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CRITERIA FOR THE DESIGN OF THE THORIUM FUEL CYCLE DEVELOPMENT FACILITY

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ABSTRACT

Criteria for the conceptual design of the proposed Thorium Fuel Cycle Development Facility to be located at the Oak Ridge National Laboratory have been established and are presented. In addition, conceptual layouts of the building and equipment are included. Reference fuel elements and processes that were selected as a basis for developing criteria for the facility are described.

CONTENTS

1. INTRODUCTION

The Thorium Fuel Cycle Development Facility (TFCDF) is proposed for construction as a part of the Oak Ridge National Laboratory (ORNL) Thorium Utilization Program.

It will be designed to do research and development for the entire thorium fuel cycle, including basic fission product removal investigations which start with irradiated fuel elements from operating or proposed power reactors. To accomplish this, the facility will have the following major features:

A. Shielding to provide biological protection from fission product radiation of sources as large as 35 kg irradiated to 25,000 Mwd/tonne and decayed for 90 days.

B. Provisions where fuel assemblies up to 12 ft in length can be received, processed, and refabricated, provided they can be broken down into and assembled from pieces not longer than 6 ft.

C. One cell for chemical process research and development equipment.

D. One cell for mechanical operations incident to reprocessing.

E. One cell for fabrication operations required to convert prepared uranium and thorium compounds into compacts, elements, etc., in which all particulate matter is contained. Sufficient space will be available for installation of equipment for two simple fabrication schemes.

F. One cell for final fabrication and inspection operations on elements in which all particulate matter is contained.

G. One cell to serve as a radiation lock and as a decontamination area.

H. One cell to function as a lightly shielded storage area for contaminated equipment which is yet useful but is not needed for the current program.

I. Sol-gel and vibratory compaction equipment to be located in the cells mentioned in D, E, and F above. No processing equipment will be provided from capital funds for the cell mentioned in C because of the experimental nature of the systems to be used.

J. A fuel receiving station and storage basin for a small number of irradiated fuel assemblies from power reactors. Included will be the enclosing structure, crane, and basin; not included are special handling equipment, storage racks, transfer carriers, or shipping casts which must be designed for the particular fuel assembly to be accommodated.

K. Liquid and gaseous waste disposal systems to safely collect and dispose of high-activity-level wastes which will result from high-burnup fuel.

L. Provisions for future use of a nonactive blanket gas. The blanket gas, purification system, etc., will not be installed for any of the cells. This provision will permit work at some future date with pyrophoric fuel materials such as carbides.

The facility will be designed to handle oxide and carbide fuels specifically, but it must have sufficient flexibility to permit work with other diverse fuels, such as alloys, dispersion-type fuels, and beryllides. Although provisions will be made for change of process equipment to accommodate other fuels, it is not visualized that equipment for making full-size, plate-type fuel elements by rolling can ever be installed. However, the fabrication of metallic rods or small plate-type specimens is within the scope of the facility. Apparently, the use of plate-type fuel elements is not planned for any reactor that is based on the $Th-U^{233}$ fuel cycle. This fact, coupled with the great amount of technological development required to make remote fabrication of plate-type elements practicable, has precluded the selection of such elements as a reference for design of the facility.

The TFCDF will be located in the Melton Valley Area, Oak Ridge, Tennessee. The design is to be such that the facility can be constructed in two increments, with the first increment completely self-sustaining. This approach will allow construction of a minimum facility should funding be insufficient to provide a complete system.

This report presents design criteria for the facility and includes a discussion of the processes that have been selected as a basis for design of the TFCDF. It is to serve as a firm basis on which to proceed with a detailed conceptual design for the facility.

To aid in the establishment of criteria for the design of the TFCDF, the anticipated initial programs and processes have been studied from the standpoint of several requirements such as space, services, utilities, process equipment, and degree of manipulation. It is thought that the selection of two diverse fuel systems for installation in the facility will ensure adequate space and design for carrying on a broad range of experimental endeavor.

2. REFERENCE FUEL ELEMENTS

Two fuel elements, those for the Consolidated Edison Thorium Reactor (CETR) and the High-Temperature Gas-Cooled Reactor (HTGR), were selected as references for considering the processes to be included in the TFCDF, since they represent differing fuels systems in the size range that is anticipated for future reactors utilizing the $Th\text{-}U^{233}$ fuel cycle. The CETR fuel element, an assembly of stainless steel tubes containing $UO_2\text{-}ThO_2$, is shown in Fig. 1. Figure 2 depicts the proposed HTGR fuel element, which consists of $UC_2\text{-}ThC_2$-graphite compacts in a graphite can. Data for both are given below:

CETR Fuel Element

Fuel element per CETR core: 120
Fuel element overall (in.): $5.7 \times 5.7 \times 137\frac{3}{4}$
Fuel rods per fuel assembly: 195
Fuel rod length overall (in.): $102\frac{1}{4}$
Fuel length (in.): $98\frac{1}{2}$
Tubing outside diameter (in.): 0.304
Tubing inside diameter (in.): 0.263
Pellet diameter (in.): 0.260
ThO_2 per fuel element, av (kg): 143
UO_2 per fuel element, av (kg): 10
Cladding: stainless steel

HTGR Fuel Element

Fuel elements per HTGR core: 855
Fuel element length (ft): 12
Fuel element diameter (in.): 3.5
Fuel length (ft): $7\frac{1}{2}$
Fuel compacts per fuel element: 30
Fuel compact length (in.): 3
Fuel compact outside diameter (in.): $2\frac{1}{2}$
Fuel compact inside diameter (in.): $1\frac{1}{2}$
$UC_2\text{-}ThC_2$ per compact (g): 223
Graphite per compact (g): 611
Carbon coating per compact (g): 41
Cladding: graphite
Fuel element core (spine): graphite

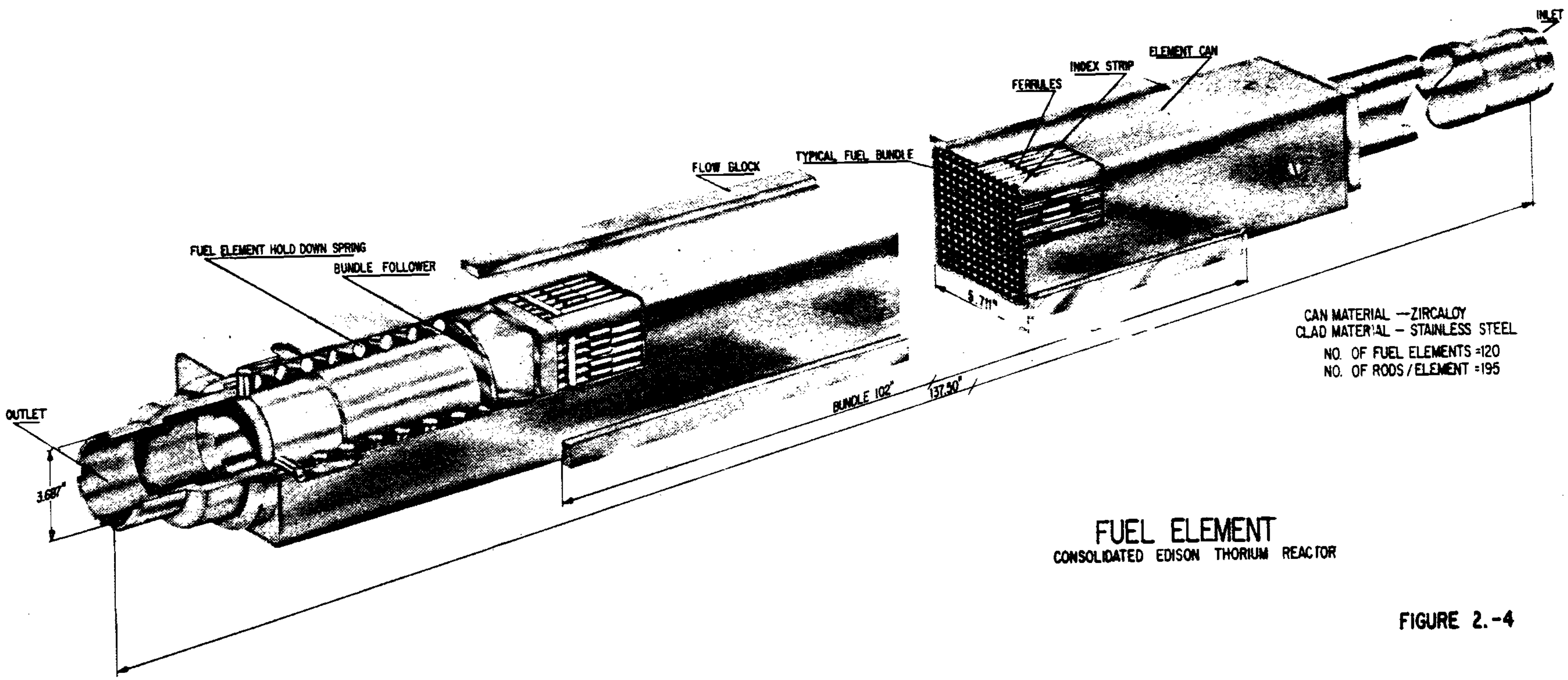

Fig. 1. CETR Fuel Element.

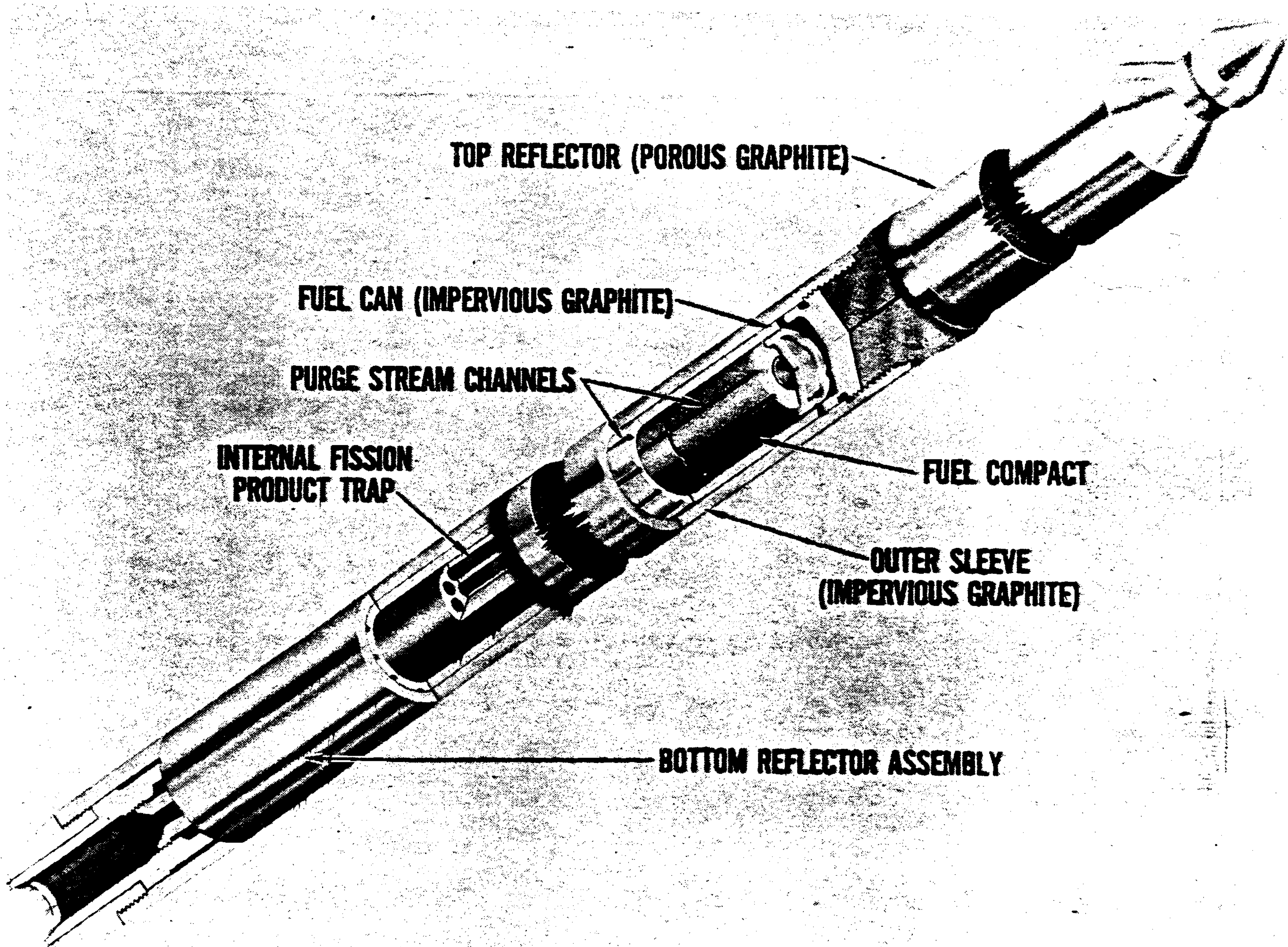

Fig. 2. HTGR Fuel Element.

3. REFERENCE PROCESSES

The processes which follow are estimates of the manner in which the recycling of the reference fuel elements might be accomplished. They are not intended to represent the exact process steps that might be included, but they do afford a basis for estimates of facility parameters. Indeed, the procedure for fabricating HTGR fuel elements from natural uranium is not yet developed; and, therefore, it would be presumptuous to assume that the process as given subsequently would be installed. Actually, the HTGR process is extremely complicated; and, unless simplifications are made, it is doubtful that remote fabrication will be practical. It is explicitly noted that the only equipment to be installed initially will be that for processing from U(Th) nitrate to finished oxide-bearing fuel rods by the sol-gel vibratory compaction route.

3.1 Mechanical Processing

Irradiated reactor fuel assemblies may require performance of various mechanical operations prior to processing for fission product removal and/or reconstitution into new fuel assemblies. These operations could include sawing to remove inert materials, chopping and leaching of oxides, removal and canning of refuse metals, disassembly to reduce the size of the piece being treated or to remove inert materials, crushing and grinding of graphite matrix fuels prior to leaching or burning, and burning or leaching of graphite matrix fuels plus numerous smaller supporting operations. Mechanical operations will also be required to transform the fissile and fertile material produced in the chemical processing cell from an aqueous form to a desired solid form. Possible specific operations are discussed in more detail below.

3.1.1 Clad $Th(U)O_2$ Mechanical Processing

One fourth of a CETR fuel assembly, less end fittings and sleeve, is transferred by the cell hoist to a shear inside the cell. The sub-assembly is laid in the horizontal feed chute from which it is forced into the shear opening. As the shear operates, pieces of the assembly, approx 1/2 in. in length, drop into a hopper from which they are conveyed to a batch leacher. The leacher has a removable basket which will retain all except very small pieces of the cladding. Dissolution is carried out by use of fluoride catalyzed 13 M HNO_3, added in at least three batches. The first batch dissolves 80 to 90% of the oxide and the second batch dissolves the remainder. A third batch of acid is added to make certain that no fissile material remains with the cladding. A water rinse removes the acid from the basket and cladding fragments. The basket is removed from the leacher, emptied of cladding fragments, and returned. The solutions used in and resulting from the leaching operation emanate from and return to the chemical cell or chemical makeup area. Figure 3 is a simplified flowsheet for the above operations; Table 1 is a listing of equipment pieces; and Fig. 4 is a first approximation layout for all items in the Mechanical Processing Cell.

3.1.2 The $(U)C_2$-Graphite Fuel Mechanical Processing

An assembly from the HTGR is brought into the Mechanical Processing Cell where the end pieces are first removed by sawing. The fueled portion is then placed in the feed chute of a coarse crusher. Pieces resulting from this operation are conveyed to a hopper which is attached to a small furnace. Graphite pieces from the hopper plus oxygen are fed into the furnace which operates at a temperature of approx 600°C. Off-gases from this operation pass through a cyclone separator and a cooler and then through an electrostatic precipitator. Gases leaving the precipitator pass through an iodine retention unit (caustic scrubber, silver nitrate bed, or charcoal bed) and then through a high-efficiency filter before entering the stack. Removal of noble gases such as krypton and xenon is not required because only small quantities of fuel are processed per day. After completion of combustion, the furnace is cooled and the thorium and uranium oxides transferred to a dissolver in the chemical processing cell. Transfer is by fluidization in either a gas or liquid stream.

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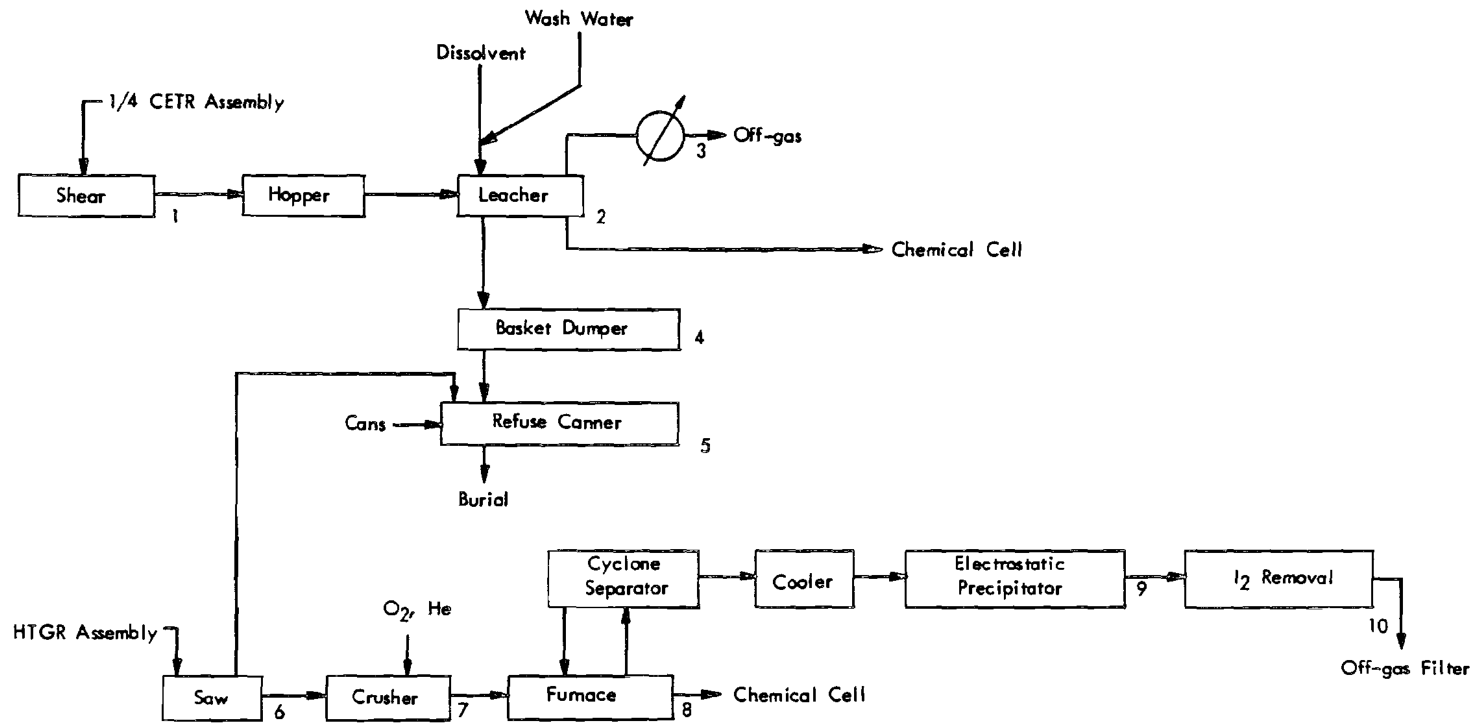

NOTE: Equipment piece numbers refer to Table 1.

Fig. 3. Mechanical Processing Cell Flowsheet for CETR and HTGR Fuel Prior to Chemical Processing.

