processing equipment as seen from the south. It shows the relative height and arrangement of important processing equipment. Both the hydrolyzer and critical storage vessels are enclosed within the concrete cells and do not appear on this drawing.

Important aspects of major items of equipment are described as follows:

1. UF_6 Heating Chamber (EP-3)

   This is a steam heated jacket, a completely safe enclosure for handling the UF_6 cylinders. It consists of an 18" flanged steel pipe 5' long, equipped with steam jackets and internal piping.

2. Hydrolyzer (V-3)

   A stainless steel vessel, 5" ID, by 8' long, equipped with agitator, NH_4OH vent trap, various inlets, and bottom discharge.

3. Dissolver

A 5" diameter x 6' high, Carpenter 20 vessel. Flanged top and full-length jacket for heating or cooling. Connected to a reflux condenser. Gases produced will be vented outside building.

4. "Safe" Storage Vessels (T-1, -2, -3, -4, -5, -6, -7 and V-16 and -20)

5" ID x 6 to 7' height, constructed of stainless steel. T-1 and -2 equipped with agitator and cooling coil. All are open-topped except T-6 and T-7 which will be under vacuum.

5. Pulse Columns

Pyrex glass construction, 17' long. The main body is 1" tubing, while settling zones are 3" tubing. Equipped with stainless steel sieve plates spaced on 2" center. Pulser consists of mechanically flexed diaphragm.

6. Precipitator (V-10)

5" ID x 2' long stainless steel, agitated vessel, open at the top. Product overflows to filters. Two incoming liquid streams converge at the suction of the impeller. Agitation prevents settling of di-uranate cake.

7. Filters (V-11 and V-12)

5" ID x 12" long, stainless steel, agitated filters. Equipped with porous stainless steel filter media. Bottom outlet for filtrate, side outlet for thickened di-uranate slurry.

8. Furnace System

F-1. 5" ID x 7-1/2' long furnace, with sections devoted to feeding, heating in a zone that has external gas firing, and cooling. The furnace has no internal restrictions that would cause buildup. Furnace converts a slurry feed to a dry powder.

F-2. 6-1/2" ID x 7-1/2' long furnace, very similar to F-1. Converts powdered oxide feed to fully reduced UO_2.

Feeder (VF-1). 2" vertical hopper joined to a 2" horizontal stem. Horizontal section equipped with a screw driven at variable speed. Feeds slurry to furnace.

Feeders (VF-2 and -3). Similar to VF-1 except that they feed a dry powder and furnish a gas seal.

Scrub Columns (C-3 and -4). 3" ID x 2' high, stainless steel vessels. Will contain dilute nitric and scrub process gases exit the furnaces to remove uranium dust.

9. Na_2CO_3-Solvent Mixer

5" ID x 2' high, stainless steel mixing chamber, equipped with stirrer. Performs 1-stage mixing for the purpose of cleaning up the extracting solvent.

C. PREVENTION OF CRITICALITY

Many features of the process design are determined by the necessity of avoiding criticality. Criticality is the prime consideration in specifying shipping containers and in spacing and locating processing equipment.

Standard 5" Monel cylinders are used for transporting enriched UF_6. A 24" square bird cage (Drawing 48-14) keeps the cylinder upright and maintains a 24" axis to axis spacing between cylinders. Five or less cylinders may be arranged in any array. Larger lots must be handled in a plane array.

Contains for finished product of either UO_2 or uranyl nitrate solution have a maximum volume of 4.5 liters and are watertight. UO_2 as dense as 6 grams per cc may be packaged in the containers. A 4.5 liter volume will hold 11 kg of U-235 if UO_2 density is 3 grams/cc. A 24" cubic bird cage is used for spacing (see Drawing 48-15). The bird cage maintains 6" between the watertight container and any face of the bird cage, always maintaining a 12" edge to edge spacing between containers. Up to 80 of these bird cages may be stacked side by side in an isolated cubic array (LA-2063).

