MASTER

OAK RIDGE NATIONAL LABORATORY

Operated by

UNION CARBIDE NUCLEAR COMPANY

Division of Union Carbide Corporation

Post Office Box X

Oak Ridge, Tennessee

External Transmittal
Authorized**ORNL**
CENTRAL FILES NUMBER

58-9-35

DATE: September 30, 1958

SUBJECT: HRP - Preliminary Studies of the Fluidized
Bed Denitration of Thorium Nitrate

TO: P. A. Haas

FROM: Harvey L. List (Research Participant - City College of New York)

COPY NO. 36

ABSTRACT

Equipment for an exploratory study of the denitration of thorium nitrate in a fluidized bed was designed and constructed. Some operating difficulties were resolved and a successful initial run was made

NOTICE

This document contains information of a preliminary nature and was prepared primarily for internal use at the Oak Ridge National Laboratory. It is subject to revision or correction and therefore does not represent a final report.

The information is not to be abstracted, reprinted or otherwise given public dissemination without the approval of the ORNL patent, legal, and information control departments.

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

LEGAL NOTICE

This report was prepared as an account of Government sponsored work. Neither the United States, nor the Commission, nor any person acting on behalf of the Commission:

- A. Makes any warranty or representation, express or implied, with respect to the accuracy, completeness, or usefulness of the information contained in this report, or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately owned rights; or
- B. Assumes any liabilities with respect to the use of, or for damages resulting from the use of any information, apparatus, method, or process disclosed in this report.

As used in the above, "person acting on behalf of the Commission" includes any employee or contractor of the Commission to the extent that such employee or contractor prepares, handles or distributes, or provides access to, any information pursuant to his employment or contract with the Commission.

CONTENTS

	<u>Page</u>
1.0 Summary	3
2.0 Introduction	3
3.0 Acknowledgment	3
4.0 Fluidization Background	3
5.0 Experimental Setup	4
5.1 Process Flow	4
5.2 Equipment Design	7
5.3 Glass Model Studies	15
5.4 Operating Difficulties	17
5.5 Possible Future Difficulties and Solutions	18
6.0 Conclusions and Recommendations	19
7.0 Bibliography	19
8.0 Appendix	19
8.1 Preliminary Process Calculations	19
8.2 Operating Procedure	22

1.0 SUMMARY

Equipment was designed and built for an exploratory study of the denitration of thorium nitrate in a fluidized bed reactor. An initial problem encountered was the plugging of the liquid spray nozzle. Suitable alteration of the nozzle resolved this problem and a run of approximately seven hours was concluded successfully. This run was made without any product removal since the thorium added was only about 5 per cent of the weight of thorium in the initial ThO_2 charge. Samples of the thorium oxide particles were taken before and after feed introduction.

Now that the process has been shown to be operable, future work will be directed toward establishing the effects of variables in order to establish optimum conditions of operation.

2.0 INTRODUCTION

Consideration is currently being given to the use of thorium oxide particles in a liquid fluidized aqueous homogeneous reactor blanket. In order to obtain the most desirable fluidization pattern in the blanket, it is felt that dense, spherical particles of approximately 100 - 200 microns in diameter would be required.

There is evidence that the characteristics of a gas fluidized bed are such that thorium oxide particles of the proper characteristics could be produced by spraying thorium nitrate solution into a high temperature fluidized bed of thorium oxide particles. It has been reported, for example, ⁽²⁾ that a fluidized bed was used to convert aluminum nitrate liquid wastes into free flowing solids by spraying the liquid into the bed. The water and oxides of nitrogen were vaporized leaving the waste as a granular aluminum oxide. Similarly, uranyl nitrate solution has been sprayed into a fluidized bed of UO_3 to produce dense, spherical particles of a desirable size ⁽³⁾.

This report presents the design features of the equipment used for this exploratory study as well as operating procedure and operating difficulties encountered.

3.0 ACKNOWLEDGMENT

Thanks are due Mr. John Holmes for the preliminary process calculations and design, Mr. E. L. Youngblood for his aid in establishing the final design and in following construction of the equipment and Mr. Sam Clinton for his help with the initial startup.

