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BUILDING 3505, METAL RECOVERY FACILITY - HAZARDS EVALUATION, VOL. 6

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ABSTRACT

This hazard evaluation of the planned operations in Building 3505 reveals no impairment of operations in neighboring facilities in the event of the maximum credible accident. The safeguards employed to prevent and minimize the effect of possible accidents are outlined.

Standards of construction and containment, assumptions made to evaluate the potential hazards of release of radioactive material, and methods of calculation used for development of this hazards analysis are given in ORNL-2956 Summary Report-Hazards Analyses of Radiochemical Processing and Waste Disposal at Oak Ridge National Laboratory, Sects. 4.0, 5.0, and 6.0.

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BUILDING 3505, METAL RECOVERY FACILITY

1.0 INTRODUCTION

1.1 Purpose and Uses

Building 3505, the Metal Recovery Plant constructed in late 1951, will provide for the final solvent extraction cycle and product concentration by evaporation for low-enrichment uranium solutions. In the past, 30 separate programs to recover uranium, plutonium, neptunium, or americium from such sources as irradiated fuel elements, precipitated sludges, sand, scrap, and fluorinator ash have been completed. Future plans will limit operations to solutions from previous operations in Bldg. 3019 so that Bldg. 3505 will at any time contain less than 250 curies of beta-gamma activity and 1 g of plutonium or its hazard equivalent. A conservative estimate of the decontamination factors in Bldg. 3019 operations on the most active feeds indicates that Bldg. 3505 will contain a total of 20 curies of activity at any one time.

1.2 Location and Distance from Other Facilities

Figure 1, part of the Oak Ridge National Laboratory Permanent Facilities Plan, shows the location of Bldg. 3505 in the plant complex. The distance of the various buildings from Bldg. 3505 are:

Bldg. No.	Name	Distance ft	Distance Direction	Activity Inventory, curies
3505	Metal Recovery Plant			20
3517	Multicurie Fission Product Plant	55	South	10^6
2527	Power Reactor Fuel Processing Addition	200	West	10^6
3508	Chemical Isolation Laboratory	170	Southeast	High-level α
3550	Old Chemistry Building	200	East	Negligible
2506	Stores, Paymaster	240	Northwest	0
3024	Central Machine Shop	290	North	0

With the operational limits and estimated curies of contained activity, Bldg. 3505 does not pose a threat to any of the nearby operations. In fact, the curie contents of Bldgs. 2527 and 3517 and the Laboratory "hot" chemical waste tanks dwarf Bldg. 3505 operations. The red overlay to Fig. 1 shows the security fence and evacuation route from Bldg. 3505.

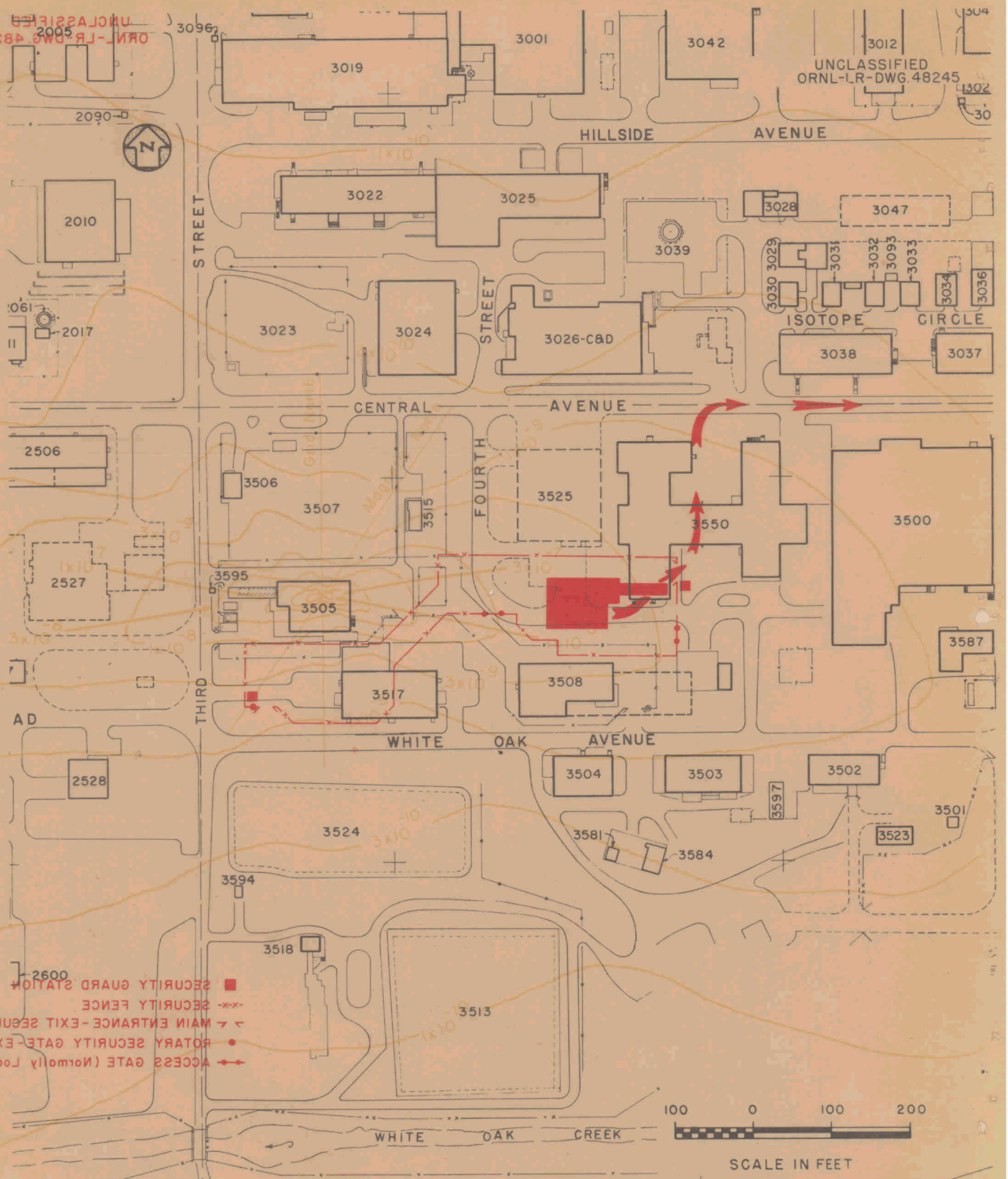

FIG. I BLDG. 3505 AREA PLOT PLAN

1.3 Building Description

Figure 2 shows a plan and sectional view of Bldg. 3505, which is a steel-frame metal-siding structure with numerous windows and a roof of mild steel decking covered with 2 in. of glass fiber batting insulation topped with sand and gravel. The primary containment zone, the radiation zone, is shown on the red overlay. The secondary containment zone, the contamination zone, is shown on the green overlay. The construction of the process cells is shown in Fig. 3. The building provides secondary containment for the sides of the cells but not for the cell tops.

1.4 Personnel Control

The numbers of people normally in Bldg. 3505 and in other buildings in the area are:

	No. of People	
Bldg. No.	Week-days	Nights and Weekends, per shift
3505	7	3
3517	12	6
2527	18	4
3508	13	0
3550	67	0
2506	28	0
3024	34	0

Personnel check points and the emergency evacuation route are shown on the green overlay of Fig. 2.

1.5 Process Description

Low-enrichment uranyl nitrate solution resulting from fuel dissolution, a uranium-plutonium partitioning and second uranium solvent extraction cycle, and evaporation at Bldg. 3019 is transferred by underground pipeline to Bldg. 3505. This solution is further purified and concentrated by a cycle of solvent extraction, evaporation, and silica gel adsorption of zirconium-niobium activity. The purified product is stored in a tank external to the building until shipped. The equipment required for these operations is shown schematically in Fig. 4.

