For Div of Compliance

GULF UNITED
NUCLEAR FUELS CORPORATION

R

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In reply, please refer
to NISM 72-28

March 30, 1972

Director, Division of Materials Licensing
United States Atomic Energy Commission
Washington, D.C. 20545

Attention: Mr. Donald A. Nussbaumer, Chief
Fuel Fabrication and Transportation Branch

Reference: AEC License No. SNM-33, Docket 70-36

Subject: Revision of Green Room Nuclear Safety Basis

Gentlemen:

On October 29, 1971, we advised you that an application for revision of the nuclear safety of low enriched scrap reprocessing based on favorable geometry and/or poisoning of process vessels and equipment would be submitted by April 1, 1972. This letter, attached revised Subpart 823, Supplemental Safety Analysis Report, and list of effective pages comprise that application.

Nuclear Safety of all of the process vessels and equipment has been assured by favorable geometry, poisoning, and specific computer analyses.

Although the Green Room revisions would be extensive, the basic process would remain the same and would be performed in the same area. As you can imagine, considerable engineering effort has gone into the preliminary design of the revision and still more detailed equipment and process design work will be required before the modifications could actually be made. Assuming your early review and approval of the application and no delays in engineering and equipment procurement, the earliest possible time that we could start the modifications would be October, 1972. However, beginning about August, 1972, processing of several contiguous orders for uranium oxide will be under way. It is anticipated that these orders will be completed during the third quarter of 1973. Because it will be necessary to completely cease Green Room operations for a period of at least three months in order to make the revisions, we intend that they be made following completion of the orders.

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As further indicated in the application, air cleaning consisting of high efficiency filtration systems and wet scrubber systems with appropriate provisions for future high efficiency filtration would be installed at the same time that the Green Room is shut down. We would also make provisions for continuous monitoring at that time. Although it might be possible to improve air cleaning on existing process equipment in the Green Room at an earlier time than proposed, it is highly preferable that all of the modifications be made at one time to avoid installing air cleaning that may be unusable with the new process equipment and to avoid another extended shut down.

Please let me know if you have any questions regarding the application.

Sincerely,

Peter Loysen, Manager
Nuclear and Industrial Safety

PL:sm
Atts.

EFFECTIVE PAGES

DOCKET 70-36, SECTION 800, SUBSECTION 820

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SECTION 800 - CHEMICAL OPERATIONS

SUBSECTION 820 - PROCESSING

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823. Green Room

823.1 System Description

The Green Room is designed for the following low enrichment processing: (1) Chemical recovery of scrap materials, (2) oxidation-reduction of UO_2, (3) blending and packaging the product. The maximum enrichment of materials to be processed will not exceed 4.1%.

When not processing low enrichment materials, certain equipment may be used to calcine combustible material of large bulk-low uranium contact with any enrichment.

The Green Room location and equipment arrangement is shown on drawing D-509-2007. Simplified flow diagrams are shown on Figure 823.3-I, II and III.

823.2 Material to be Processed

2.1 Wet Recovery

Wet recovery operations may be performed on all types of scrap materials such as contaminated uranium compounds, rejected pellets, cleanup residues, etc.

2.2 Oxidation - Reduction

Oxidation-reduction may be performed on UO_2 pellets or other material for which wet recovery is not required.

2.3 Blending and Packaging

The material may be in the form of ADU, UO_2, U_3O_8, etc.

2.4 Calcining

Combustible material such as paper, absolute filters of large bulk, low uranium content may be processed.

823.3 Process and Equipment Design

3.1 Muffle Box Loading and Unloading Hood, Muffle Boxes, Furnace & Cooler.

UO_2 transferred into 240-3 for wet recovery or dry reprocessing will be transferred into trays in the Muffle Box Hood (5-8). Trays will then be loaded into a Muffle Box (5-7-1 through 5-7-6). A maximum of 18 trays will be loaded into one box and the box will be sealed. The boxes will be placed into 1 of 2 Furnaces (5-4) (5-5) for oxidation, oxidation-reduction, calcining or pyrohydrolysis. Upon completion of the furnace cycle, the boxes will be placed in the cooler (5-6) for cooling the boxes and contents with a water spray.

The cooled boxes will be moved to the Muffle Box Hood (5-8) for unloading from individual trays. In the case of clean scrap, the UO_2 will be screened through a screen and a magnetic separator located in hood (5-8). The sized product will be collected in a 5 gallon pail for blending on blender (5-12), sampling in hood (5-9), and weighing on scale (5-11).

UO_2 that has been oxidized or calcined to U_3O_8 for wet recovery will also be unloaded in hood (5-8).

3.2 Feed Preparation

The U_3O_8 will be transferred to the feed preparation hood (1-10). All feed material for wet recovery will be processed through a screen and a magnetic separator prior to introduction of the U_3O_8 into the slurry feed hood (1-1-1).

3.3 Dissolution

A pre-determined weight of U_3O_8 from the feed preparation hood (1-10) is introduced into a 6" to 9"Ø vessel (1-1) via the slurry feed hood (1-1-1). Water will also be introduced into (1-1) from a 9"Ø water feed vessel (1-9-2). The U_3O_8 and water will be mixed by an agitator in the vessel. The resulting slurry will be pumped into one of three 9"Ø dissolvers (1-2) (1-3) (1-4) with external steam/water coils. Nitric acid will be added to the dissolvers from the 9"Ø HNO_3 feed vessel (1-9-3). The dissolvers will be steam heated and mixed by an agitator. After the U_3O_8 is dissolved, the impure $UO_2(NO_3)_2$ solution, with a uranium concentration of 50 to 250 grams

823.3 Process and Equipment Design (con't)

3.3 Dissolution (con't)

U/l., is allowed to digest to insure complete uranium dissolution. After digestion, steam may be introduced through the hot $UO_2(NO_3)_2$ solution to remove the excess HNO_3. The excess HNO_3 may also be removed by boiling the $UO_2(NO_3)_2$ solution. After the excess nitrates have been removed, the $UO_2(NO_3)_2$ solution is cooled prior to acid insoluble filtration.

In the case of the low grade dissolver (1-4), the solids are allowed to settle to the bottom of the vessel. After settling, the supernatant $UO_2(NO_3)_2$ solution is removed from the top into dissolvers(1-2) or (1-3)for nitrate removal. After the $UO_2(NO_3)_2$ solution is removed, the solids are removed from the bottom of the vessel (1-4) via the acid insoluble discharge hood (1-4-1) and collected in a 5 gallon pail.

3.4 Acid Insoluble Filtration

The $UO_2(NO_3)_2$ solution containing acid insolubles is pumped through an initial filter press (1-5) to remove the majority of solids. To improve the clarity of the $UO_2(NO_3)_2$ solution, a filter aid may also be introduced into the press or $UO_2(NO_3)_2$ solution from the 9"Ø filter-aid make up vessel (1-8). After the initial filtration, the $UO_2(NO_3)_2$ solution is pumped through a polish filter (1-6) to insure maximum clarity prior to pumping it into the $UO_2(NO_3)_2$ hold tank (1-7). A turbidmeter may be utilized as an overcheck to prevent solids from collecting in the hold tank (1-7). Details of the $UO_2(NO_3)_2$ hold tank (1-7) are shown on sketch 823.3 - IV. The acid insolubles will be removed from the filter presses(1-5) and(1-6)into a 5 gallon pail, for additional processing or disposition to burial.

3.5 $UO_2(NO_3)_2$ Hold Tank and Dilution

The 500 gallon $UO_2(NO_3)_2$ hold tank (1-7) is filled with Raschig rings.

The $UO_2(NO_3)_2$ solution will be recycled in the tank (1-7) to obtain homogeneity prior to sampling for uranium concentration, etc. After mixing and sampling, the $UO_2(NO_3)_2$ solution will be diluted

823.3 Process and Equipment Design (con't)

3.5 $UO_2(NO_3)_2$ Hold Tank and Dilution (con't)

with water from the 9"Ø water dilution feed vessel (2-2) to obtain the desired uranium concentration.

3.6 $UO_2(NO_3)_2$ Solution pH Adjustment

The diluted $UO_2(NO_3)_2$ solution is pumped into a 9"Ø pH adjustment vessel (2-3) where the pH is adjusted with NH_4 OH from the NH_4OH make up (9-2). The NH_4OH make up vessel is a sealed tank with one (1) vent to atmosphere. The NH_4OH addition may be controlled by a continuous pH monitor and flow control system.

3.7 UO_4 Precipitation and Aging

The UO_4 is precipitated in a 9"Ø vessel (2-4) with a hydrogen peroxide solution pumped from the hydrogen peroxide make up tank (9-3). The peroxide make up tank is a sealed tank with a vent to atmosphere. The resulting UO_4 slurry is recycled through another 9"Ø vessel (2-5) to ensure complete precipitation and to assure particle growth. After aging is complete, the overflow from (2-5) is collected in a 9"Ø surge vessel (2-6) for pumping to the centrifuge.

3.8 UO_4 Separation

The UO_4 slurry is pumped from vessel (2-6) into a Sharples centrifuge (3-1) model No. P-600 or P-660.The UO_4 cake is discharged from the centrifuge into a furnace tray and placed into dryer (5-2) via the transfer hood (5-1). Details of the dryer are shown on Sketch 823.3-V. After the UO_4 is dry, it is removed from the oven and transferred to muffle box (5-7-1 through 5-7-6) via transfer hood (5-1). Boxes are sealed and placed in furnaces (5-4) (5-5) for reduction.

The centrifuge supernatant is discharged into a 9"Ø filtrate feed vessel (3-2) for final clarification in filter press (3-3). Solids from the press (3-3) are treated the same as the solids from the centrifuge (3-1). Details of the centrifuge are shown on Sketch 823.3-VI. The filtrate is pumped into filtrate hold tanks (4-1) (4-2) and mixed prior to sampling for uranium and discharge to the

823.3 Process and Equipment Design (con't)

3.8 UO_4 Separation (Con't)

effluent holding pond. Details of the filtrate hold tanks are shown on Sketch 823.3-IV.

A turbidmeter may be used as an overcheck to insure that no solids are transferred into the hold tanks containing Raschig rings.

The alternate method of UO_4 separation will be utilization of the filter press (3-3) as the primary filter and the impure ADU polish filter (4-6) as the final filtration. Details of the filter press are shown on Sketch 823.3-VII.

3.9 Filtrate Treatment

In the event of filtrates containing recoverable quantities of uranium, the filtrate is pumped into a 9"Ø filtrate sparge vessel (4-3) with external steam/water coils. Steam is introduced into the heated filtrate to remove the hydrogen peroxide. After peroxide removal, the sparged filtrate is pumped into a 9"Ø filtrate cooling vessel (4-4) with external cooling coils prior to uranium precipitation in a 9"Ø ADU precipitation vessel (4-5). Uranium is precipitated with ammonium hydroxide made up from the vessel(9-2). The impure ADU Slur is pumped into press (3-3) for filtration. The impure ADU cake is removed from the press for additional processing or disposition to burial. The filtrate from the press (3-3) is pumped into a 9"Ø impure ADU polish filter (4-6) for final clarification before pumping into the filtrate hold tank (4-1) (4-2). The filtrate is mixed and sampled for uranium before discharge to the effluent holding pond.

3.10 UF_6 Cylinder Wash

The uranyl fluoride solution obtained from washing the heel from the low enriched cylinders are transferred into the ADU precipitation vessel (4-5) for uranium precipitation. The treatment of the uranyl fluoride solution is the same as described in Subpart 823.3.9.

823.3 Process and Equipment Design (con't)

3.11 Analytical Control Hood

The analytical control hood (1-11) will be utilized for analytical control work. Typical work performed in hood will be centrifuging of samples, acid base titrations, preparation of liquid samples, and pH overchecks.

3.12 Utility Hood

The utility hood (1-12) will be used as a general purpose hood. The hood will have a 9"Ø vessel (1-12-1) for leeching filter media and a 3-1/2" safe slab vessel (1-12-2) for acid washing of empty trays.

3.13 Mill Hood

The mill hood (5-10) will be used to mill coarse powder and dewaxed pellets. Product will be collected in a 5 gallon pail.

3.14 Blending and Packaging

Milled and blended product is blended in a 5 gallon pail on the blender (5-12), weighed on scale (5-11), and sampled in hood (5-9). One pail at a time is handled in each of these locations.

Individual batches are cross-blended into a lot in the hood (10-0). The hood is a specially designed dust control hood. A maximum of 5 pails can be combined in a single operation in the following manner:

A single pail will be placed in the hood. After closing the hood, the lid will be removed and the pail placed on a four wheel dolly in a canted position. The dolly rides on rails along the back of the hood.

In front of the rail carrier will be located five stations, each separated from the next by a concrete slab one foot thick, approximately three feet high and two feet wide to isolate each station from the next from a neutron interaction standpoint. An empty five gallon pail will be positioned in each station.

823.3 Process and Equipment Design (con't)

3.14 Blending and Packaging (con't)

This operation will be repeated until the entire batch is blended. The individual pails having received the incremental parts of the blend will be fitted with a lid, removed from the hood, and placed on a blender (5-12) and tumbled to accomplish blending. At this point, the pails will be weighed and transferred to storage.

3.15 Transfer

Furnace tray carts (11-1-1 and 11-1-2) will be used to transport filled trays to and from various process operations and for empty tray storage. The top of the cart will hold a maximum of nine (9) filled furnace trays stacked on 3" centers. The bottom of the cart will provide storage area for empty trays in a vertical position. Details of this cart are shown on Sketch 823.3-VIII.

Four (4) muffle box carts and a muffle box lift are provided for the transport of muffle boxes. These carts may be positioned near the furnaces or coolers during loading and unloading operations and placed in the north west portion of the area when awaiting further processing.

3.16 Storage

Inprocess storage racks are placed strategically throughout the storage area. These racks provide either three (3) or four (4) unit horizontal rows and two (2) tiers high. Three (3) foot center to center spacing is provided in both directions.

A storage area is provided for longer term and scrap storage. This area provides space for twenty units with the same separation as for the inprocess storage racks.