Table 1. Mechanical Processing Cell Equipment

Piece No.	Item	Dimensions (in.)			Services	Electrical Requirements	
		Width	Length	Height		Volts	kw
			For CETR Fuel				
1	Shear, 30 ton	36	150	72	High-pressure oil, air	220	1
2	Leacher, 500 liter capacity	36	48	48	Steam, water, chemical addition		
3	Condenser, 25 ft^2	12	48	12	Water		
4	Basket Dumper	24	48	48	Air	220	0.5
5	Refuse Canner	24	36	48	Air	220	0.5
			For HTGR Fuel				
6	Saw with table	48	150	48	Air	220	1
7	Crusher with hopper	24	150	48		220	1
8	Furnace with accessories	48	48	72	Oxygen, He	220	5
9	Electrostatic Precipitator	24	24	36		20,000	.05
10	Iodine removal unit	24	24	70		220	2
5	Refuse Canner	24	36	48		220	0.5
			For Solids Preparation				
11	Crystallizer	36	36	48	Air, steam	220	0.2
12	Condenser for Crystallizer	12	12	48	Water		
13	Rotary Calciner	36	72	36	Steam, air	220	4
14	Condenser for calciner	12	12	48	Water		
15	Weighing station	24	24	42		110	0.1
16	Blending tank with accessories	12	36	60	Steam		
17	Sol dryer	36	36	48	Air, steam	220	0.2
18	Condenser, dryer	12	12	48	Water		
19	Hopper	12	12	24	Air		
20	Furnace	36	48	48	Air, A, A-H_2	50	7

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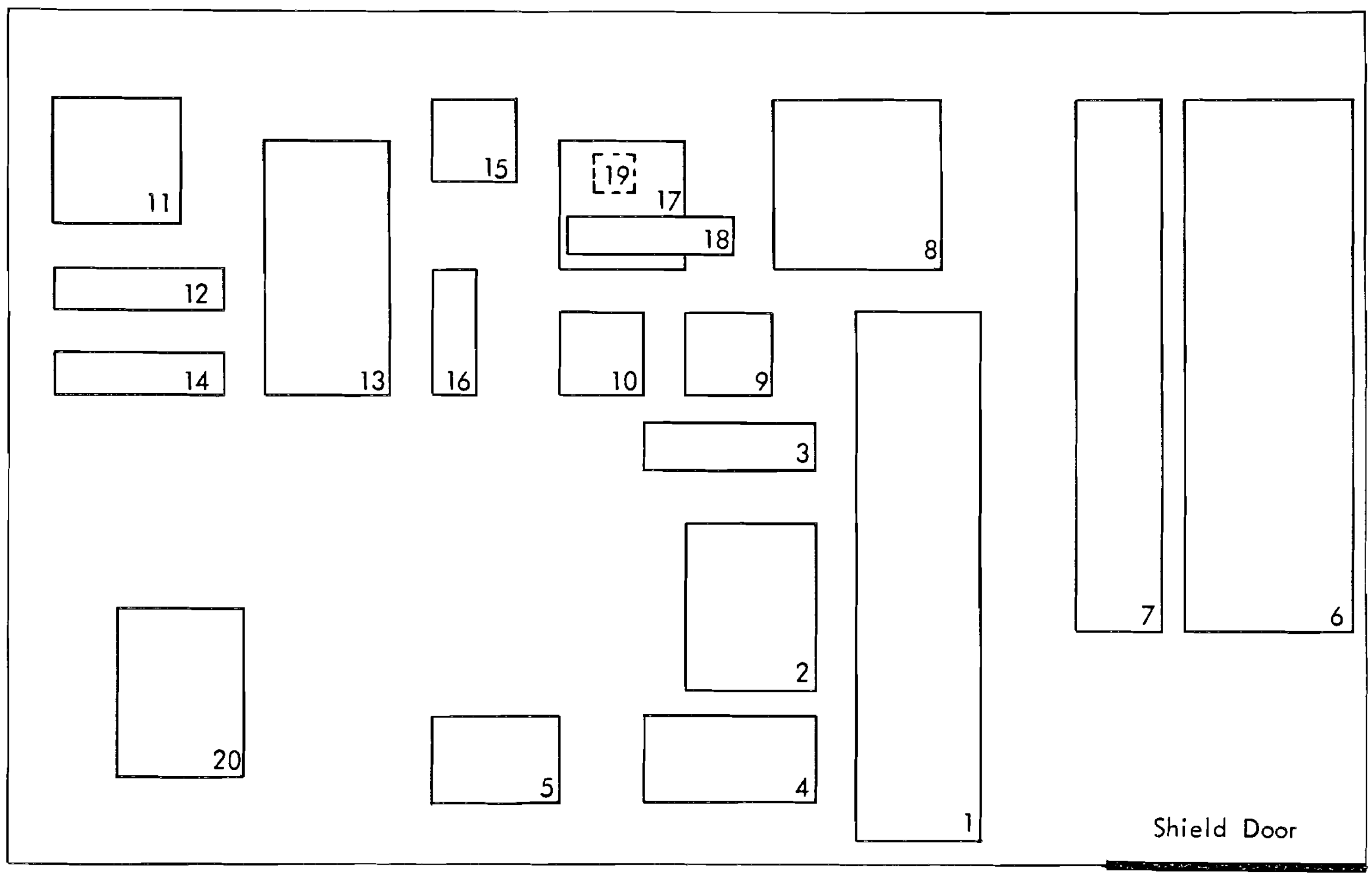

Plan

Note: Equipment numbers refer to Table 1.

Fig. 4. Mechanical Processing Cell Equipment Layout.

3.1.3 Processing Chemical Cell Solutions Utilizing Mechanical Operations

Thorium nitrate solutions are transferred from a surge tank located in the Chemical Cell to a crystallizer located in the Mechanical Processing Cell. The crystallizer evaporates the thorium nitrate to solid crystals in a number of trays. The trays are emptied and the contents transferred to the calciner. In the calciner the temperature is elevated and steam admitted driving off water and decomposing the thorium nitrate to thoria and nitrogen oxides. The product of the calciner is weighed and transferred to a blend tank where an appropriate amount of uranyl nitrate and water is added from the uranium surge tank located in the Chemical Cell. Upon blending, the above components form a sol which is transferred to a shallow-tray evaporator in which a gel is formed from the sol. The dried gel is then transferred into crucibles and placed in a high-temperature, controlled-atmosphere furnace. The temperature is gradually raised to approx 1150°C in an air atmosphere; the atmosphere is then changed to reduce uranium to UO_2; and then the temperature is reduced in an inert atmosphere. The product is a coarse aggregate ready for size reduction suitable for vibratory compaction or use in a carbide fuel. Figure 5 is a simplified flowsheet for this operation.

3.2 Chemical Processing

Chemical processing of either CETR or HTGR fuel might well be quite similar in nature. The treatment in the Mechanical Processing Cell described in the preceding section in the case of CETR fuel produces a nitrate solution, whereas, the product from HTGR is a ThO_2-UO_2 powder. In the second case, dissolution of the oxide nitric acid is required. After this treatment, the processes are identical for the two feed materials.

Starting with a nitrate solution, the feed material is filtered or centrifuged to remove objectionable particulates. Solids are rinsed and transferred to waste via a steam jet siphon. The resulting solution is carried to a feed adjustment tank where excess water and nitric acid

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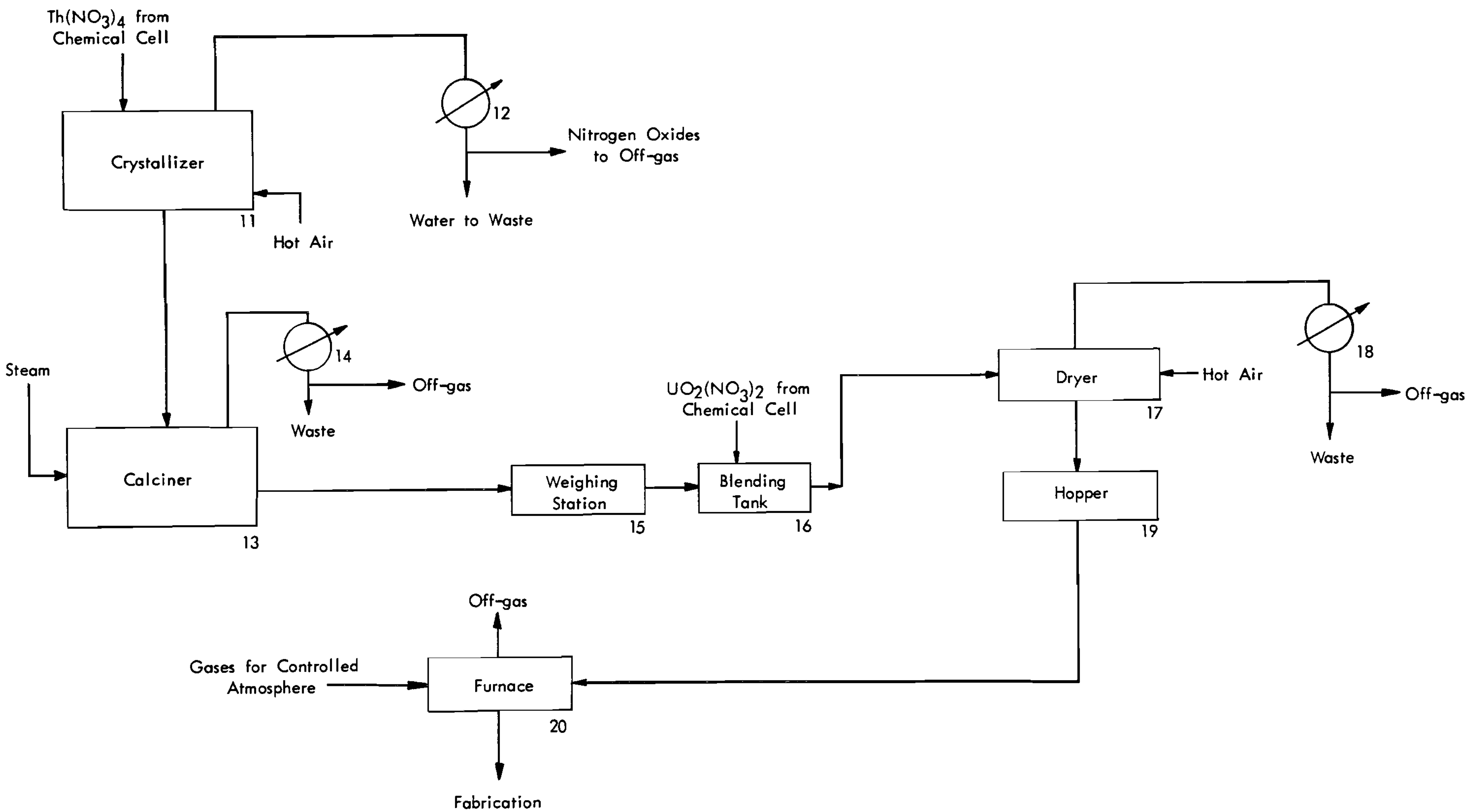

NOTE: Equipment piece numbers refer to Table 1.

Fig. 5. Mechanical Processing Cell Flowsheet for CETR and HTGR Fuel Subsequent to Chemical Processing.

are evaporated. Because this is an experimental and not a production facility, the dilute acid is sent to waste rather than to an acid recovery system.

Adjusted feed is transferred to one of two feed tanks from which it is pumped to a simple solvent extraction system. It is assumed that in this system the uranium and thorium are coextracted and that any protactinium leaves the contactor with the raffinate stream. The extracted uranium and thorium is either partitioned or co-stripped as demanded by the subsequent process. It is assumed that they are partitioned and that the two products are evaporated to a convenient concentration. The raffinate containing protactinium might be adjusted for pH and transferred to a second solvent extraction system where the protactinium is extracted and then stripped. The protactinium solution is stored in several small containers where it decays and possibly self-concentrates. Periodically the contents of one of the decay pots are transferred to the U-Th solvent extraction complex feed tank. Figure 6 is a simplified flowsheet for the above operation; Table 2 lists the equipment and approximate sizes; and Fig. 7 is a first approximation layout of the equipment in the Chemical Cell.

3.3 Fabrication (Contaminated and Clean)

The fabrication steps of both the $Th(U)O_2$-bearing and the $Th(U)C_2$-graphite fuel elements have been divided into two categories depending on the potential of the steps for contamination of their environments. This breakdown is adequately noted in Figs. 8–11.

3.3.1 Clad $Th(U)O_2$ Fabrication and Inspection

The fabrication scheme for fuel elements of the CETR is given in Fig. 8. It was assumed that input material would come from sol-gel processing and that the facility would produce one fuel element assembly per week.

The operation starts with comminution of the oxide by crushing, pulverizing, and ball milling. The crushed material is classified to obtain selected size fractions. Undesirable fractions are recomminuted. An appropriate amount of each selected fraction for a batch is metered,

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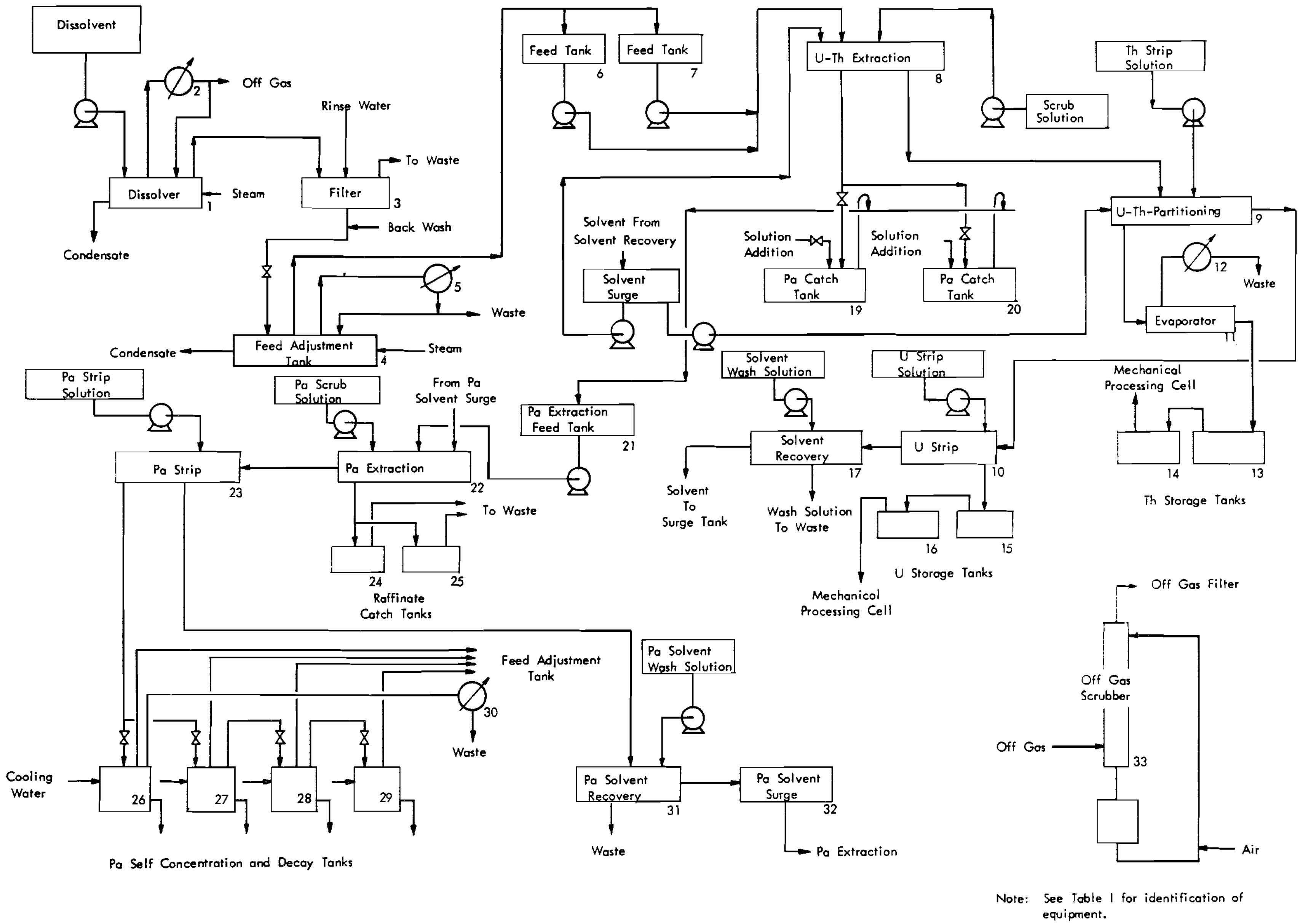

Fig. 6. Chemical Cell Process Equipment Flowsheet.

Table 2. Chemical Cell Equipment

Piece No.	Item	Total Volume (liters)	Dimension (in.) Diameter	Dimension (in.) Length	Service[a]
1	Dissolver	1000	36	72	Steam, water, air sampler, LL, S.G., T
2	Condenser for dissolver		18	60	Water
3	Filter		24	48	
4	Feed Adjustment Tank	1000	36	72	Steam, water, air sampler, LL, S.G., T
5	Condenser for Feed Adjustment Tank		18	60	Water
6 and 7	Feed tanks	200	18	66	Steam, water, air sampler, LL, S.G., T
8	U-Th Extraction		2	240	LL, S.G., T
9	U-Th Partition (two units)		2	480	LL, S.G., T
10	U Stripping		2	240	LL, S.G., T
11	Th Evaporator		24	72	Steam, LL, S.G., T
12	Condenser for Th Evaporator		18	60	Water
13 and 14	Th Storage Tanks	200	18	66	Steam, water, air sampler, LL, S.G., T
15 and 16	U Storage Tanks	200	18	66	Steam, water, air sampler, LL, S.G., T
17	Solvent Recovery System		24	240	Steam, water, air sampler, LL, S.G., T
18	Solvent Surge	200	18	66	Steam, water, air sampler, LL, S.G., T
19 and 20	Pa Catch Tanks	200	18	66	Steam, water, air sampler, LL, S.G., T
21	Pa Extraction Feed Tank	200	18	66	Steam, water, air sampler, LL, S.G., T
22	Pa Extraction		2	240	LL, S.G., T
23	Pa Strip		2	240	LL, S.G., T
24 and 25	Raffinate Catch Tanks	200	18	66	Steam, water, air sampler, LL, S.G., T
26–29	Pa Decay Tank	25	5	72	Steam, water, air sampler, LL, S.G., T
30	Condenser for Decay Tank		18	60	Water
31	Pa Solvent Recovery		24	72	Steam, water, air sampler, LL, S.G., T
32	Pa Solvent Surge	200	18	66	Steam, water, air sampler, LL, S.G., T
33	Off-Gas Scrubber		24	180	Steam, water, air sampler, LL, S.G., T

[a] LL – Liquid Level
S.G. – Specific Gravity
T – Temperature

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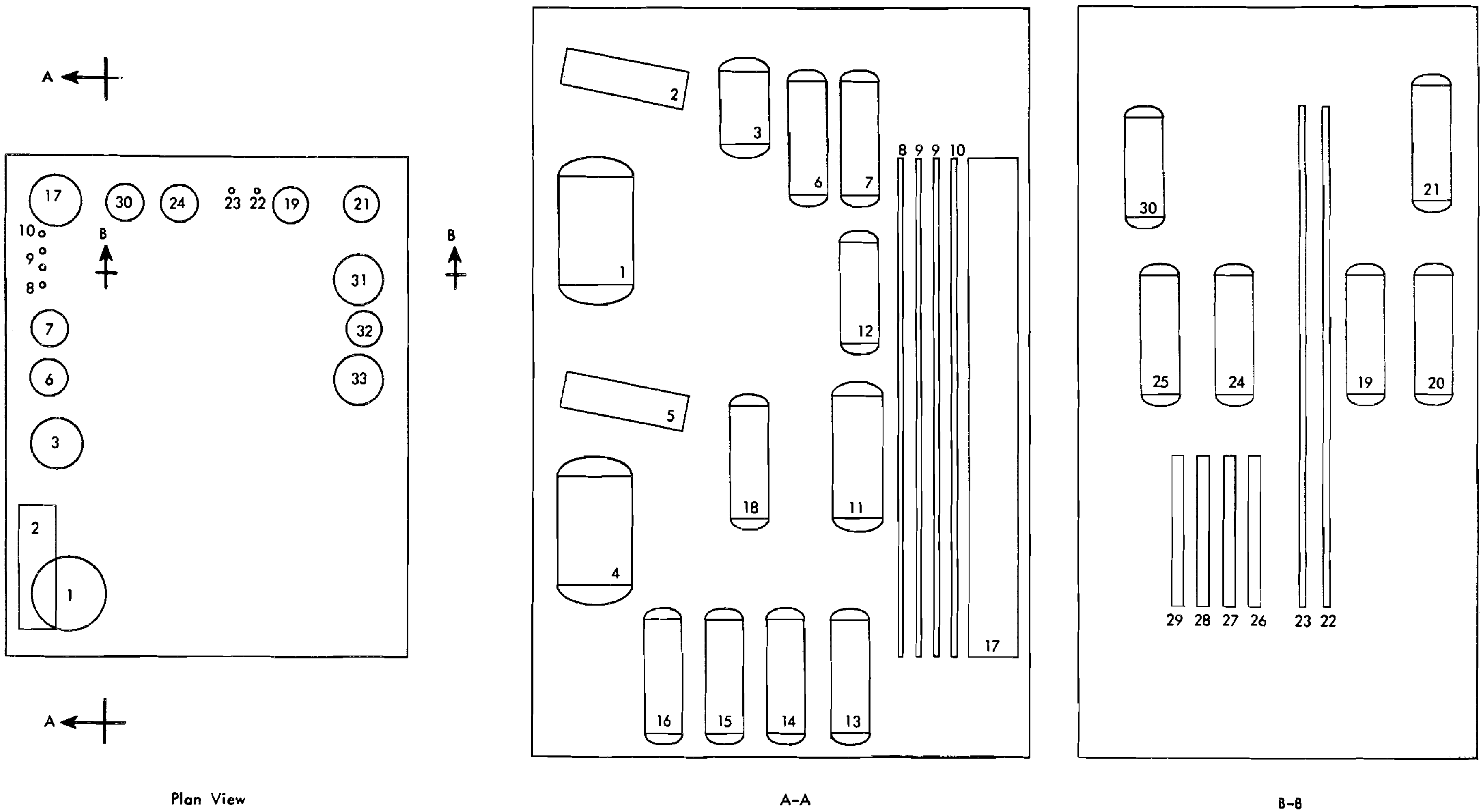

Fig. 7. Chemical Cell Equipment Layout.