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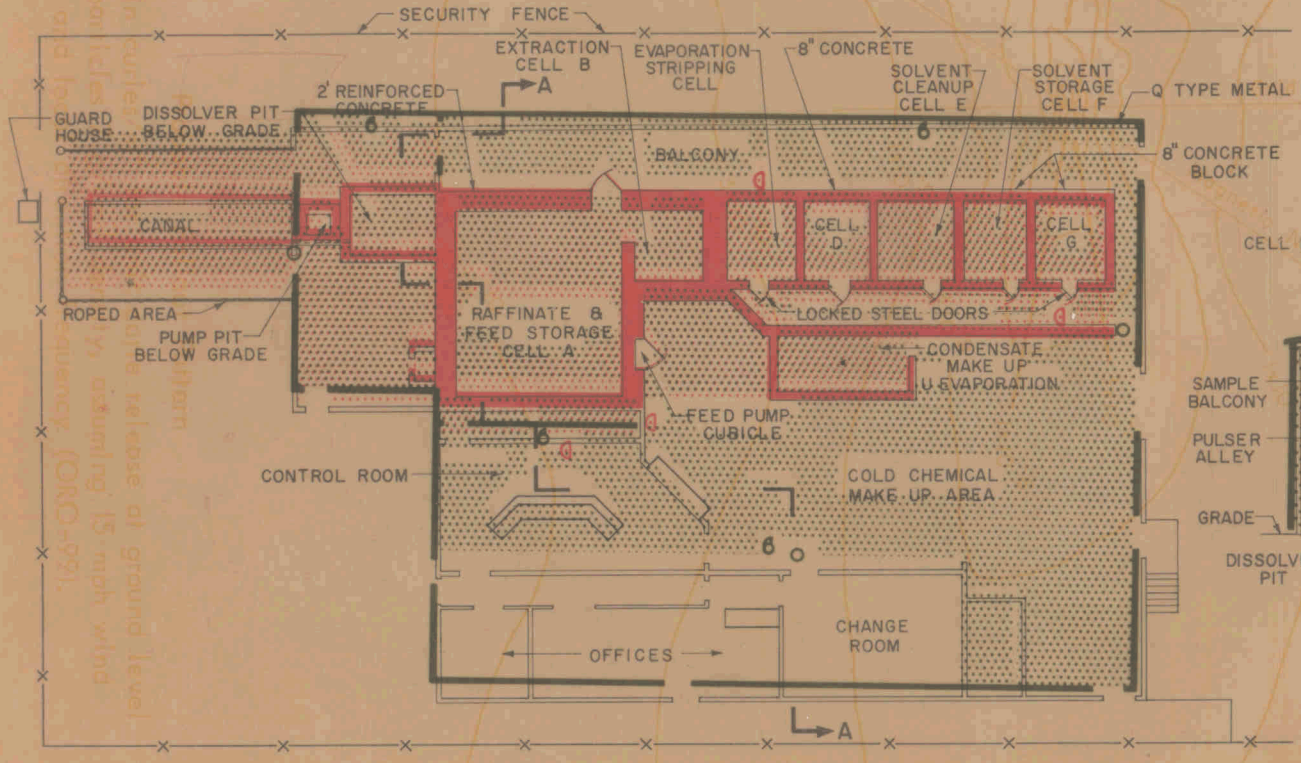

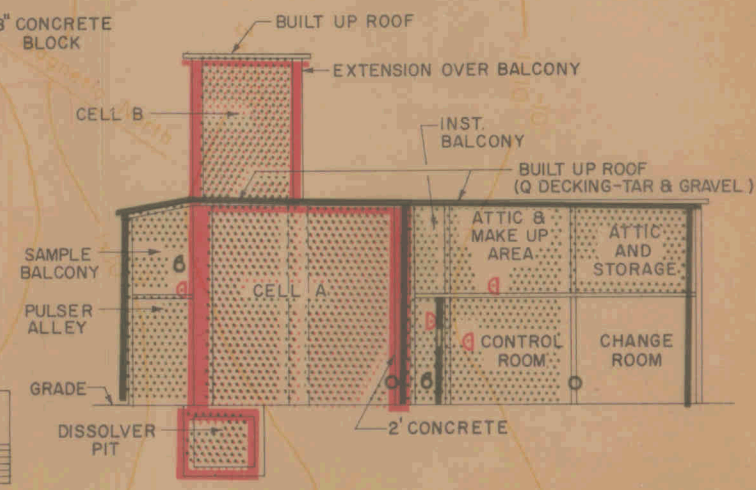

ELEVATION - SECTION A-A

FIG. 2 PLAN OF BUILDING 3505
LIMITS OF PRIMARY CONTAINMENT
LIMITS OF SECONDARY CONTAINMENT

— RADIATION ZONE LIMITS
— GAMMA RADIATION MONITOR
— CONTAMINATION ZONE LIMITS
— AIRBORNE PARTICULATE ACTIVITY MONITOR

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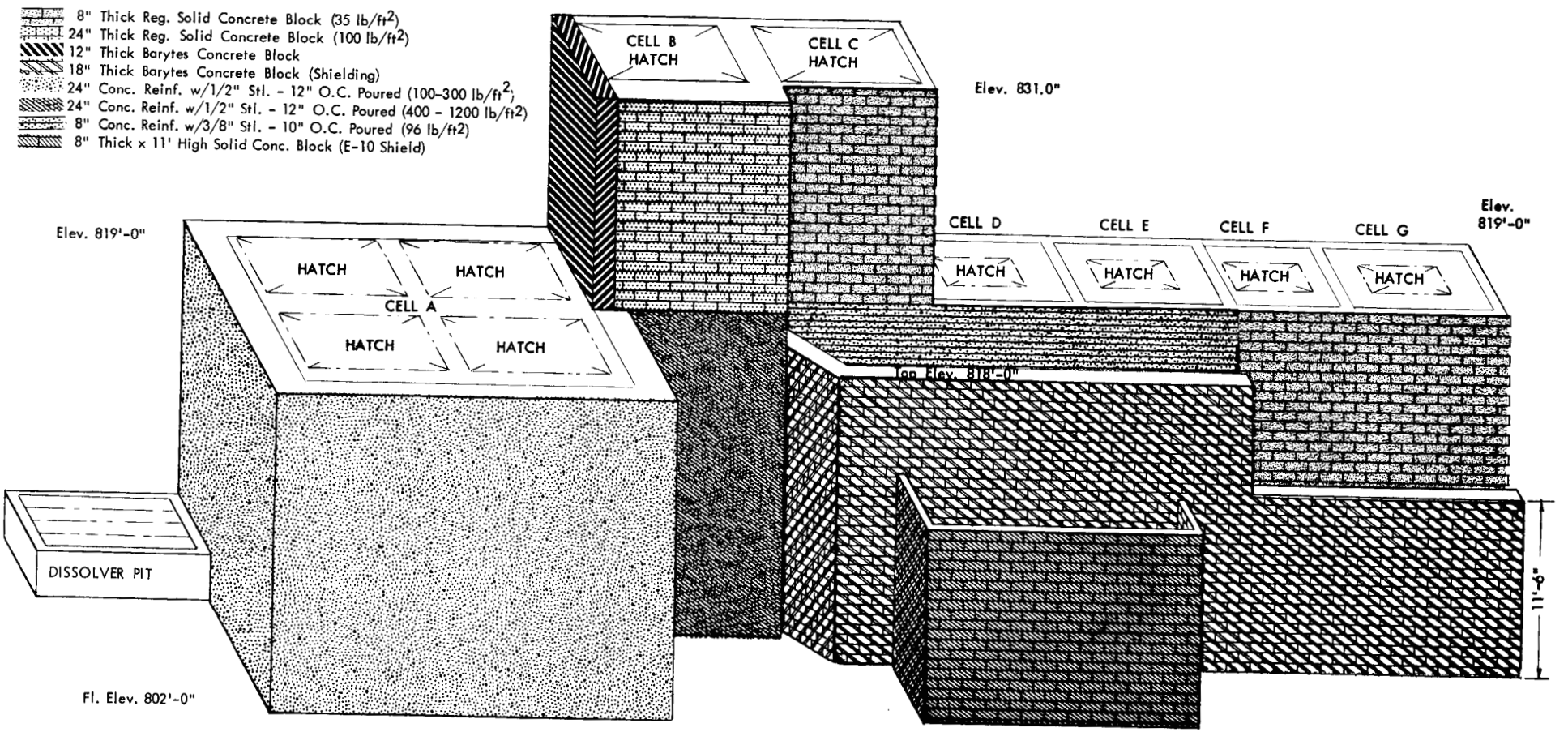