Containers for solid uranium feed materials are sections of 5" pipe which can be packed in the UF_6 cylinder bird cage. The closure on the pipe is watertight. The maximum U-235 content of a container is limited to a fully water reflected, "limited-safe" mass (11 kg x mass allowance factor if H/U-235 2), (LA-2063).

Only the south wall of the vault is used for storing uranium. Containers may be stacked, provided that when cylinders are stacked a 12" spacing between top and bottom cylinders is maintained and provided that the cylinders are on the same axis.

A heating chamber allows melting of UF_6 while keeping the UF_6 cylinder totally enclosed. The chamber is sized to allow the entire contents of a UF_6 cylinder to spill on the bottom without exceeding a "limited-safe" cylinder, 17-1/2" in diameter by 1-3/4" high. The UF_6 cylinder is high enough to minimize interaction between a portion spilled on the bottom and the remainder in the cylinder.

A dissolver with safe diameter of 4-7/8" ID allows dissolution of uranium feed material other than UF_6. It is located in a concrete cell so that it is isolated from other uranium vessels. The maximum quantity of U-235 which may be added to the dissolver is limited to a fully water reflected "limited-safe" mass the same as the shipping container above.

The extraction columns are pulse columns 1" ID with 3" ID top and bottom sections and are of glass. The UF_6 cylinder, hydrolyzer vessel, solvent mixer and 4 pulse columns (2 possible future columns) are separated for safe interaction. The jack legs for the column are half inch tubing with an enlarged 2" section near the top of the column.

The eastern future column sees the largest solid angle in this configuration, this being less than 1.25 steradians compared to a permissible solid angle for 3" ID vessels of 1.6 (K-1019). The hydrolyzer sees less than 0.7 steradians out of a permissible 1.00 (8% of 4) for 5" vessels. A chain guard restricts movement of the UF_6 cylinders.

Two furnaces are located (Drawing 48-13) one above the other with the closest approach to each other being greater than 3-1/2'. The top furnace has a 5" ID. Under no condition will the density of the uranium in this furnace exceed 3.2 grams U-235/cc, so that the furnace is of "always-safe" geometry. The lower furnace has an ID of 6-1/2". The maximum depth of material in this furnace for effective operation is 1" which corresponds to about 12% of the cross-sectional area of the tube. Under no circumstances will it be possible for material to occupy more than 25% of the cross-sectional area of the tube. At 25% the area is equal to that of a 3-1/4" ID tube. For criticality purposes the furnace is considered equivalent to a 3-1/4" cylinder.

In the lower furnace the density of UO_2 may exceed 3.2 grams U-235/cc but it will not be greater than 6.0 grams/cc (5 grams U-235/cc). A safe diameter under these conditions is not as readily available as under lower density conditions. The safety can be justified on two bases.

First, the safe diameter of a fully water reflected, full density metal cylinder is 2.5". The mass allowance factor for UO_2 with a density of 6 is 2.6. The cylinder diameter which gives 2.6 times as much uranium at this reduced density is 7.6".

The precipitator and filters are on top of the storage vessel cell which has a 1'3" concrete slab as a roof. The concrete effectively isolates the precipitator and filter from the dry box, the lower furnace, the hydrolyzer and the UF_6 heating chamber. Both the precipitator and filter vessels are less than 5" ID. The precipitator is directly above one filter and the other filter is 2' away.

Secondly, safe storage conditions (LA-2063) allow 2' spacing of safe units of uranium. Safe units are 4.5 liters which will hold as much as 28.6 kg of U-235 if the UO_2 density is 6.0. The 7' dryer tube, when 25% full, has a volume of 11.5 liters and would contain 60 kg of U-235 if the UO_2 density were 6.0. Compare this with 3 units at 2' spacing containing 13.5 liters and 144 kg.

The feed to the first furnace is a slurry. The feed end of the furnace is essentially the intersection of a 2" pipe teeing into 2" pipe. Experience with feeding a slurry has shown that there is no trouble with caking or buildup in the furnace tube. A short rod lying inside the furnace which rolls as the furnace turns has been found effective in insuring free flow through the furnace.