3.17 Utility and Support

Several utility or support tanks or vessels are located in the process area. These tanks or vessels are:

823.3 Process and Equipment Design (con't)

3.17 Utility and Support (con't)

1) Ammonium Hydroxide Make Up (9-2)
2) Hydrogen Peroxide Make Up (9-3)
3) Deionized Water Storage (9-1), and
4) Nitric Acid Bulk Storage (1-9-1)

All of these vessels will be totally enclosed with one (1) vent to atmosphere.

823.4 Nuclear Criticality Safety

4.1 General

Vessels, tanks and other equipment used to process solutions have nuclear safe geometries or are filled with Borosilicate Glass Raschig Rings. Process equipment used to process wet and dry powders and cakes have been analyzed by the use of computer codes to determine their degree of criticality under normal operating conditions and after one (1) administrative error. Storage containers have nuclear safe geometries and the interaction of arrays have been analyzed using the solid angle method.

Several basic conditions apply throughout the area and are listed below:

1) Vessels which do not normally contain SNM will be separated from pipes or other vessels containing SNM by air breaks or they will have nuclear safe geometries or they will be filled with Borosilicate Glass Raschig Rings.

2) Pipe sizes and pipe intersections will meet the criteria listed on page 20, TID-7016, Rev. 1.

3) The use of Borosilicate Glass Raschig Rings will meet the standards and criteria set forth in the standard ANSI N 16.4 - 1971.

4.2 Safe Geometry Vessels and Tanks

Feed, mixing, dissolving and hold tanks or vessels have 9" inner diameters. A 9" inner diameter is nuclearly safe for enrichments

823.4 Nuclear Criticality Safety (con't)

4.2 Safe Geometry Vessels and Tanks (con't)

not exceeding 4.1% as shown on Figure 309-XVI. Tanks and vessels with 9" or less inner diameters are:

1) Slurry Make-up(1-1)
2) Water Feed(1-9-2)
3) Dissolver(1-2)
4) Dissolver(1-3)
5) Low Grade Dissolver(1-4)
6) Nitric Acid Feed(1-9-3)
7) Filter Aid Make-up(1-8)
8) Dilution Water Feed(2-2)
9) PH Adjustment(2-3)
10) UO_4 Precipitator(2-4)
11) UO_4 Aging(2-5)
12) UO_4 Surge(2-6)
13) Filtrate Feed(3-2)
14) Filtrate Sparge(4-3)
15) Filtrate Cooling(4-4)
16) ADU Precipitation(4-5)
17) Impure ADU Polish Filter(4-6)
18) Filter Leach Vessel(1-12-1)

The interaction effects are analyzed in the Nuclear Safety Evaluation-Interaction Calculations.

A centrifuge is used for the separation of solids and supernatant. The centrifuge has a void volume not exceeding 24 liters which is nuclearly safe for enrichments not exceeding 4.1% as shown on Figure 309-XVIII. The interaction effects are analyzed in the Nuclear Safety Evaluation - Interaction Calculations.

Wet solids may be removed directly from the dissolvers and collected in 5-gallon pails (18.9 liters). This volume is nuclearly safe for enrichments not exceeding 4.1% as shown on Figure 309-XVIII.

4.3 Poisoned Vessels and Tanks

Large, unsafe tanks are filled with Borosilicate Glass Raschig Rings to provide nuclear safety. Poisoned tanks and vessels are:

823.4 Nuclear Criticality Safety (con't)

4.3 Poisoned Vessels and Tanks (con't)

1) $UO_2(NO_3)_2$ Hold Tank(1-7)
2) Filtrate Hold Tank(4-1)
3) Filtrate Hold Tank(4-2)

4.4 Equipment Safe by Analysis

Solids may be collected in polish filters and filter presses. The largest and most reactive filter or filter press is the UO_4-ADU filter press 3-3. The maximum effective multiplication factor for this filter press is 0.859 as shown in NED-1759. Since this is the largest and most reactive filter or filter press, other smaller filters or filter presses are less reactive than the one evaluated. Nuclear safe filters and filter presses are:

1) Acid Insoluble Initial Filter(1-5)
2) Acid Insoluble Polish Filter(1-6)
3) UO_2-ADU Filter Press(3-3)
4) Impure ADU Polish Filter(4-6)

These filters and filter presses are separated from other process equipment containing SNM by at least 2½ feet. Thus with the relatively low effective multiplication factor plus this separation distance, neutron interaction is considered negligible and is not evaluated further.

Furnace trays have dimensions of 1½"x 16"x21". The 1½" thickness is nuclearly safe for enrichments not exceeding 4.1% as shown on Figure 309-XIX.

Furnace trays are placed in a dryer to remove excess liquid prior to pyrohydrolysis. The effective multiplication factor for a loaded dryer under normal process conditions is 0.695. Under conditions where the material might be at optimum moderation and complete water reflection, the maximum effective multiplication factor is 0.960. These results are shown in NED-1759. Nuclear safe equipment used with these dryers are:

1) Dryer(5-2)
2) Dryer(5-3)

823.4 Nuclear Criticality Safety (con't)

4.4 Equipment Safe by Analysis (con't)

3) Furnace Tray Cart(11-1-1)
4) Furnace Tray Cart(11-1-2)

These dryers are separated from each other and other process equipment containing SNM by at least three (3) feet. Thus with the low effective multiplication factor plus this separation distance, neutron interaction is considered negligible and is not evaluated further.

Dried furnace trays are next placed in muffle boxes for loading into furnaces for pyrohydrolysis. After pyrohydrolysis, the muffle boxes are transferred to a cooler for cool down. The effective multiplication factor for a loaded muffle box under normal process conditions is 0.650. Under conditions where the material might be at optimum moderation, the maximum effective multiplication factor is 0.958. These results are shown in NED-1759. Nuclear Safe equipment used with these muffle boxes are:

1) Furnace(5-4)
2) Furnace(5-5)
3) Cooler(5-6)
4) Muffle Box Carts (4)
5) Muffle Box Lift

Individual muffle boxes are separated from each other and other process equipment c ontaining SNM by at least two (2) feet. Thus, with the low effective multiplication factor plus this separation distance, neutron interaction is considered negligible and is not evaluated further.

4.5 Array Analysis

The containers used for storage are 5-gallon pails (18.9 liters). This volume is nuclearly safe for enrichments not exceeding 4.1% as shown on Figure 309-XVIII.

Arrays of 5-gallon pails will be used for both inprocess and long term storage. Interaction is analyzed in the Nuclear Safety Evaluation - Interaction Calculations.

823.4 Nuclear Criticality Safety (con't.)

4.6 Batch Control Safety

Material to be calcined will be low level combustible residues, wastes and scraps. This material contains small amounts of SNM in metal or compound form with enrichments up to and including full enrichment. Nuclear safety will be maintained by using batch processing with a limit of 350 grams of U-235 per batch. Only one 350 gram U-235 batch may be handled in each piece of equipment at any time. All other SNM will be removed from inidividual pieces of equipment before such transfer and processing may take place. The limit of 350 grams of U-235 per batch will be determined by means of material balance, chemical analysis or other appropriate analytical techniques. A 350 gram batch limit is nuclearly safe as shown on Table 309-I. Equipment used for this batch processing are:

1) Muffle Boxes (5-7-1 through 6)

2) Muffle Box Loading & Unloading Hood (5-8)

3) Furnace (5-4)

4) Furnace (5-5)

5) Cooler (5-6)

6) Muffle Box Carts (4)

7) Muffle Box Lift

When each batch is processed, it will be removed from the Green Room for further processing or storage according to Subsection 810 or 820.

823.5 Health Physics

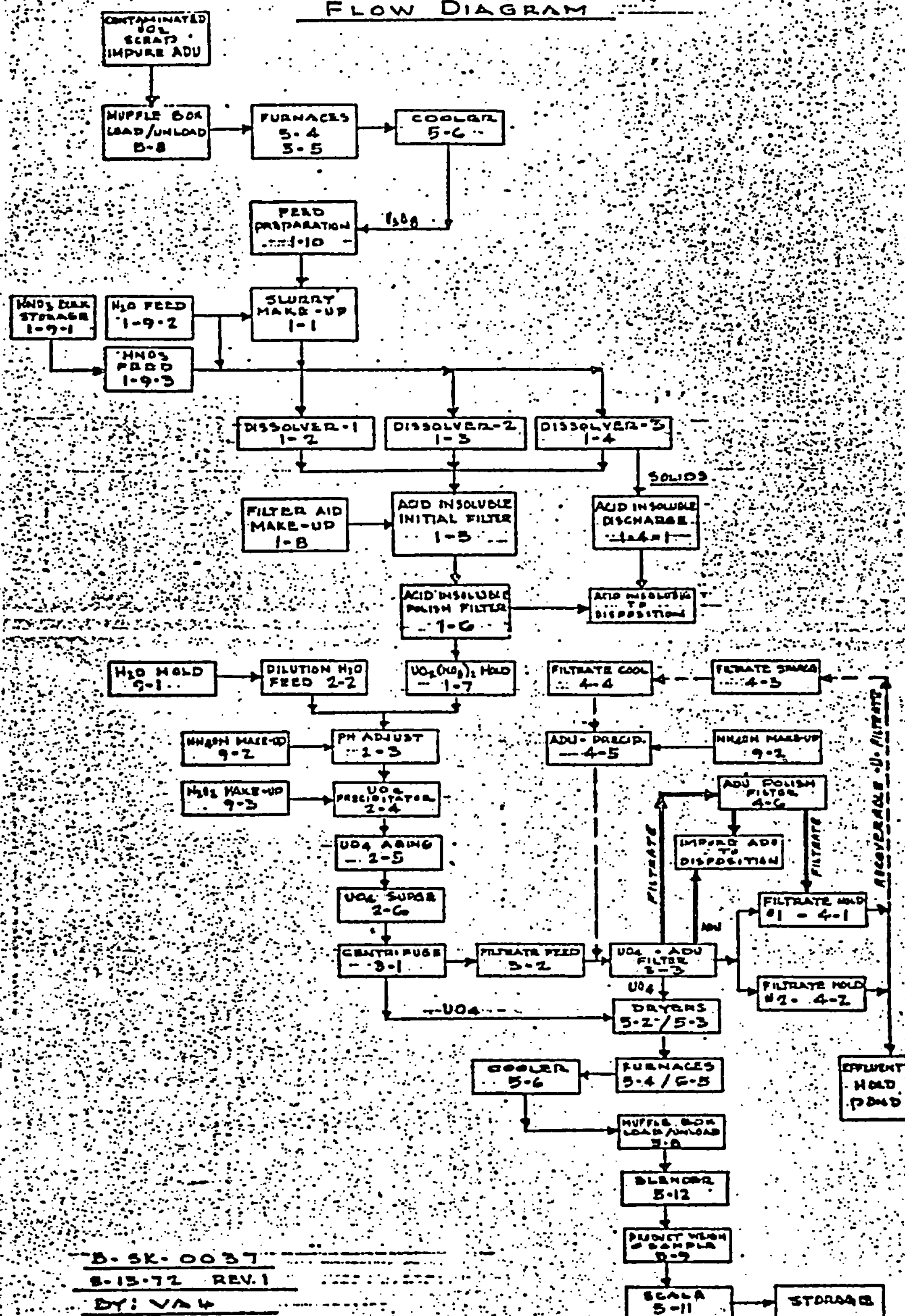
5.1 Ventilation

Ventilation control will be accomplished by installation of equipment that conforms to the criteria of Subpart 404.2. Cleaning of air and gaseous effluents will be achieved in accord with the criteria of Subpart 404.3. Sketch 823.5 - IX diagrams the general ventilation control and air cleaning systems serving this equipment.

5.2 Liquid Effluents

Process liquid effluents are treated as described in Subpart 823.3.9 prior to discharge to the holding pond. Muffle box cooling water is discharged to the effluent pond, the output of which is monitored in accord with the requirements of Subpart 404.4.

LOW ENRICHED SCRAP RECOVERY
PERURANATE PROCESS EQUIPMENT
FLOW DIAGRAM

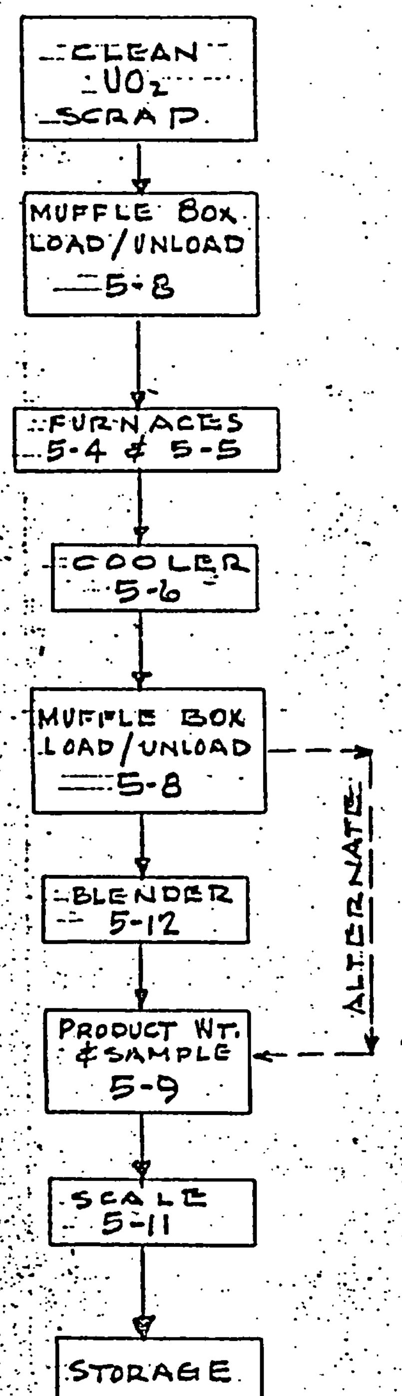


License: SNM-33 Docket: 70-36 Section: 800 Subsection/Subpart: 823

Subject: Sketch 823.3-I --Peruranate Process Flow Diagram Page 1 of 1

Issued: 3/30/72 Supersedes: 10/31/68 Approved:

LOW ENRICHED SCRAP RECOVERY
CLEAN PROCESS EQUIPMENT
FLOW DIAGRAM



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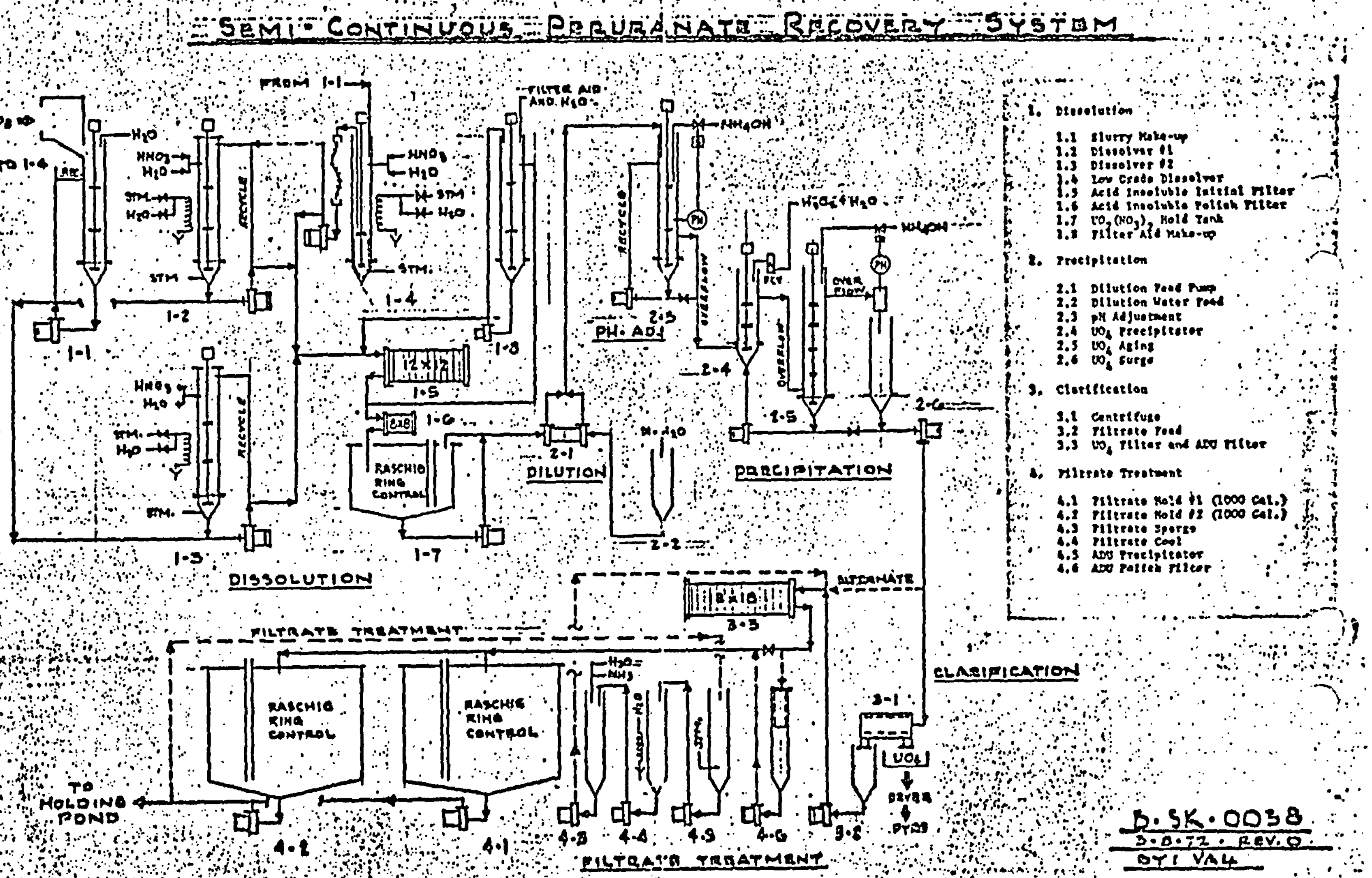
Subject: Sketch 823-II--Clean Process Flow Diagram Page 1 of 1

Issued: 3/30/72 Supersedes: 10/31/68 Approved:


SEMI-CONTINUOUS PERURANATE RECOVERY SYSTEM
1. Dissolution
1.1 Slurry Make-up
1.2 Dissolver #1
1.3 Dissolver #2
1.4 Low Grade Dissolver
1.5 Acid Insoluble Initial Filter
1.6 Acid Insoluble Polish Filter
1.7 $UO_2(NO_3)_2$ Hold Tank
1.8 Filter Aid Make-up
2. Precipitation
2.1 Dilution Feed Pump
2.2 Dilution Water Feed
2.3 pH Adjustment
2.4 UO_4 Precipitator
2.5 UO_4 Aging
2.6 UO_4 Surge
3. Clarification
3.1 Centrifuge
3.2 Filtrate Feed
3.3 UO_4 Filter and ADU Filter
4. Filtrate Treatment
4.1 Filtrate Hold #1 (1000 Gal.)
4.2 Filtrate Hold #2 (1000 Gal.)
4.3 Filtrate Sparge
4.4 Filtrate Cool
4.5 ADU Precipitator
4.6 ADU Polish Filter
DISSOLUTION
DILUTION
PH ADJ
PRECIPITATION
CLARIFICATION
FILTRATE TREATMENT
RASCHIG RING CONTROL
TO HOLDING POND
FROM 1-1
TO 1-4
FILTER AID AND H_2O
NH_4OH
HNO_3
H_2O
STM
RECYCLE
OVERFLOW
ALTERNATE
UO_4
DRYER
PYRO
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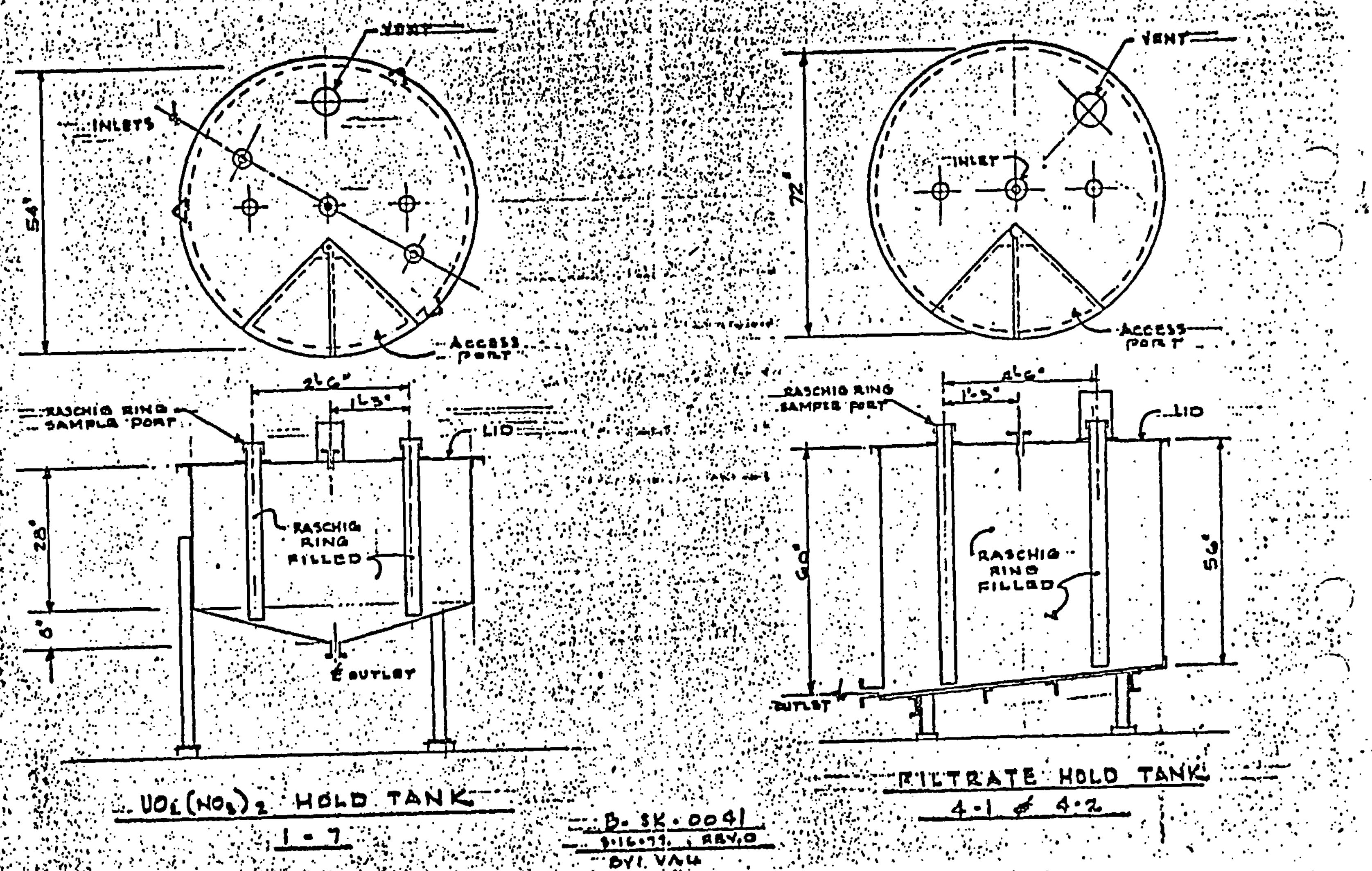
License: SNM-33 Docket: 70-36 Section: 800 Subsection/Subpart: 823

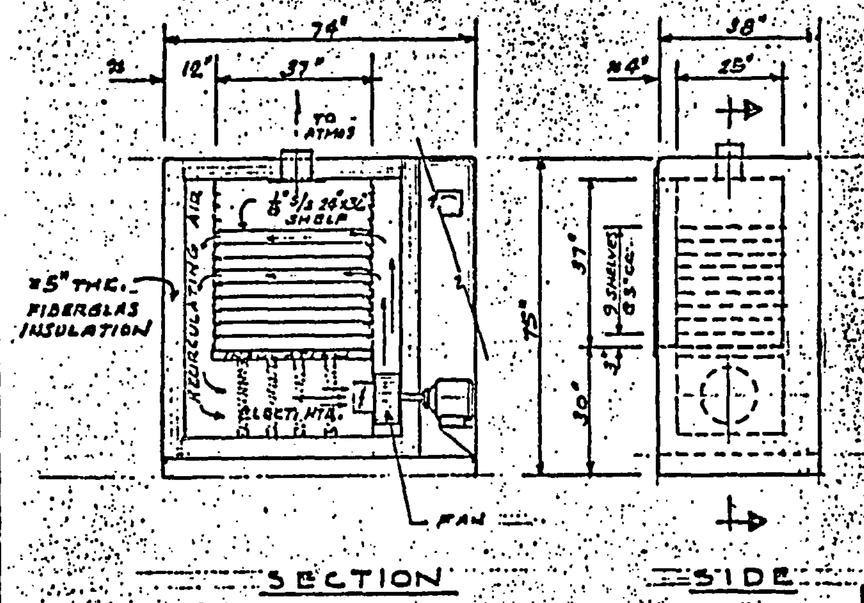
Subject: Sketch 823.3-IV--Hold Tank Details Page 1 of 1

Issued: 3/30/72 Supersedes: New Approved:



MATERIAL FOR COMPLETE ASSEMBLY

ITEM NO.	PART DESCRIPTION	NO. REQ'D	SOURCE



"PROPOSED ONLY"

DESPATCH OVEN CO.

MODEL: V29 SUPERDUTY
KW: 52
CONSTR'TN: 18 GA. STL. EXTERIOR
16 GA. S/S INTERIOR
TEMP.: 850°F

REV.	BY	DATE	APP'D.	DATE	JOB NO.	DESCRIPTION	W. O. NO.

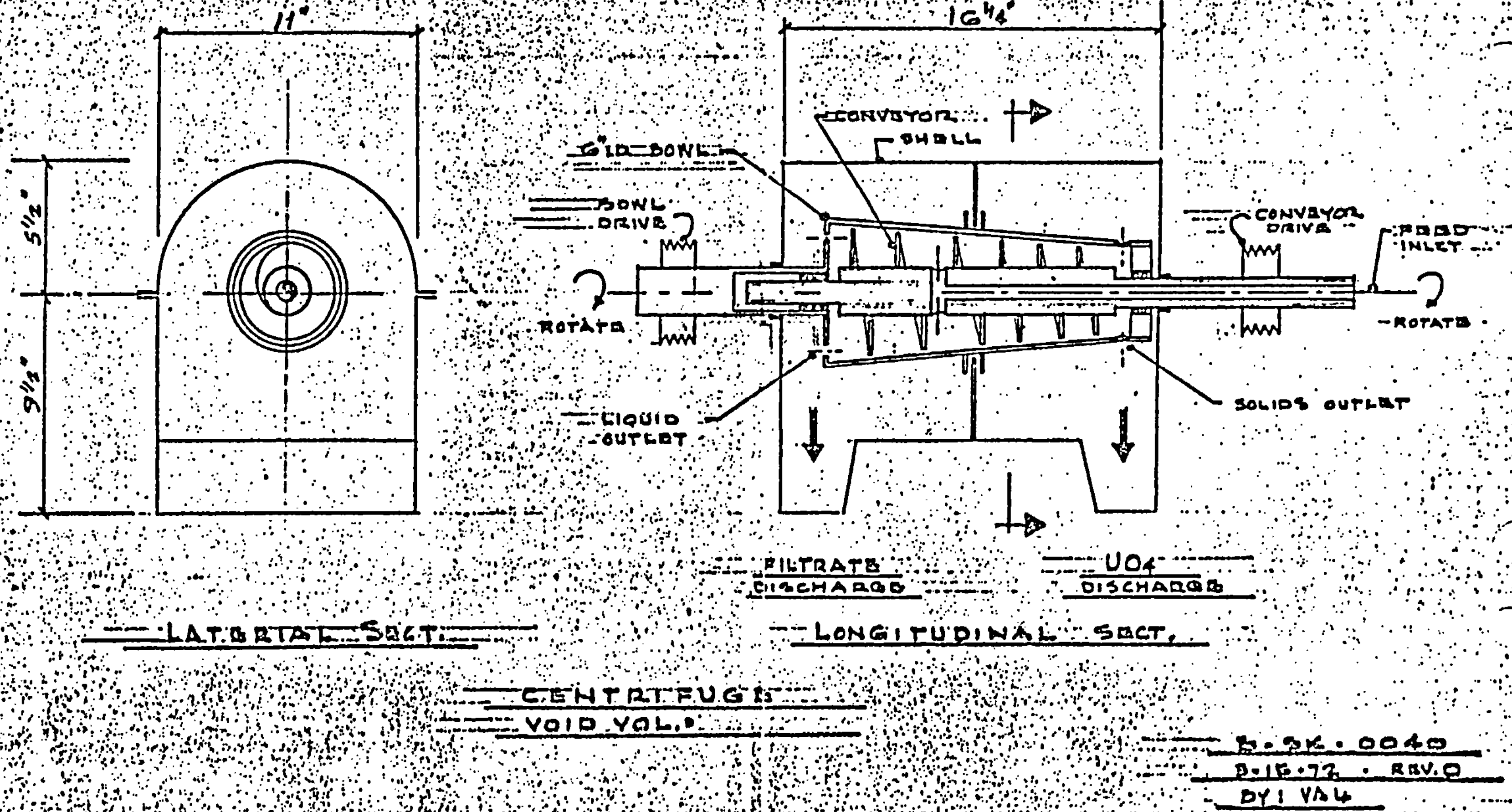
TOLERANCES UNLESS OTHERWISE SPECIFIED
FRACTIONAL ±
DECIMAL ±
ANGULAR ±
FINISH SYMBOL ASA B7.0