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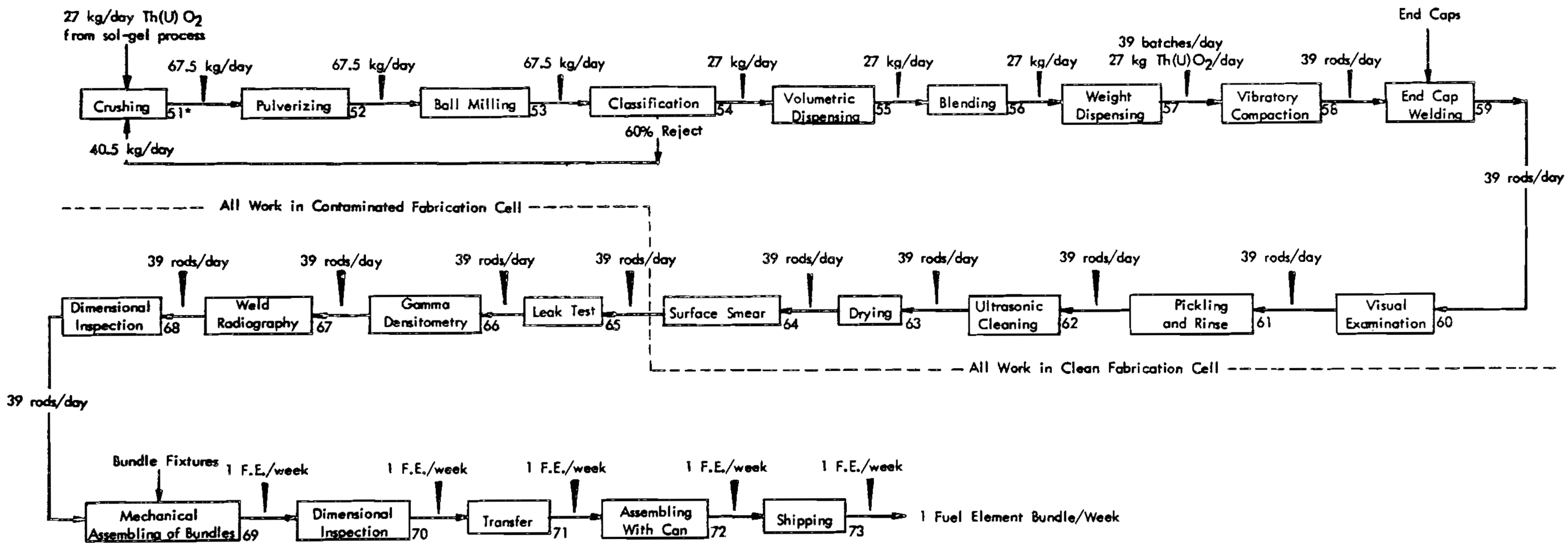

*Subscript numbers are process step numbers (see Table 2 for equipment).

Fig. 8. Fabrication Diagram for Clad $Th(U)O_2$ Fuel Rod Bundle.

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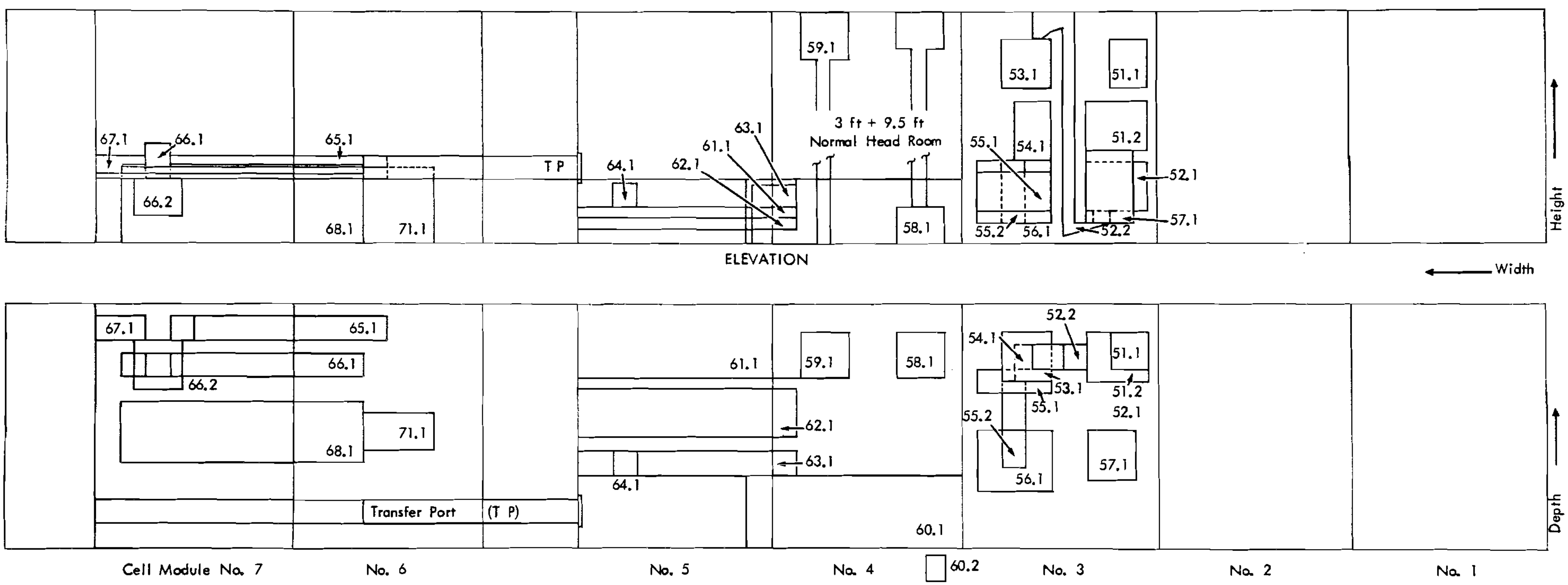

Note: See Table 3 for equipment identification.

Fig. 9. Cell Layout of Fabrication Equipment for Clad $Th(U)O_2$ Fuel.

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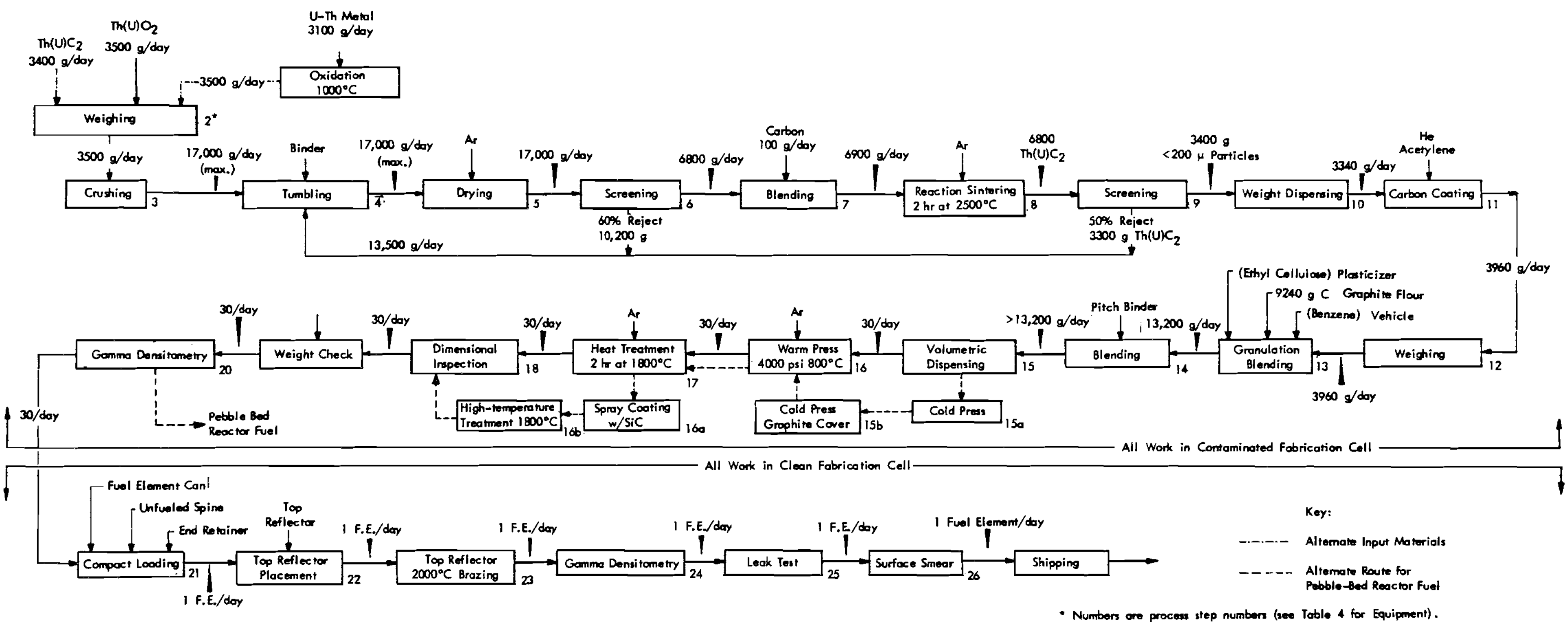
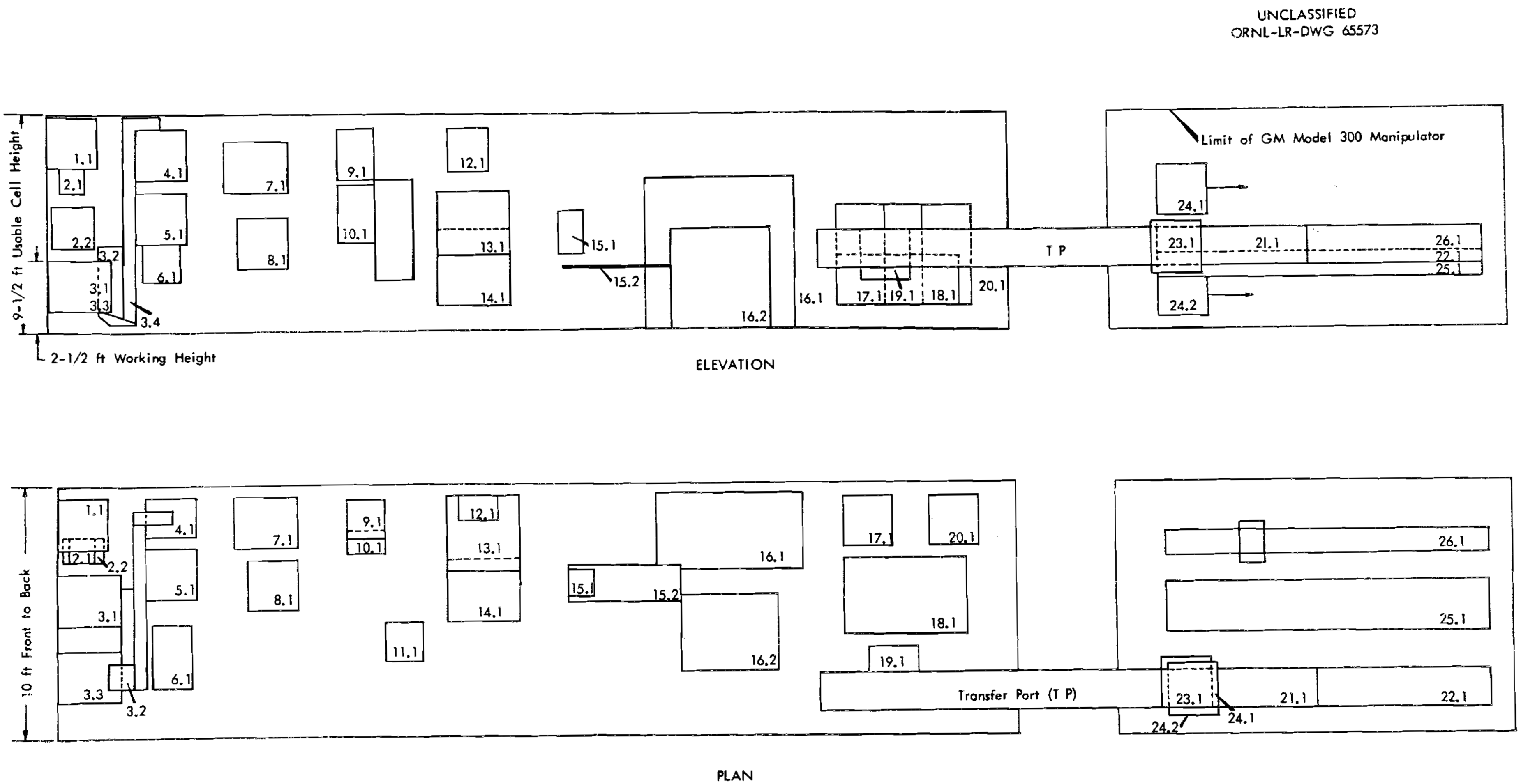


Fig. 10. Fabrication Diagram for $Th(U)C_2$-Graphite Fuel Elements.



Note: See Table 1 for identification of equipment.

Fig. 11. Cell Layout of Fabrication Equipment for $Th(U)C_2$-Graphite Fuel Elements.

and all fractions for a batch are then blended. The blended mixture, having an optimum particle-size distribution, is then dispensed by weighing and loaded into tubes by vibratory compaction. The tubes are enclosed by welding end caps to them. The weld is visually examined. The $Th(U)O_2$-bearing rods are decontaminated by pickling and rinsing, followed by ultrasonic cleaning. The rods are dried and smeared to determine the efficiency of the cleaning steps.

The tubes are then transferred to a clean cell and inspected for leaks, fuel distribution, and dimensions. Following the inspection of individual rods, the rods are assembled to form a fuel element bundle, which is subsequently dimensionally inspected before shipping. The fabrication scheme is for mechanical assembly only; there are no provisions for brazing of fuel element bundles.

The CETR fuel element is canned and has additional hardware; and, possibly, other fuel elements will be of similar design. However, it was assumed that assembly of the fuel bundles with these components can be done in the same cell position as assembly of the rod bundle.

The equipment for fabrication of clad $Th(U)O_2$ is listed in Table 3 and is shown schematically in Fig. 9. Three cell modules are provided for fabrication steps culminating in a sealed rod containing $Th(U)O_2$. All of these operations would be accomplished in a remotely maintained, contaminated cell area. Two noncontaminated cell modules are required for the remaining operations.

3.3.2 $Th(U)C_2$-Graphite Fuel Fabrication and Inspection

The fabrication of HTGR fuel elements is visualized as depicted in Fig. 10. It was assumed that input to the process would be primarily relatively large-sized $Th(U)O_2$ from the sol-gel process. Alternative input materials could be $Th(U)C_2$ or uranium-thorium metal as shown on the diagram. To enable the establishment of equipment sizes, it was assumed that one fuel element assembly per day would be fabricated.

The process commences with a check-weighing step which is followed by crushing and then tumbling to obtain spheroidal particles. After drying, the powder is screened to obtain a selected size fraction which is then mixed with carbon and reacted to form $Th(U)C_2$ at a temperature

Table 3. Equipment for the Fabrication of Clad $Th(U)O_2$ Fuel Rod Bundles

Process Step	Equipment No.	Equipment Item	Capacity Required	External Size (In-Cell Portion) d × w × h* (in. × in. × in.)	Services Required	Electrical Requirements (Inside Cell)	Special Services or Remarks
51	51.1	Storage hopper with metering equipment	135 kg	18 × 18 × 24		110v–700w	
	51.2	Crusher	67.5 kg/day	24 × 30 × 24		220v–1500w	
52	52.1	Pulverizer	67.5 kg/day	24 × 30 × 24		220v–1500w	
	52.2	Powder conveyer	67.5 kg/day	12 × 48 × 9 ft		110v–700w	
53	53.1	Ball mill	67.5 kg/day	24 × 24 × 24		220v–1500w	
54	54.1	Classifier	67.5 kg/day	18 × 18 × 30		110v–500w	
55	55.1	Hoppers and metering equipment	Storage: 195 kg Dispensing: 27 kg/day	12 × 36 × 18		110v–500w	
	55.2	Powder conveyer	27 kg/day	42 × 12 × 30		110v–700w	
56	56.1	Blender	27 kg/day	30 × 36 × 30		110v–500w	
57	57.1	Weighing device with hopper	39 batches/day 0.700 kg/batch	24 × 24 × 36		110v–500w	
58	58.1	Tandem vibratory compaction device with hopper	39 rods/day	24 × 24 × 12.5 ft	100 lb air	110v–500w	Elect. service is for auxiliary equipment
59	59.1	Welding device	39 rods/day	24 × 24 × 12.5 ft	He	110v–500w	Elect. service is for auxiliary equipment
60	60.1	Table		36 × 9 ft × 30			
	60.2	Periscope					
61	61.1	Assembly of 3 tanks	39 rods/day	36 × 9 ft × 18	Water		

Table 3 (continued)

Process Step	Equipment No.	Equipment Item	Capacity Required	External Size (In-Cell Portion) d × w × h* (in. × in. × in.)	Services Required	Electrical Requirements (Inside Cell)	Special Services or Remarks
62	62.1	Ultrasonic decontamination apparatus	39 rods/day	24 × 9 ft × 24	Water	220v–2000w	
63	63.1	Dryer with rod holder	39 rods/day	12 × 9 ft × 12		110v–500w	
64	64.1	Surface smear device	39 rods/day	12 × 12 × 12		110v–500w	
65	65.1	Leak test device	39 rods/day	12 × 9 ft × 12		110v–500w	12 × 12 × 12 vacuum chamber, remainder is rod holder
66	66.1	Gamma densitometer	39 rods/day	12 × 10 ft × 12		110v–500w	12 × 12 × 12 pickup heat, 10-ft-long bed
	66.2	Lead pig		24 × 24 × 18			Complements Item 66.1
67	67.1	Radiograph head	39 rods/day	12 × 24 × 12			Power supplied from outside
68	68.1	Dimensional inspection and mechanical assembly device	39 rods/day	30 × 10 ft × 36		110v–500w	
69	68.1	Use above equipment					
70	68.1	Use above equipment	1 F.E. bundle/week				
71	71.1	Transfer device	1 F.E. bundle/week	18 × 36 × 36		220v–1000w	

*d × w × h indicates respectively dimensions of depth, width, and height for the equipment referred to the cell module. (See Figure 9.)

not greater than 2500°C. The product of this operation is screened for particles 100 μ, or greater, in size. This fraction, averaging possibly 150 μ in diameter, is weighed and then coated with pyrolytic carbon at approx 1400°C using a fluidized bed technique (coating thickness — approx 50 μ). The product is weighed to determine the amount of carbon added during the coating step, then mixed with appropriate amounts of plasticizer and graphite flour, and granulated. The granulated material is subsequently blended with pitch binder; the amount of this mixture required for each compact is volumetrically dispensed to the graphite die. The material is warm pressed at 800°C and 3000 to 5000 psi, and the resulting compact is heat treated at 1800°C to effect removal of gas and to enhance the strength of the compact. The compact is inspected for dimensions, weight, and uniformity of fuel distribution.