FIG. 3. METAL RECOVERY CELL STRUCTURE

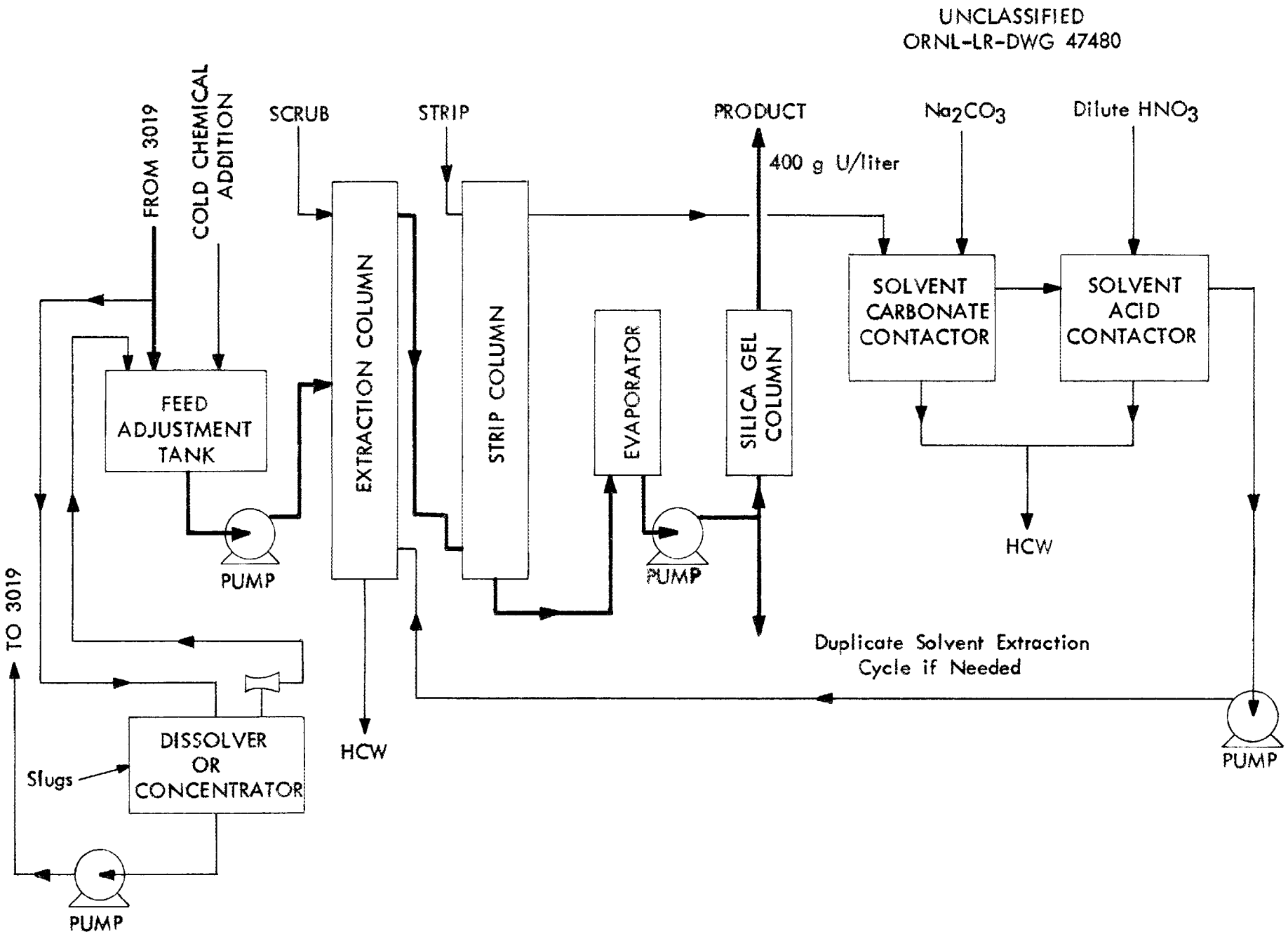

Fig. 4. Schematic process flowsheet - Building 3505

1.6 Criticality

With building operations restricted to low-enrichment uranium the maximum U^{235} concentration will be less than 4 g/liter and hence "always safe."

1.7 Liquid Waste Systems

Two types of liquid wastes are generated in this building. All process wastes, such as the extraction column raffinate, condensate from evaporation, or solvent cleanup raffinates, are collected and sampled in the building waste tank P, and transferred to the Laboratory "hot" chemical waste system via waste tanks W-5 or W-6. Wastes such as condenser cooling water or condensed steam from heat exchangers are discharged to the Laboratory low-level waste system via manhole 16.

1.8 Gaseous Waste System

Airflow in the building (Fig. 5) is from nonradioactive areas to radioactive areas to equipment items. The building exhaust is to the atmosphere with no treatment. The cell exhaust (Fig. 6) is to the Laboratory 3039 stack cell ventilation system after passing through a roughing and absolute filter. The equipment off-gas system (Fig. 7) discharges via a deep bed filter to the Laboratory 3039 stack equipment off-gas system.

1.9 Monitoring Systems

Manhole 16 is equipped with a monitoring station for liquid wastes. Any appreciable activity detected is the signal for a building shutdown for the necessary maintenance to eliminate the source. Both the cell exhaust and the equipment off-gas are monitored for activity after being filtered and before being discharged to their respective plant systems. Any appreciable activity detected in either system is the signal for a building shutdown and appropriate action to eliminate the source. The monitoring systems are shown in the green overlay of Fig. 2.

Personnel monitoring instruments are located at the check points indicated on the green overlay of Fig. 2.

Area radiation and air contamination monitors are also available and are equipped with audible alarms which sound if any abnormal activity appears.

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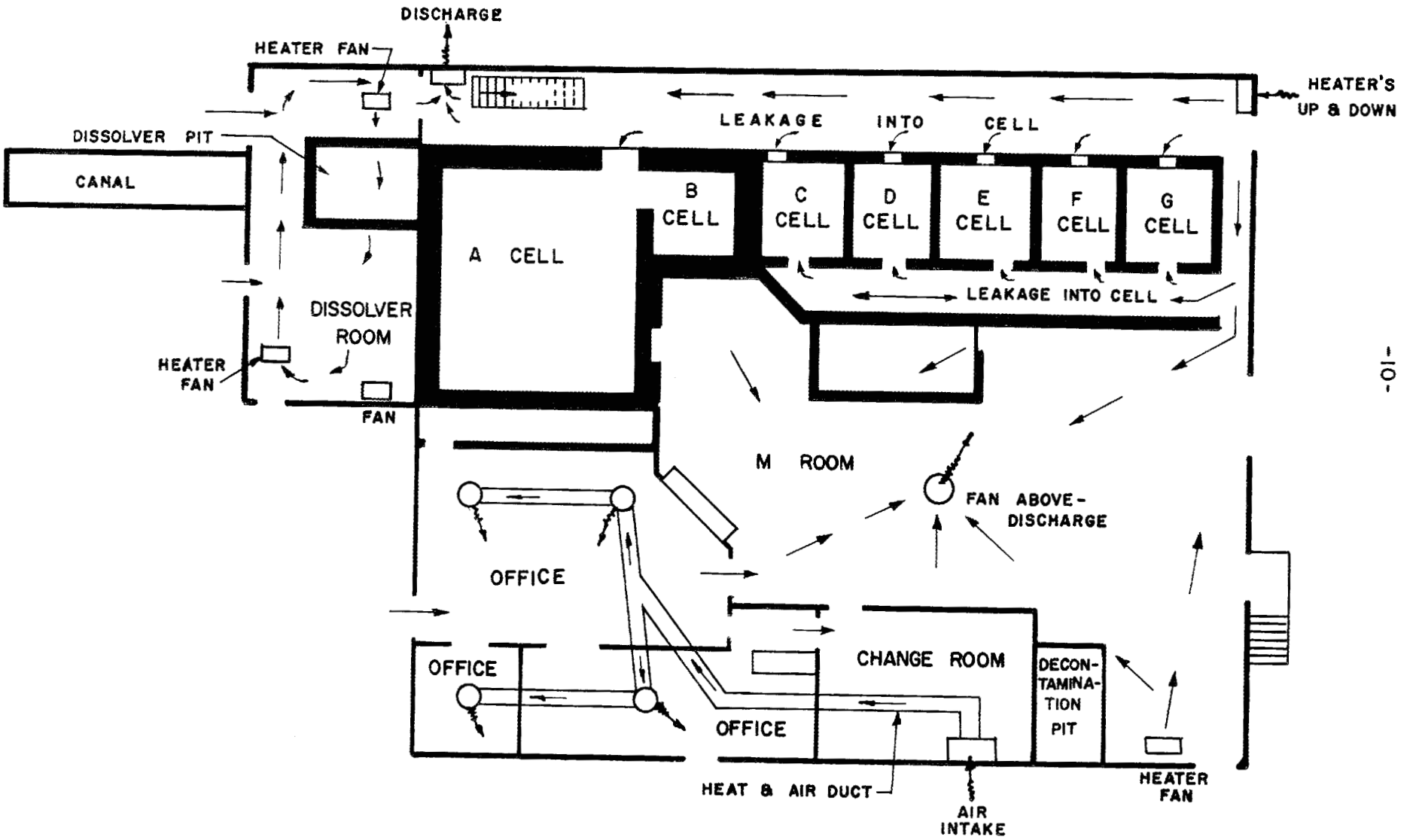