4.0 FLUIDIZATION BACKGROUND

The phrase "fluidization of solids" may be briefly defined as a phenomenon which occurs when a fluid passes upward through a bed of solid particles at a velocity sufficient to prevent the particles from remaining in intimate contact with one another. Since each particle is surrounded by a film of fluid, a certain

degree of freedom to move is imparted to the solid particles. In its application to chemical processes the fluid solids technique simply involves providing a zone in which a concentration of solids is maintained for a specific purpose. The fluidized catalyst behaves like a liquid and as such can be transported through the unit under the influence of a static head. It is this property which permits continuous operations. At high velocities a large part of the gas forms pockets and flows upward through the bed resulting in vigorous agitation. This results in excellent heat transfer coefficients between the bed and heating or cooling surfaces in contact with it as well as in excellent temperature control.

This vigorous motion results in attrition and abrasion of the particles and the formation therefore of fines, which, in this process, are necessary as "seed" particles for the growth of larger spheres.

5.0 EXPERIMENTAL SETUP

5.1 Process Flow

A process flow plan (see Figure 1) and installed view (see Figure 2) of the equipment setup used in this exploratory study illustrate the use of gases to contain and transfer the process material. The gas, either air or nitrogen is metered and used for the following:

1. Main gas for fluidization of the reactor bed itself. The gas is heated before entering the reactor proper.
2. Classifier gas for elutriation of fines from the product particles.
3. Spray nozzle gas for atomizing the liquid thorium nitrate feed. Liquid thorium nitrate is pressured to the feed nozzle, atomized by the nozzle gas and sprayed into the fluidized bed.
4. Filter blowback gas for removing the fines cake on the porous metal filters. This gas is also heated before entering the reactor proper.
5. Bleed gas for four pressure taps, safety valve, solids feed line and classifier feed line.

Solids are introduced into the reactor from the solids feed tank. This is done intermittently as required. Once the initial bed is in the reactor it can remain there at the conclusion of a run. The classifier gas, together with the elutriated fines from the classifier is heated and returned to the reactor in the liquid feed zone so that it will better serve as "seed" particles for the buildup of the thorium oxide spheres. The coarse thorium oxide from the classifier is withdrawn.

The gaseous reaction products consisting of excess air or nitrogen, water vapor and oxides of nitrogen pass through the disengaging section atop the reactor, through the porous metal filters where the thorium oxide fines are retained and then into the hood and out the hood exhaust system.

Fig. 1. Process Flowsheet for the Fluidized Bed Denitration of Thorium Nitrate.

UNCLASSIFIED
PHOTO 44671

Fig. 2. Installed View of Experimental Fluidized Bed Equipment.

5.2 Equipment Design

The high temperature components were of high nickel alloys wherever practical to minimize corrosion (see Drawing Nos. D-28743 and D-28744)

5.2.1 Reactor

The heart of the process is the fluidized bed reactor. This was constructed of 3-in. I.P.S. Schedule 40, Inconel pipe. It is in this section that the fluidized bed is maintained and the calcination of the thorium nitrate to thorium oxide is accomplished. When the equipment is not operating, the solids are supported on a 16 gauge Inconel plate with 3/64-in. holes drilled on 1/8-in. centers. During the actual fluidization of the solids this plate distributes the gas to aid in the uniform fluidization of the solid particles. Above the reactor is a 6-in. I.P.S. Schedule 40 Inconel pipe which is necked down to form a conical transition piece to the reactor itself. This section serves a dual purpose. It permits a decrease in superficial velocity so that some of the entrained solids will fall back into the reactor. It also houses the filter assembly which prevents the loss of thorium oxide fines to the atmosphere. Figure 3 shows the reactor and disengaging section. Also shown in this picture are the pressure taps and gas bleeds for these taps, solids feed line, fines return line, spray nozzle and thermocouple well.