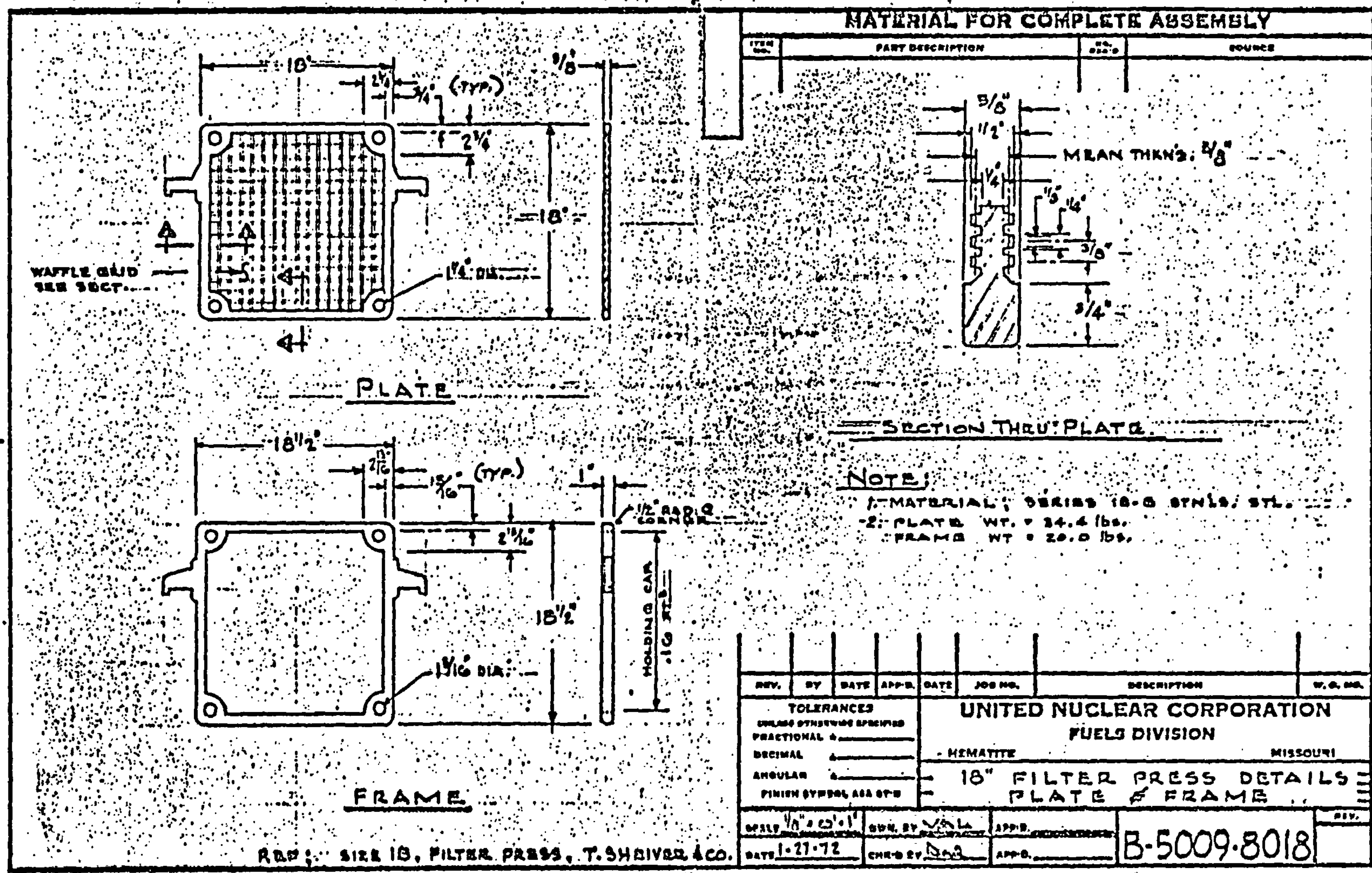
UNITED NUCLEAR CORPORATION
FUELS DIVISION
HEMATITE MISSOURI

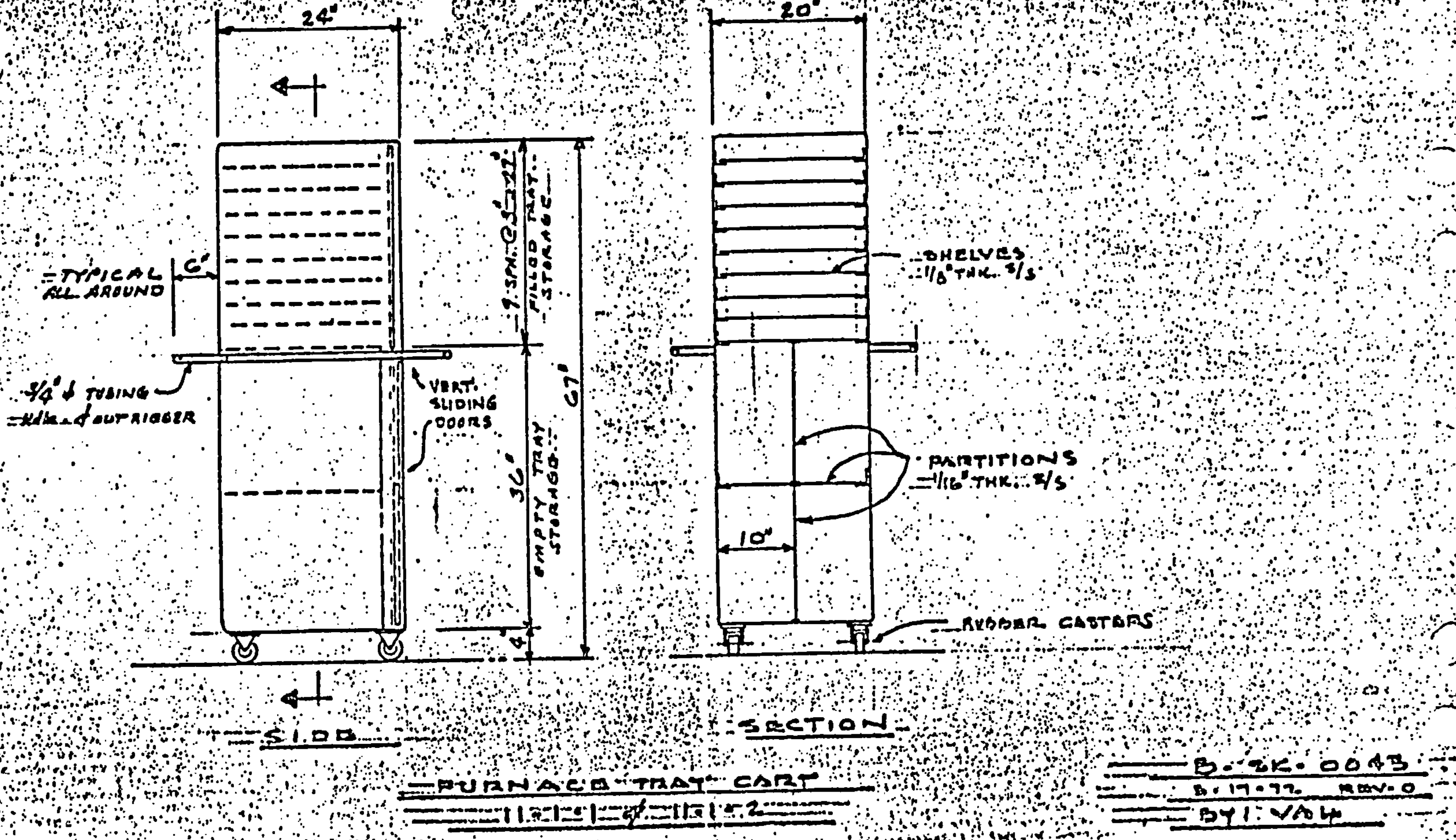
GREEN ROOM DRYER SPECIFICATIONS

SCALE 1/2" = 1'-0" DWN. BY VAL APP'D.
DATE 2-2-72 CHK'D BY [illegible] APP'D.

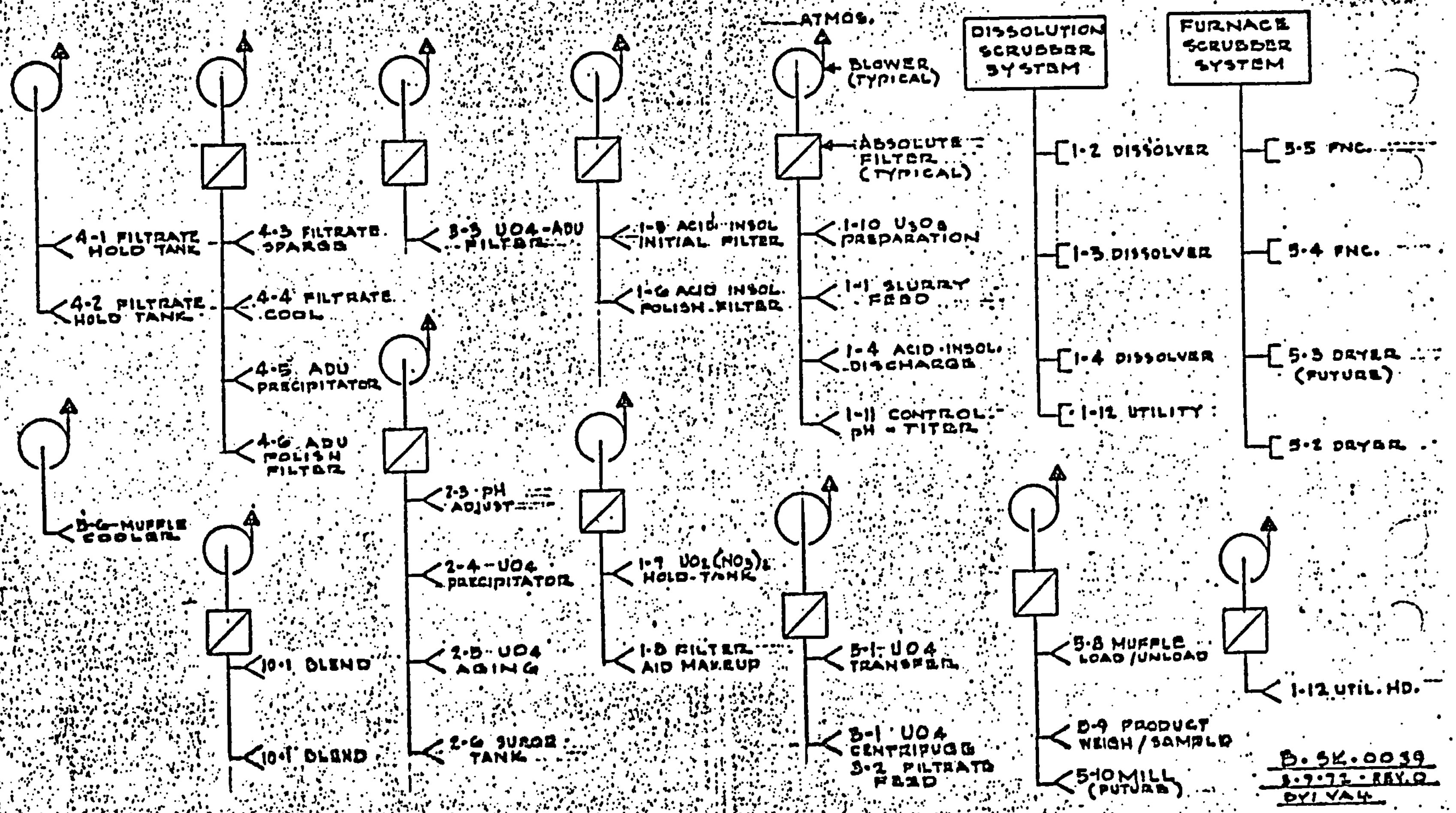
B-5009-8021 REV.


11"
5½"
9½"
16¼"
CONVEYOR
SHELL
6" ID BOWL
BOWL
DRIVE
CONVEYOR
DRIVE
FEED
INLET
ROTATE
ROTATE
SOLIDS OUTLET
LIQUID
OUTLET
FILTRATE
DISCHARGE
UO4
DISCHARGE
LATERAL SECT.
LONGITUDINAL SECT.
CENTRIFUGE
VOID VOL.
B-SK-0040
3-15-72 . REV.0
BY: VAL


MATERIAL FOR COMPLETE ASSEMBLY
PART DESCRIPTION
SOURCE
PLATE
SECTION THRU PLATE
MEAN THKN'S. 3/8"
FRAME
NOTE:
1. MATERIAL: SERIES 18-8 STNLS. STL.
2. PLATE WT. = 34.4 lbs.
FRAME WT = 20.0 lbs.
WAFFLE GRID SEE SECT.
1¼" DIA.
1 9/16" DIA.
1/2" RADIUS CORNER
HOLDING CAR
UNITED NUCLEAR CORPORATION
FUELS DIVISION
HEMATITE MISSOURI
18" FILTER PRESS DETAILS
PLATE & FRAME
TOLERANCES
FRACTIONAL
DECIMAL
ANGULAR
1-21-72
B-5009-8018
REF: SIZE 18, FILTER PRESS, T. SHRIVER & CO.