The compacts are then loaded into the graphite can and the remaining fuel element hardware is positioned. The top reflector, which is the top sealing device, is then brazed to the can at a temperature not greater than 2000°C. The fuel element is inspected for uniformity of fuel loading along its length dimension, for leaks, and for degree of external contamination before shipping.

The equipment, together with capacity, size, and services required for performing the above operations, is listed in Table 4. Figure 11 depicts the equipment, with the exception of alternative equipment, as it might be placed in cell modules 8-ft wide and 10-ft deep. The equipment requires seven such cell modules, five of which are to be in a cell capable of maintaining an argon atmosphere and two of which are to be in a cell having an air atmosphere. It is notable that all work up to placement of the compacts in cans will be done in a contaminated cell requiring remote maintenance, while subsequent operations will be done in a noncontaminated cell which can be maintained by contact methods when fuel assemblies are not present.

An alternative fabrication sequence is shown in Fig. 10 for Pebble Bed Reactor (PBR) fuel. This fuel is conceived to be spheres, 1 1/2 in. in diameter, consisting of an external oxidation barrier, such as SiC,

Table 4. Equipment for the Fabrication of $Th(U)O_2$-Graphite Fuels

Process Step	Equipment No.	Equipment Item	Capacity Required	External Size (In-Cell Portion) d × w × h* (in. × in. × in.)	Services Required	Electrical Requirements (Inside Cell)	Special Services or Remarks
1	1.1	Resistance-heated furnace (to 1000°C)	3.5 kg $Th(U)O_2$. Heating zone 50 $in.^3$	24 × 24 × 24	Ar-Air	220v–4000w	
2	2.1	Storage hopper with metering equipment	17 kg $Th(U)O_2$ 200 $in.^3$	6 × 6 × 10		110v–700w	
2	2.2	Weighing scale	4 kg max	12 × 20 × 20		110v–100w	
3	3.1	Primary jaw crusher	17 kg/day	24 × 30 × 24		220v–1500w	
	3.2	Powder conveyer	17 kg/day	36 × 12 × 48		110v–700w	
	3.3	Secondary crusher	17 kg/day	24 × 30 × 24		220v–1500w	
	3.4	Powder conveyer	17 kg/day	84 × 18 × 96		110v–700w	
4	4.1	Ball mill	17 kg/day	18 × 24 × 24		110v–500w	
5	5.1	Dryer (to 350°C)	17 kg/day	24 × 24 × 24		220v–1000w	
6	6.1	Vibrating screens and hoppers	17 kg/day	18 × 18 × 30		110v–500w	
7	7.1	Blender	7 kg/day	24 × 30 × 24		110v–500w	
8	8.1	Induction-heated furnace (to 2500°C)	7 kg/day 100 $in.^3$ heating zone	24 × 24 × 24	Ar	110v–500w	Power for auxiliary items only
9	9.1	Vibrating screens and hoppers	7 kg/day	18 × 18 × 20		110v–500w	
10	10.1	Weighing scale	4 kg max	12 × 20 × 20		110v–100w	
11	11.1	Particle coating apparatus (to 1400°C)	4 kg/day	18 × 18 × 48	He, Acetylene	220v–4000w	
12	12.1	Weighing balance	4 kg max	12 × 20 × 20		110v–100w	
13	13.1	Blender	14 kg/day	30 × 36 × 30		110v–500w	

Table 4 (continued)

Process Step	Equipment No.	Equipment Item	Capacity Required	External Size (In-Cell Portion) d × w × h* (in. × in. × in.)	Services Required	Electrical Requirements (Inside Cell)	Special Services or Remarks
14	14.1	Blender	14 kg/day	30 × 36 × 30		110v–500w	
15	15.1	Hopper and volumetric metering device	14 kg/day	6 × 6 × 20		110v–100w	
	15.2	Die table	30 dies/day	18 × 54 × 30			
16	16.1	Tandem hot press (to 800°C). Capacity: 25 ton/die	30 compacts/day	36 × 72 × 72	Ar		Induction heated, press a number of simultaneously; pump outside
	16.2	Die shakeout equipment	30/day	36 × 48 × 48			For removal of compacts from dies
17	17.1	Resistance-heated furnace (to 1800°C)	30 compacts/day	24 × 24 × 48	Ar	550v–10 kw	
18	18.1	Dimensional inspection assembly	30 compacts/day	36 × 60 × 24	Air	110v–500w	
19	19.1	Weighing balance	30 compacts/day	12 × 20 × 20		110v–100w	
20	20.1	Gamma densitometer	30 compacts/day	24 × 24 × 48		110v–500w	
21	21.1	Loading device	1 F.E./day	18 × 20 ft × 18		110v–1000w	
22	22.1	Reflector placement device	1 F.E./day	24 × 13 ft × 24		110v–1000w	
23	23.1	Reflector brazing equipment (2000°C)	1 F.E./day	24 × 24 × 24	Ar-He	110v–1000w	Power unit outside cell
24	24.1	Gamma densitometer	1 F.E./day	24 × 24 × 24		100v–500w	Scans on bed of reflector placement device
	24.2	Lead pig		24 × 24 × 18			

Table 4 (continued)

Process Step	Equipment No.	Equipment Item	Capacity Required	External Size (In-Cell Portion) d × w × h* (in. × in. × in.)	Services Required	Electrical Requirements (Inside Cell)	Special Services or Remarks
25	25.1	Leak check device	1 F.E./day	24 × 13 ft × 24		110v–500w	Pumps, etc., located externally
26	26.1	Surface smear device	1 F.E./day	12 × 13 ft × 12		110v–500w	
		Alternative Equipment (for Pebble Bed Reactor Fuel)					
15a		Cold press ~ 50 ton		24 × 36 × 72			External power supply
15b		Cold press ~ 50 ton		24 × 36 × 72			External power supply
16a		Spray hood		36 × 36 × 72	Ar	110v–500w	
16b		Same as for Step 8					

*d × w × h indicates respectively dimensions of depth, width, and height of equipment referred to the cell module. (See Figure 11.)

and a core of pyrocarbon-coated $Th(U)C_2$ spheroidal particles dispersed in graphite. Alternative equipment for accomplishing the fabrication of PBR fuel is given in Table 1, but is not shown in Fig. 6. If this equipment were installed, it would probably be necessary to displace part of the oxide line in the Contaminated Fabrication Cell.

4. GENERAL DESCRIPTION OF THE FACILITY

A three-story building with a gross floor area (exclusive of cells) of approx 21,000 ft^2 is proposed to enclose a hot-cell structure. This building will contain all necessary offices, shops, working areas, control areas, and services to support the functions of this laboratory and the personnel within. The building is to be designed so that Units 1 and 2 can be constructed either separately or at the same time.

Since the main problem associated with the handling of U^{233} (and associated U^{232}) revolves about protection of personnel from alpha contamination and gamma radiation, the areas in the building are designed to achieve the following:

1. Protection from gamma radiation is provided by walls of sufficient mass to attenuate the radiation to permissible levels in all areas inhabited by personnel.

2. Protection from ingestion or inhalation of alpha-bearing particulates is provided by completely sealing the cells and maintaining these cells at a negative pressure relative to inhabited areas.

3. Areas adjacent to the cells are zoned and controlled to promote localization of any contamination.

Based on particular functions and traffic flow associated with any area, the building is divided into four zones and the major areas falling into each zone are listed below.

Cold Areas (Zone 1)	Suspect Cold Areas (Zone 2)	Suspect Warm Areas (Zone 3)
Entrance Corridor	Cold Change Room	Hot Change Room
Technical Offices	Cell Operating Area	Stairways 3, 4, 5, and 6
Ladies' Room	H and V Equipment Rooms 2 and 3	Fuel Storage Room

Cold Areas (Zone 1)	Suspect Cold Areas (Zone 2)	Suspect Warm Areas (Zone 3)
Secretary's Office	Operating Office	Maintenance Operating Area (first and second floors)
Airlock	Electrical Equipment Room	Receiving Area
Lunch Room	Health Physics Office	Checking and Holdup Area
	Development Laboratory	Warm Shop
	Chemical Makeup Room	Sampling Area
	Stairways 1 and 2	Mockup Area
	Circulating Water Equipment Room	Storage Cell Corridor
		Airlock
		Chemical Cell Pump Tunnel
		Cell Roof Area

Hot Cell Areas (Zone 4)
Chemical Cell
Mechanical Processing Cell
Contaminated Fabrication Cell
Clean Fabrication Cell
Decontamination Cell
Glove Maintenance Room
Equipment Storage Cell
Fuel Storage Basin

Cracks, crevices, ledges, and any particle- and dust-catching items must be avoided to facilitate decontamination. Materials such as stainless steel, vinyl asbestos, vinyl tape, as well as special finishes and protective paints are used in accordance with requirements of the zone and particular operating functions.

Spreading of airborne contamination is minimized by directing air flow from clean areas to potentially contaminated areas and by use of air locks.

A waste system is provided which channels liquid wastes in accordance with the zone from which it originates and which is capable of further differentiation on the basis of a monitored diversion system which is designed to temporarily store radioactive wastes for further disposal into the ORNL plant system. Process water with radiation no greater than the maximum permissible concentration (MPC) will be held temporarily in a retention basin for further disposal.

A recirculating cooling system is provided for process and equipment cooling in the hot cells as protection against spread of contamination due to possible leakage from the process.

A summary of estimated services and utilities is given in Table 5.

Table 5. Estimated Services and Utilities Required for Process

Service or Utility	Estimated Capacity	Remarks
Process water	180 gpm	
Recirculated cooling water	250 gpm	
Demineralized water	10 gpm	Assumed to come from Transuranium building
Radioactive waste sewer	30 gpm	New system required
Process sewer	550 gpm	Retention basin capacity; 100,000 gal, fed by 6-in. gravity line
Compressed air:		
plant (100 psi) instrument (22 psi)	175 scfm	Located in TFCDF
Steam	2000 lb/hr	
Electrical power (cell process only)	104 kw	

5. SITE DEVELOPMENT

5.1 Location

The TFCDF will be located on a site within the general area of the High Flux Isotope Reactor (HFIR).

The center coordinates of the facility are approx N 17695 - E32640;* the final location to be adjusted, after coordination with the final location and configuration of the proposed Transuranium Process Facility, approx 115 ft to the south.

The building will be located a minimum of 100 ft from the Transuranium Process Facility and a minimum of 250 ft from any other inhabited structure.

5.2 Excavation

A preliminary report on foundation investigation as performed by the Corps of Engineers is available.**

Excavation for basement and building foundations shall include removal of an old process waste pond and overburden.

The overburden, approx 20–25 ft thick, consists of clay and weathered shale, the clay appearing near the surface. Below the clay there is a gradual transition from poor-grade rock through weathered rock to the fresh underlying shale.

Since the overburden is composed of weathered rock, it also retains many of the structural characteristics of the underlying fresh rock. The weathered strata beneath this site have an average strike of approximately east-west on the plant grid and an average dip of 35 deg toward the south. The strata are highly folded and faulted. Locally, the dip may vary from horizontal to vertical.

The weathered rock probably can be excavated with mechanized earth-moving equipment, but it may be necessary to use a rooter to loosen the lower portions.

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*Drawing D-39516.

**Corps of Engineers, Foundation Investigations, U^{233} Metallurgical Development Laboratory, Preliminary Report (April 1961).

In excavations the weathered rock or overburden can be expected to fail along the lowest bedding plane exposed at the toe of the excavation at the north side. On the east, west, and south sides, fairly steep slopes should be stable for the length of a construction period.

The bedrock beneath the overburden is dark, calcareous clay shale with numerous interbedded strata of hard, light-gray, dense to crystalline limestone.

Although the fresh rock is more stable than the overlying weathered material, the stability of the up-dip (north) side of any excavation slope is questionable if the dip of the rock is flatter than the slope of the excavation. In any other direction, it is believed that nearly vertical slopes in the fresh rock will be stable if they are protected against weathering disintegration. In addition to being subject to fairly rapid weathering disintegration, the fresh shale is moderately soft and is easily broken, if shot.

Because of the inclination of the strata and the alternating sequence of hard and soft layers, hard strata may extend up into the overburden considerably higher than the general base of weathering with a resulting irregular contact between the fresh and weathered rock.

The water table on the site is apparently high. Both the weathered rock and the fresh rock are relatively impermeable, and the amount of ground water entering an excavation should be relatively small. Because of the high water level, waterproofing and drainage should be provided where floor grades are below the surface.

5.3 Grading and Drainage

The site shall be graded so that ground surface will slope away from all the sides of the building. Storm water will be controlled on surface by proper grading. A tile footer drain around basement walls should drain to a low point within the site area.

5.4 Roads

No new roadwork is contemplated; the intent is to utilize the proposed roadways of the proposed Transuranium Process Facility.

5.5 Underground Lines

The following service lines shall be run from the building perimeter.

5.5.1 Potable Water

Cast iron pipe from west side of TFCDF, then south to connect to fire water supply line on supply side of post indicator valve.

5.5.2 Fire Water

Cast iron pipe from west side of TFCDF, then south to fire water loop of the proposed Transuranium Process Facility.

5.5.3 Cooling Tower Water

Steel pipe lines from TFCDF to plant cooling tower.

5.5.4 Radioactive Waste Drain

Cast iron pipe from hot liquid waste pit to join radioactive waste sewer near facility.

5.5.5 Process Drain

Vitrified clay pipe from TFCDF to proposed TFCDF process waste basin.

5.5.6 Sanitary Drain

Vitrified clay pipe from TFCDF to existing sanitary manhole.

5.5.7 Storm Drain

Vitrified clay pipe from TFCDF.

5.5.8 Steam

Steam line from TFCDF to common point with Transuranium Process Facility system and Plant 4-in.-high pressure supply main.

5.5.9 Electrical Power

Conduit from new substation, shared with Transuranium Process Facility, to building.

5.5.10 Cell Exhaust

Reinforced concrete pipe from TFCDF to proposed fan adjacent to stack.

5.5.11 Hot Off-Gas

Stainless steel duct from TFCDF to cell exhaust air duct.

5.5.12 Demineralized Water

Aluminum pipe from TFCDF to Transuranium Process Facility system.

5.5.13 Subdrain

Drain tile pipe around periphery of basement walls.

5.6 Landscaping

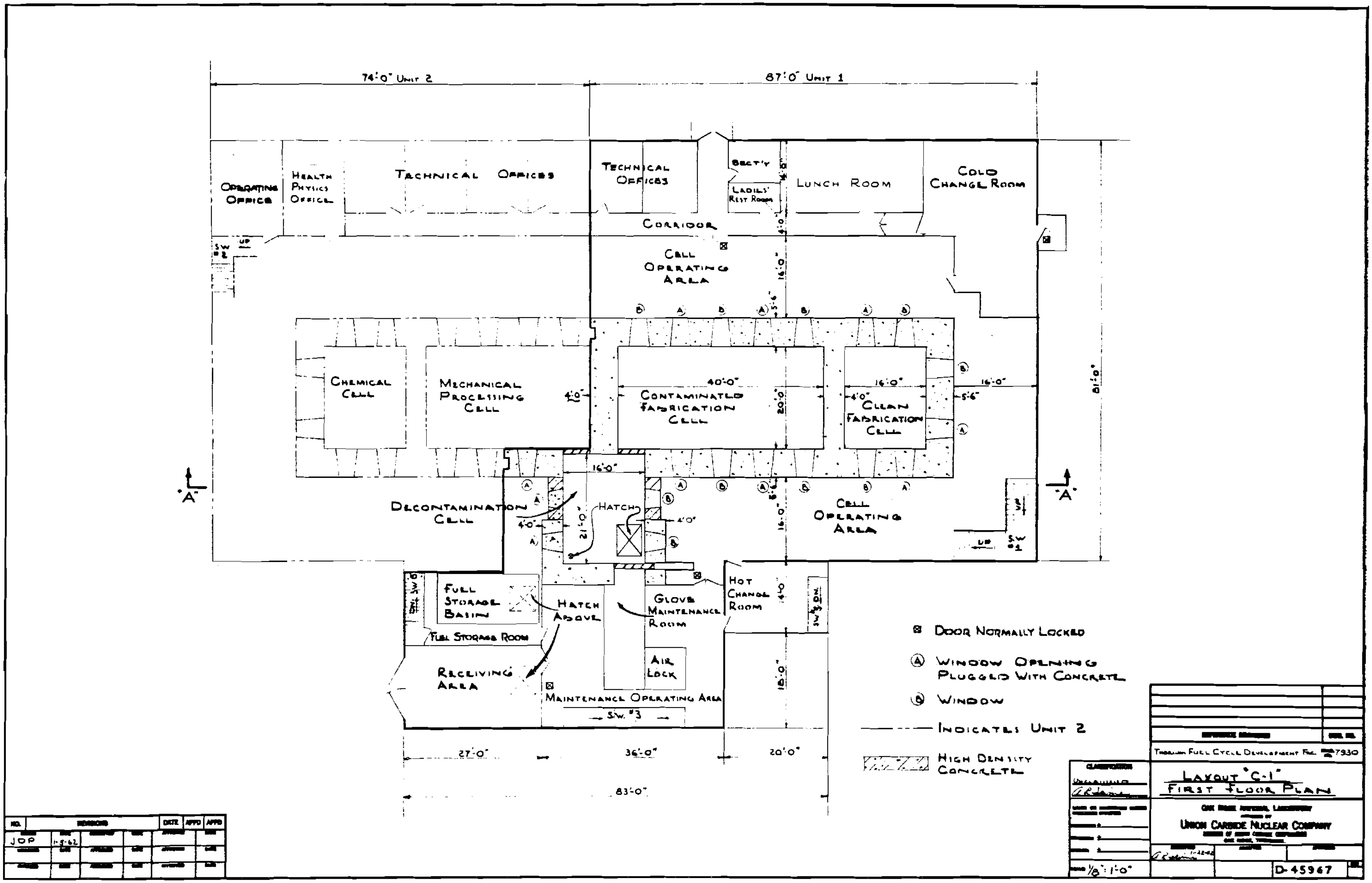
The area disturbed by construction shall receive a dressing of topsoil.