5.2.2 Filter Assembly

The filter assembly consists of four filter elements of the bayonet type constructed of 304 stainless steel. They are manufactured by the Micro Metallic Corp. This type is designated as porosity G (10 micron pore size) but it will stop a considerably smaller particle once a cake is built up on the filter metal itself. The area into which the filter assembly fits is divided into four baffled sections to permit "blowing back" of each filter element independently during operations while the remaining three elements are filtering the off-gas. Figure 4 shows the details of the filter assembly and Figure 5 shows how this assembly fits into the disengaging section.

5.2.3 Classifier Assembly

The classifier assembly (see Figure 6) was designed to produce a rough separation of fine from course thorium oxide spheres. It is basically a second fluidized bed in which the superficial velocity can be independently varied from that in the reactor itself. It is a well established fact that in a fluidized bed the concentration of coarse particles in the lower part of the bed is higher than that in the upper section. Therefore, at a given velocity it should be possible to entrain fines while the course particles remain behind and fall through the distribution grid and into the product storage tank. A rough classification was made in a similar (but not identical) classifier constructed of glass and operated with sand but the efficiency of this device on thorium oxide spheres is yet to be established. The fines are returned to the reactor and reintroduced into the section where the thorium nitrate solution is being sprayed.

The classifier is fed from the bottom of the reactor bed through a downcomer that extends above the main distribution grid.

UNCLASSIFIED
PHOTO 44518

Fig. 3. Fluidized Bed Reactor Section.

Fig. 4. Filter Assembly for Fluidized Bed Denitration Reactor.

UNCLASSIFIED
PHOTO 44517

Fig. 5. Exploded View of Fluidized Bed Denitration Reactor.

Fig. 6. Classifier Assembly for Fluidized Bed Denitration Reactor.

5.2.4 Thorium Nitrate Feed Assembly

The thorium nitrate feed assembly consists of two Pyrex feed tanks, one for water and the other for thorium nitrate solution. It is valved so that either water or thorium nitrate or any mixture of the two can be pressured to the feed spray nozzle and from there into the reactor. A Lapp Pulsafeeder pumps the nitrate from a storage vessel to maintain a constant level in the feed tank. The pump was not originally considered for direct feed into the reactor because it was felt that the pulsating flow would lead to unsteady operation. The primary use of the water was to permit flushing of the nitrate solution from the lines and spray nozzle to prevent plugging with thorium oxide at the end of the run.

The spray nozzle assembly used for introducing atomized thorium nitrate solution was obtained from Spraying Systems Company and consisted of fluid nozzle 2850 and air nozzle 645. Alterations made to this basic assembly will be discussed later.

5.2.5 Heaters

The following heaters were required:

1. Reactor heaters
2. Main gas heater
3. Blowback gas heater
4. Fines return heater

The reactor, main gas and blowback heat were all supplied by means of Thermoshell Electric heating elements which are basically resistance coils embedded in a ceramic block of semi-cylindrical shape so as to make intimate contact with the pipe. Each third of the 3-in. Inconel reactor was heated by two semi-cylindrical heaters, 8-in. long and connected in parallel. Each third was controlled independently. Figure 7 shows the reactor heaters as well as the fines return heater.

The main gas and blowback gas heaters (see Figure 8), consisted of 1-in. I.P.S. Schedule 40 stainless steel pipe, filled with stainless steel shot and electrically heated by 5-6-in. long cylindrical thermoshell heating elements (10 halves). The purpose of the shot was to increase turbulence and therefore the heat transfer coefficient and also aid in heat transfer due to conduction.

The fines return heater was simply a "Calrod" heating element in intimate contact with the fines return line. The heater was placed on the classifier gas stream after the solids were present so that advantage could be taken of the increase in heat transfer coefficient due to the presence of the solids.

UNCLASSIFIED
ORNL LR DWG 32876

Fig. 7. Reactor and Fines Return Heater for Fluidized Bed Denitration Reactor.

UNCLASSIFIED
ORNL LR DWG 32845

Fig. 8. Gas Heaters for Fluidized Bed Denitration Reactor.