24"
20"
TYPICAL ALL AROUND
6"
3/4" ϕ TUBING
OUTRIGGER
VERT. SLIDING DOORS
FILLED TRAY STORAGE
EMPTY TRAY STORAGE
36"
67"
4"
SHELVES 1/8" THK. S/S
PARTITIONS 1/16" THK. S/S
10"
RUBBER CASTERS
SIDE
SECTION
FURNACE TRAY CART

VENTILATION CONTROL DIAGRAM - LOW ENRICHED SCRAP RECOVERY



I. DESCRIPTION

As can be seen from Dwg. D-509-2007, the centermost unit in the dissolver complex would be the Low Grade Dissolver 1-4.

II. INTERACTION CALCULATIONS

A. Contribution from Slurry Make-up Vessel 1-1

$d = 9'' = .75'$, $L \cong 7'$, $L/2 = 3.5'$, $h = 4.5'$

$\Omega_A = \frac{2d}{h} \sin\Theta = \frac{1.5}{4.5}(.614) = .167$ where $\tan\Theta = \frac{L/2}{h} = \frac{3.5}{4.5} = .78$, $\sin\Theta = .614$

B. Contribution from Dissolver 1-2

$d = 9'' = .75'$, $L \cong 7'$, $L/2 = 3.5'$, $h = 6'$

$\Omega_B = \frac{2d}{h} \sin\Theta = \frac{1.5}{6.0}(.50) = .096$ where $\tan\Theta = \frac{L/2}{h} = \frac{3.5}{6} = .58$, $\sin\Theta = .50$

C. Contribution from Dissolver 1-3

$d = 9'' = .75'$, $L \cong 7'$, $L/2 = 3.5'$, $h = 9.25'$

$\Omega_C = \frac{2d}{h} \sin\Theta = \frac{1.5}{9.25}(.353) = .044$ where $\tan\Theta = \frac{L/2}{h} = \frac{3.5}{9.25} = .378$, $\sin\Theta = .353$

D. Contribution from Acid Insoluble Initial Filter 1-5

$d = 18'' = 1.5'$, $L = 4'$, $L/2 = 2'$, $h = 8.25'$

$\Omega_D = \frac{2d}{h} \sin\Theta = \frac{3}{8.25}(.236) = .086$ where $\tan\Theta = \frac{L/2}{h} = \frac{2}{8.25} = .24$, $\sin\Theta = .236$

E. Contribution from Acid Insoluble Polish Filter 1-6

$d = .75'$, $L = 1'$, $L/2 = .5'$, $h = 14.25'$

$\Omega_E = \frac{2d}{h} \sin\Theta = \frac{1.5}{14.25}(.35) = .037$ where $\tan\Theta = \frac{L/2}{h} = \frac{.5}{14.25} = .35$, $\sin\Theta = .35$

F. Contribution from Utility Hood Vessel 1-12-1

$d = 9'' = .75'$, $L \cong 7'$, $L/2 = 3.5$, $h = 20.75$

$\Omega_F = \frac{2d}{h} \sin\Theta = \frac{1.5}{20.75}(.166) = .013$ where $\tan\Theta = \frac{L/2}{h} = \frac{3.5}{20.75} = .16$, $\sin\Theta = .166$

II. INTERACTION CALCULATIONS (continued)

G. Contribution from $UO_2(NO_3)_2$ Hold Tank 1-7

$d = 4.5'$, $L = 3'$, $L/2 = 1.5'$, $h = 9.75'$

$\Omega_G = \frac{2d}{h} \sin\Theta = \frac{9}{9.75}(.154) = .142$ where $\tan\Theta = \frac{L/2}{h} = \frac{1.5}{9.75} = .154$; $\sin\Theta = .154$

H. Contribution from 5-Gal Pail in Feed Prep Hood 1-10

$d = 11''$, $L = 13''$, $L/2 = 6.5''$, $h = 7' = 84''$

$\Omega_H = \frac{2d}{h} \sin\Theta = \frac{22}{84}(.077) = .020$ where $\tan\Theta = \frac{L/2}{h} = \frac{6.5''}{84''} = .077$; $\sin\Theta = .077$

I. Contribution From PH Adjustment Vessel 2-3

$d = .75'$; $L \cong 7'$, $L/2 = 3.5'$, $h = 14.25'$

$\Omega_I = \frac{2d}{h} \sin\Theta = \frac{1.5}{14.25}(.240) = .025$ where $\tan\Theta = \frac{L/2}{h} = \frac{3.5}{14.25} = .245$; $\sin\Theta = .240$

J. Contribution from UO_4 Precipitator 2-4

$d = .75'$, $L \cong 7'$, $L/2 = 3.5'$, $h = 18'$

$\Omega_J = \frac{2d}{h} \sin\Theta = \frac{1.5}{18}(.191) = .016$ where $\tan\Theta = \frac{L/2}{h} = \frac{3.5}{18} = .194$; $\sin\Theta = .191$

K. Contribution from UO_4 Aging Vessel 2-5

$d = .75$, $L \cong 7'$, $L/2 = 3.5$, $h = 22'$

$\Omega_K = \frac{2d}{h} \sin\Theta = \frac{1.5}{22}(.159) = .011$ where $\tan\Theta = \frac{L/2}{h} = \frac{3.5}{22} = .159$; $\sin\Theta = .159$

L. Contribution from UO_4 Surge Vessel 2-6

$d = .5$ (partially shielded), $L \cong 7'$, $L/2 = 3.5'$, $h = 26'$

$\Omega_L = \frac{2d}{h} \sin\Theta = \frac{1}{26}(.135) = .005$ where $\tan\Theta = \frac{L/2}{h} = \frac{3.5}{26} = .135$; $\sin\Theta = .135$

(NEGLECT)

M. Contribution from Filtrate Sparge Vessel 4-3

$d = .75'$, $L \cong 7'$, $L/2 = 3.5$, $h = 16.25'$

$\Omega_M = \frac{2d}{h} \sin\Theta = \frac{1.5}{16.25}(.210) = .019$ where $\tan\Theta = \frac{L/2}{h} = \frac{3.5}{16.25} = .215$; $\sin\Theta = .210$

II. INTERACTION CALCULATIONS (continued)

N. Contribution from F[illegible] Cool Vessel 4-4

$d = .75'$, $L \cong 7'$, $L/2 = 3.5'$, $h = 19.5'$

$\Omega_N = \frac{2d}{h} \sin\Theta = \frac{1.5}{19.5}(.177) = .014$ where $\tan\Theta = \frac{L/2}{h} = \frac{3.5}{19.5} = .18$, $\sin\Theta = .177$

O. Contribution from ADU Precipitator 4-5

$d = .75'$, $L \cong 7'$, $L/2 = 3.5'$, $h = 23.25'$

$\Omega_O = \frac{2d}{h} \sin\Theta = \frac{1.5}{23.25}(.147) = .009$ where $\tan\Theta = \frac{L/2}{h} = \frac{3.5}{23.25} = .149$, $\sin\Theta = .147$

P. Contribution from Filtrate Hold Tank 4-2

$d = 72'' = 6'$, $L = 60'' = 5'$, $L/2 = 2.5'$, $h = 22.5'$

$\Omega_P = \frac{2d}{h} \sin\Theta = \frac{12}{22.5}(.11) = .059$ where $\tan\Theta = \frac{L/2}{h} = \frac{2.5'}{22.5} = .111$, $\sin\Theta = .11$

Q. Contribution from Filtrate Hold Tank 4-1

$d = 6'$, $L = 5'$, $L/2 = 2.5'$, $h = 28'$

$\Omega_Q = \frac{2d}{h} \sin\Theta = \frac{12}{28}(.088) = .038$ where $\tan\Theta = \frac{L/2}{h} = \frac{2.5}{28} = .089$, $\sin\Theta = .088$

R. Contribution from UO_4-ADU Filter 3-3

$d = 18'' = 1.5'$, L = diagonal $\cong 2'$, $L/2 = 1'$, $h = 18'$

$\Omega_R = \frac{2d}{h} \sin\Theta = \frac{3}{18}(.055) = .009$ where $\tan\Theta = \frac{L/2}{h} = \frac{1}{18} = .056$, $\sin\Theta = .055$

S. Contribution from Muffle Box at Transfer Hood 5-1

$d = 21'' = 1.75'$, L = diagonal $\cong 5'$, $L/2 = 2.5'$, $h = 19'$

$\Omega_S = \frac{2d}{h} \sin\Theta = \frac{3.5}{19}(.13) = .024$ where $\tan\Theta = \frac{L/2}{h} = \frac{2.5}{19} = .131$, $\sin\Theta = .13$

T. Contribution from Furnace Tray Cart 1-11 in Aisle

$d = 24'' = 2'$, $L = 20''$, $L/2 = 10'' = .83'$, $h \cong 10'$

$\Omega_T = \frac{2d}{h} \sin\Theta = \frac{4}{10}(.083) = .033$ where $\tan\Theta = \frac{L/2}{h} = \frac{.83}{10} = .083$, $\sin\Theta = .083$

II. INTERACTION CALCULATIONS (continued)

U. Contribution from Surrounding Equipment not Specifically Analyzed

$\Omega_U = .5$ (assumed)

V. Total Interaction

$$\Omega_V = \Sigma\, \Omega_A + \cdots + \Omega_U = 1.352 \text{ steradians}$$

III. K-EFF of Low Grade Dissolver 1-4

The Low Grade Dissolver 1-4 has the follow dimensions

$r = 4.5'' = 11.4$ cm, $L = 84'' = 213$ cm

Using Eqn. (7), NDEO-1050, the geometric buckling is

$$B_g^2 = \left(\frac{2.405}{r+\delta}\right)^2 + \left(\frac{\pi}{L+2\delta}\right)^2 = .0281 \text{ cm}^{-2}$$

Where δ (bare) = 3 cm, DP-532

The infinite multiplication factor and migration area at optimum moderation ($V_{H_2O}/V_{UO_2} \cong 3.75$) are

$k_\infty = 1.4$, Fig. 1, NEDO-1137

$M^2 \cong 35$ cm, Fig. 2, NEDO-1137

Using Eqn. (3), NDEO-1050, the effective multiplication factor is

$$k_{eff} = \frac{k_\infty}{1 + M^2 B_g^2} = .706$$

IV. ALLOWABLE INTERACTION

The allowable interaction is

$\Omega_A = 9 - 10K = 1.94$ steradians

V. CONCLUSIONS

Since the total interaction is less than the allowable interaction, the equipment arrangement is nuclearly safe.

License: SNM-33 Docket: 70-36 Section: 800 Subsection/Subpart: 823.4

Subject: Nuclear Safety Evaluation - Interaction Calculations - Low Grade Dissolver 1-4

Issued: 3/30/72 Supersedes: New Approved:

I. DESCRIPTION

As can be seen from Dwg. D-509-2007, the centermost unit in the UO_4-filtrate complex would be the UO_4 Aging Vessel 2-5

II. INTERACTION CALCULATIONS

A. Contribution from UO_4 Precipitator 2-4

$d = 9'' = .75'$, $L \cong 7'$, $L/2 = 3.5'$, $h = 3.5'$

$\Omega_A = \frac{2d}{h} \sin\theta = \frac{1.5}{3.5}(.707) = .303$ where $\tan\theta = \frac{L/2}{h} = \frac{3.5}{3.5} = 1$, $\sin\theta = .707$

B. Contribution from UO_4 Slurry Vessel

$\Omega_B = \Omega_A = .303$

C. Contribution from Filtrate Sparge Vessel 4-3

$d = .75'$, $L \cong 7'$, $L/2 = 3.5'$, $h = 9'$

$\Omega_C = \frac{2d}{h} \sin\theta = \frac{1.5}{9}(.39) = .065$ where $\tan\theta = \frac{3.5}{9} = .39$, $\sin\theta = .36$

D. Contribution from Filtrate Cool Vessel 4-4

$d = .75'$, $L \cong 7'$, $L/2 = 3.5'$, $h = 6'$

$\Omega_D = \frac{2d}{h} \sin\theta = \frac{1.5}{6}(.50) = .125$ where $\tan\theta = \frac{3.5}{6} = .58$, $\sin\theta = .50$

E. Contribution from ADU Precipitator 4-5

$d = .75'$, $L \cong 7'$, $L/2 = 3.5'$, $h = 4.5'$

$\Omega_E = \frac{2d}{h} \sin\theta = \frac{1.5}{4.5}(.61) = .203$ where $\tan\theta = \frac{3.5}{4.5} = .78$, $\sin\theta = .61$

F. Contribution from Impure ADU Polish Filter 4-6

$d = .75'$, $L \cong 7'$, $L/2 = 3.5'$, $h = 6.5'$

$\Omega_F = \frac{2d}{h} \sin\theta = \frac{1.5}{6.5}(.48) = .111$ where $\tan\theta = \frac{3.5}{6.5} = .54$, $\sin\theta = .48$

G. Contribution from Filtrate Hold Tank 4-1

$d = 72'' = 6'$, $L = 60'' = 5'$, $L/2 = 2.5'$, $h = 11.5'$

$\Omega_G = \frac{2d}{h} \sin\theta = \frac{12}{11.5}(.213) = .221$ where $\tan\theta = \frac{L/2}{h} = \frac{2.5}{11.5} = .218$, $\sin\theta = .213$

1.323

License: SNM-33 Docket: 70-36 Section: 800 Subsection/Subpart: 823.4

Subject: Nuclear Safety Evaluation - Interaction Calculations - UO_4 Aging Vessel 2-5

Issued: 3/30/72 Supersedes: New Approved:

II. INTERACTION CALCULATIONS (continued)

H. Contribution from Filtrate Hold Tank 4-2

$\Omega_H = \Omega_G = .221$

I. Contribution from Filtrate Feed Vessel 3-2

$d = .75'$, $L = 7'$, $L/2 = 3.5'$, $h = 8.25'$

$\Omega_I = \frac{2d}{h} \sin\Theta = \frac{1.5}{8.25}(.39) = .072$ where $\tan\Theta = \frac{L/2}{h} = \frac{3.5}{8.25} = .424$, $\sin\Theta = .39$

J. Contribution from UO_4-ADU Filter Press 3-3

$d = 18'' = 1.5'$, $L = 4.25'$, $L/2 = 2.13'$, $h \cong 7'$

$\Omega_J = \frac{2d}{h} \sin\Theta = \frac{3.0}{7}(.290) = .124$ where $\tan\Theta = \frac{L/2}{h} = \frac{2.13}{7} = .304$, $\sin\Theta = .290$

K. Contribution from Surrounding Equipment

All other equipment is greater than 10' away and partially shielded, or is completely shielded. Therefore, their contribution is neglected

L. Total Interaction

$\Omega_L = \Sigma\, \Omega_A + \cdots + \Omega_K = 1.740$ steradians

III. K-EFF OF UO_4 AGING VESSEL 2-5

The k-eff is the same as for the Low Grade Dissolver 1-4 since they are the same size and type vessels

$k_{eff} = .707$

IV. ALLOWABLE INTERACTION

The allowable interaction is

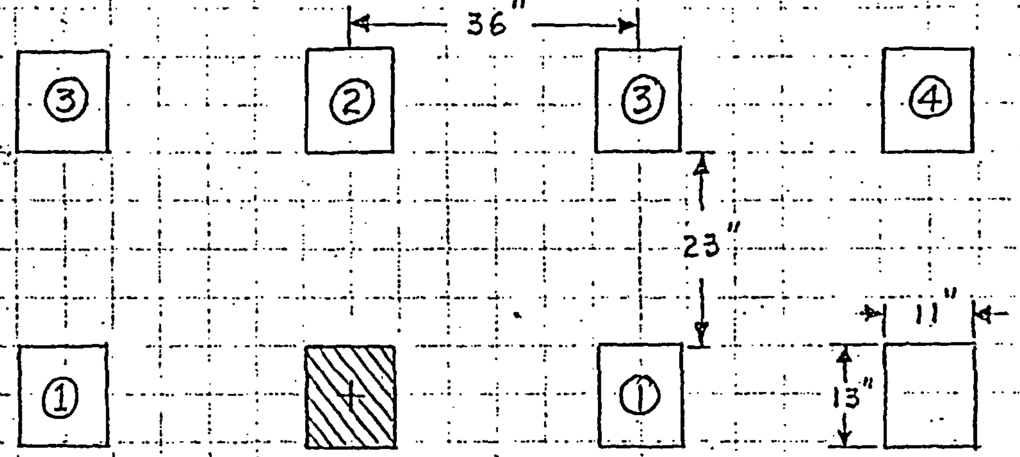
$\Omega_A = 9 - 10K = 1.94$ steradians

V. CONCLUSIONS

Since the total interaction is less than the allowable interaction, the equipment arrangement is nuclearly safe.

INTERACTION CALCULATION

FIVE GALLON PAILS ON 3' CENTERS HORIZONTALLY AND VERTICALLY, TWO PAILS IN HEIGHT.



1. INTERACTION WITH OTHER UNITS IN ARRAY

A. UNITS ON EITHER SIDE:

$d = 11"$ $h = 36" - 5.5" = 30.5"$ $\tan\theta = \frac{6.5}{30.5} = 0.213$

$\sin\theta = 0.208$

$\Omega_1 = \frac{2d}{h}\sin\theta = \frac{22}{30.5}(0.208) = 0.150$ STERAD.

FOR 2 UNITS $2\Omega_1 = $ 0.300 STERADIANS

B. UNIT ABOVE:

$r = 5.5"$ $h = 24" + 6.5" = 30.5"$ $\tan\theta = \frac{5.5}{30.5} = 0.180$

$\cos\theta = 0.984$

$\Omega_2 = 2\pi(1 - \cos\theta) = 6.28(1 - 0.984) = $ 0.101 STERADIANS

C. DIAGONAL UNITS #3

$h = \sqrt{30.5^2 + 29.5^2} = 42.5"$ (TO NEAREST POINT)

$d = 11"$ $L = \sqrt{11^2 + 13^2} = 17.0"$ $\tan\theta = \frac{8.5}{42.5} = 0.200$

$\sin\theta = 0.196$

$\Omega_3 = \frac{2d}{h}\sin\theta = \frac{22}{42.5}(0.196) = 0.101$ STERAD.

$2\Omega_3 = $ 0.202 STERADIANS

D. DIAGONAL UNIT #4

$$h = \sqrt{29.5^2 + 66.5^2} = 70.5''$$

$d = 11''$, $L = 17.0''$

$\tan\theta = \frac{8.5}{70.5} = 0.120$

$\sin\theta = 0.119$

$$\Omega_4 = \frac{2d}{h}\sin\theta = \frac{22}{70.5}(0.119)$$

$$= \underline{0.037 \text{ STERADIANS}}$$

2. TOTAL INTERACTION WITH UNITS IN ARRAY

$$\Omega_T = 2\Omega_1 + \Omega_2 + 2\Omega_3 + \Omega_4 = 0.300 + 0.101 + 0.202 + 0.037$$

$$= \underline{\underline{0.640 \text{ STERADIANS}}}$$

3. ALLOWABLE INTERACTION

FIVE GALLON PAILS HAVE THE FOLLOWING DIMENSIONS

$r = \frac{11''}{2}(2.54\ cm/in) = 14.0\ cm$. $h = 13''(2.54\ cm/in) = 33.0\ cm$.

FROM EQ.(7), NDEO-1050, THE GEOMETRIC BUCKLING IS

$\delta(bare) = 3.0\ cm$ (REF. DP-532)

$$B_g^2 = \frac{J_0^2}{(r+\delta)^2} + \frac{\pi^2}{(h+2\delta)^2} = \frac{2.405^2}{(14.0+3.0)^2} + \frac{9.89}{(33.0+6.0)^2}$$

$$= \frac{5.78}{289} + \frac{9.89}{1520} = 0.0200 + 0.0065 = 0.0265\ cm^{-2}$$

USING EQ.(3), NDEO-1050

$k_\infty = 1.36$ ($V_{H_2O}/V_{UO_2} \cong 3.75$) FIG. 1, NDEO-1137 (MOST REACTIVE CASE)

$M^2 = 30\ cm^2$ ($V_{H_2O}/V_{UO_2} \cong 3.75$) FIG. 2, NDEO-1137

$$k_{eff} = \frac{k_\infty}{1 + M^2 B_g^2} = \frac{1.36}{1 + (30 \times 0.0265)} = 0.76$$

THEREFORE, $\Omega_p = 9 - 10k = 9 - 7.6 = \underline{1.4 \text{ STERADIANS}}$

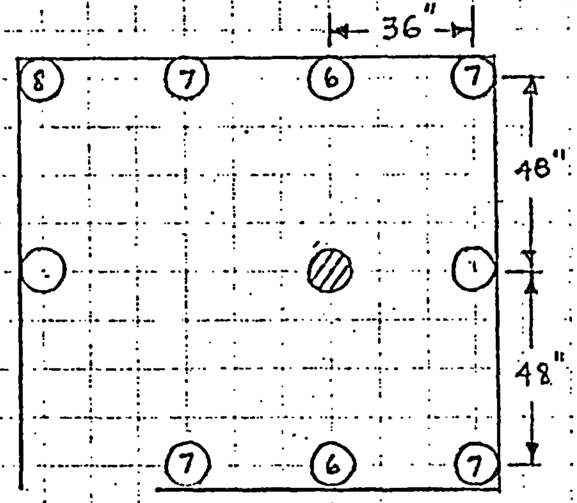
License: SNM-33 Docket: 70-36 Section: 800 Subsection/Subpart: 823.4

Subject: Nuclear Safety Evaluation - Interaction Calculations Inprocess Storage

Issued: 3/30/72 Supersedes: New Approved:

INTERACTION CALCULATIONS

FIVE GALLON PAILS IN STORAGE AREA. PAILS IN EACH ROW ON 3' CENTE HORIZONTAL AND VERTICAL, TWO PAILS HIGH. ROWS SPACED ON 4' CENTER FROM OTHER ROWS.



CALCULATED FOR CENTERMOST UNIT (CROSSHATCHED)

1. INTERACTION WITH OTHER UNITS IN ROW

FROM INTERACTION CALCULATIONS FOR IN-PROCESS STORAGE

$$\Omega_T = 1\Omega_1 + \Omega_2 + 1\Omega_3 + \Omega_4 + \Omega_5$$ (HIDDEN BY UNIT *3 FROM REF. CALCS)

INTERACTION FOR UNIT *5

$d = 11"$ $L = 13"$ $h = 66.5"$

$\tan\theta = \frac{6.5}{66.5} = 0.098$

$\sin\theta = 0.097$

$$\Omega_5 = \frac{2d}{h}\sin\theta = \frac{11}{66.5}(0.097) = \underline{0.017} \text{ STERADIANS}$$

$$\therefore \Omega_{TR} = 0.150 + 0.101 + 0.101 + 0.037 + 0.017$$
$$= \underline{\underline{0.406}} \text{ STERADIANS}$$

2. INTERACTION WITH UNITS IN OPPOSING ROWS

FOR SIMPLICITY OF CALCULATION, UNITS IN OPPOSING ROWS ARE CONSIDERED AS A SINGLE CYLINDER OF HEIGHT THE SUM OF THE HEIGHT OF A DRUM PLUS THE DIAGONAL DIMENSION OF THE SECOND DRUM. SEPARATION WILL BE THE CLOSEST STRAIGHT LINE DISTANCE BETWEEN THE UNITS.

A. UNITS #6

$h = (48 - 5.5) = 42.5''$ $d = 11''$ $\tan\theta = \frac{15}{42.5} = 0.353$

$L = 13.0'' + 17.0'' = 30''$ $\sin\theta = 0.333$

$$\Omega_6 = \frac{2d}{h}\sin\theta = \frac{11}{42.5}(0.333) = 0.086 \text{ STERAD}$$

$$2\Omega_6 = \underline{0.172 \text{ STERADIANS}}$$

B. UNITS #7

$h = \sqrt{42.5^2 + 30.5^2} = 52.3''$ $d = 11''$ $L = 30''$ $\tan\theta = \frac{15}{52.3} = 0.287$

$\sin\theta = 0.276$

$$\Omega_7 = \frac{2d}{h}\sin\theta = \frac{11}{52.3}(0.276) = 0.058$$

$$4\Omega_7 = \underline{0.232 \text{ STERADIANS}}$$

C. UNIT #8

$h = \sqrt{42.5^2 + 66.5^2} = 79.0''$ $d = 11''$ $L = 30''$ $\tan\theta = \frac{15}{79} = 0.190$

$\sin\theta = 0.187$

$$\Omega_8 = \frac{2d}{h}\sin\theta = \frac{11}{79}(0.187) = \underline{0.026 \text{ STERADIANS}}$$

D. TOTAL INTERACTION WITH OPPOSING ROWS

$$\Omega_{T01} = 2\Omega_6 + 4\Omega_7 + \Omega_8 = 0.172 + 0.232 + 0.026$$
$$= \underline{\underline{0.430 \text{ STERADIANS}}}$$

INTERACTION CALCULATIONS (CONTD)

3. TOTAL INTERACTION FOR CENTERMOST UNIT.

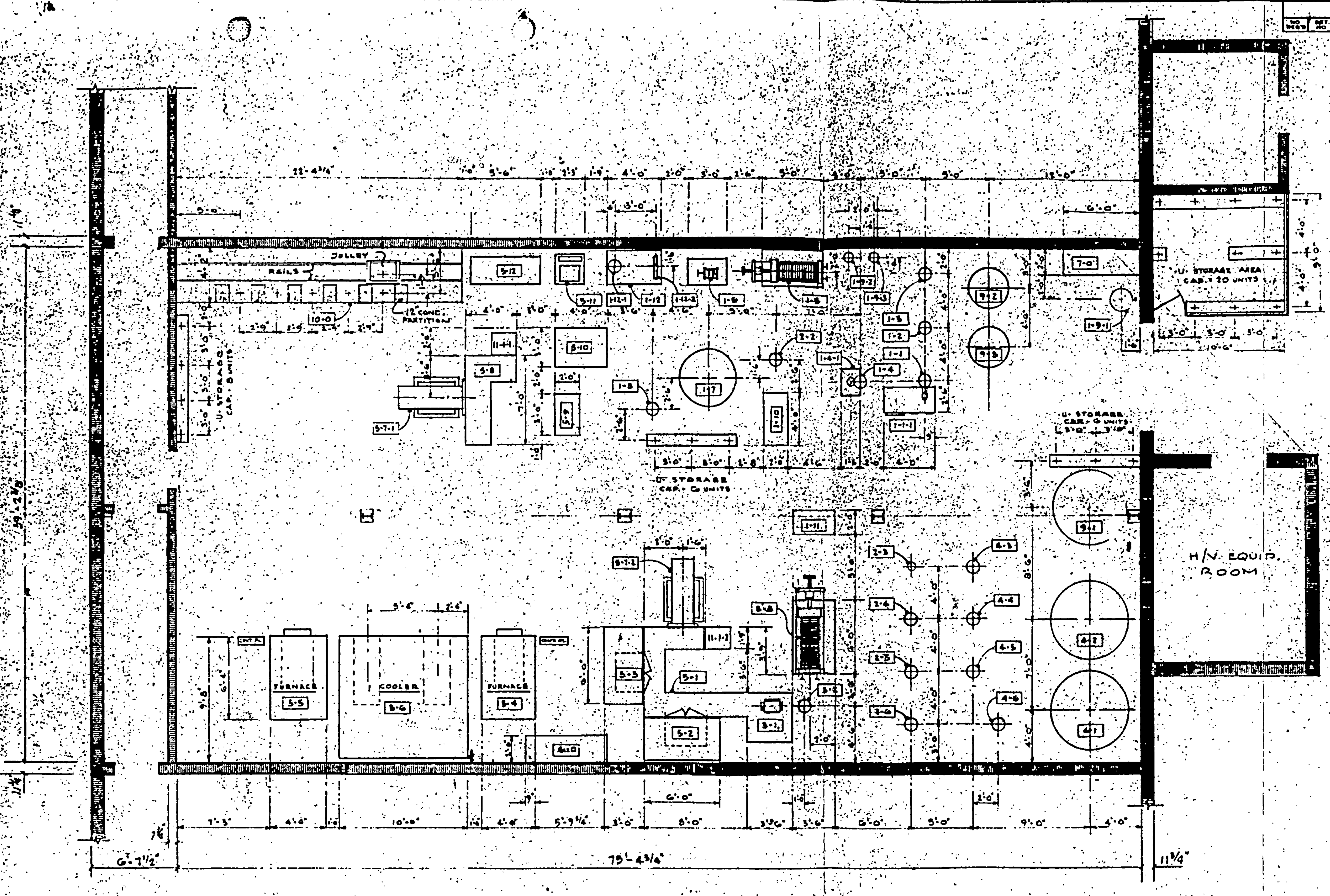
$$\Omega_T = \Omega_{TR} + \Omega_{TO} = 0.406 + 0.430$$

$$= \underline{0.836 \text{ STERADIANS}}$$

4. PERMISSIBLE INTERACTION

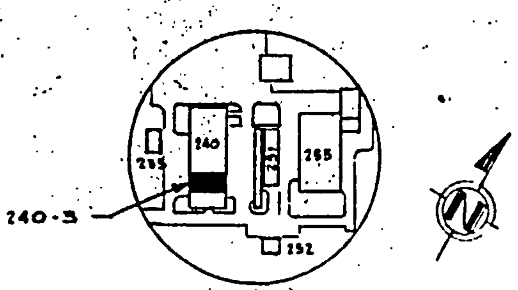
FROM INTERACTION CALCULATIONS FOR IN-PROCESS STORAGE