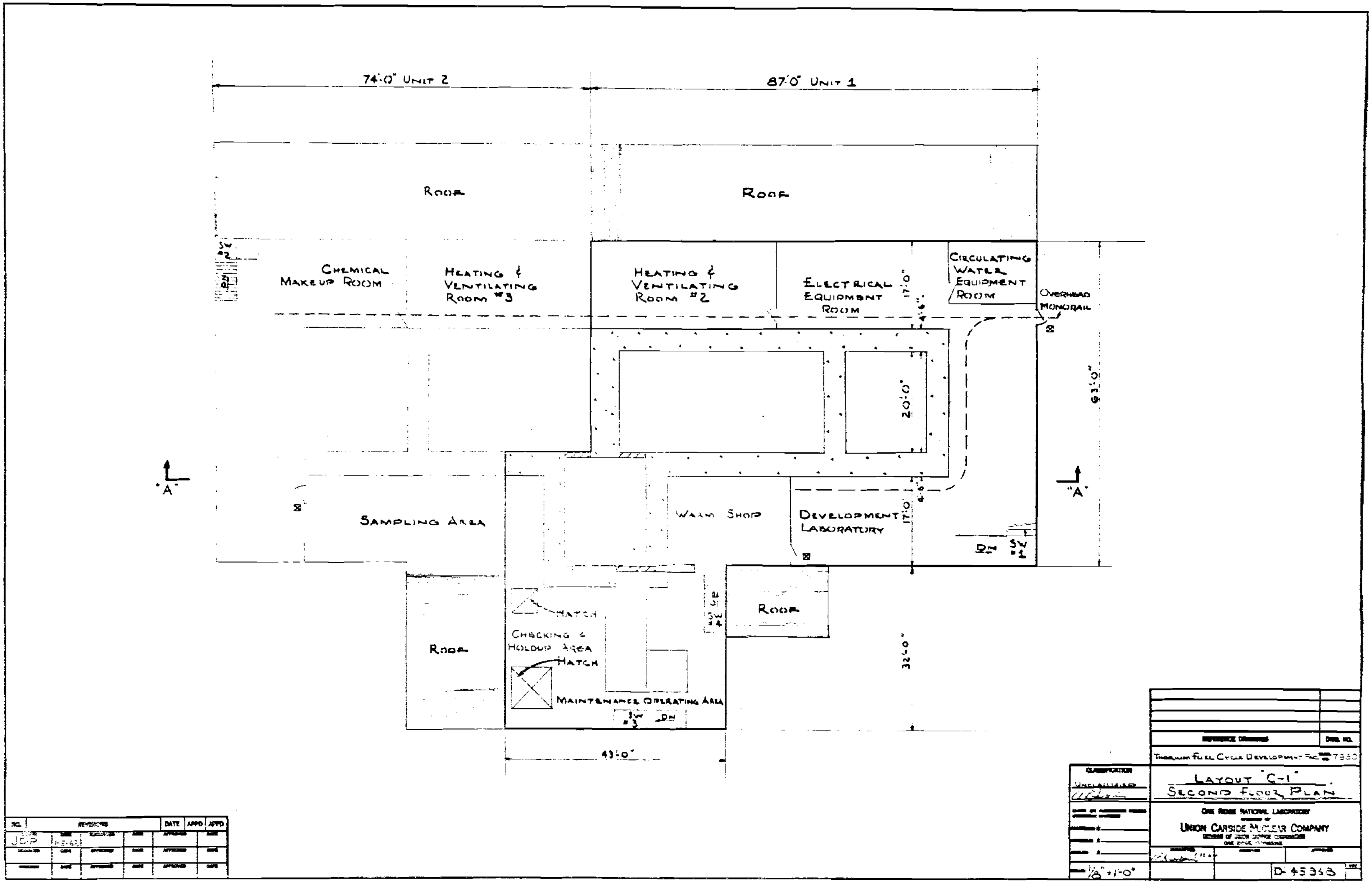
5.7 Fencing

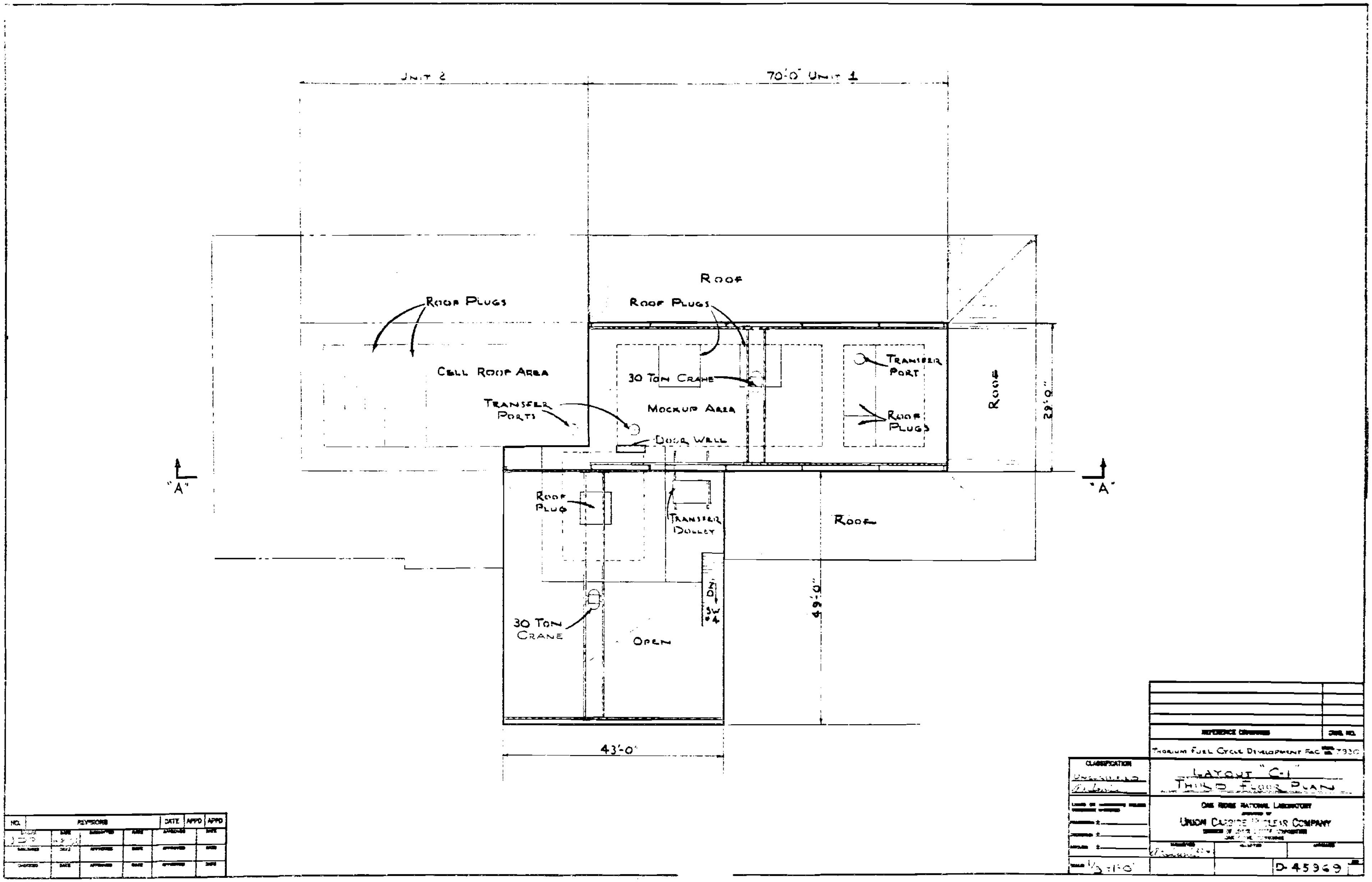
A portion of existing fencing on south side of TFCDF is to be removed. A new 7-ft-high chain-link fence will be included to enclose TFCDF on the west, north, and east sides with the existing fence of the area.

6. STRUCTURAL AND ARCHITECTURAL

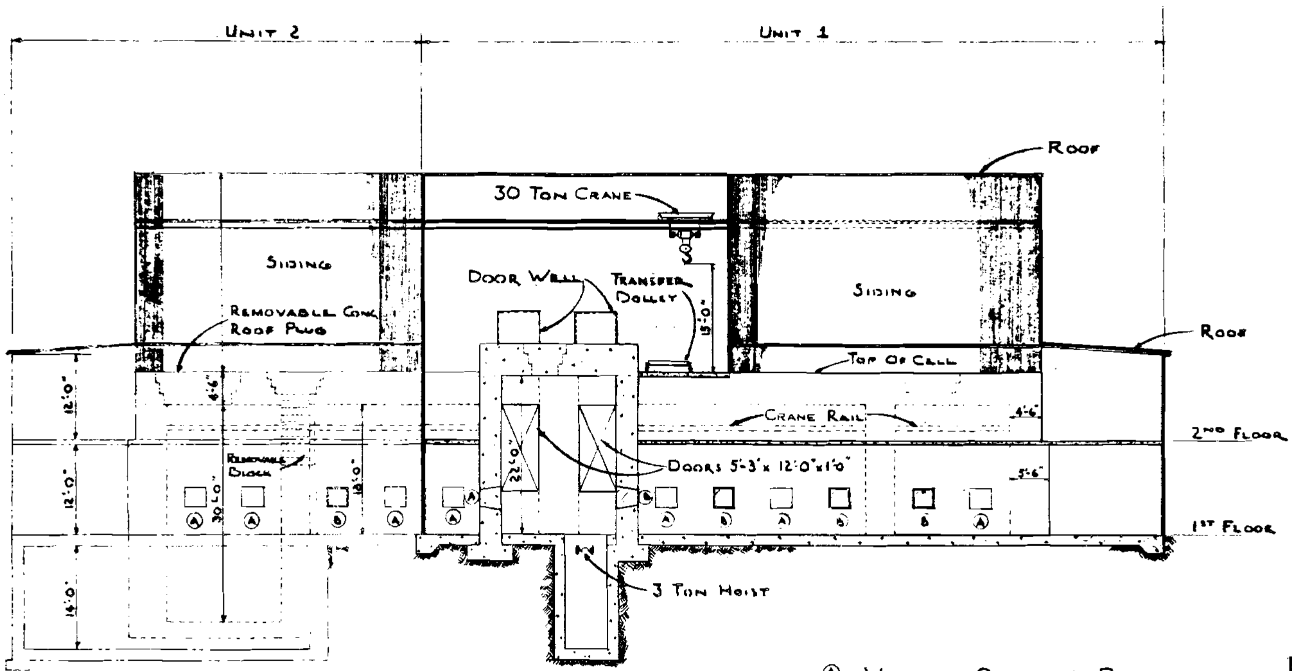
The TFCDF will be designed to comply with the Southern Building Code, Group G, Industrial Occupancy, Type IV, Non-Combustible Construction. The building will provide space for cells, offices, shops, and working areas, as shown on ORNL DWGS D-45967–45971. It will be noted that the facility is shown as two units. It is hoped that funding will be sufficient for construction of the entire facility; in the event that sufficient funds are not available, it is desired that this facility be so designed that construction of part or all of Unit 2 can be delayed without materially increasing the overall cost of the facility.


74'-0" Unit 2
87'-0" Unit 1
Operating Office
Health Physics Office
Technical Offices
Technical Offices
Sect'y
Ladies' Rest Room
Lunch Room
Cold Change Room
Corridor
Cell Operating Area
Chemical Cell
Mechanical Processing Cell
Contaminated Fabrication Cell
Clean Fabrication Cell
40'-0"
16'-0"
16'-0"
81'-0"
Decontamination Cell
Hatch
21'-0"
Cell Operating Area
Full Storage Basin
Hatch Above
Glove Maintenance Room
Hot Change Room
Fuel Storage Room
Receiving Area
Air Lock
Maintenance Operating Area
S.W. #3
27'-0"
36'-0"
20'-0"
83'-0"
"A"
"A"
Door Normally Locked
Window Opening Plugged With Concrete
Window
Indicates Unit 2
High Density Concrete
Thorium Fuel Cycle Development Fac. 7930
Layout "C-1"
First Floor Plan
Union Carbide Nuclear Company
1/8" = 1'-0"
D-45967
JOP
1-8-62


74'-0" Unit 2
87'-0" Unit 1
Roof
Roof
SW #2
Chemical Makeup Room
Heating & Ventilating Room #3
Heating & Ventilating Room #2
Electrical Equipment Room
Circulating Water Equipment Room
Overhead Monorail
17'-0"
4'-6"
20'-0"
93'-0"
"A"
"A"
Sampling Area
Warm Shop
Development Laboratory
17'-0"
4'-6"
DN
SW #1
Roof
Roof
Hatch
Checking & Holdup Area
Hatch
Maintenance Operating Area
SW #3
DN
SW #4
32'-0"
43'-0"
Thorium Fuel Cycle Development Fac. 7930
Layout "C-1"
Second Floor Plan
Oak Ridge National Laboratory
Union Carbide Nuclear Company
1/8" = 1'-0"
D-45368
JDP



Unit 2
70'-0" Unit 1
Roof
Roof Plugs
Roof Plugs
Cell Roof Area
30 Ton Crane
Transfer Port
Mockup Area
Roof
29'-0"
Transfer Ports
Roof Plugs
Door Well
"A"
"A"
Roof Plug
Transfer Dolly
Roof
49'-0"
30 Ton Crane
Open
SW 4
43'-0"
Reference Drawings
Dwg. No.
Thorium Fuel Cycle Development Fac. 7930
Classification
Layout "C-1"
Third Floor Plan
Oak Ridge National Laboratory
Union Carbide Nuclear Company
1/8" = 1'-0"
D-45969
No.
Revisions
Date
Appd
Appd



Ⓐ Window Opening Plugged With Concrete

Ⓑ Window

Section "A-A"

Thorium Fuel Cycle Development Fac. 7930

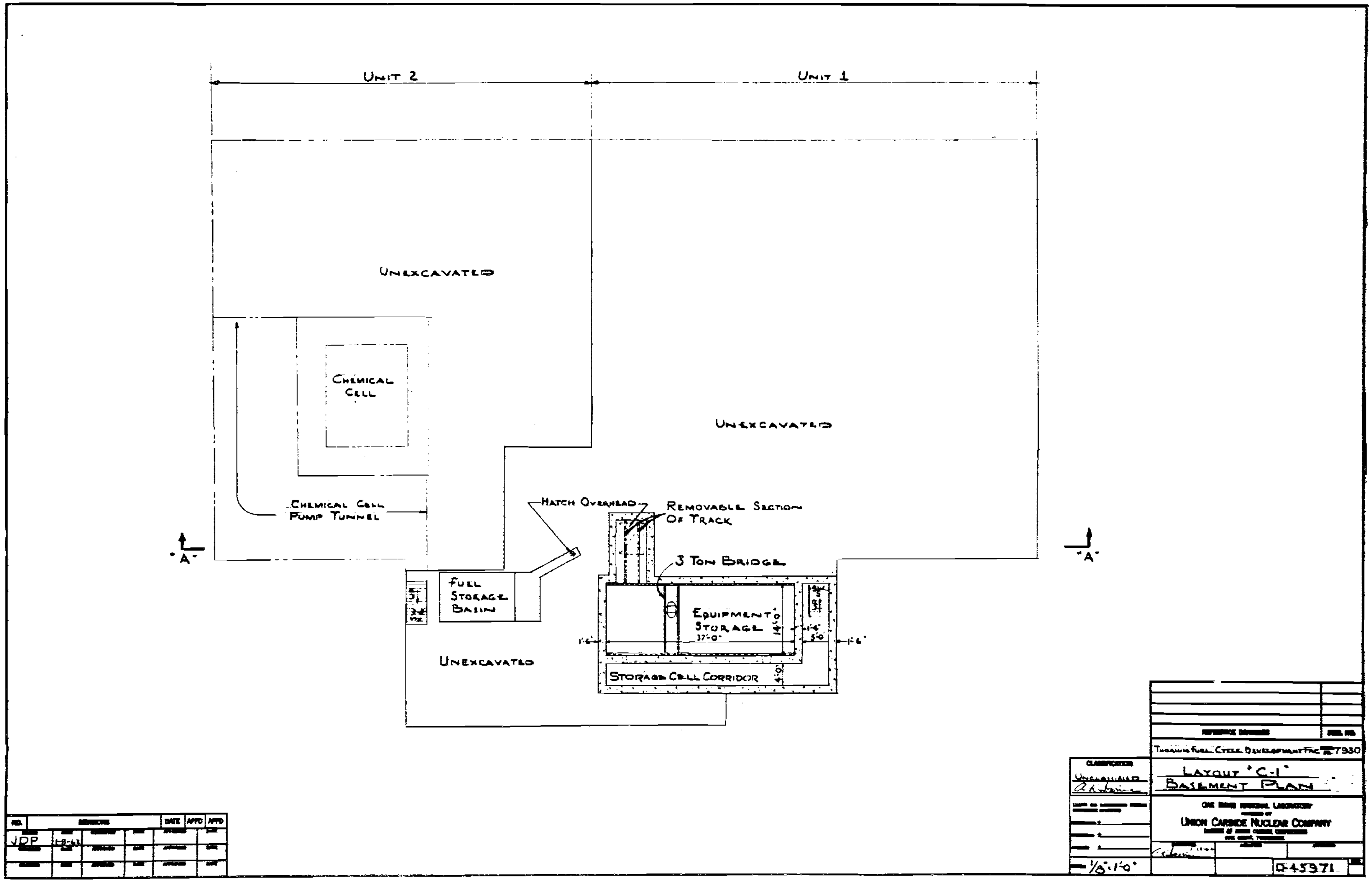
Unclassified

Layout "C-1"
Longitudinal Section

Union Carbide Nuclear Company

JDP

D-45970


UNIT 2
UNIT 1
UNEXCAVATED
CHEMICAL CELL
UNEXCAVATED
CHEMICAL CELL PUMP TUNNEL
HATCH OVERHEAD
REMOVABLE SECTION OF TRACK
3 TON BRIDGE
"A"
"A"
FUEL STORAGE BASIN
EQUIPMENT STORAGE
37'-0"
14'-0"
1'-6"
5'-0"
UNEXCAVATED
STORAGE CELL CORRIDOR
4'-0"
Thorium Fuel Cycle Development Fac. 7930
LAYOUT "C-1"
BASEMENT PLAN
UNION CARBIDE NUCLEAR COMPANY
1/8" = 1'-0"
D-45371
JDP

The TFCDF will be classified for radiation hazard and exposure control in accordance with ORNL Health Physics Manual, as revised August 4, 1961. Table 6 provides an order of magnitude comparison of alpha and gamma contamination within the building. Each area is evaluated on the basis of the functions it is designed to do. The columns on the left indicate the radiation levels likely for each area most of the time. The right-hand columns indicate the probable peak levels these areas are likely to attain during the performance of their functions. Good housekeeping procedures will maintain the laboratory at the figures given under the "normal level" column. Laboratory personnel requirements are based on a maximum of 30 people on any one shift and a maximum of 50 people for all shifts.

Table 6. Radiation Level Schedule

Areas	Normal Level: Alpha (MPC)* (Above Background)	Normal Level: Gamma (mr/hr)	Special Operations: Alpha (MPC)*	Special Operations: Gamma (mr/hr)
Zone 1 areas	< 0.1	background	< 0.1	background
Zone 2 areas	< 0.1	0.25	1	0.25
Zone 3 areas (Except as noted below)	0.2	2.5	2	2.5
Hot change room	0.2	0.25	2	2.5
Maintenance operating area (In vicinity of glove maintenance room)	0.2	2.5	2	10**
Airlock	10	2.5	10	10**

*Maximum permissible concentration for mixture of alpha emitters in air (1×10^{-11} μC/ml). MPC higher than this if only U^{233}, U^{232}, Th involved.

**When one shield door is open or a fuel element is in decontamination room.

6.1 Personnel and Equipment Flow

The alpha-contamination hazard and the high-level gamma radiation within the cells require particular attention in dealing with the personnel and equipment flow. Figure 12 represents personnel traffic flow within the laboratory. The zoning of the areas and the limit to normal personnel entry are shown.