FIG. 5 VENTILATION AIR PATTERN BLDG. 3505

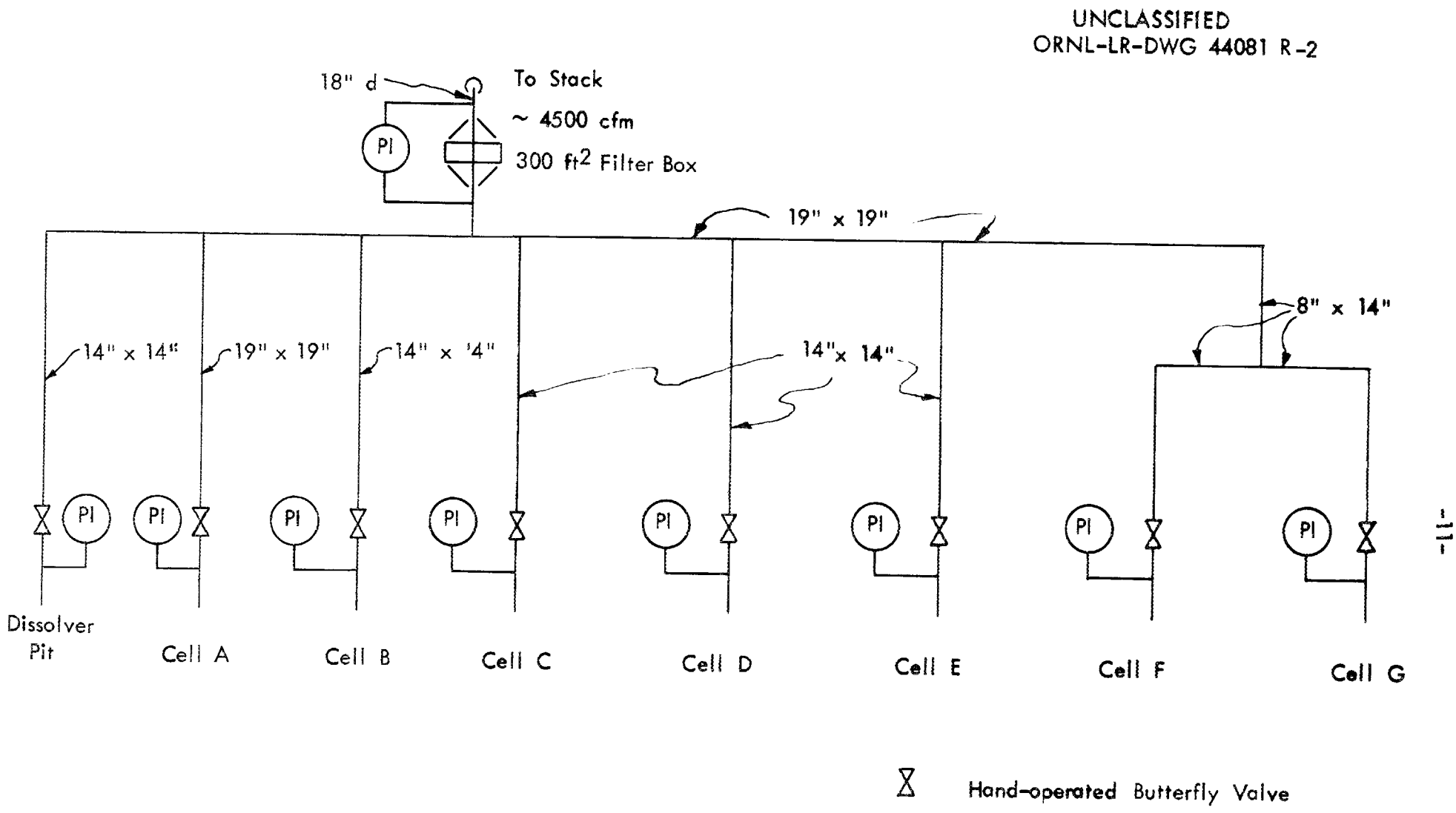

Fig. 6. Building No. 3505 Cell Ventilation

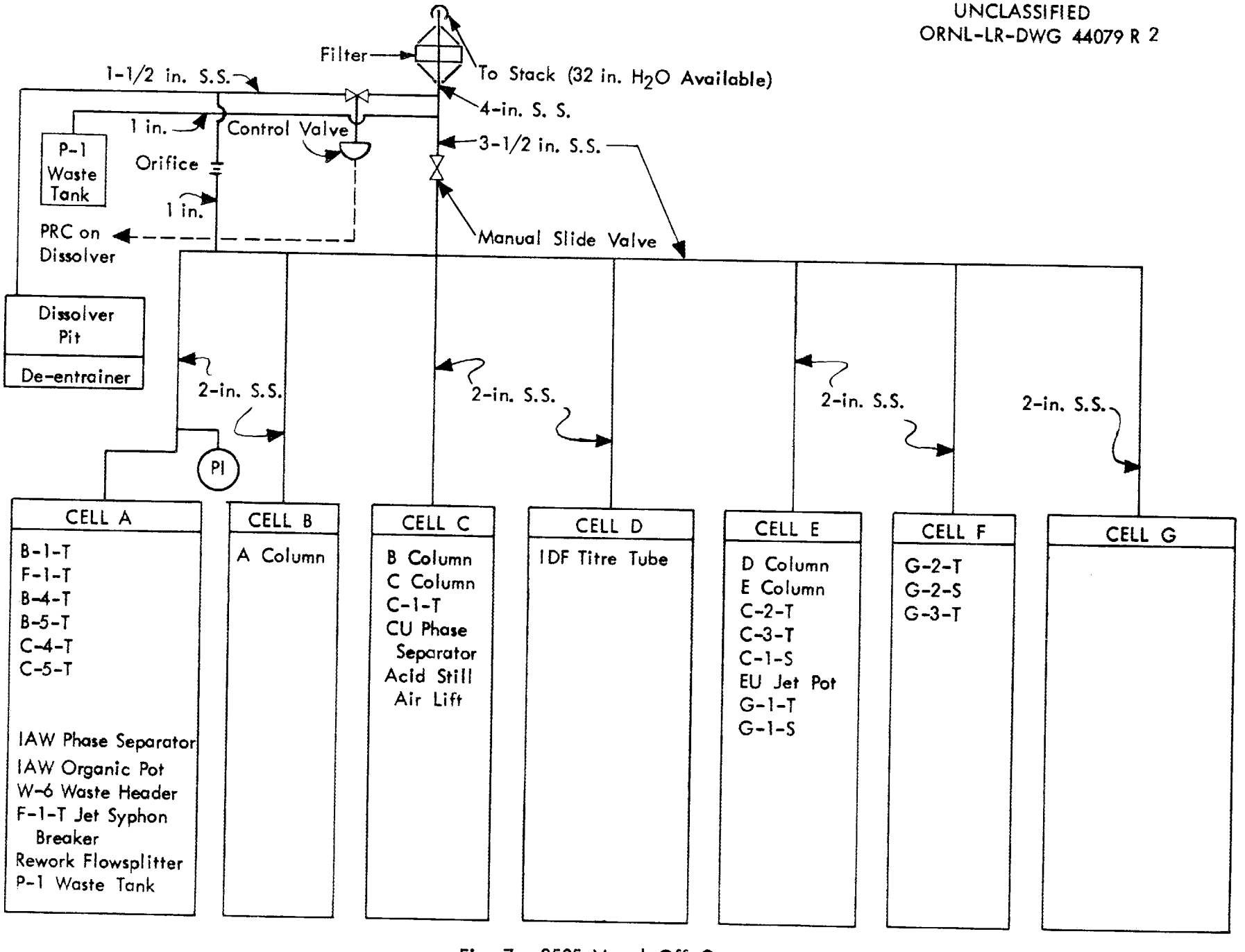

Fig. 7. 3505 Vessel Off Gas.