$k_{eff} = 0.76$ $\Omega_p = \underline{1.4 \text{ STERADIANS}}$



EQUIPMENT ARRANGEMENT
SCALE 1/8" = 1'-0"

BLDG. 240-3
DEPT. 509



PLOT PLAN

MATERIAL FOR COMPLETE ASSEMBLY

NO. REQ'D	DET. NO.	DWG. NO.	NAME OF PART	STOCK SIZE & MATERIAL

LEGEND

Equip. No.	Description	Reference
1-1	Slurry Make up	
1-1-1	Slurry Feed Hood	
1-2	Dissolver #1	
1-3	Dissolver #2	
1-4	Low Grade Dissolver	
1-4-2	Acid Insoluble Discharge Hood	
1-5	Acid Insoluble Initial Filter	B-5009-8019
1-6	Acid Insoluble Polish Filter	B-5009-8020
1-7	$UO_2(NO_3)_2$ Hold Tank	
1-8	Filter-aid Make up	
1-9-1	Nitric Acid Bulk Storage	
1-9-2	Water Feed	
1-9-3	Nitric Acid Feed	
1-10	Feed Preparation Hood	
1-11	Analytical Control Hood	
1-12	Utility Hood	
2-2	Dilution Water Feed	
2-3	pH Adjustment	
2-4	UO_4 Precipitator	
2-5	UO_4 Aging	
2-6	UO_4 Surge	
3-1	Centrifuge	B-SK-0040
3-2	Filtrate Feed	
3-3	UO_4-ADU Filter	B-5009-8018
4-1	Filtrate Hold #1	
4-2	Filtrate Hold #2	
4-3	Filtrate Sparge	
4-4	Filtrate Cool.	
4-5	ADU Precipitator	
4-6	Impure ADU Polish Filter	
5-1	Transfer Hood	
5-2	Dryer	B-5009-8021
5-3	Dryer	B-5009-8021
5-4	Furnace	W.Hee. E. 329-7250,
5-5	Furnace	44A-4498 & 48-A-6698
5-6	Cooler	
5-7	Muffle Box	3229-124 & C-5009-8017
5-8	Muffle Box Loading & Unloading Hood	
5-9	Product Weigh & Sample Hood	
5-10	Mill Hood	
5-11	Scale	
5-12	Blender (5 Gal. Pail)	
6-0	Furnace Scrubber System	
7-0	Dissolution Scrubber System	
8-0	Ventilation Control Diagram	B-SK-0039
9-1	Deionized Water Storage	
9-2	Ammonium Hydroxide Make up	
9-3	Hydrogen Peroxide Make up	
10-0	Cross Blending Hood	
11-1-1	Furnace Tray Cart	B-SK-0043
11-1-2	Furnace Tray Cart	B-SK-0043
1-12-1	Filter Leech	
1-12-2	Tray Cleaning	

REV	DATE	REVISION	BY	DATE	APP'D	DATE

APPROVED BY SIGN	DATE
[signature]	3/17/72
[signature]	3/17/72
[signature]	3/17/72
[signature]	3/17/72

GEOMETRIC SYMBOLS MIL-STD-8: FLATNESS, STRAIGHTNESS, ANGULARITY, PERPENDICULARITY, PARALLELISM, ROUND, CONCENTRICITY, TRUE POSITION

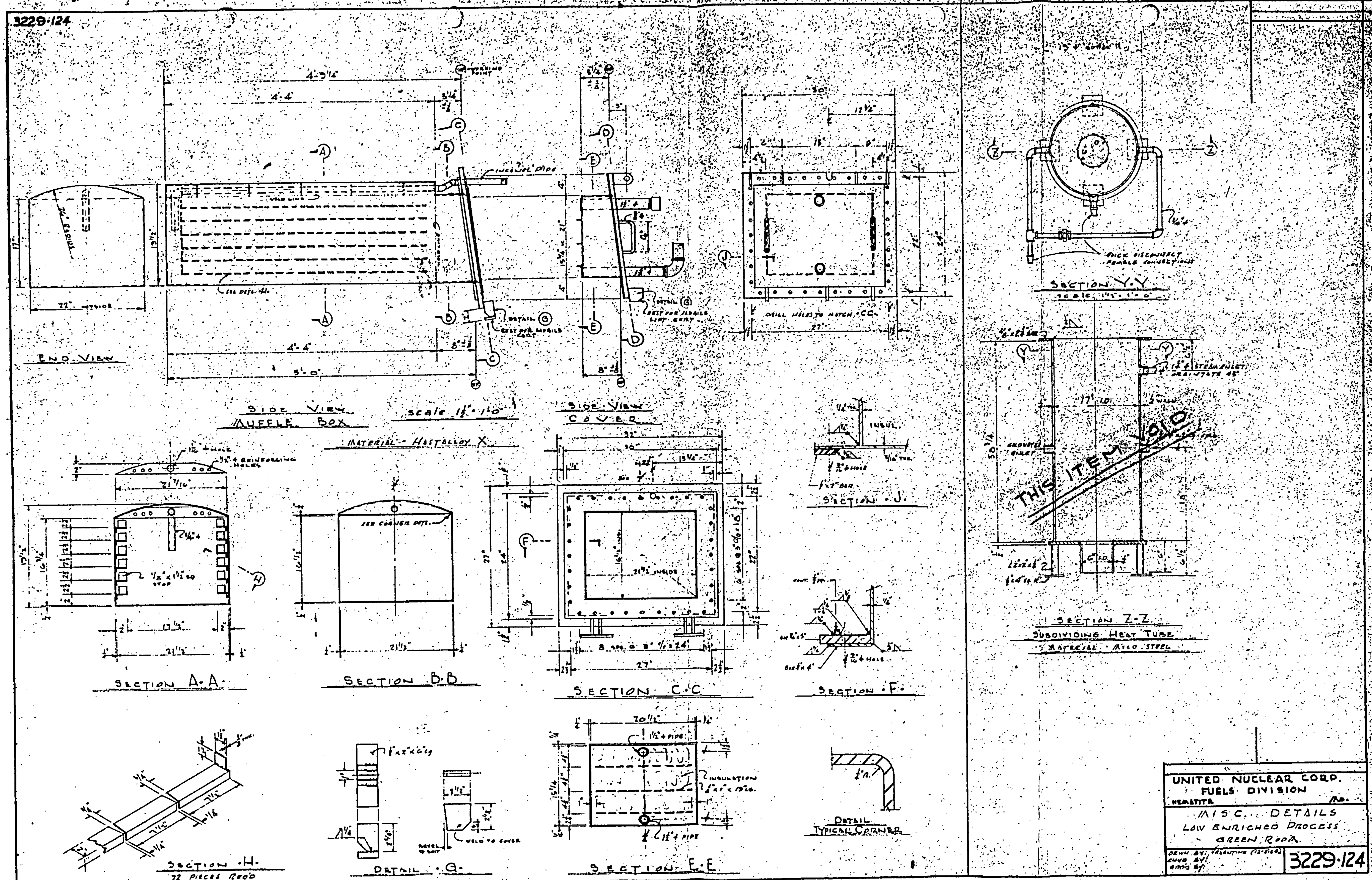
TOLERANCES UNLESS OTHERWISE SPECIFIED: FRACTIONAL ±, DECIMAL .XXX ±, .XXXX ±, ANGULAR ±, SURFACE FINISH

SCALE 1/8" = 1'-0"
DRAWN BY V.A.L. DATE 3-15-72
CHECKED BY [signature] DATE 3-17-72
APPROVED BY [signature] DATE 3-17-72

UNITED NUCLEAR CORPORATION
COMMERCIAL PRODUCTS DIVISION

LOW ENRICHED SCRAP RECOVERY PROCESS
EQUIPMENT ARRANGEMENT

D-509-2007



3229-124
END VIEW
SIDE VIEW
MUFFLE BOX
SCALE 1½" = 1'-0"
MATERIAL - HASTALLOY X
SIDE VIEW
COVER
SECTION Y-Y
SECTION J
THIS ITEM VOID
SECTION A-A
SECTION B-B
SECTION C-C
SECTION F
SECTION Z-Z
SUBDIVIDING HEAT TUBE
MATERIAL - MILD STEEL
SECTION H
72 PIECES REQ'D
DETAIL G
SECTION E-E
DETAIL
TYPICAL CORNER
UNITED NUCLEAR CORP.
FUELS DIVISION
HEMATITE
MISC. DETAILS
LOW ENRICHED PROCESS
GREEN ROOM
3229-124

GULF UNITED
NUCLEAR FUELS CORPORATION

INTER-OFFICE MEMO

NED-1759

TO R. Kropp AT DATE March 31, 1972

FROM E. Fass AT COPY TO

SUBJECT Criticality Safety Analysis of the Gulf United Green Room Process Equipment (7801-012)

1.0 Summary and Conclusions

An analysis has been performed to determine the criticality safety of three pieces of process equipment in the Green Room at the Gulf United Hematite plant. The three pieces of equipment examined were: 1) the 18" filter press, 2) the proposed drying ovens, and 3) the muffle boxes and furnace. The uranium enrichment in each step in this process was fixed at a maximum 5 w/o U^{235}.

The analyses of the filter press and drying ovens considered a full swing of water content in the uranium product. For both these pieces of equipment the calculated k_{eff} was less than 0.900 and are therefore considered safe.

For normal operations with the muffle boxes and furnace, the calculated effective multiplication factors were less than 0.900 and therefore these pieces of equipment are safe. The muffle box process was also examined for varying amounts of excess water in the product as was done in the case of the filter press and drying ovens. The maximum multiplication of the muffle boxes was 0.958 ± 0.011 and the furnace was 0.955 ± 0.012, at the 95% confidence interval. Although these calculated values of k_{eff} are greater than 0.900 the process is considered safe from a criticality accident because of the confidence in the computing technique used and the high degree of conservatism used in modeling the problems. For example, a more realistic representation of the U^{238} resonance integral used in the muffle box analysis at the peak in its reactivity curve reduced the maximum k_{eff} from 0.958 ± 0.011 to 0.914 ± 0.011.

2.0 Description of the Process Equipment

The filter press consists of a linear array of alternating stainless steel plates and frames.(1) The plates are 18" square in cross section and 5/8" thick. The face on each side of the plate is a recessed "waffle" grid 16 1/2" square with a mean thickness of 3/8". The frame has an outer square dimension of 18 1/2" and a 1" thickness, the inner section of the frame is a void of 16 5/8" square dimension. The plates and frames can be stacked alternately until a maximum linear dimension of 40" is reached which is the limit of the 18" filter press. The array is secured at both ends by steel plates of an estimated mean thickness of 2". The wet uranium product is collected in the frames between opposing faces of the neighboring plates.

When operations with the filter press are complete, the frames and plates are separated and the wet product is put into trays(2) of either 18 gage stainless steel or Inconel. The inside dimensions of the trays are 21"x 16'x 1 1/2".

A maximum of 18 such trays are loaded into a Despatch model V29 drying oven(3) to drive off free water from the product. The trays are loaded onto shelves of 1/8" stainless steel, two to a shelf. It is not physically possible to stack two trays vertically on any shelf other than the top. The vertical spacing of the shelves is 3" and nine shelves are used to provide the space for 18 trays. This inner portion of the oven is constructed of a 37" x 39" x 25" 16 gage steel shell. This is contained within an outer 18 gage shell with overall dimensions of 74" x 75" x 38", the inner surface of this outer shell is lined with 5" thick fiberglas insulation.

After the product is dried in the ovens, the trays are removed and placed in the muffle boxes(4). Each box can hold 3 trays in line on each of 7 shelves giving a maximum of 21 trays. The vertical spacing between shelves is approximately 2 1/2" and the outer shell of the box is made of 1/4" thick Hastelloy X. The overall outer dimensions of the muffle box are 60" x 19 1/2" x 22". The boxes are supported on stands which keep the boxes 42" above the floor.

To reduce the product to its final chemical form, UO_2, a single box is loaded into the furnace(5) and fired. In the furnace the box is exposed to heating coils and surrounded by insulating and supporting brick. The neutron reflective properties of the furnace walls were treated in a conservative approach by replacing the walls with tight fitting water reflectors around the muffle box.