5.2.6 Instrumentation

Three manometers measure pressure drop across sections of the fluidized bed itself (top, center and bottom thirds). These are therefore useful in evaluating the fluidization pattern in the bed. Figure 9 shows the instrument panel with the exception of one Variac and two manometers that were mounted locally. The top of the central section shows a Wheelco temperature controller. The primary element of this controller is a thermocouple extending through the top of the reactor and into the fluid bed. This thermocouple can be moved longitudinally and set at any point. If the temperature reaches the set point the central reactor heater is turned off.

Below the Wheelco are the rotameters for the major gas flows. These measure the main gas flow through the reactor, classifier gas, spray nozzle gas and filter blowback gas. Eight bleed gas rotameters are mounted below the main rotameters. Four are used for bleed gas to the pressure taps to prevent solids from plugging the tap itself, one each to insure solids flow from the solids feed tank and to the classifier, and one to keep the safety valve line free of solids. The final bleed rotameter is a spare to be used as conditions dictate.

A twelve point temperature recorder is mounted at the top of the right section. The thermocouple measuring the temperature of the actual fluid bed itself is movable so that a radial temperature profile can be obtained if desired.

Two additional mercury manometers were mounted outside of the instrument panel. One measures the pressure below the reactor distribution grid and the other the reactor top pressure which is essentially the pressure drop across the filter bank and is therefore a good indication of plugged filters.

5.3 Glass Model Studies

Prior to operations with the high temperature equipment some preliminary qualitative studies were made with glass models of some of the component parts. Preliminary fluidization studies were made in a 3-in. Pyrex glass column initially using sea sand from 150-300 microns in size. The fluidization pattern without any distributor was found to be poor with slugging causing very unsteady operation. The fluidization pattern was improved somewhat when screening was used but was best using a distributor of the type finally employed in the design. It was found that the onset of good fluidization occurred at a superficial gas velocity of approximately 0.3 ft/sec. Microscopic examination of this sand showed that while the particles were not spherical, rough edges for the most part were rounded off. While these particles are similar in shape to what is expected in our ultimate fluid bed, the difference in density between sand and thorium oxide makes quantitative conclusions impossible.

The sand was then removed from the glass column and replaced with the thorium oxide particles to be used as the starting bed. These particles were smaller than the size expected in the equilibrium fluid bed and in addition revealed under microscopic examination to have jagged edges. They showed therefore, as expected, a

Fig. 9. Instrument Panel for Fluidized Bed Denitration Reactor.

greater tendency to pack than the sand did or than we expect once an equilibrium fluid bed is established and spherical particles of larger size are present. For this bed however, with which it was initially necessary to operate, fairly good fluidization was observed at superficial velocities of from about 0.4 to 1 ft/sec.

A glass classifier which differed somewhat from the one ultimately designed was tested with sand. This classifier was cylindrical (rather than the final conical shape) and had no gas distributor. Table I shows the approximate classification obtained with this device for several superficial gas velocities. The data show that some classification was realized, particularly at the extremes. That is, the very fine particles were taken overhead and the very coarse were in the bottoms. The intermediate sizes were distributed between overhead and bottoms. It was noted that some swirling occurred during the classification experiments. When a grid was inserted to distribute the gas it was noted that the swirl disappeared and it was qualitatively noted that an improvement in classification resulted and at considerably lower velocities. Slugging, however, occurred in the narrow exit line. It was apparent that a disengaging section was desirable. On the basis of these data and observations the final design of the classifier was developed.

TABLE I

CLASSIFICATION DATA

Particle Size Microns	Feed Wt. %	Weight % Size Distributions for Superficial Velocities of:					
		3.0 ft/sec		5.9 ft/sec		9.0 ft/sec	
		Overhead	Bottoms	Overhead	Bottoms	Overhead	Bottoms
Less than 53	0.3	neg.	0.1	0.2	neg.	0.1	neg.
53-74	0.7	3.0	0.5	1.7	0.2	0.6	neg.
75-149	12.8	14.7	5.5	19.9	11.1	9.1	10.4
150-250	34.0	82.3	69.1	74.0	71.3	77.7	74.3
251-297	32.8	neg.	11.2	4.2	11.6	9.0	8.8
298-500	17.9	neg.	12.5	neg.	4.1	3.5	4.2
501-840	1.5	neg.	1.1	neg.	1.7	neg.	2.3
% Overhead	-	4.4		27.3		51.9	
% Bottoms	-	95.6		72.7		48.1	