2.0 SUMMARY*

2.1 Radioactive Material Content of Facility

Material	Design Capacity	Estimated Inventory In Plant	Estimated Inventory In Largest Vessel
Iodine-131, curies	0	0	0
Krypton-85, curies	0	0	0
Mixed nonvolatile fission products, curies	250	20	20* (<1**)
Heavy elements			
Pu^{239}, g	<1	<1	<1
U^{233}, g	0	0	0
U^{235}, kg	2.1	10.5	8.96
U^{238}, kg	300 per day	1500	1280
Th^{232}, curies	0	0	0
Am^{241}, curies	0	0	0
Other, curies	0	0	0

*Feed tank, 4000 liters at 320 g uranium per liter.
**Product evaporator, 40 liters at 400 g of uranium per liter.

2.2 Criticality Incident Potential

With building operations restricted to low-enrichment uranium the maximum U^{235} concentration will be less than 4 g/liter and hence "always-safe."

2.3 Explosion and Fire Potential

The solvent used in the Purex process is a 30-70 volume % mixture of tributyl phosphate and Amsco 125-82. The diluent, Amsco 125-82, has a closed cup flash point

*Calculations and assumptions are given in Volume I of this report.

of 128°F and is flammable in air from 1.1 to 6.1 volume %. The solvent mixture can be nitrated by concentrated nitric acid above 135°C.

The plant has the capacity to hold 350 gal of solvent. The largest single tank in the system can, and must, hold all this solvent.

Each pound of solvent consumed in a fire releases more than 10,000 Btu. If all the solvent in the system burned, more than 22,000,000 Btu of heat would be released.

Each pound of solvent nitrated in a detonation releases approximately 1000 Btu. Detonation reactions will, with almost 100% certainty, rupture the containing process vessel when as much as 1 lb of material is involved. To prevent a detonation reaction, all heated vessels are provided with temperature shutoff of steam at 118°C (reaction will not proceed below 135°C), steam pressure limitation to 35 psig, and density control by water addition with an alarm set at the density of solution that boils at 118°C. With these safeguards, the probability of a detonation is extremely low. The construction of Bldg. 3505 is such that a detonation reaction would rupture the primary containment shell.

All cells that can conceivably contain solvent are equipped with a rate-of-rise detection system which actuates a wet-pipe sprinkler system. In-process solvent inventory is kept as low as possible to decrease the magnitude of the fire hazard. All solvent is stored in closed grounded vessels. No fire has occurred to date, and with the above precautions this record should be maintained. A large solvent fire exterior to the vessels would release but little activity to the environment. A solvent fire in a closed vessel would extinguish itself in a short time.

2.4 Release of Radioactive Material

A detonation reaction, the maximum credible accident, produces about 100 cu ft of gas. If all this gas containing 100 times the content of process solution a stable aerosol could carry should be released to the secondary containment area, the resulting concentration would be 6.8×10^{-9} μc/ml air. The 40-hr mpc for the material being handled is 2×10^{-8} μc/ml. This accident would result in reaching 34% of the 40-hr mpc level.

Using the more realistic assumptions usually employed, the release of activity is estimated as:

1.	Total activity released through VOG system, curies	2.2×10^{-7}
2.	Total activity released through COG system, curies	1.2×10^{-6}
3.	Total activity released to stack, curies	1.5×10^{-6}
4.	Total activity released into building, curies	1.76×10^{-9}
5.	Activity in building, curies/m^3	8.1×10^{-13}
6.	Total activity released from building, curies	6.6×10^{-10}

7. Ground activity due to fallout 20 meters downwind from building, curies/m^2	2.4×10^{-15}
8. Distance to which ground is contaminated to hazard level, meters	0
9. Maximum downwind dose, rem	$<10^{-6}$

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3.0 FACILITY DESCRIPTION

3.1 Building Description

Building 3505 is located in the main Oak Ridge National Laboratory area and is bounded by the plant liquid "hot" chemical waste tanks on the north, the fission product plant on the south, and Third and Fourth Streets on the west and east, respectively (Fig. 1).

The present structure (Fig. 2) is the result of several additions to the facility built in 1951 to recover uranium from precipitated sludges in the plant tank farm. The principal building is a steel-frame metal-siding structure, 78 x 58 x 17 ft, enclosing the radioactive processing cells, chemical makeup area, control room, offices, change room facilities, and a maintenance area. A similarly constructed two-level addition on the north side of the cell block houses a sample gallery on the second floor and a pulser alley on the first floor. The dissolver room at the northwest corner is constructed of hollow concrete block and houses two underground equipment pits. The roof of the building is a Class II combustible roof built up of tar and gravel over composition roll-type roofing on metal decking.

West of the building a 35 x 6 x 13-ft storage canal is located. The concrete walls, which are 1 ft thick and extend 3.5 ft above ground level, extend beyond the west end of the canal to enclose a decontamination pad which drains back into the canal. A monorail moves over the centerline of the canal, servicing the complete length of the canal and, through a double door, the equipment pits in the dissolver room. A metal canopy covers the monorail and canal. The canal is contaminated from previous operations.

The cell block construction is shown in Fig. 3. The explosive force necessary to breech the walls is also indicated on this figure.

3.2 Process Description

Uranyl nitrate solution is received in batches from Bldg. 3019 through an underground pipeline. Each batch is adjusted by the addition of nitric acid and ferrous sulfamate to the chemical conditions necessary for a Purex type solvent extraction cycle. Final decontamination of the low-enrichment uranium is obtained by the extraction, by 30% tributyl phosphate, of uranium in preference to fission products. The uranium is removed from the organic extract by contact with water. The resulting solution is evaporated to approximately 400 g of uranium per liter and passed through a bed of silica gel, for additional zirconium-niobium removal, to a product surge tank. The solvent raffinate is treated by successive contacts with sodium carbonate and dilute nitric acid solutions, filtered, and then re-used. The flow is shown in Fig. 4.

Equipment exists for two cycles of solvent extraction, recovery of nitric acid, and continuous dissolution of fuel elements. Any new future use for this dissolver must provide for scrubbing the dissolver off-gas, sealing the secondary containment shell, secondary containment of the canal, and treatment of the storage canal water.

3.3 Waste Disposal

All plant effluents are regarded as waste streams and sources of possible spread of contamination. In addition to all process liquid wastes, this includes cooling water, floor drains, condensed steam, and all gaseous material leaving the building.

The various process wastes and the floor drain flow to the building waste tank, P-1, where they are sampled before transfer to the ORNL intermediate-level waste system via W-5 or W-6. The concentration of the building feed is estimated to be 0.019 curie per gal (Sect. 4.1.1). Cooling water and condensed service steam are discharged to the ORNL low-level waste system via manholes 16 and 185. Manhole 16 is equipped with a beta-gamma monitor, which samples and records the relative activity of 1% of the total flow. In addition, samples are taken at 4-hr intervals for laboratory determination of gross alpha and gamma.

Degraded solvent is removed from the building to drums, which are then transferred to the ORNL burial ground.

The flow of air through the building is from nonradioactive to active areas and from active areas to equipment items located in these areas (Fig. 5).

The cell ventilation exhaust is to the ORNL 3039 stack cell ventilation system via a roughing and absolute filter (Fig. 6). The flow downstream of the absolute filter is monitored for activity.

The off-gas exhaust from the vessels is to the ORNL 3039 stack vessel off-gas system via a high-efficiency Hanford type deep-bed filter (Fig. 7). The flow downstream from the filter is monitored for activity.

The building exhausts directly to the atmosphere through a roof-mounted fan. This is permissible with the low-activity operations allowed in the building.

4.0 HAZARD DESCRIPTION

4.1 Radiation

4.1.1 Quantity

Because of the physical limitations of the process cells, operations in the future will be restricted to those meeting the following criteria:

1. The feed shall be depleted or low-enrichment uranium solutions that result from two cycles of decontamination at Bldg. 3019.

2. The total activity in the building at any one time shall be less than 250 curies of beta-gamma and/or 1 g of plutonium or its hazard equivalent.