6.1.1 Cell Access Criteria

The entire cell structure will be sealed. Maximum permissible leak rate is 0.02% of cell volume per hour. The cell structure will be divided into three types of cells based on the potential contamination hazard which is associated with the operations to be performed in each. The Mechanical Processing and the Contaminated Fabrication cells will become highly contaminated; and, hence, they must be remote maintenance cells. The Chemical Cell, having a lesser potential for becoming contaminated, will be maintained by contact techniques. Should operations in the Chemical Cell become dirty in nature, the removable blocks between it and the Mechanical Processing Cell will allow a changeover to remote maintenance technique. The Clean Fabrication Cell will have the least potential for contamination; thus, equipment in this cell will be serviced by contact maintenance after the gamma source is removed.

Cell equipment for the highly contaminated cells (Mechanical Processing and Contaminated Fabrication) is to be designed for operations on the basis of no-personnel-entrance into the cells proper, with all maintenance of equipment being accomplished by remote control or through gloves after decontamination. No personnel are expected to enter farther than the interior of the decontamination cell. Special precautionary procedures are required for such entrance. Normally, no entrance farther than the maintenance operating area is contemplated.

Access to the contact maintenance cells will be through holes in the cell roofs. Normally, these holes will be closed and sealed with removable concrete plugs.

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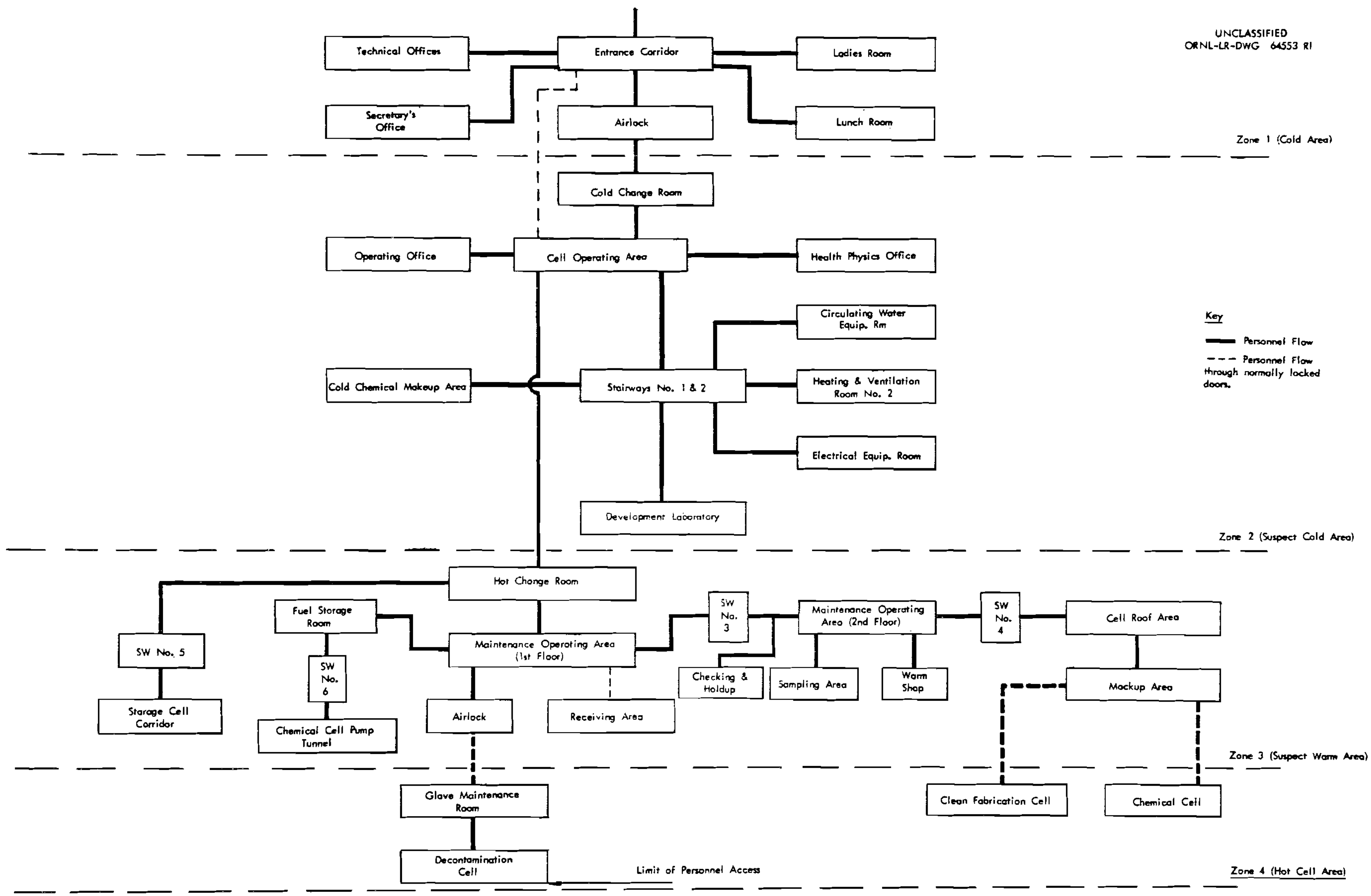

Fig. 12. Personnel Flow Control Scheme.

6.1.2 Equipment Flow

Figure 13 illustrates the flow scheme for equipment within the building and cells. All cold equipment for the remote maintenance cells will enter through the Airlock into the Glove Maintenance Room. There it is remotely picked up by the cell crane or rectilinear manipulator and the item passes through the gamma-shields gates into the cells.

A cask, weighing up to 30 tons, may be brought in through the roof hatch of the Airlock. A truck can transport this cask into the Decontamination Cell where the contents may be removed by the cell crane or rectilinear manipulator.

Radioactive objects from the cells can be removed directly through the transfer ports and into a cask. One large transfer port is located in the top of each cell except the Chemical Cell; thus, there are three large transfer ports in the roof. One transfer port is located in the common wall between the Contaminated Fabrication and the Clean Fabrication Cells. In addition, holes will be provided for future transfer ports in the following wall locations: (a) between the Clean Fabrication Cell and the Contaminated Fabrication Cell; (b) between the Contaminated Fabrication Cell and the Mechanical Processing Cell; and (c) between the Mechanical Processing Cell and the Chemical Cell. A pneumatic transfer system for transferring small solid samples from the cell interior to the cell roof will be provided in both the Mechanical Processing Cell and the Contaminated Fabrication Cell.

Thorium and uranium nitrate solutions may be received in shielded-transfer casks. Provisions will be made for possible future installation of a feed-cask glove-box cubicle on the roof of the Chemical Cell. From this area solutions may be transferred by gravity to the cell below.

One-way transfer ports (transfer into cell only) will be provided for passing objects from the operating area to the cell area. They will be distributed as follows: Chemical Cell, 1; Mechanical Processing Cell, 2; Contaminated Fabrication Cell, 2; Clean Fabrication Cell, 1; Decontamination Cell, 1.

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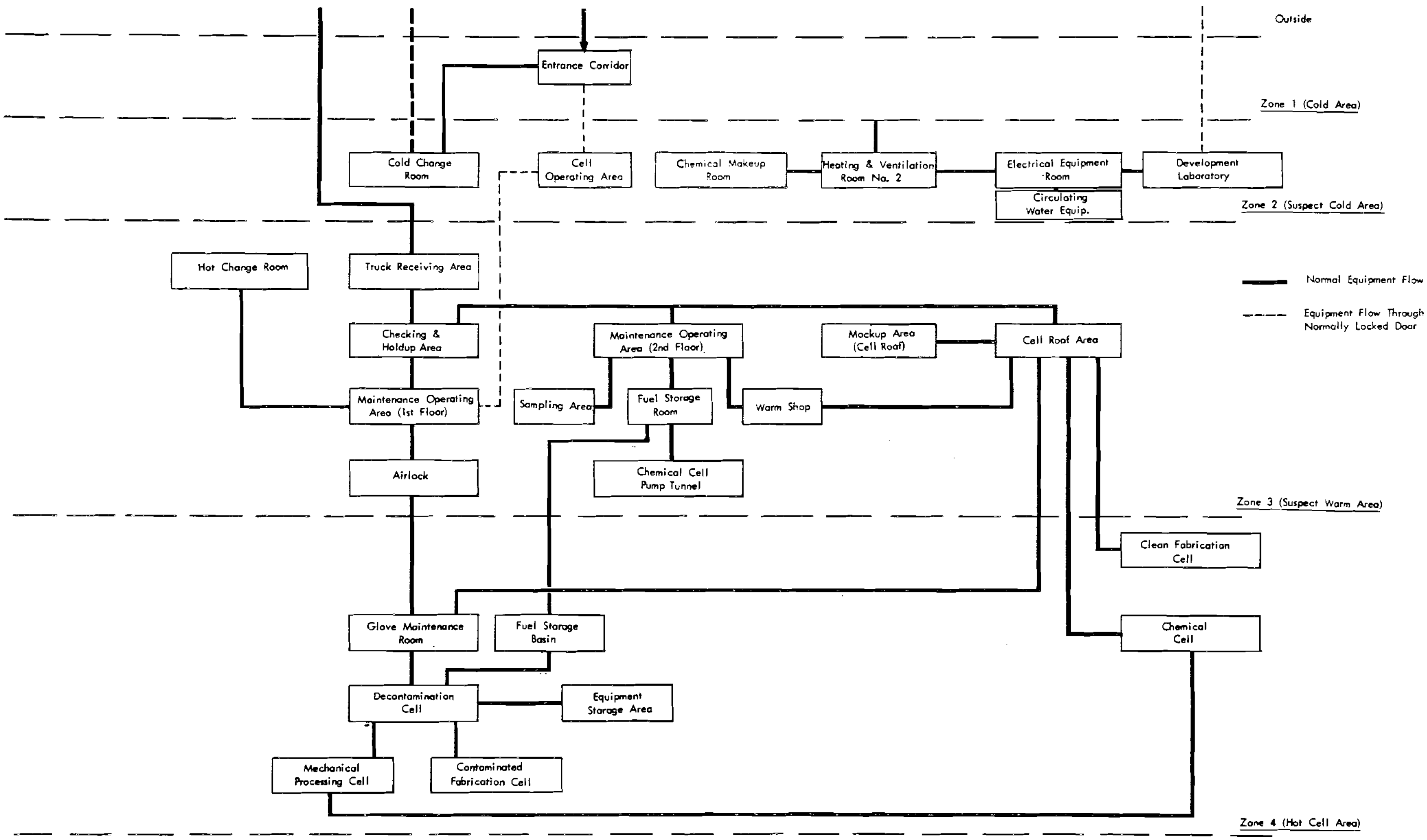

Fig. 13. Equipment Flow Control Scheme.

6.2 Area Descriptions

6.2.1 Cell Structure (General)

The hot-cell structure consists of the Clean Fabrication Cell, the Contaminated Fabrication Cell, the Mechanical Processing Cell, the Chemical Cell, the Decontamination Cell, and the Hot-Equipment Storage Cell. The Glove Maintenance Room and the Airlock are appended to this structure. Regular concrete of 5-1/2-ft thickness is used for most of the biological shielding; lesser thicknesses of regular concrete will be used where radiation intensities are reduced; and high-density concrete or steel will be used where space is important. The interior faces of the cells will be finished according to the following schedule:

Cell	Floor and Wainscoting*	Walls and Ceiling
Contaminated Fabrication	Type 304L stainless steel	Carbon steel
Clean Fabrication	Type 304L stainless steel	Sealed and painted
Mechanical Processing	Type 304L stainless steel	Carbon steel
Chemical Processing	Type 304L stainless steel	Type 304L stainless steel
Decontamination	Type 304L stainless steel	Carbon steel
Hot-Equipment Storage	Painted	Sealed and painted

The liner at the roof of the Mechanical Processing, Contaminated Fabrication, and Decontamination Cells will be designed to permit cutting and rewelding after the roof blocks have been removed. The roof blocks will be preformed concrete slabs and will be provided with lifting bails. The roof block will be designed in sections so that no single block will weigh more than 30 tons (crane capacity).

The cells will be designed to withstand an internal shock wave of 900 psf and a maximum energy of 270 ft-lb-ft^2.

A Decontamination Cell having three shield door assemblies will be provided to permit the crane and manipulators to pass from the Remote Maintenance Cells to the Decontamination Cell and then to the Glove Maintenance Box. The Remote Maintenance Cell cranes will use underslung

*Wainscoting will extend to the bottom of the windows.

hoists such that the hoists can run from one bridge to another. The mechanism in the Remote Maintenance Cells and in the Decontamination Cell and Glove Maintenance Room shall be arranged to permit the hoists to travel from the Glove Maintenance Room into either of the Remote Maintenance Cells without interruption for plugging the hoist into a wall socket (a device which either plugs into the bridge or uses trolley pickups from the bridge will be acceptable). Suitable devices must be provided both in the Remote Maintenance Cells and in the Decontamination Cell to permit the remote cell bridges to be removed to the Glove Maintenance Room for maintenance purposes. Manipulator bridges will be removed by the cell hoist.

6.2.1.1 Contaminated Fabrication Cell. - The Contaminated Fabrication Cell has interior dimensions of approx 20 ft × 40 ft × 18 ft high; one area in the cell shall have a false floor covering a pit 6 ft deep × 20 ft long × 10 ft wide. The cell is provided with nine window openings with liners, five of which are to be filled with removable concrete blocks and four of which are to be equipped with windows. All openings will be sealed with a glass plate, removable on the hot side. Removable wall plugs for future service installation will penetrate the walls of the cell from the second floor of the building. Ten plugs approx 4 in. in diameter will be arranged at each cell module. These plugs must be so designed that services provided by them may be changed without contamination of the cell exterior. In addition, ten 1-in.-diam stainless steel pipes extending through the wall from the second floor will be provided for each cell module. These will be equipped with a suitable disconnect fitting inside the cell and capped on the outside. All service pipes shall be accessible to the rectilinear manipulator.

A 3-ton crane and one General Mills (GM) Model 300 manipulator are located in the Contaminated Fabrication Cell. Four pairs of Central Research Laboratory (CRL) Model A manipulators will be provided at the window locations. Plugged and sealed sleeves for future manipulators will be provided in each module that has a plugged window liner.

A total of four holes, with removable plugs and alpha seals on the inside of the cell, shall be provided for periscope installation.

6.2.1.2 <u>Clean Fabrication Cell</u>. - The Clean Fabrication Cell, with interior dimensions of approx 20 ft × 16 ft × 24 ft high, is located at one end of the cell structure. Personnel and equipment access will be through a roof plug. The cell will be provided with six window liners, each with a gas-tight-seal glass on the hot side. Three shield windows will be provided for this cell, and the extra liners will be blocked with removable concrete plugs which may be readily replaced by a shield window from outside the cell. Each module will have six 2-in.-diam stainless steel conduits cast in the concrete for a total of 36 for the cell. This conduit will run from the second floor of the building to the cell interior. Also, ten 1-in.-diam stainless steel pipes extending through the wall from the second floor and flanged at both ends will be provided for each module. Three pairs of CRL Model D heavy-duty master-slave manipulators will be provided for the windows. Manipulator sleeves shall be suitable for Model A manipulators; spare manipulator sleeves shall be plugged and sealed. A Model 100 GM manipulator or equal will be provided. The manipulator will be arranged so that the manipulator and the bridge drive motor can be lifted out of the cell by the building crane. A 3-ton, remote-operated, top-riding overhead crane shall be provided. A total of three holes, with removable plugs and alpha seals on the inside of the cell, shall be provided for periscope installation.

6.2.1.3 <u>Mechanical Processing Cell</u>. - The Mechanical Processing Cell has interior dimensions of approx 20 ft × 32 ft × 18 ft high and is provided with seven window liners, each of which is sealed on the inside with a replaceable, 1-in.-thick glass plate on the hot side. Four of the liners will be equipped with windows, and the remaining three will be filled with removable concrete blocks. Ten removable wall service plugs at each cell module will penetrate the walls from the second floor. Plugs will be designed to prevent contamination of the building when the service is changed. Also, ten 1-in.-diam stainless steel pipes extending through the wall from the second floor will be provided for each module; these will be equipped with a suitable disconnect inside the cell and capped outside. One 3-ton, underslung bridge crane and one Model 300 GM manipulator are to be provided for this cell. Four pairs of CRL Model A manipulators are required for the four shield windows. Plugged and sealed manipulator sleeves will be provided at the three spare window liners. A total of three holes, with removable plugs and alpha seals on the inside of the cell, shall be furnished for periscope installation.

6.2.1.4 Chemical Cell. - The Chemical Cell has interior dimensions of approx 16 ft × 20 ft × 30 ft high. Provisions are to be made to convert this cell from contact maintenance to remote maintenance. Six window liners designed to receive a 1-in.-thick-glass seal window on the inside face will be provided. The liners will be plugged with removable concrete blocks. Plugged and sealed holes for Model A manipulators will be provided above all window liners. Two slots, approx 12 in. wide × 3 ft long in cross section, are to be cast into each of the three exterior walls. These slots will run from the second-floor level outside the cell to a point approx 20 ft above the floor inside the cell. Stepped horizontal holes, 4 in. in diameter, shall run through the cell wall at the basement level. Ten holes shall be provided on each wall. In addition, ten 1-in.-diam stainless steel pipes through the wall from the second floor are to be provided at each cell module. They will be capped inside the cell and valved at the outside. Provisions shall be made to allow future passage of the Mechanical Processing Cell bridge crane and GM manipulator onto a set of translating tracks in the Chemical Cell. A total of two holes, with removable plugs and alpha seals on the inside of the cell, shall be furnished for periscope installation.

6.2.1.5 Decontamination Cell. - The Decontamination Cell, with interior dimensions of approx 22 ft × 16 ft × 24 ft, is designed to permit decontamination and disassembly of hot equipment as well as entrance and exit from the limited access area into the cell structure. Four window liners, each with a gas-tight-seal glass on the hot side, will be provided. Two shield windows will be provided and the other liners will be blocked with a removable concrete plug which may be replaced readily by a shield window from outside the cell. One pair of Model A master-slave manipulators will be provided at each window, and plugged and sealed through-tubes will be provided at the plugged-window opening. Each module will have six 2-in.-diam bent carbon steel conduits and ten 1-in.-diam stainless steel bent pipes at convenient elevations. Sealed ports to the equipment storage room and to the fuel storage basin shall be provided.

6.2.1.6 Glove Maintenance Room. - The Glove Maintenance Room will consist of a lower section for equipment transfer, manual repair through gloves, decontamination, and an upper section designed for the remote maintenance of the cell crane and the GM manipulators. The upper portion of the Glove Maintenance Room will contain a monorail and one 3-ton electric hoist to assist in disassembly and repair work. The walls will consist of a carbon steel plate approx 1/2 in. thick with numerous acrylic plastic windows and glove ports strategically located to permit the performance of the work. A 12-in. bagging port will be provided on each face of the Glove Maintenance Room. A hatch, approx 6 ft × 7 ft, for introduction and removal of casks and equipment will be provided on the roof of the room. The hatch will be designed for bagging operations and will be sealed with a horizontally operating door. Rails for a 30-ton transfer truck will be provided on the floor. A removable section of the rail will be provided for the gap created by the sliding shield door of the Decontamination Cell. The interior and exterior of the Glove Maintenance Room will be coated with Amercoat No. 99 protective paint system. Hinged work benches will be located on the interior wall to facilitate the maintenance work. Floors will be type 304L stainless steel.

6.2.1.7 Airlock. - An Airlock will be provided adjoining the Glove Maintenance Room. A sealed door, 4 ft wide and 7 ft high, for personnel and equipment is provided from the Maintenance Operating area. The seal door between the Airlock and the Glove Maintenance Room will be 7 ft wide × 7 ft high. A sealed hatch, approx 7 ft^2, will be provided in the top of the Airlock. The walls will consist of carbon steel plate approx 1/2 in. thick and will be coated with protective paint on the interior and exterior. Acrylic plastic windows with glove ports will be provided in this area. The floors will be type 304L stainless steel.