5.4 Operating Difficulties

Fluidizing the bed and maintaining desired temperatures presented no problem. There was however, some difficulty in getting the spray nozzle to operate properly. Initially, plugging of the nozzle occurred immediately upon introducing the thorium

nitrate solution. It was felt that the nozzle was so hot that calcination of the thorium nitrate occurred within the nozzle itself and caused plugging. The same nozzle was therefore equipped with a cooling jacket so that the nozzle could be maintained at a lower temperature. Even with this arrangement plugging occurred almost immediately. When the lines to the nozzle were opened it appeared that they were filled with thorium oxide slurry. It is possible that some of the bed particles had worked their way back into the liquid nozzle. It was therefore decided to remove the straight section of the nozzle (about 1/8-in.) to keep it blanketed by the spray nozzle gas and help prevent backflow of the thorium oxide particles. This change solved the problem and at this writing operation on thorium nitrate solution feed has been accomplished for a run of approximately seven hours.

5.5 Possible Future Difficulties and Solutions

Now that the spray nozzle problem has been solved three possible additional difficulties can be foreseen to prevent a truly continuous and stable operation.

1. Problem of bed "boggling". At the design feed rate it is possible that sufficient heat and feed atomization are not available to prevent bogging. Bogging may be defined as a loss of fluidization that would occur when the thorium nitrate cannot be calcined as fast as it is introduced. The result would be a sticky mass between particles and an eventual joining of the particles into a relatively solid mass of thorium oxide. When bogging appears to be approaching (as determined by non-uniform temperatures in the bed and decrease in pressure drop across the bed) decreasing feed rate will probably halt it.

2. The exploratory run was made to prove the basic operability of the process. During the course of the run no attempt was made to withdraw solid thorium oxide. This was done so that a bed of more desirable fluidization characteristics (spherical and of larger size) could be produced. It is hoped that ultimately conditions of operation can be established so that the formation of fines in the reactor will balance withdrawal of coarse particles. That is, the only stream introduced will be thorium nitrate solution and the only stream removed will be coarse thorium oxide spheres. Fines are produced by attrition or abrasion, calcination of fine feed droplets, and disintegration of particles as a result of very rapid denitration in a hot medium. Coarse particles are probably built up of layer of oxide on seed particles as well as agglomeration of particles. If too many fines are produced some may have to be removed with the coarse particles to maintain an equilibrium bed. If too few fines are produced, fines may have to be added to the bed or produced in the bed by some means such as jet grinding as used in the petroleum industry's fluid coking process⁽¹⁾.

3. At this time the operation of the classifier is still to be established. While it is felt that some classification will be realized, a narrow range may not be produced and further classification of the product thorium oxide particles may be required. This will be established in future experimentation.

6.0 CONCLUSIONS AND RECOMMENDATIONS

Equipment has been designed and built for an exploratory study of the denitration of thorium nitrate in a fluidized bed. An initial run of approximately seven hours duration has been successfully concluded to establish the basic operability of the process.

Future efforts with this equipment should be directed toward determining the effects of the variables in order to establish the optimum conditions for the process. Of prime importance among these variables are:

1. Effect of reaction temperature
2. Effect of superficial gas velocity
3. Effect of using nitrogen gas in place of air.

7.0 BIBLIOGRAPHY

- (1) Dunlop, D. D., Griffin, Jr., L. I. Moser, Jr., J. F., Chemical Engineering Progress: Vol. 54; No. 8; August 1958.
- (2) Grimmett, E. S., "Calcination of Aluminum-Type Reactor Fuel Wastes in a Fluidized Bed", IDO-14416.
- (3) Jonke, A. A., Levitz, N. M., Petkus, D. J., and Taecker, R. G., "Fluidized Bed Process for the Production of Uranium Tetrafluoride (Green Salt) from Uranyl Nitrate", ANL-5363.
- (4) Allred, V., ORNL Notebook 4073.
- (5) Johnson, E. M., "Quarterly Progress Report for Period Ending August 31, 1957", PAR Report WCAP-668.