The maximum activity content of any power reactor fuel to be processed has been calculated as 700,000 curies per 300 kg of uranium. Conservative estimates of

1000 and 150 for decontamination factors in a partitioning and second uranium cycle, respectively, indicate that the activity in the building will actually be:

Location	Volume, liters	Pu, g	U, kg	β-γ Activity, curies
Feed tank	4000	0.004	1280	20
Extraction column	230	< 0.001	12	1
Raffinate separator	40	< 0.001	< 0.01	< 1
Raffinate catch tank	750	< 0.01	< 0.1	4
Stripping column	435	< 0.001	11	< 1
Product phase separator	173	< 0.001	9	< 1
Product evaporator	40	< 0.001	16	< 1
Product surge tank	500	< 0.001	160	< 1
Silica gel columns	25	< 0.001	10	< 1
Product storage tank (west of building)	7500	< 0.001	3000	< 1

If the 20 curies in the feed tank is pessimistically assumed to be a point 0.8-Mev gamma source, an observer 4 ft from this source, with the cell 2-ft concrete wall in the intervening space, would be exposed to approximately 2.3 mr/hr.

4.1.2 Control

Although this building operates with a low activity level, strict standards for radiation exposure control are practiced to minimize personnel exposure. The standards, in use officially since May 6, 1958, are outlined in a Building Standard Practice Manual. Strict adherence to these standards has been largely responsible for achieving an average plant exposure of only 33.7 mr/week, although past programs have included complete process cycles for material irradiated to over 500 Mwd/ton.

Two essential parts of the control system, shown in the red overlay to Fig. 2, are the radiation control zone and the radiation monitors. The radiation control zone is monitored daily by Health Physics. Radiation levels are clearly noted if significant. The process cells are locked except during approved entry, as described in the standards manual. The permanently installed monitors are checked for calibration daily.

4.2 Criticality

With building operations restricted to low-enrichment uranium, the maximum U^{235} concentration will be less than 4 g/liter and hence "always safe."

4.3 Chemical

4.3.1 Quantity

The maximum quantity, use, and hazard of the various chemicals used in the plant are given in Table 1.

Table 1

Chemical	Approved Inventory	Use	Hazards[a]	Maximum Energy Release, Btu/lb reacted
HNO_3, 13.7 M or 60%	2500 gal	Salting agent for solvent extraction, scrub makeup, dissolution, decontamination	Health, explosive, corrosive	~ 1000[b]
TBP	30 gal (1 drum)	Uranium extractant	Fire	~ 10,000
Amsco	70 gal (2 drums)	Extractant diluent	Fire	~ 10,000
$NaNO_2$	50 lb (2 drums)	Adjust valence of feed for solvent extraction	Explosive, fire	~ 1000 ~ 10,000
Soda ash (Na_2CO_3)	1000 lb	Solvent cleanup, decontamination	Health	
Sulfamic acid (NH_2SO_3H)	150 lb	Decontamination, valence adjustment	Health	
Ferrous ammonium sulfate	200 lb	Valence adjustment	Health	
Ferrous sulfamate	50 gal	Valence adjustment	Health	
Oxalic acid	150 lb (3 drums)	Decontamination	Health	
Turco 4501A	50 gal	Decontamination	Explosive, health	~ 1000
Turco 4502	10 lb	Decontamination	Health	

[a]For health hazard see ORNL Metal Recovery Plant Safety Manual.

[b]Organic nitration, essentially instantaneously. Turco 4501A is never allowed in any process vessel; use restricted to hand cleanup of small equipment.

4.3.2 Control

With the exception of the fire and explosion hazard controls discussed in Sect. 4.4.2, normal chemical plant safety practices are adquate for control of chemical hazards. These safety practices are obtained through a continuing safety program which includes issuance of a building safety manual, shift safety committees', and weekly foremen's meetings. The building safety manual covers all chemical hazards individually, with regard to hazardous properties of the material, treatment and antidotes, storage and handling, and technical data. The safety manual and the minutes of safety committee and foremen's meetings are made available to all employees.

4.4 Fire and Explosion

4.4.1 Hazard

In the Purex process the solvent is a 30-70 volume percent mixture of tributyl phosphate and Amsco 125-82. The flash point of the hydrocarbon diluent is 128°F and the presence of tributyl phosphate has little effect on this point. The possibility of both fire and explosion exists in conjunction with the use of solvent. The explosion possibility is an essentially spontaneous nitration reaction, which will not start below 135°C.* The maximum in-plant inventory of solvent by cell is as follows: cell A, 5 gal; cell B, 80 gal; cell C, 50 gal; cell D, 10 gal; cell E, 125 gal; and cell F, 300 gal.

A recent fire protection survey** pointed out the large fire and explosion risk. The Class II combustible roof, the limited strength of the cell block structure, and the cell roof access hatches contribute to the magnitude of the risk. The force to rupture the cells is indicated on Fig. 3. The roof hatches would be opened by a force of 10 lb/ft^2.

The potential release of activity to the building and to the atmosphere can be estimated. In a detonation reaction approximately 100 ft^3 of gas is generated. Assuming that this gas carries a light rain (1000 mg of solution/m^3 of gas) of the most active solution (see Sect. 4.1) from the cell, 1.5×10^{-5} curie would be released to the secondary containment shell. If this activity were evenly dispersed in the building the concentration would be 6.8×10^{-9} μcurie/ml. The maximum permissible concentration in air, for a 40-hr week, of the materials encountered has been calculated as 2×10^{-8} μcurie/ml. From the above conservative assumptions, the maximum release all in the building would result in a concentration of only one-third of the allowable concentration. In the event of an actual release, the vessel off-gas and cell ventilation systems would certainly remove a considerable portion of the released activity. Further, the likely release to the building and atmosphere would be an aerosol which is but 1/100 as concentrated as the light rain assumed.

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*T. J. Colven, Jr., et al., "TNX Evaporator Incident, Jan. 12, 1953," DP-25, May 15, 1953.

**T. W. Hungerford, "Special Fire Protection Survey of Reactor Fuels Processing Plant Building 3505," ORNL-CF-60-1-35, Jan. 19, 1960.

4.4.2 Control

To minimize the solvent fire hazard, the solvent inventory is kept as low as possible. All process vessels are sealed and vented to the vessel off-gas system. Unused solvent is stored in a metal storage shack 50 ft from the building.

To minimize the damage if a fire should start, a rate-of-rise detection system actuating a wet-pipe sprinkler system will be installed in the cells containing organic.

Nitration of the solvent exothermically requires concentrated nitric acid and a minimum temperature of 135°C. Reaching this temperature is prevented by:

1. 30 lb/in.^{2} gage limit on the steam to the evaporator calandria
2. Temperature alarm set at 118°C on solution in the evaporator
3. Water addition controlled by density of boiling liquor such that the boiling point of liquid is below 118°C

In addition, all solutions to be evaporated are first passed through a phase separator to remove entrained organic. Other organics that might react with nitric acid are not allowed in the system.

4.5 Maximum Credible Accident

The nitric acid-solvent detonation, discussed above, is the maximum credible accident. An accident of the magnitude of those previously experienced in other atomic energy plants would rupture the cell structure. This possibility, believed impossible with current safeguards, and the lack of adequate neutron shielding are the reasons for the operating restrictions placed on this facility.

5.0 OPERATING PROCEDURES

5.1 Routine

Detailed instructions in the form of step-by-step run sheets are prepared by operations supervision for all operations. Each shift foreman supervises the operations on his shift to see that the run sheets are followed. Equilibrium run sheets, similarly prepared, are used to record pertinent data on equipment operation, samples required, and material balance. Several of these sheets are attached as an appendix to this report.

A shift log is maintained to provide a record of status of operation at shift change, work accomplished, personnel present, and information that will help achieve a smooth transition from shift to shift.

An operating manual, available to each shift, covers such items as: (1) sampling instructions, (2) chemical flowsheet, (3) chemical and physical data pertinent to the system, (4) analysis specifications, (5) 8 x 10-in. drawings of all equipment items, and (6) emergency procedures.

5.2 Nonroutine

Operations performed only at long intervals, such as decontamination or startup after an emergency shutdown, are covered by written instructions as needed. These instructions must be approved anew by the section chief if any new chemical is to be admitted to the system or if access to a cell is required.

If process conditions outlined by the run sheets must be changed to obtain the desired low loss and high decontamination, technical supervision is called for assistance. Minor deviations are approved at this level, but major changes must be approved by the section chief.