The feed end of the second furnace is essentially the intersection of a 2-1/2" pipe teeing into a 2" pipe. The discharge end contains a negligible holdup.

The top furnace is the most central item in the configuration and sees the precipitator, the filters, the lower furnace, the dry box and the closest extraction column. The precipitator and filter are partially isolated from the furnace by concrete, although this is not considered in analyzing for interaction. The precipitator and filter are 5" ID vessels with a total length of 6'. Their closest approach to the top furnace is 2'. The closest approach of the furnace is 3-1/2'. The dry box is farther than 7' and the extraction column is farther than 6'. The total solid angle seen is less than 0.8 steradians compared to an allowable 1.0.

The dry box is spaced farther than 2' from the lower furnace. A half inch, 2' conveyor carries product from the furnace to the dry box. The conveyor also acts as a seal between the two atmospheres.

The maximum quantity of uranium allowed in the dry box is 33.5 kg of highly enriched UO_2 (28.6 kg of U-235, 30 kg of 95% U-235). This mass limit is based on a thick water reflector, on a maximum UO_2 density of 6.0 gram/cc and on an allowance for double batching (LA-2063). Inventory will be maintained low by daily packaging of all finished product.

The dry box has a controlled filtered atmosphere so that dust is not released into the building atmosphere. There are no water taps into the dry box and every precaution is taken to assure that water (or any fluid hydrogenous material) never enters the dry box. A flange on the floor of the dry box permits loading product into finished product shipping containers.

The storage vessels in the cells are placed in two associated plane arrays (greater than 7-1/2' edge to edge spacing). In each plane array the vessels are spaced 24" axis to axis. All tanks in the system which could conceivably contain U-235 at concentrations higher than 1 gram/liter are 5" ID or less, so that they are of "always-safe" geometry. Those tanks with sight glasses still have a combined cross-sectional area less than that of a 5" diameter circle. A 1/2" ID sight glass adds to the cross sectional area as does .025" on the diameter. All tanks normally containing uranium are stainless steel.

Two tanks for very dilute uranium solutions are provided outside the building. The maximum concentration of uranium that can be pumped to these tanks is 1 gram/liter so that the tanks are both concentration and mass safe and precipitation is not a problem. Since these tanks contain only dilute solutions of U-235, interaction is not a problem except that they be located at least 1' from any uranium containing vessel (K-1317).

Almost all piping which might conceivably carry a rich uranium solution is 1/4" stainless steel tubing. It is overhead or on the floor as far as possible. Except for piping to a vessel, the closest approach of piping to a vessel is 8". Interaction between piping of this size and arrangement and other vessels is negligible.

There are forty-eight 3/4" pipes cast in the south wall of the cell used for storage vessels. These pipes are 4-6' off the floor and are used for tubing runs, into and out of the cell. There are a similar number of such holes in the other cells. The maximum solid angle visible through any hole is 0.002 steradians which is negligible for interaction.

Metering pumps (P-5, -3 and -1) have such a small holdup volume (less than 600 ml) that their criticality and interaction effects are negligible. Centrifugal pumps (P-15) have even less holdup (less than 200 ml). Location of the pumps is shown on the diagram.

Spill pans are located under any vessel or operation which might leak. Although the pans are formed with 4" x 6" curbs, overflow occurs to the floor at a depth of 1/2". Limiting the depth to 1/2" makes interaction between accumulation in the pan and other vessels negligible (K-1019). The pans are sized to allow accumulation from reasonable accidents without overflowing.

The pan under the extraction column holds the contents of a column at a depth of less than 1/4". The pan under the front seven storage vessels holds the contents of any tank at a depth of 1/2". The pan under the rear storage vessels holds 40% of the contents of any tank at a depth of 1/2". The pan under the precipitator and filter can hold the contents of the precipitator at a depth of 1/2".

Several pieces of equipment will contain only minor amounts of uranium. These are the gas scrub columns (C-3, -4), the cold trap (V-4), the chemical trap (V-5), the hydrolyzer trap (V-7), and the dry filter (V-17). The amount of uranium that these can contain is so small that their location is not considered in interaction.