6.2.1.8 Fuel Storage Basin. - The Fuel Storage Basin will be located in the Fuel Storage Room and will connect with the Decontamination Cell by means of a canal. The basin is to be water-filled to a 22-ft level. The end under the hatch (approx 10 ft × 8 ft) is to have a depth of 32 ft. The Storage Basin shall be painted. A 25-gpm-demineralizer system shall be provided.

6.2.1.9 Hot Equipment Storage Cell. - A Hot-Equipment Storage Cell will be provided in the basement of the building and will connect to the operating cells through a 6-ft × 7-ft hatch in the floor of the Decontamination Cell. The cell walls will be 18 in. of regular concrete. Six zinc bromide windows, approx 12 in. × 18 in. with alpha-seal windows, will be provided. The walls, ceilings, and floors of this cell will be finished with Amercoat No. 99. A 3-ton, top-riding crane and hoist will be provided. Means will be provided for maintenance of the bridge. The hoist will be maintained in the Glove Maintenance Room.

6.2.2 First Floor

6.2.2.1 Offices. - The following offices will be provided: an Operating Office to provide room for six desks with access to the Cell Operating Area; six Technical Offices, each to provide room for two desks with access to the entrance corridor; Health Physics Office with access to the Cell Operating Area plus a Secretary's Office with access to the entrance corridor.

6.2.2.2 Lunch Room. - A combination lunch and conference room equipped with sink, refrigerator, and stove.

6.2.2.3 Cell Operating Area. - The Cell Operating Area will be located on the first floor. All controls, viewing, and operation of the cells will take place from this area.

6.2.2.4 Maintenance Operating Area. - The Maintenance Operating Area surrounds the Glove Maintenance Room and is to provide working space for personnel and easy movement of equipment. This area extends upward through the second and third floors.

6.2.2.5 Receiving Area. - The Receiving Area will be provided with a truck access and a double door with an opening of 12 ft × 12 ft. The door will be normally secured and made weather tight to minimize air leakage. The hatch above the Receiving Area will be motorized and interlocked with the exterior door.

6.2.2.6 Fuel Storage Room. - The Fuel Storage Room will be located on the first floor and will house the Fuel Storage Basin and related equipment.

6.2.3 Second Floor

6.2.3.1 Equipment Rooms. - Space shall be provided for installation of air conditioning, electrical, and circulating-water equipment. A space adjacent to the cell wall approx 5 ft wide shall be left free of equipment in order to allow for installation of service in the special service tubes and for movement of equipment by an overhead powered monorail crane (1-ton capacity).

6.2.3.2 Chemical Makeup Room. - The preparation and short-term storage of chemicals for the process will take place in the Chemical Makeup Room.

6.2.3.3 Development Laboratory. - This room is reserved for the cold development of equipment and for operations involving preparation of materials that are to be used in the fabrication cells.

6.2.3.4 Warm Shop. - The Warm Shop is an open area where slightly radioactive equipment may be repaired or set up.

6.2.3.5 Sampling Area. - Samples of process solutions from the Chemical Cell will be taken in this area.

6.2.3.6 Checking and Holdup Area. - This area is located on the second floor directly above the Receiving Area and serves as a checkpoint for equipment movements in and out of the Maintenance Operating Area.

6.2.4 Third Floor

This area houses the cell roof and the top of the Glove Maintenance Room. Two bridge cranes (30-ton capacity) on separate track systems serve these areas and provide for easy movement of heavy objects such as casks and roof blocks. The crane over the Maintenance Operating Area will have a span of approx 50 ft and will be of standard construction. The crane over the cell roof will have a span of approx 25 ft and will be of the double drum-two hook type in order that roof plugs may be held in a horizontal attitude. Shifting of a load from one crane to another will be accomplished by placing the load on a track-mounted dolly which moves between the two-crane service area.

A portion of the Cell Roof Area will be used as a mockup area for cell equipment; the remaining area will be used for access to transfer ports, roof plugs, et cetera.

6.2.5 Basement

6.2.5.1 Chemical Cell Pump Tunnel. - The Chemical Cell Pump Tunnel will extend along two sides of the Chemical Cell. It will be used to house vulnerable equipment items during periods when the cell is used as a contact maintenance facility.

6.2.5.2 Storage Cell Corridor. - The Storage Cell Corridor will extend along two sides of the Equipment Storage Cell to provide viewing and access for emergency maintenance purposes.

6.2.6 Outside Facilities

Final filtration equipment for both cell ventilation air and for vessel off-gas shall be situated outside the building and provided with minimum equipment necessary for replacement of filters and containment of radioactivity. Waste surge tanks shall also be separately house. Heating and lighting will be minimal as the building will be occupied for only short periods each week.

6.3 Building Structure

6.3.1 Below Grade

Footings, slab, and walls shall be 3000-lb reinforced concrete designed in accordance with latest ACI code. Reinforcing bars shall be billet or rail steel ASTM A-305. Foundations shall be waterproofed below grade. Footings shall extend below frost line. Bearing pressures shall be: 6000 psf maximum on overburden; 12,000 psf maximum on fresh rock.

6.3.2 Above Grade

Building structural framing shall consist of structural steel columns, beams, and girders (including crane rails) designed in accordance with AISC standards and American Welding Society Specifications. Floor slabs shall be reinforced concrete having compressive strength of 4000 psi for slabs on grade and 3000 psi for all other slabs.

6.4 Exterior Walls

Exterior walls shall be constructed of concrete, load bearing, hollow masonry block conforming to ASTM C-90-52 with Duro-wall reinforcement at every second course. All exterior surfaces of concrete block wall exposed to weather shall receive two coats of clear waterproofing.

6.5 Roof

The roof shall consist of metal roof decking supported on structural steel framing with fireproof vapor barrier Lexsuco or equal, 1 1/2-in.-thick rigid fiberglass insulation board, Class A — 5-ply built-up roofing — 20-year type.

6.6 Floors

6.6.1 Loadings

Maintenance Operating Area, first floor — 600 psf; all second floor area — 150 psf; slab over cells — 2000 psf; all other floor areas — 100 psf in accordance with the Southern Building Code.

6.6.2 Finishes

Floors in the Zone 3 area will have a finish application of Amercoat No. 99 protective paint system to a thickness of 10 mils. Floors in the Cell Operating Area, Development Laboratory, Chemical Makeup Room, Offices, and Corridor shall be covered with vinyl asbestos floor covering. Floors in change rooms and Ladies' Room shall have quarry tile flooring. A Portland cement cove base shall be applied to all walls where floors are not to be covered with tile.

6.7 Interior Walls and Partitions

All interior walls and partitions (other than cell walls) shall be constructed of 6-in. limestone aggregate, hollow nonload-bearing block with Duro-wall reinforcement every second course. Where hung ceilings occur, the walls and partitions shall be extended one course above the hung ceiling except for the partition walls between zones; in which case, the walls shall extend from the floor to underside of slab above.

Walls in change rooms shall have structural glazed tile wainscot 5 ft 0 in. high and coved base. A three-coat Keene plaster finish will be provided on walls above wainscot to ceiling.

Walls in the Zone 3 area, except Receiving Area, shall receive Amercoat No. 99 protective coating system.

Walls in Zones 1 and 2 and in Receiving Area shall receive three-coat system of rubber-latex-base paint.

6.8 Doors and Exits

Exits will conform to all appropriate codes. Interior doors and personnel entrance shall be 1 3/4-in., 18-gage, swing-type, flush, hollow metal doors filled with noncombustible-type insulation. Secretary's Office door shall be glazed on top half. Exterior doors and doors between Zones 2 and 3 shall be provided with neoprene interlock weather stripping and automatic bottom seals. Swinging doors are required for truck entrance. Door frames shall be 16-gage cold-rolled steel, reinforced for 1 1/2 pairs of hinges and strikes and furnished with loose T anchors and welded on adjustable nose anchors.

The finish on all exposed hardware shall be dull bronze US-10. A mortise lockset with push and pull knobs and 1 1/2 pairs butts per door shall be provided. All doors shall have door closers except Janitor's Closet and H and V Equipment Room. Butt hinges for exterior doors shall be ball-bearing brass and for interior doors ball-bearing steel with prime coating. All cylinders shall be Best Universal Lock Company cylinders, 7-pin core. All cores are to be designed to permit adoption of present master keying system in the building. Door stops shall be furnished wherever an opened door or an item of hardware strikes a wall, column, or other part of the building. All doors leading to the exterior shall receive panic hardware; all exterior doors not used for normal entry shall be operated from inside only.

Doors and frames in the Zone 3 area shall receive Amercoat No. 99 protective coating. All other doors and frames shall receive a factory prime coat and two finish coats of enamel.

Floor hatches shall be flush-floor type with reinforced 3/16-in. diamond-checkered cover, compensating spring hinges, and flush-lift handle. A neoprene gasket shall be provided around perimeter between cover and frame to reduce air leakage. Hatches shall be painted the same as the doors.

6.9 Windows

Exterior windows will be provided in all offices in Zone 1. Two observation windows, 1/4-in. plate glass fixed in hollow metal frames, are to be provided in the wall separating the Corridor from the Cell Operating Area.

6.10 Ceilings

Ceilings in Operating Area shall be acoustical, mechanically suspended type. The acoustical tiles shall be Sonaface size 24 in. x 48 in. of noncombustible mineral fiber. The panels shall conform to light reflection range A, flame resistance A, and noise reduction coefficient 0.80 to 0.90. All joints and voids around penetrations through the ceiling shall be sealed with vinyl tape which matches the Sonaface tile.

Ceilings in offices and corridors shall be Sonaface acoustical suspended-access type supported on extruded aluminum, T bar system. The tiles shall be Sonaface noncombustible mineral fiber.

6.11 Stairs and Gratings

6.11.1 Stairs

Stairs shall be designed to support a live load of 100 psf. Stairs shall be depressed pan type with safety nosing and with not less than No. 12 U.S. gage integral subtreads, risers, and platforms and filled with concrete. Appropriate railings will be provided.

6.11.2 Gratings and Frames

Checker plate shall be used to cover floor openings where feasible. Where ventilation is required, gratings shall be steel subway type with abrasive finish. Frames shall be constructed of steel angles secured to the structure where feasible. All corners shall be mitered and welds shall be ground smooth. Stairs and gratings will be painted with Amercoat No. 99 protective system.

6.12 Plumbing Fixtures and Accessories

Appropriate plumbing fixtures shall be provided in the change rooms and Ladies' Room with a distribution commensurate with the expected occupancy of the building. No more than one third of the number working in the building are expected to occupy Zone 3 at any one time.

In addition, appropriate fixtures for safety showers, eyewash stations, drinking fountains, and janitor's closets are to be provided.

7. PIPING SERVICES

7.1 Waste Disposal System

7.1.1 Process Waste

The Process Waste system shall drain the entire building of normally nonradioactive waste. After leaving the building on the south side, it shall enter a weir-box-type beta-gamma radiation monitor which will sound an alarm in the control room. From the monitoring station, the stream shall flow by gravity to the new earthen retention basin in the vicinity of process waste basin No. 2 (approx 1100 ft south of the building). This discharge line is to be sized to drain approx 50% of the sprinkler system flow.

At the new 100,000-gal retention basin, an overflow line shall run to the Transuranium basin. The basin shall also include a valve diversion arrangement for routing the basin contents to either environment or to the plant cleanup system. Environment discharge may be accomplished by gravity flow. For plant cleanup discharge, a process Waste disposal transfer pump (30 gpm — 100 ft Total discharge head (TDH) — 1 hp) will be furnished by others.

The system shall accept the water from all building floor drains, equipment drains, and safety showers.

System piping shall be of extra heavy cast iron bell and spigot pipe. Joints shall be an acid-resisting type using Durco No. 190 impregnated asbestos packings and caulked with virgin lead.

7.1.2 Radioactive Wastes

The Radioactive Waste system shall drain the radioactive areas of the building. A Radioactive Hot Drain - Recoverable (RHDR) header (3-in. diam) shall pick up drains containing potentially recoverable material. A Radioactive Hot Drain (RHD) header (3-in. diam) shall pick up the remaining radioactive drains.

The RHDR header shall drain the floor troughs in the processing and fabrication cells and process waste discharge from the Chemical Cell. The header shall drain directly to two collection (recovery) tanks located in the concrete waste pit outside the building. The tanks shall be equipped with air-lift pumps for pumping a sample stream to a lead-shielded colorimeter and sample station. The tank shall also be equipped with a RHDR return pump (steam jet type). From this pump a 1-in. line shall run back to the Chemical Cell. The RHDR shall also drain one 2-in. drain from a future feed cask glove box on the third floor.

The RHD header shall collect drainage from the following points: (a) transfer ports; (b) ultrasonic washer in clean fabrication; (c) decontamination cell floor drain; (d) glove box floor drain; and (e) equipment storage area floor drain.

The RHD header shall drain through a strainer, which is located near the waste pit, directly to the collection (waste) tank located in the concrete waste pit outside the building. The tank shall be equipped with an air-lift pump for pumping a sample stream to a sample station. The radioactive waste system shall be vented to the hot off-gas system.

All piping shall be sched-40 type 304L stainless steel. The entire system shall be of all-welded construction using 8-in.-diam bending radii and lateral fittings. The minimum slope shall be 1/8 in./ft. All drain collection points shall include a plug-float valve.

7.1.3 Waste Collection Pit

The RHD and RHDR headers mentioned in Section 7.1.2 shall run to an underground concrete waste pit located outside the building. The lower portion of wall and the floor shall be lined with No. 12-gage type 304L stainless steel sheet to form an impervious basin with a capacity slightly greater than that of the largest vessel in the pit. The bottom of the basin shall slope toward an RHD waste pit sump which shall be equipped with a steam jet pump. At all surface intersections, the liner shall be rounded or filleted with minimum 2-in. radii. The pits shall contain a shielded-access port above each tank. Two RHDR collection tanks and one RHD collection tank shall be located in this pit. Steam jet siphons shall be used to transfer from the RHDR tanks to the RHD tank.

The RHDR collection tanks are on hand and measure approx 6-ft diam × 6 ft 6 in. tan-tan for a net capacity of 1370 gal. They are fabricated of type 304L stainless steel 5/16 in. thick, fully radiographed, and designed for a pressure of 15 psig, a vacuum of 50-in. water gage, and a temperature of 250°F. The RHD tank, which is also on hand, measures 7 ft in diameter × 6 ft 6 in. tan-tan for a net capacity of 1870 gal. Wall thickness is 3/8 in. and material is type 304L stainless steel.

From the RHD collection tank, the RHD transfer pump shall pump the tank contents through a 2-in.-diam line to the plant waste system. The RHD waste pit sump pump shall discharge into the same 2-in.-diam header.

7.2 Water Systems

7.2.1 Potable Water

Potable water shall be supplied from the existing underground Transuranium Laboratory fire loop. The potable water will be supplied to the process water surge tank and a potable water heater. There shall be no cross ties between the potable and process water systems.

Potable water shall be supplied to all drinking fountains, safety showers, change rooms, ladies' rooms, and janitor's closets. The potable water system shall consist of type L copper tubing in sizes 2 in. and smaller. For sizes 2 1/2 in. and larger, galvanized sched-40 pipe shall be used. Underground piping for this system shall be bell and spigot or mechanical joint cast iron pipe, 150-lb class.

The potable water storage heater shall be a steam coil package unit.

7.2.2 Process Water

Process water shall be supplied from the potable water system with a tank to provide an air gap and a pump to supply the various areas. Hot water for this system shall be provided from the process water heater. The process water surge tank shall be a 200-gal carbon steel tank. A standard bronze fitted pump rated at 80 gpm at 70 ft TDH shall be furnished. The process water storage heater shall be a steam coil package unit.

The hot and cold process water headers shall run along the cell wall on the second floor to serve the cell modules. Hot and cold process water headers shall also be provided in the Maintenance Operating Area, the Chemical Cell Pump Tunnel, and on the Cell Roof Area.

7.2.3 Chilled Water

Recirculating chilled water for the building air conditioning shall be supplied from water chillers located on the second floor.

7.2.4 Demineralized Water

Demineralized water shall be supplied from an existing system and run underground to the TFCDF. This system shall service the Development Laboratory and the Chemical Makeup Room on the second floor. Piping for this system will be type 304 stainless steel.

7.3 Compressed Air

Air shall be compressed and dried in equipment located on the second floor. The equipment shall include one 75 scfm air compressor, one after-cooler, and an air receiver and an air dryer. The air shall be compressed to 100 psig and dried to a -40°F dew point. Air at 100 psig shall be locally reduced for instrument air at 20 psig. Compressed air shall be distributed to the Maintenance Operating Area, the Cell Operating Area, the Development Laboratory, and to each cell module.

7.4 Steam

Steam shall be supplied from an existing 250 psig underground steam main. A pipe shall tie into this main and extend underground to the TFCDF. A pressure-reducing station shall be installed in the building to reduce the steam pressure to 100 psig. The 100 psig steam shall be reduced to 15 psig for building and cell heating to service the potable and process water heaters and for the steam lance in the Decontamination Cell.

The high-pressure steam pipe shall be sched-80 seamless steel with seamless-steel butt-welding fittings. The portion of this line that is installed underground shall be insulated with Gilsulate.

7.5 Recirculated Cooling Water

Water shall be circulated in a closed loop for use in cooling process equipment in the cells. The closed water loop shall include a receiver, recirculating cooling water pumps, and a heat exchanger. The equipment for this system shall be located in the circulating water equipment room. The heat exchanger shall be designed for 1,000,000 Btu/hr. The unit shall have a carbon steel shell with type 304L stainless steel tubes and tube sheets and designed in accordance with ASME Code for 125 psig. A beta-gamma monitor with an alarm shall be provided for this system.

For emergency operation, process water shall be substituted for cooling tower water; and standby power shall be furnished for the recirculating water pump.

7.6 Cooling Tower Water System

Cooling water will be supplied from the HFIR cooling tower to the condenser of the building air-conditioning refrigeration unit, the recirculated cooling water exchanger, and the jacket and after cooler of the air compressor. The cooling tower water system is to operate at a higher pressure than the recirculated cooling water system. A maximum of 1000 ppm of cooling water at a pressure of approx 30 psig and a maximum temperature of 85°F will be available. Outlet temperature shall be no greater than 114°F.

8. HEATING, VENTILATING, AND AIR CONDITIONING

8.1 Design Conditions

8.1.1 Basis of Calculations

The latest edition of the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) Guide shall be used as the basic reference of design for heating, ventilating, and air-conditioning systems. Heating and cooling load calculations shall be prepared by the procedure established by the ASHRAE.

8.1.2 Containment Requirements

The containment of the building shall conform to the requirements set forth in Section 6 of the ORNL Radiation Safety and Control Training Manual.

8.1.3 Temperature and Humidity Requirements

All Zone 1 areas, Cold Change Room, Cell Operating Area, the Development Laboratory, and the Maintenance Operating Area shall be designed to be maintained at 76 ± 2°F all year with an outside summer design of 95°F dry bulb (db) and 77°F wet bulb (wb) and winter design of 0°F db. In the summer the relative humidity is limited to approx 50%, and in winter humidification shall not be provided.

The cell temperature shall be limited to a maximum of 125°F. Humidification shall not be provided. The Glove Maintenance Room shall be designed to be maintained at a temperature not exceeding 76°F. Chilled air may be supplied to the Zone 4 area if economically desirable.

The heating and ventilating systems for all other areas except the Receiving Area shall be designed to maintain 76 ± 5°F in winter and a maximum of 105°F in summer. Humidification is not required. The Receiving Area will not be heated or cooled.

8.1.4 Internal Loads

Cooling loads shall be based on the installed lighting load and the following internal equipment loads and people:

Zones 1 and 2	20 people	Mechanical Processing Cell	30 kw
Zone 3	10 people	Chemical Cell	20 kw
Contaminated Fabrication Cell	44 kw	Decontamination Cell	neg
Clean Fabrication Cell	10 kw	Glove Maintenance Room	neg

8.2 System Description

The air flow pattern in the building shall be, insofar as reasonable, from the Zone 1 area into the first-floor Zone 2 area, to the second-floor Zone 2 area, and then to the Zone 3 area. From Zone 3 air will be drawn into the cells through roughing and high-efficiency filters. Cell-inlet air ducts shall be equipped with backflow preventers. Use of a recirculated-air system for Zone 1 and locally mounted unit coolers and heaters in Zones 2 and 3 areas is permissible.