When an equipment item fails, a maintenance engineer assigned to the facility surveys the situation. Craftsmen, permanently assigned to the facility, are available to repair the equipment. If entry to a cell is required, the engineer must be sure the building procedure radiation control is followed and that the operational status of the equipment is such that no safety hazard exists.

6.0 EMERGENCY PROCEDURES

Emergency procedures in the building conform to the practices outlined in the ORNL Emergency Manual. The general plant practices are reduced to specific building instructions in the Building Operating Manual. An emergency squad is organized to make maximum use of all personnel possible if an emergency should occur. A public address system can carry instructions to all parts of the building. A fire alarm box is located on the east exterior wall. Each telephone has a list of emergency call numbers.

Spills of contamination in this facility will not affect other plant divisions and will be cleaned up by standard radiation-control procedures.

A power failure is not a serious incident, with past experience indicating that normal operations are achieved shortly after power is again available.

7.0 APPENDIX

Three equilibrium run sheets are attached.

ORNL PRFR PILOT PLANT
RUN SHEET
SLUG DEJACKETING
(Aug. 12, 1959)

Run _____ Batch _____ Date _____

1.0 SYSTEM CHECK

Close the Following Valves

_____ M-1 drain
_____ M-1 sampler
_____ M-1-P suction
_____ LPW to M-1-P suction
_____ NaOH to M-1
_____ NaOH to M-1-P discharge
_____ M-1-P to C-17
_____ M-1-P to HCW
_____ M-1-P to S-12
_____ M-1-P to S-1 (line blanked)
_____ M-1-P Recirculation
_____ M-1-P to M-20
_____ M-20-P to S-1
_____ M-20-P suction
_____ M-20 drain
_____ M-6-P suction
_____ M-6 Recirculation
_____ M-6-P to S-1
_____ M-6 drain
_____ M-6 sampler

Instrument Check

_____ LI-M1 manometer indicating
_____ DI-M1 manometer indicating
_____ LI-M6 unplugged and indicating
_____ IR-M20 unplugged and indicating

Solution Check

_____ Sample M-1 _____ M OH^-
_____ M-1 full. Sp. Gr.= _____.M _____ OH^-
_____ M-20 full. Sp. Gr.= _____.M _____ OH^-
_____ M-6 made up. Sp. Gr.= _____.

1.2 S-1 System

Close togs:

_____19 _____21 _____33

_____S-1 external water

_____Close tog 21 block valve

_____Close tog 33 block valve

_____Close tog 19 block valve

_____Open block valves to:

_____2500-A _____2500-B

_____Set TRC-2 to 0°

_____Set PIHC-3 to 0 psi

_____S-1 sparger off

_____Set S-1 jacket service open

_____LR-S1 recording

_____DR-S1 recording

_____PICA-1 controlling at 10" vacuum

_____Close valve on slug chute

1.3 S-3 System

_____Open block valve to 2505-B (LPW to S-3)

_____Close block valve 2506 (80# steam to S-3)

_____Set PIHC-6 to 0 psi and air switch to "open"

_____Open block valves _____1513B;

_____1513C (S-7 off-gas); _____1514C;

_____1514B.

_____Close valve 1514A by putting air on with S-7 by-pass tog.

1.4 S-5 System

Close togs:

_____20, _____25

_____Set PCV-2 at 0

1.5 S-14 System

_____Route DOG thru S-14

_____Close S-14 by-pass

_____Fill S-14 with _____

_____Start S-14-P recirculating thru spray nozzles.

2.0 LIQUID HEEL ADDITION

_____2.1 Open _____M-6-P suction; _____M-6-P to S-1; _____M-20-P to S-1 valves

_____2.2 Pump _____liters of _____to S-1 from M-6.

	M-6 Start	M-6 End		S-1 Start	S-1 End
L. L.	_____	_____	L. L.	_____	_____
Sp. Gr.	_____	_____	Sp. Gr.	_____	_____
Vol.	_____	_____	Vol.	_____	_____
Vol. Change	_____		Vol. Change		_____

Time _____

Date _____

_____2.3 Close _____ M-6 to S-1; _____M-20-P to S-1 valves.

3.0 SLUG ADDITION

_____ 3.1 Place loaded slug charger on pedestal.

_____ 3.2 Open V 1509 (slug chute).

_____ 3.3 Open slug gate (bottom of charger).

_____ 3.4 Begin loading slugs into S-1 by cranking handle on slug charger.

CAUTION: DO NOT FORCE HANDLE.

IF HANDLE DOES NOT TURN EASILY SOMETHING IS JAMMED AND MUST BE FREED.

_____ 3.5 Add _____ slugs to dissolver.

_____ 3.6 If doubtful that charger is empty, revalve magazine one more turn.

_____ done _____ not done.

_____ 3.7 Close slug gate.

_____ 3.8 Close V 1509

SLUG CHARGING RECORD

Date	Time	Charger No.	No. Slugs	From Bin No.	Comments

4.0 SLUG DEJACKETING

4.1 Calculate No. of liters caustic needed.

$$\text{Liters Caustic} = \frac{(\qquad)\ (\text{No. of slugs})}{\text{M-1 Molarity}}$$

_____ 4.2 Heat S-1 to boiling.

_____ 4.3 Open _____ M-20-P suction and _____ M-20-P to S-1.

_____ 4.4 Add _____ liters (calculated amount) of caustic to S-1 at _____ liters/hr. Time _____ Date _____

Operator _____

M-20

	1st		2nd		3rd		4th		5th	
	Start	End	Start	End	Start	End	Start	End	Start	End
L. L.										
Sp. Gr.										
Vol., liters										
Vol., Change										

Total Vol. Transferred _____ liters.

Time _____ Date _____

S-1

	Start	End
L. L.	_____	_____
Sp. Gr.	_____	_____
Vol.	_____	_____
Vol. Change		_____

_____ 4.4 Set TRC-2 at _____ °C.

_____ 4.41 Let temp. rise to _____ °C. Time _____ Date _____

_____ 4.42 Digest for _____ hours at _____ °C.

_____ 4.43 Set TRC-2 at 40°C.

_____ 4.44 Open manual valve to S1 Jacket Time _____ Date _____

_____ 4.45 Turn on S-1 sparger and cool to 60°C.

_____ 4.46 Sample S-1. Code AJ _____ 1/2

Request Pu ($< 10^3$), U (< 1 g/liter).

S-1

LL. _____

Sp.Gr. _____

Vol. _____

Temp. _____

Time _____

_____ 4.47 Jet S-1 to HCW.

5.0 HEEL WASH

_____ 5.1 Pump _____ caustic to S-1 and hold at 100° for 1 hour.

_____ 5.2 Jet S-1 to HCW.

_____ 5.3 Add _____ gallons process water to S-1.

_____ 5.4 Jet S-1 to HCW.

6.0 LIQUID HEEL ADDITION

_____ 6.1 Add _____ liters of _____ to S-1 from S-5.

	S-5		S-1	
	Start	End	Start	End
L. L.	_____	_____	_____	_____
Sp. Gr.	_____	_____	_____	_____
Vol.	_____	_____	_____	_____
Vol. Sent		_____		_____

Time _____ Date _____

WTMcCarley/vm
9/22/59

ORNL THOREX PILOT PLANT

RUN SHEET

SLUG DISSOLUTION

RUN NO. (_____)

BATCH (_____)

Revised Sept. 2, 1959

FILL IN EACH BLANK BEFORE PROCEEDING TO THE NEXT

Objective: _____

_____

_____

Conditions:

No. of slugs to be dissolved: (_____)

No. of slugs to be charged: (_____)

% Heel (_____): kg U heel (_____)

Metallic aluminum to be added: (_____) kg

1.0 SYSTEM CHECK

1.1 M-2 System

Valve Check

Open	Location	Closed	Location
_____ 1162B	M-U Area (M-2-P to M-33)	_____ 1161	M-U Area (M-2-P-S Suct.)
_____ 1170C	M-U Area (M-33 to S-1)	_____ 1163	M-U Area (M-2-P-S Disch.)
_____ 1170A	M-U Area (M-33 to S-1)	_____ 1160	M-U Area (M-2-P Suct.)
_____ 1164	M-U Area (M-2-P recir.)	_____ 1162A	M-U Area (M-2-P Disch.)
		_____ 1171	M-U Area (FE-1 bypass)

_____ Set FRC-1 on manual at zero output.

1.2 M-1 System

Valve Check

Open	Location	Closed	Location
		_____1153	M-U Area (M-1 drain)
		_____M-1-SU	M-U Area (M-1 sampler)
		_____1154	M-U Area (M-1-P Suct.)
		_____H_2O to M-1-P	M-U Area (LPW to M-1-P Suct.)
		_____1149	M-U Area (NaOH to M-1)
		_____1149A	M-U Area (NaOH bypass to M-1)
		_____1271	M-U Area (M-1-P to C-17)
		_____1273	M-U Area (M-1-P to HCW hdr)
		_____1525A	M-U Area (M-1-P to S-12)
		_____1155	M-U Area (M-1-P to S-1)
		_____1156	M-U Area (M-1-P recir.)