8.0 APPENDIX

8.1 Preliminary Process Calculations*

Calculations were made for producing ThO_2 particles of approximately 140 micron size in a fluidized bed. The bed would be made up of particles under 140 microns in dia which would be grown by depositing ThO_2 decomposed from a thorium nitrate solution sprayed into the bed. Separation of the large particles would be accomplished by maintaining the bed inlet velocity at the settling velocity for 140 micron particles and collecting all particles falling through this stream. The calculated bed design conditions were:

* These calculations were presented by J. M. Holmes in a letter of March 24, 1958 to P. A. Haas, "Production of Large Size ThO_2 in a Fluidized Bed".

1. Bed temperature - 700°C +
2. Fluidization Velocity - 0.8 - 1.0 ft/sec
3. Fluidizing gas - nitrogen or air
4. Bed height/diameter - 5/1
5. Bed holdup time - 2 hours
6. Bed particle size distribution

<u>Size microns</u>	<u>Wt.%</u>
10-20	5
20-50	20
50-100	55
100-140	20

These design parameters were selected on the basis of the following requirements:

(a) Liquid Fluidization of 140 Micron Particles

ThO_2 particles produced by this process would be used in a liquid fluidized HRT blanket. Estimated liquid fluidized bed characteristics for 140 micron ThO_2 in D_2O at 260°C are shown in Figure 10. The fluidization velocity is approximately 4 ft/min while the Stokes velocity is approximately 38 ft/min.

(b) Particle Growth in Fluidized Beds

E. S. Grimmer⁽²⁾ reports that a fluidized bed was used to convert aluminum nitrate liquid wastes into free flowing solids by spraying the liquid into the bed. The water and oxides of nitrogen were vaporized, leaving the waste as a granular aluminum oxide. The data show a continual increase in bed particle size during operation; the starting bed had a particle size range between 150-840 microns which increased to a 420-1190 micron range after 26 hr of operation. The data also indicate that the smaller size particles tend to grow more rapidly producing a more uniform bed of large particles. Therefore, it may be necessary continually to add new "seed" particles to the bed.

(c) Reaction Kinetics

Several investigators have found that thorium nitrate decomposes to thorium oxide readily at temperatures above 200°C , but that a second slower reaction rate begins when the decomposition reaches 90% of completion. Kinetic calculations from the data of V. Allred⁽⁴⁾ for small quantities of TNT indicate that the chemical reaction rate is controlling up to about 90% conversion but diffusional rates control between 90-100% conversion. The data of E. M. Johnson⁽⁵⁾ show that the diffusion rate is controlling up to 90% conversion in a packed bed. No rate data above 90% conversion are reported. Therefore, it appears that in order to carry

UNCLASSIFIED
ORNL-LR-DWG. 33561

Fig. 10. Fluidization of Thorium Oxide in D_2O .

the reaction to completion, the highest practical temperatures ($700^{\circ}\text{C} +$) should be used in a fluidized bed reactor to minimize diffusional resistances. Holdup times greater than one hour are indicated by a calculation which shows that 0.8 hour is needed to complete the reaction to 99.9% conversion at 700°C using very small quantities of TNT.

(d) Fluidized Bed Calculations

Figure 11 gives the calculated Stokes and minimum fluidization velocities for spherical ThO_2 particles in N_2 at 700°C . To fluidize particles of 140 microns maximum dia, a velocity of at least 0.6 ft/sec will be needed. Therefore, a velocity range of 0.8-1.0 ft/sec is recommended. The bed inlet velocity should be about 6 ft/sec to allow settling of the 140 micron particles. A bed of wide particle size distribution is recommended to produce good fluidization uniformity but filters must be used in the off-gas to prevent escape of fines from this bed. Micrometallic grade G or H porous SS bayonet elements should suffice. A bed length to dia ratio of 5:1 is believed necessary to prevent excessive back gas mixing of the gaseous products from the reaction.