3.0 Method of Analysis

Reactivity levels for the filter press were calculated using the DTF[6] code. The 16 group Hansen-Roach cross sections [7] were used and linear anisotropic hydrogen scattering was accounted for in the S_4 approximation to the transport equation. The calculational model assumed infinite slab geometry of homogeneous mixtures of materials with the finite square cross section accounted for by an appropriate input buckling.

Reactivity levels for the most reactive loadings of the filter press and for all cases studied for the drying ovens and muffle boxes were calculated using the KENO [8] multi-group Monte Carlo criticality code. Again, the 16 group Hansen-Roach cross sections were used with P_1 linear anisotropic hydrogen scattering.

These codes have been widely used to determine criticality of similar individual unit and array type systems. References 9 and 10 contain thorough discussions on the accuracy of the methods.

3.1 The 18" Filter Press

There are two kinds of product which may be processed in the filter press as well as in the other process equipment. One is $UO_4 \cdot 2H_2O$ with a maximum theoretical density of 4.66 gm/cm^3(: and the other is ammonium diuranate (ADU) whose classic anhydride formula is $(NH_4)_2U_2O_7$ with a maximum theoretical density estimated at 3.0 gm/cm^3[11].

To determine the most reactive condition in the press, a series of DTF calculations were performed assuming that either product may be found in any amount in the filter press with the remaining volume being occupied by water. The results of the DTF calculations are given in Table 1 and Figure 1. Since the $UO_4 \cdot 2H_2O$ has a higher theoretical density than ADU, and hence a greater U^{235} concentration for a given H/U^{235} ratio, it shows a higher reactivity curve than the corresponding one for ADU. For this reason, further calculations of the filter press and other process equipment was restricted to the $UO_4 \cdot 2H_2O$ product.

It may be noted on the curves in Figure 1 that some of the calculated data points lie off the smooth curves. This deviation is the result of changing U^{238} cross section sets which cannot be done as a continuous function of $\sum_s^{epi}/N_{U^{238}}$ with the Hansan Roach library but only as a step-wise function. The maximum multiplication constant of 0.915 occured for $UO_4 \cdot 2H_2O$ with 30 volume percent water, $H/U^{235} = 150$.

KENO calculations were performed for this loading of the filter press. With the three dimensional geometry, it was possible to treat the finite extent of the press in the KENO input. The calculated k_{eff} after 14,100 neutron histories was 0.845 ± 0.010.

A KENO calculation was also performed for this problem with a thick water reflector placed around the outside of the filter press. The KENO calculated k_{eff} was 0.859 ± 0.010. KENO results for this problem, and for the other pieces of process equipment are presented in Table 2.

3.2 The Drying Ovens

The wet product (assumed to be only $UO_4 \cdot 2H_2O$ because of its higher reactivity for a given volume) is placed into trays and loaded into the ovens. The trays were assumed to be stainless steel since this material has a smaller neutron absorption cross section than Inconel. The following conservative assumptions were made regarding reflective properties around the oven: (1) The concrete block wall in back of the oven and the concrete floor under it were replaced by thick water reflectors. (2) operating personnel may be standing at the face of the oven and so a 15 cm water reflector was also placed at this surface. Since another oven may be placed next to the one being considered, a neutron reflecting boundary condition was improved adjacent to one side of the oven. The top and other side were taken to be nonreentrant surfaces. Thus, the calculated k_{eff}'s are really those for a system of two fully loaded, partially reflected, drying ovens.

The k_{eff} of the drying ovens was calculated as a function of the amount of water in the product as was done for the problem with the filter press. However, since the method used here was Monte Carlo, it was necessary to restrict the number of calculations to the vicinity in which the maximum k_{eff} was expected to occur. Table 2 and Figure 2 give the results of the KENO calculations for this system. The maximum k_{eff} calculated was 0.806 ± 0.012 at 30% water by volume ($H/U^{235} = 150$).

3.3 The Muffle Boxes and Furnace

When the product is removed from the ovens, it has lost most of the free water present before being dried. For the first part of the muffle box analysis, it was assumed that the only water present in the product was the water of hydration of the UO_4 giving an $H/U^{235} = 80$ for the dry product. It was also assumed the bulk product density was 70% of theoretical, i.e. 3.26 gm/cm^3.

While loaded with product, a muffle box may either be loaded in the furnace or placed on its stand among other boxes similarly charged.

The first problem examined was that involving the box in the furnace. Since the material and geometry description of the furnace would have been difficult to treat in the KENO input it was decided that a conservative simplification would be to replace the furnace walls by a thick water reflector wrapped around the box. The KENO calculated k_{eff} was 0.695 ± 0.012.

Next, the problem of the planar array of boxes was considered. The flange on the face of the boxes provides a minimun side to side separation of 10", it was assumed that the face to back separation of adjacent boxes was zero, that is, the array is packed as tight as the physical dimensions of the boxes will permit. It was further assumed that the concrete floor, 42" below the boxes, was a thick water reflector. In KENO, the boundaries on the sides, face, and back of a single box were assigned meutron reflective boundary conditions to simulate the infinite array in the X-Y dimensions, the top of the box was considered a nonreentrant surface. The KENO calculated k_∞ for this array was 0.651 ± 0.010.

The planar array was evaluated as a function of water content in the $UO_4 \cdot 2H_2O$ product. That is, the product was not dried, but was assumed to take any form possible as in the filter press stage. The KENO calculated k_∞ as a function of array water content is shown in Figure 2. The maximum calculated k_∞ was 0.958 ± 0.011. It may be added that in order to maintain a smooth curve through the peak in the reactivity curve the U^{238} cross section set of σ_p=100 barns was used for all points, even through this represents a high degree of conservatism in this region. A single box from this array was then surrounded by a thick water reflector, simulating the furnace, giving a calculated k_{eff} of 0.955 ± 0.012. Since these values of k_{eff} are high, the peak in the reactivity curve for the muffle boxes was examined with a more accurate value of the potential scattering cross section per resonance absorber atom. In particular the σ_p at this peak is 202 barns. When the U^{238} cross section set corresponding to σ_p = 200b was used in KENO, the peak dropped from $k_\infty = 0.958 \pm 0.011$ to 0.914 ± 0.011. This point is plotted on Figure 2 with the reactivity curve for the muffle boxes.

4.0 References

1. Gulf United Nuclear Fuels Corporation Drawing Number B-5009-8018
2. Gulf United Nuclear Fuels Corporation Drawing Number C-5009-8017
3. Gulf United Nuclear Fuels Corporation Drawing Number B-5009-8021
4. Gulf United Nuclear Fuels Corporation Drawing Number 3229-124
5. Westinghouse Electric Corporation Drawing Number 32-B-7250
6. Carlson, B. G., et.al., DTF Users Manual, United Nuclear Corporation, UNC Physics Math 3321, Vol. 1 (November 1963); Vol. II (May 1964).
7. Hansen, G.E., and Roach, W.H., "Six and Sixteen Group Cross Sections for Fast and Intermediate Critical Assemblies," LAMS-2543, Los Alamos Scientific Laboratory (December 1960).
8. Whitesides, G.E., and Cross, N.F., "KENO - A Multigroup Monte Carlo Criticality Program," CTC-5, Union Carbide Corporation, Nuclear Division, Computing Technology Center, Oak Ridge, Tennessee, (September 1969).
9. Webster, J.W., "Calculated Neutron Multiplication Factors of Uniform Aqueous Solutions of ^{233}U and ^{235}U", ORNL-CDC-2, Oak Ridge National Laboratory, Oak Ridge Tennessee (October 1967).
10. Crume, E. C., "Some Considerations in Regard to the Development and Use of the KENO Program", CONF-680909 Proceedings of the Livemore Array Symposium, Lawrence Radiation Laboratory, pp. 18-22 (September, 1968).
11. Personal Communication with L. Swallow, Gulf United Nuclear Fuels Corporation, Hematite Missouri, February 8, 1972.

E. Fass

EF/ah
Attachments

Table 1

DTF Results for the 18" Filter Press as a Function of Product Form and Water Content

Product	Water Volume, %	Corresponding H/U^{235}	k
$UO_4 \cdot 2H_2O$	0.0	79	0.842
	10.0	97	0.875
	20.0	119	0.900
	30.0	147	0.915
	40.0	185	0.899
	50.0	238	0.879
	60.0	317	0.827
	70.0	450	0.762
	80.0	714	0.658
$(NH_4)_2U_2O_7$	0.0	79	0.600
	10.0	104	0.663
	20.0	136	0.693
	30.0	177	0.711
	40.0	231	0.732
	50.0	307	0.714
	60.0	421	0.679
	70.0	610	0.630

Table 2

Summary of KENO Calculated Results
for the Green Room Process Equipment

Filter Press - with 5 w/o U^{235} as $UO_4 \cdot 2H_2O$ in 30 v/o water

Reflector	k_{eff} ± 1 std.deviation
None	0.845 ± 0.005
15 cm. water	0.859 ± 0.005

Drying Ovens - with 5 w/o U^{235} as $UO_4 \cdot 2H_2O$

v/o of water in Product	k_{eff} ± 1 std. deviation
20.0	0.787 ± 0.007
30.0	0.806 ± 0.006
40.0	0.786 ± 0.006

Muffle Boxes -

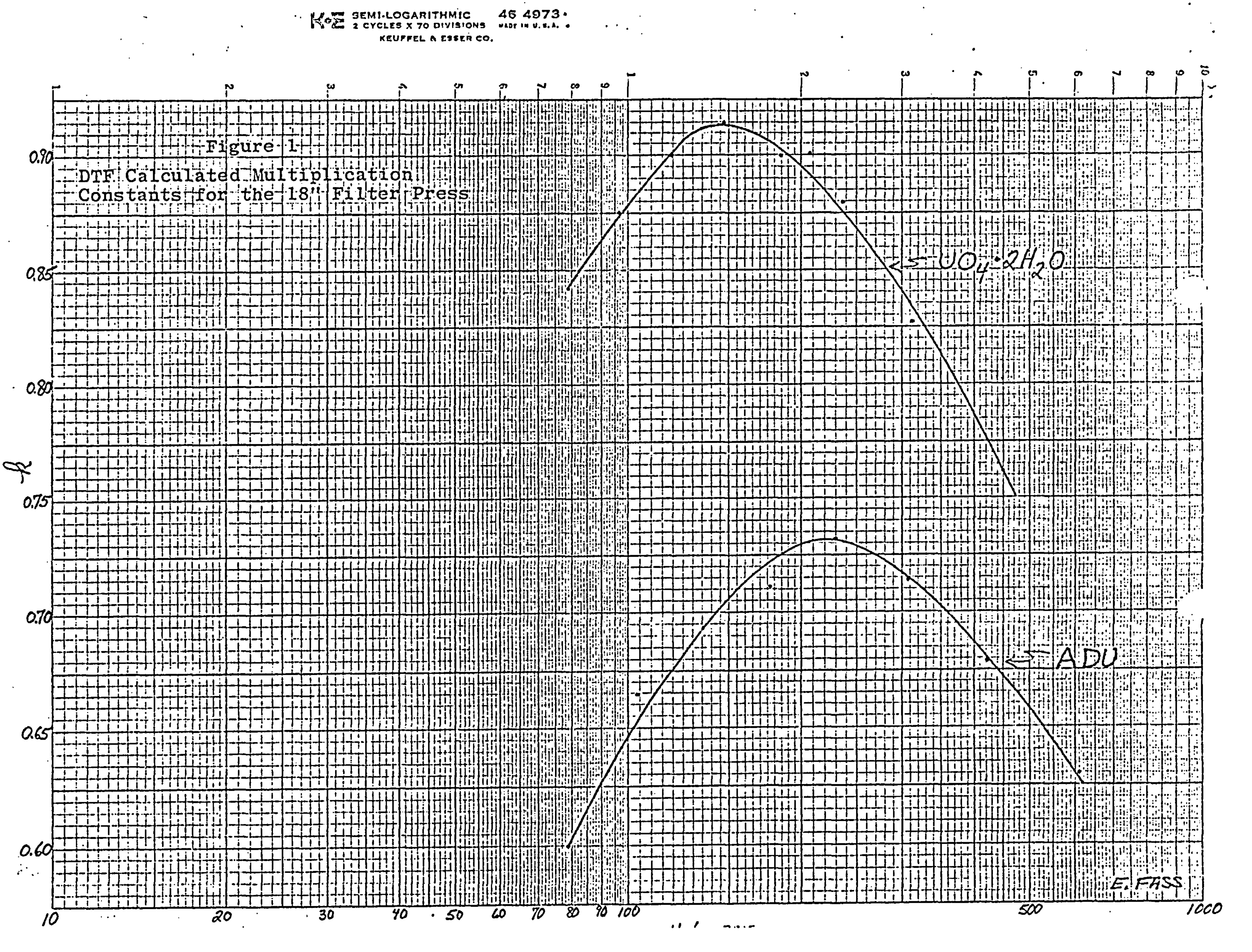
1) Normal Operating Conditions, 5 w/o U^{235} as $UO_4 \cdot 2H_2O$, density = 3.26 gm/cm^3, no excess water in the product.

System	k ± 1 std. deviation
Infinite Planar Array of Boxes	k_∞ = 0.651 ± 0.005
Single Box with 15 cm Water Reflector	k_{eff} = 0.695 ± 0.006

2) Abnormal Operating Conditions, 5 w/o U^{235} as $UO_4 \cdot 2H_2O$ with excess water in the product.

Infinite Planar Array: v/o Water in Product	k_∞ ± std. deviation
0.0 (ρ = 4.66 gm/cm^3)	0.875 ± 0.005
20.0	0.925 ± 0.006
30.0	0.958 ± 0.006
40.0	0.933 ± 0.006

Single Box with 30 v/o water in product and 15 cm Water reflector k_{eff} = 0.955 ± 0.006



K+E SEMI-LOGARITHMIC 46 4973
2 CYCLES X 70 DIVISIONS MADE IN U.S.A.
KEUFFEL & ESSER CO.
Figure 1
DTF Calculated Multiplication
Constants for the 18" Filter Press
0.90
0.85
0.80
0.75
0.70
0.65
0.60
k
<- $UO_4 \cdot 2H_2O$
<- ADU
E. FASS
10
20
30
40
50
60
70
80
90
100
500
1000

Figure 2
KENO Results for the Drying Ovens and Muffle Boxes. Values are given ± 1 standard deviation