The cell ventilation system as installed shall be a once-through system. It shall be designed such that a recirculating system can be installed later to serve any or all cells except the Clean Fabrication Cell should it later be necessary to provide an inert-atmosphere system.

All air leaving the cells shall pass through one roughing filter and two high-efficiency filters in series. The roughing and first high-efficiency filters shall be installed inside the cell in a location convenient for changing by the GM manipulator and/or overhead bridge crane. The final set of high-efficiency filters is to be installed in a pit outside the building.

The hot off-gas system shall consist of an opened and a closed portion. The open portion of the hot off-gas system shall be used as a hood exhaust system for radioactive off-gases from equipment. Vacuum cleaner-type connections shall be provided at each cell module in all cells including the Decontamination Cell. The open portion shall have a capacity of 800 cfm.

The closed portion of the hot off-gas system shall serve as a vessel off-gas system which shall receive all vapors from closed process vessels. It shall have a capacity of 200 cfm. A capped connection shall be provided at each cell module in all cells except the Decontamination Cell. All off-gas shall pass through a special packed-deep bed high-efficiency filter located in a pit outside the building. A stand-by filter shall be provided. A normal and stand-by fan located at the building shall discharge the gas to the cell ventilation duct.

8.3 Duct Work

Conventional supply and exhaust duct work shall be constructed of galvanized steel and coated carbon steel. Duct work that is buried in concrete or essentially irreplaceable and that is contaminated at times shall be stainless steel. Contaminated duct work that is exposed and replaceable shall be coated carbon steel. Valves in contaminated exhaust ducts shall be accessible and constructed of iron or steel with a protective coating.

8.4 Filters

High-efficiency filters shall remove 99.97% of particulate as determined by dioctyl phthalate (DOP) smoke test.

9. ELECTRICAL

9.1 Power Feed

Power will be supplied from a substation to be shared with the Transuranium Process Facility. The cost of the substation will not be budgeted in this project.

9.2 Building Voltages

The power will be furnished at 480 v, 3-phase, 60 cps. Lighting will be 120 v; convenience outlets and low-voltage power receptacles will be 120 v, 1-phase.

9.3 Building Load

The maximum power demand of the process (cells only) is for each cell:

Chemical Cell	20 kw	Contaminated Fabrication Cell	44 kw
Mechanical Processing Cell	30 kw	Clean Fabrication Cell	10 kw

9.4 Motor Control Centers

Motor control centers, housing breakers, and combination starters will be located in the Cell Operating Area and in the Electrical Equipment Room. Control components for cell equipment will be located outside the cells.

9.5 Low-Voltage Power

Low-voltage power for lighting and receptacles and small motors shall be furnished by 480 – 208/120 v, 3-phase, 60 cps, 4-wire transformers fed from motor control centers. There will be separate panels for lighting and power receptacles. All panels are to be circuit breaker type and will have at least 20% spares.

9.6 Power Receptacles

An adequate number of receptacles shall be provided throughout the building. Each cell module will be provided with the following number of receptacles:

Inside cells — 4 each — 4-wire, 30-amp leads running from cell face on second floor to inside cell, first floor. Leads are to terminate inside cell in a special receptacle.

Cell face — first floor — 5 15-amp, 120 v, 1-phase
1 20-amp, 208 v, 3-phase

Cell face — second floor — 6 15-amp, 120 v, 1-phase
4 15-amp, 208 v, 3-phase
1 15-amp, 480 v, 3-phase

9.7 Cell Lighting

Lighting intensities in the operating cells at a point 5 ft in front of windows and 3 ft above floor will be 50 foot candles effective at the viewing side of the windows. The fixtures will be located inside the cells (over the window) and shall be designed for remote relamping and replacement. In the cell structure, each cell module shall be considered as an individual cell for the purpose of lighting design. The lighting system shall be capable of providing 50% excess fixtures. The fixtures shall be wired through independent circuits for each module. In addition to the window lights, push-through lights will be located in the cell ceiling for general illumination and to illuminate walls and equipment above the cell fixtures. The minimum lighting intensity in the cells at any point up to the 10 ft level on the walls shall be 20 foot candles effective at the viewing side of the window.

Lighting intensity in the Equipment Storage Cell at the floor level 5 ft in front of window shall be 20 foot candles effective on the viewing side of the windows. Push-through lights will be located in the wall of the Hot Equipment Storage Cell.

9.8 Building Lighting

Light intensities and types of fixtures for the building areas shall be as shown in Table 5. Lighting level in Cell Operating Areas shall be infinitely adjustable from 60 foot candles to 2 foot candles for optimum cell viewing.

Table 5. Lighting Requirements for Building Areas

Building Area	Intensity fc*	Type of Light
Glove Maintenance Room	50	Fluorescent
Airlock	50	Fluorescent
Cell Operating Area	60	Fluorescent
Fuel Storage Room	25	Fluorescent
Maintenance Operating Area	50	Fluorescent
Cell Roof Area	25	Fluorescent
Mockup Area	50	Fluorescent
Development Laboratory	50	Fluorescent
Chemical Makeup Room	50	Fluorescent
Warm Shop	50	Fluorescent
Offices	60	Fluorescent
Change Rooms	30	Fluorescent
Stairs	20	Incandescent
H and V Equipment Rooms	20	Incandescent
Electric Equipment Room	20	Incandescent
Receiving Area	20	Incandescent
Corridor	20	Fluorescent
Chemical Cell Pump Tunnel	20	Incandescent
Storage Cell Corridor	20	Incandescent

*Foot candle.

9.9 Grounding

A ground grid connected to driven ground rods and the incoming water main will be provided. All electrical equipment building steel, cell liners, cranes, monorails, et cetera, will be connected to this ground grid. Minimum size of ground wires shall be as recommended by the NEC. Motors and other 480-v equipment will be grounded either by a wire run directly to the ground network or by a grounding wire run with the circuit in the same conduit.

9.10 Conduit and Wire

All conduit and wire will be sized and installed according to NEC with the following exceptions:

Minimum conduit size to be 1/2 in. exposed and 1 in. concealed.

Minimum wire size to be No. 12. Type Tw insulation to be used up to and including No. 8 and RH/RW will be used for No. 6 and larger. Wiring in radioactive areas shall have polyethylene insulation and sheaths where appropriate. Wire size No. 10 and smaller may be solid; No. 8 and above will be stranded.

All conduits will be standard rigid galvanized, aluminum, or EMT. Only in cases where lighting and receptacle circuits are run above hung ceiling will EMT be used. Only standard rigid galvanized will be run in concrete walls, floors, or underground in concrete envelope.

Conduits will be embedded or concealed in walls or above ceilings except in equipment rooms. In general, panels will be flush mounted.

9.11 Emergency Power

Emergency power will be required for the cell and hot off-gas exhaust fans, emergency lighting, recirculating cooling water, and essential controls and instruments. A diesel engine-driven a-c generator will be located and installed in the building.

9.12 Communications and Alarm Systems

9.12.1 Fire Alarm

The fire alarm system will be designed to transmit its signal through the existing ORNL Gamewell System. A local energy master box of the threefold, noninterfering, succession type will be located at the main entrance. Code wheel will be supplied by ORNL. A separate master box shall be provided to transmit a signal to fire headquarters on failure of the building primary power supply. Auxiliary boxes and annunciator will be strategically located. A minimum of two evacuation horns will be located on each floor with additional horns as necessary to give complete coverage of all personnel areas. The entire installation is to be in accord with NFPA Bulletin No. 72 for a local energy fire alarm system and all parts shall be listed by Underwriters Laboratories or Associated Factory Mutual's Engineering Division.

9.12.2 Intercom

Master and slave stations will be installed as required for the efficient operation of the facility (to be specified by ORNL).

9.12.3 Telephone

A conduit system (with pull wires installed) for the Bell Telephone System will be installed with outlets in offices, operating areas, and at other strategic points. This system to be coordinated with Southern Bell Telephone Company.

9.12.4 Evacuation

A conduit system for radial speaker distribution will be designed for the evacuation PA system (installed and maintained by Bell Telephone). This system will be tied into the building emergency alarm system. When the emergency button is actuated, the evacuation of all building personnel and any necessary ventilation changes will occur simultaneously (system to be specified by ORNL).

9.12.5 Radiation Instrumentation

A conduit system shall be provided for wiring to transmit signals from local radiation instruments to central panel boards in all operating areas. All radiation instruments will be specified and powered by ORNL.

9.12.6 Instruments and Controls

Six 2-in. carbon steel conduits, capped at the second floor end, shall be run between the second floor and first floor areas at each cell module near the cell wall.

10. MECHANICAL

10.1 Shield Doors

The shield door assemblies are to be located at the two ends of the Decontamination Cell. The two doors between the process cells and the Decontamination Cell are to operate vertically and the other door will operate horizontally. All three doors are to be sealed with inflatable gaskets. The clear opening of the two inner doors shall be 6 ft wide by sufficient height to pass the cell bridge crane while carrying an 8-ft-high load. The clear opening of the outer door shall be 6 ft wide and shall extend from the floor to the height necessary to pass the cell bridge crane.

The doors shall be mild steel (either cast or rolled plate) approx 12 in. thick. Wear areas shall be covered with stainless steel; other parts will be protected with paint. The enclosure for the door shall be made of mild steel and painted.

The operation of the doors will be interlocked such that an inner door and the outer door cannot be open at the same time.

The shield doors and their enclosures will be designed to withstand a shock-wave pressure of 900 psf and a maximum energy of 270 ft-lb/ft^2.

10.2 Seal Doors

A carbon steel hinged seal door will be provided between the Maintenance Operating Area and the Airlock for personnel entrance. The door will provide a clear opening 3 ft wide × 7 ft high. Manual latches positioned about the periphery of the door will be used as a means of closure. A seal door will be provided between the Airlock and the Glove Maintenance Room with a minimum opening of 7 ft wide × 10 ft high. This seal door will operate by sliding vertically into the upper section of the Glove Maintenance Room. The seals for this door may be of the inflatable type or other suitable seal. The door will be made of carbon steel plate, approx 1/2 in. thick, and properly reinforced to accommodate pressure differentials in the system.

A horizontal seal door or roof hatch will be provided at the top of the Airlock and will be large enough to permit an object 6 ft × 7 ft to be passed into the Airlock. A mechanical operator will be provided to open and close this door. Manual latches will be provided to obtain sealed closure. An interlock will be provided between the sliding seal door and the roof hatch so that only one can be opened at a time.

Another sealed door is to be provided between the Mechanical Processing Cell and the Chemical Cell. This door must be the full width of the cell and of sufficient height to pass the cell bridge crane and

GM manipulator when the manipulator telescope is in the collapsed condition. It will be made of carbon steel and painted for protection against atmospheric corrosion. The door will operate vertically. When in the open position, the door will be resting alongside the concrete partition between the Chemical Cell and the Mechanical Processing Cell.

The door operator will be located inside the Mechanical Processing Cell and capable of maintenance by the cell bridge crane and rectilinear manipulator. The seal will be replaceable by contact maintenance methods from the Chemical Cell. The inflatable gasket seal is to be protected from radiation by recessing the seal into the shielding.

10.3 Viewing Windows

Each viewing window will consist of a steel liner embedded in the concrete structure of the cell with installed glass shielding of approx 12-in. total thickness on the radioactive side and zinc bromide solution for the remaining wall thickness. All glass and gaskets on the radioactive side will be removable from that side by either remote means (in the case of the Mechanical Processing and the Contaminated Fabrication Cells) or contact methods (for the other cells).

Each window will have a hot side aperture of 30 in. × 42 in. and a cold side aperture of 20 in. × 30 in.

10.4 Master-Slave Manipulators

One pair of CRL Model A master-slave manipulators will be provided for each viewing window in the Decontamination Cell, Contaminated Fabrication Cell, and Mechanical Processing Cell. One pair of CRL Model D heavy-duty master-slave manipulators will be provided for each window in the Clean Fabrication Cell.

10.5 Rectilinear Manipulators

Two GM Model 300 mechanical arms on two separate bridges will be provided to operate in the Contaminated Fabrication Cell, the Mechanical Processing Cell, and the Decontamination Cell. Bridge span will be approx 20 ft. The manipulators will be located such that they will be able to reach the floor and the special wall service plugs.

The manipulator bridges will be equipped with suitable devices such that they can be lifted from tracks inside one of the processing cells and transferred to another set of tracks in the Decontamination Cell or to the Glove Maintenance Room for maintenance. Each bridge will be powered by a special cable reel located either in the cell or on the bridge. Means must be provided such that the power cable can be connected either by the overhead cell crane or by a master-slave manipulator. All parts of the power system must be designed for replacement. The section of track in front of the Decontamination Cell shield door must be readily removable in order that long loads may be readily moved in and out of the processing cells by the overhead crane.

Individual components or component groups should be installed in the arm and telescope drive system to facilitate ready replacement of these parts. The housing should be gas and water tight in order to prevent contamination of the manipulator drives and to allow washing to remove external contamination. It must be possible to retract the telescope and raise the arm to a near-vertical position with the overhead crane hook.

One GM Model 100 mechanical arm is to be provided for the Clean Fabrication Cell. This unit will be cable powered and installed on a separate set of tracks from the cell bridge crane. The arm shall be removable from the cell by the building bridge crane through a roof plug. The bridge drive motor should be replaceable by the cell overhead crane.

10.6 Cell Cranes

Two 3-ton overhead traveling cranes with a span of approx 20 ft and underslung hoists will be provided to operate in the Glove Maintenance Room, Decontamination Cell, Contaminated Fabrication Cell, and the Mechanical Processing Cell. They will be so located that the bridge crane may pass over the GM manipulators. Two wire ropes will be provided which will follow the bridge as it traverses the cell. In the event of failure of the bridge drive, the crane in-haul lines will pull the bridge back onto a section of track which can be moved into the

Decontamination Cell where the offending bridge with hoist can be picked up by the other hoist. The cranes will be double-hook devices with either hook capable of independent or joint operation. The hooks shall be capable of orientation but will not be motorized. All motions of the crane shall be infinitely variable between zero and the maximum speed.

The bridge will be powered by a follower cable which can be connected inside the cell by either a master-slave manipulator or the GM manipulator. The hoist will be powered by trolley pickups from the bridge and will be able to pass from the bridge in the processing cells onto the bridge in the Decontamination Cell and on into the Glove Maintenance Room.

A 3-ton overhead traveling crane with a bridge span of approx 20 ft and a top-riding hoist will be provided for the Clean Fabrication Cell and located so that the crane bridge may pass over the GM manipulators. Two wire ropes will be attached to the bridge and will follow it in all its motion. Two crane in-haul reels will be located in a sealed box and attached to the upper portion of the cell structure. Removal of the hoist and the bridge drive must be easily accomplished through a roof plug by the building crane.

At the top of the Glove Maintenance Room, a 3-ton bridge crane of the same type as used in the cells will be provided to permit handling of the GM arm or the entire bridge, or the cell bridge and hoist, for maintenance purposes. On one side of the Glove Maintenance Room a panel will be provided to permit removal of an entire bridge.

10.7 Building Cranes

Two 30-ton-capacity overhead traveling cranes are to cover almost the entire third-floor area. The crane located over the cell roof will have a bridge span of approx 25 ft and a maximum hook height of 15 ft above the cell roof. Maximum lift should be approx 30 ft. The second crane will be located over the Maintenance Operating Area and will be of standard design having a bridge span of approx 50 ft. Total lift will be approx 50 ft and maximum hook height the same as for the first crane. Transfer of objects from one crane to the other will be by means of a motorized, track-mounted dolly which extends from the Maintenance Operating Area into the Cell Roof Area.

10.8 Cell Service Carriage

On the interior walls of all cells except the Decontamination Cell and located under the window level, tracks shall be provided to permit a cart to ride along each straight length. A total of four carts will be provided, each big enough to hold an object 10 in. in diameter and 48 in. long, weighing up to 100 lb. They will be propelled by electric motors.

10.9 Transfer Ports

One transfer port will be provided in the roof of each of the four processing cells. These transfer ports will be designed to permit fully shielded transfer of radioactive objects from the interior of the cell to a previously positioned cask on the cold side. A shield gate will be provided on the cold side where a gasket will be located to permit tight placement of a cask against the face of the port. An alpha-seal closure will be provided for the inside face. Washdown equipment will be provided inside the ports to remove loose particulates adhering to the exterior of the can. The ports will be able to accommodate cans up to 10 in. in diameter and 48 in. long. A similar horizontal transfer port will be located in the wall between the Clean and Contaminated Fabrication Cells.

10.10 Maintenance Airlock Truck

A system shall be provided whereby objects up to 6 ft × 7 ft × 8 ft high and weighing up to 30 tons may be transferred from the Airlock to the Glove Maintenance Room and into the Decontamination Cell. The truck will be remotely operated and electrically powered, and it will pass through the 7 ft × 10 ft sliding seal door and the shield door. Supplementary track sections will be supplied to permit track continuity at the shield door. Special devices will be required to permit motion in one direction when passing from the Airlock to the Glove Maintenance Room and in a perpendicular direction to the first motion when passing from the Glove Maintenance Room to the Decontamination Cell.

10.11 Special Service Wall Plugs

All special service wall plugs will lead from the second-floor areas into the cells. The point at which the service plugs enter the cell must be accessible to the GM manipulator. The Contaminated Fabrication and Mechanical Processing Cells require the plugs to be designed so that the service line which has contacted the alpha-contaminated atmosphere is not withdrawn into the limited-access area but is disposed into the cell itself. The push-through type of plug, similar to the design used in the High Radiation Level Examination Laboratory (HRLEL), falls within these criteria and has been successfully tested in mockup operation. This system must be modified to reduce costs; presumably this can be accomplished by changing materials of construction and by using seals which do not require close tolerances.

10.12 Rolling Hatch Cover

A rolling hatch cover will be provided over the Receiving Area. The hatch will provide a clear opening of 6 ft 6 in. × 8 ft 0 in. and will be motor-operated from a push-button station on the second floor.

11. FIRE PROTECTION

All interior spaces in the building will be served by fire protection facilities as subsequently described.

A dry pipe, preaction-type sprinkler system with spray heads in compliance with requirements of "ordinary hazard." This will conform to the latest published standards of the National Fire Protection Association, Pamphlets Nos. 13 and 14, including a monitor and connections to the existing fire alarm system in the ORNL area. Wire guard protective devices will be required for all sprinkler heads.

A system of standpipes and hose cabinets will be provided to serve all areas. The hose cabinets will contain one hose 1 1/2 in. size and 75 ft long and will be located throughout the building so as to serve single-level floor areas not to exceed 95 ft from the nearest cabinet. All standpipes and hose cabinets will conform to the latest standards of NFPA Pamphlet No. 14.

Auxiliary fire alarm boxes will be installed adjacent to each exit and connected to the required alarm equipment for the preaction-type system (see Section 9 "Electrical").

A Fire Department connection, Siamese type, will tie into the standpipe and sprinkler systems above ground level where the main enters the building. This location must be accessible to the Fire Department. A valve with postindicator will be installed in the incoming supply main at least 40 ft from the face of the building. No other pipe connections will be permitted downstream from this valve except for fire protection purposes. All outside water supply will conform to Factory Mutual Engineering Division Specifications.

The cells will have fire protection system of "metalex" cylinders placed at various locations in the cells. Cylinders shall be located outside the cell and connected heads inside the cell.

Potable water from the existing plant system will supply this fire protection system. The potable water main pressure will be approx 80 psig.

12. SANITARY PLUMBING AND STORM DRAINAGE

12.1 Sanitary Plumbing

Furnish and install plumbing fixtures as specified under Architectural and Structural work in accordance with National Plumbing Code.

12.2 Storm Drainage

A sufficient storm drainage system shall be included.

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