Instrument Check

_____PICA-1 controlling at 10" vacuum. (Move controller to insure response).

_____TRC-2 indicating and controlling.

_____LR-S1 recording and bubblers adjusted.

_____DR-S1 recording and bubblers adjusted.

1.3 S-1 System

_____Close togs:

_____20 _____21 _____25 _____34

_____Close block valves for togs:

_____25 _____20 _____34 _____21 _____S-1 to HCW jet

_____Open block valves to valves:

_____2500-A _____2500-B

_____Set TRC-2 to 0°

_____Set PIHC-3 to 0 psi

_____S-1 sparger off.

_____Set PCV-2 to 0 psi

1.4 S-3 System

_____ Open block valve to valve 2505-B

_____ Close valve 2506 (steam to S-3)

_____ Set PIHC-6 to 0 psi and air switch to "open"

_____ Open block valves ____ 1513B and _____ 1513C (S-7 off-gas) and _____ 1514C and ____ 1514B (S-7 off-gas to Stack). Check off.

_____ Close valve 1514A by putting air on with Tog near PICA-1.

1.5 Slug Chute

_____ Close valve 1509 below slug chute

1.6 BDF System

_____ Close valve at bottom of BDF catalyst tank

1.7 Heel Addition

_____ Add 150 liters of acid from S-5 to S-1

Sample code _____ Concentration _____ M H^+

Volume actually added _____ liters

2.0 SLUG ADDITION

_____ Place loaded slug charger number (_____) in position on the pedestal.

_____ Open V-1509 (slug chute).

_____ Open slug gate (bottom of slug charger).

_____ Begin loading slugs into dissolver by cranking handle on slug charger.

CAUTION: DO NOT FORCE HANDLE. IF HANDLE DOES NOT TURN EASILY SOMETHING IS JAMMED AND MUST BE FREED.

Add (_____) slugs to dissolver. Each turn of the handle should charge 3 slugs.

_____ If doubtful that charger is empty revolve slug barrel one more turn (40 turns of handle)

_____ Inspect charger according to Standard Practice.

_____ Close slug gate on charger.

_____ Close V-1509

_____ Record charging below

_____ Put next charger in position and charge

(2.0 Cont'd) _____Record below

_____Repeat until (_____) slugs have been charged.

	Charger No.	No. Slugs	Charged by	Time and Date
1st charger				
2nd charger				
3rd charger				
4th charger				

3.0 SLUG DISSOLUTION

3.1 Equipment Check

_____Set TRC-2 at 0

_____Disconnect steam line from S-1 to HCW jet

3.2 Aluminum Addition - (_____) required, (_____) not required

_____Set PIHC-3 to 0 psi to put full jacket water on S-1.

_____Add (_____) kg metallic aluminum to S-1

Use (_____)

Charge via (_____)

3.3 DC Addition

_____If level in DC catalyst make-up tank, M-36, is below(_____)inches make up catalyst according to catalyst make-up run sheet.

Required_____ Not Required_____

_____Open valve between catalyst make-up tank and S-1 and drain(_____ inches of catalyst solution to S-1.

Time_____ Date_____ Operator_____

_____ Set PIHC-3 to 15 psi

_____ Set TRC-2 on (_____)°C and let temp rise to (_____)°C

_____ Air lift acid still in S-5 to S-1

Volume transferred_____liters

Sample code_____. Concentration_____M H^+

CAUTION: WATCH PICA-1 CLOSELY. IF S-1 PRESSURIZES START TAKING STEPS TO CONTROL THE REACTION. SEE DIRECTIONS POSTED NEAR PICA-1.

_____ Determine acid still required.

Moles acid required for dissolution (_____) moles

Volume added as heel = _____ liters x _____ M = _____ moles

Volume from S-5 after catalyst = _____ liters x _____ M = _____ moles

Total _____ moles

Amount of acid still to be added _____ moles

Volume to be added from M-2 = moles/M acid in M-2 = _____ l.

_____ Determine what final M-2 L. L. (LI-2) should be after additions.

M-2 L.L. _____ Sp G _____ Vol _____ liters

Vol. present _____ less vol. to be added _____ = _____ final volume in M-2 after acid addition to S-1.

From calibration curve determine L. L. reading which corresponds to final M-2 volume. _____ true L. L.

Final L. L. = true L. L. _____ x _____ Sp G (DI-2/9.6) = _____ L.L.

_____ Open M-2-P suction valve 1160 and discharge valve 1162A.

_____ Set FRC-1 on automatic at (_____)% and start M-2-P.

Time _____ Date _____ Operator _____

_____ Record data at (_____) hour intervals.

_____ When LI-2 drops to the final L. L. calculated above, shut off M-2-P.

Let M-33 drain.

Time _____ Date _____ Operator _____

M-2 after addition: L. L. _____ Sp G _____ Vol. _____

_____ Close valves

_____ 1160 _____ 1162A _____ 1162B

_____ 1170C _____ 1164 _____ 1170A

_____ Set TRC-2 at 120°C and continue digesting.

If S-1 Sp G levels off below (_____), add 1 inch more catalyst (this shouldn't be necessary until at least 10 hours after all acid is in).
If S-1 Sp G levels off again below desired point add 1 inch more catalyst (wait at least 2 hours between catalyst additions). Continue adding catalyst as needed until correct Sp G is reached.
Record catalyst additions below:

Extra Catalyst Additions			
Time and Date	Amount DC Added	S-1 Sp G	S-1 Temp

_____ When S-1 Sp G reaches (_____) set TRC-2 at 40°C and PIHC-3 at 10 psi for 15 minutes.

Time _____ Date _____

_____ Set PIHC-3 to 0 psi and turn on S-1 sparger.

_____ When TRC-2 reaches 40-60°C set PIHC-3 to 15 psi

Time _____ Date _____

_____ Sample S-1
Code MD-(_____)-1 and 2

_____ Rinse sampler lines for about 5 minutes after pulling samples.

4.0 S-1 TRANSFER TO S-2

Do not wait for sample result. Transfer until S-2 contains (_____)liters

Start next dissolving even if S-1 is not completely empty.

_____ Record following information:

	S-1	S-2
LL	_____	_____
SG	_____	_____
LL (True)	_____	_____
Temp.	_____	_____
Vol.	_____	_____

_____ Turn on S-1 to S-2 jet.

Time_____ Date _____ Operator _____

_____ When S-2 stops building up, turn off jet.

Time_____ Date _____ Operator _____

_____ Record following information:

	S-1	S-2
LL	_____	_____
SG	_____	_____
LL (True)	_____	_____
Temp.	_____	_____
Vol.	_____	_____

Build-up in S-2 = _____liters

_____ Depletion in S-1 = _____liters

Jet dilution = _____liters

5.0 _____ Agitate S-2 (_____) hours and sample. Rinse sampler lines about 5 minutes after sampling.

Code: UAF (_____) 1 and 2

Time_____ Date_____ Operator_____

6.0 _____Close block valve to V-2500B and set PIHC-3 to 15 psi.

_____Close block valve to V-2505B and set PIHC-6 to 15 psi.

7.0 _____Start next dissolving immediately. Go at least as far as liquid heel addition. DO NOT LEAVE S-1 EMPTY.

DATA SHEET
SLUG DISSOLUTION

RUN NO. _____

BATCH NO. _____

Shift and Date	Time	S-1 Dissolver						M-2		M-33	Acid Rate		Remarks
		LRA 16	DR 12	TRC-2		PICA-1		LIA 2A	DI 2	LRA 39b	FRC-1		
				Set	Temp.	Set	Vac				Set	Rate	

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