8.2 Operating Procedure

The following startup procedure is recommended: (refer to valve numbers on process flowplan)

1. Start with all valves closed.
2. Open off-gas valves 1, 2, 3, 4.
3. Open gas stream main valves - 40 and 41 if using nitrogen; 42 and 43 if using air.
4. Feed initial solids charge to reactor (open valve 10). If flow stops it may be necessary to add bleed gas (open valve 30 - adjust flow rate by means of valve 38).
5. Close valve 10 (and 30 and 38 if they were used). After solids charge is in the reactor steps 4 and 5 may be eliminated unless additional solids are required.
6. Start main fluidizing gas stream (open valve 19 - adjust flow rate by means of valve 23 to a setting of 20*).
7. Start gas bleeds (open valves 24 through 29 inclusive - adjust flow rate by means of valves 32 through 37 inclusive to a setting of 0.4 on each rotameter).

* Optimum setting to be determined.

UNCLASSIFIED
ORNL-LR-DWG. 33562

Fig. 11. Fluidization of Thorium Oxide in Nitrogen.

8. Start spray nozzle gas (open valve 17 - adjust flow rate by means of valve 21 to a setting of 10*).

9. Start classifier gas (open valve 18 - adjust flow rate by means of valve 22 to a setting of 10*). Open valve 13.

10. Start blowback gas. During the time filter blowback is not required the heated gas will pass out with the off-gas. (Open valves 5, 6, 7, 8, 16 - adjust flow rate by means of valve 20 to a setting of 10*). When blowback becomes necessary the off-gas line from the filter being cleaned will be closed and the blowback gas valves to all but this filter will be closed. For example, when filter #1 is to be blown back close valves 1, 5, 6, 7. When filter #2 is to be blown back close 2, 5, 6, 8, etc.

11. Activate manometers. Open valves 44 through 56 inclusive. Close bypass valves 47, 48, 49, 53, 54 slowly to make sure manometer fluid will not be blown out of tube.

12. Activate heaters, temperature recorder and temperature controller.

13. Allow bed to build up to operating temperature.

14. Introduce water. (Open valves 58 and 60).

15. Switch to thorium nitrate solution feed. (Open valve 61 - adjust flow rate by means of valve 57. Close valves 58 and 60. Open valve 63, start Pulsafeeder to maintain constant level in liquid feed tank.)**

Shutdown procedure is as follows:

1. Change liquid feed to water. (Shut Pulsafeeder pump - open valves 58 and 60 - close valves 57, 61, 63).

2. When water flush tank is empty reverse startup steps 12 and 11.

3. Allow temperatures to drop to essentially room temperature.

4. Reverse startup steps 10 through 6.

5. Close all valves.

* Optimum setting to be determined.

** Initial run by-passed feed system. Pulsafeeder fed directly to spray nozzle.

DISTRIBUTION

1. S. E. Beall
2. R. E. Blanco
3. E. G. Bohlman
4. J. C. Bresee
5. K. B. Brown
6. F. R. Bruce
7. S. D. Clinton
8. E. L. Compere
9. F. L. Culler
10. W. K. Eister
11. D. E. Ferguson
12. H. E. Goeller
13. A. T. Gresky
14. P. A. Haas
15. C. C. Haws, Jr.
16. P. R. Kasten
17. R. B. Korsmeyer
18. R. B. Lindauer
- 19-20. H. L. List, City College of New York
21. J. P. McBride
22. L. F. Parsly, Jr.
23. F. N. Peebles
24. M. J. Skinner
25. E. H. Taylor
26. D. G. Thomas
27. W. E. Unger
28. C. E. Winters
29. E. L. Youngblood
30. HRP Director's Office
- 31-32. Laboratory Records
33. Laboratory Records (RC)
34. Central Research Library
35. Document Reference Section
- 36-50. TISE