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AN INTRODUCTION TO THE PUREX PLANT

By

J. J. Courtney and B. E. Clark, Jr.

Separations Section

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INTRODUCTION TO THE PUREX PLANT

I. FOREWORD

A. Scope of the Manual

The intent of this manual is to present a description of the main process building, equipment, and auxiliary facilities as well as a process summary. Material is of a scope nature with more detail devoted to features unlike those of existing separations systems. An attempt is made to convey some of the basic design philosophy and the problems encountered in the development of design criteria. This information is written primarily for Separations Section supervision who have not had an opportunity to become conversant with the Purex Project. The manual may also be of assistance in orientation and training of personnel. In order to avoid repetition and duplication of effort, one line service diagrams, equipment sketches, tables, and detailed data are not a part of this manual. Such material is presented in the Purex Equipment Manual (Official Use Only).

B. Justification for the Purex Project

In the 1952 Hanford Expansion Program, irradiation capacity is being increased by the two new K Area reactors of 1300 megawatts nominal capacity each. With the completion of these piles, it was estimated at that time that a minimum of 275 tons of uranium would be processed at H.A.P.O. recognizing prospects through other technological developments for a potential capacity requirement of as much as 400 tons of uranium per month. The total capacity of the existing separations facilities in 1952 was approximately 210 to 235 tons of uranium per month. After much study and considering many factors, such as potential increases in pile production and the more economical operating costs of a plant with a high operating capacity, General Electric

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recommended the construction of a new 200 ton debottlenecked separations plant. Accordingly, the Hanford Operations Office, Atomic Energy Commission issued Work Authority No. CA-513 on August 19, 1952 for a new chemical separations plant to process 200 tons of irradiated uranium per month.

The decision to adopt the Purex process was based upon an overall evaluation of known processes. It has been demonstrated that it is more economical to process uranium through the Redox plant than the Bismuth Phosphate plants. It is estimated that it will be appreciably less expensive to process uranium through the Purex plant as compared to the Redox plant.

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Original estimates revealed that a gross annual savings in production costs of could be realized by using the Purex process as compared to the Redox process based on the processing of 200 tons of uranium per month.(1)

An economic study incorporating the most recent changes in the Redox and Purex flowsheets shows that the annual operating cost of a Purex plant with backcycle is $1,900,000 less than a Redox plant with complete backcycle.(2) Also, the annual operating cost of a Purex plant with no backcycle is $2,900,000 less than a Redox plant with partial waste backcycle. These figures were based on operating costs of new plants capable of processing 400 tons of uranium per month.

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The Purex process has certain distinct advantages over the Redox process:[3]

1. The salting agent, nitric acid, is cheaper and can be economically recovered.
2. Waste volumes are less than one-third those for the Redox process.

There are several advantages of the Purex process which are less tangible in terms of cost:

1. There is greater safety owing to the higher flash point of the solvent (over 145 F compared to 81 F for hexone).
2. Greater chemical stability of the solvent (no exothemic reactions with nitric acid, except under extreme conditions).
3. Greater ease of recovery of specific fission products from wastes.
4. Better possibility of eventual permanent waste disposal.

C. Project Administration

Expansion of the 200 area facilities by the addition of the Purex separations plant and expansion of supporting facilities was authorized by Work Authority No. CA-513, dated August 19, 1952 and Project Authorization No. 255, dated August 25, 1952. The Project Proposal (HW-26220) was issued November 24, 1952 and approved by the Atomic Energy Commission early in 1953.

Scope design by General Electric Company was completed in February 1953. Detailed design for CA-513-A was started in November 1952, by the Vitro Corporation, Architect Engineers, and was essentially complete in May 1954. Construction by Blaw-Knox Company, Cost Plus Fixed Fee Contractor, was started in April 1953. Smaller portions of the project such as waste storage facilities, and expansion of the steam and filter plant were let on lump sum contracts. The scheduled construction completion date for the Purex project is

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February 1, 1955. Funds authorized for Project CA-513 as of June 21, 1954, are as follows:

Parts	Authorization
CA-513-A - Purex Facility	$69,280,000
CA-513-B - UO_3 Facility	330,000
CA-513-C - 300 Area Prototype Equipment	570,000
CA-513-D - 200 East Area Hot Semiworks	820,000
	$71,000,000

D. Capacity of the Purex Plant

The plant is designed on the basis of operating twenty-seven days per month, 90 per cent operating time efficiency.* During the time the plant is operating (27 days), it will operate at an average production rate of 89 per cent of its design instantaneous capacity.** The combination of these factors gives an over-all production efficiency of 80 per cent. To meet the average monthly production of 200 tons which was established as the added separations capacity requirement, the plant is designed for an instantaneous rate of 8.33 short tons of uranium per day.(4)

The design basis of the feed is aluminum jacketed slugs which have had an exposure level averaging 600 MWD/T and which have had a "cooling" period of not less than 90 days. Plutonium production is equivalent to 4.25 kilograms per day at the design exposure level.

* Operating time efficiency is that per cent of the time that the plant is operating, but not necessarily at the peak rate. This factor allows time for complete shutdown for scheduled and unscheduled maintenance, system flushing, revision, or correction of difficulties.

**The production rate factor represents the actual production expressed as per cent of that production which would have been realized if the plant had operated at its instantaneous rate for the given time increment. This factor allows for less than peak rate operation for start-up, shutdown, rework, and stream adjustment during off-standard operation.

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Canyon equipment and auxiliaries such as pumps are sized at 1.25 times design capacity. Fixed piping is designed with a 1.50 factor, and hot pipe trench headers and gravity flow lines are sized at 2.0 ± 0.2 times design capacity. Process solution rotameter sizing is based on a rangeability of 1.8 to 18 tons per day.

E. Description of Separations Plant and Supporting Facilities

Selection of 200 East Area as the site of the Purex plant was based on recommendations of the Working Committees -- RDA DC-4 and RDA DC-7.[5] Since economic considerations were of the same order of magnitude in either East or West Area, the need for plant dispersion for purposes of assurance of production continuity was the determining factor for location of the new facility in the 200 East Area.

The Purex separations plant is composed of many new installations, and alterations to existing facilities in the 200 East Area as follows:

New Installations

202-A - Process Building
203-A - Recovered UNH Storage
211-A - Chemical Tank Farm
216-A - Waste Cribs
240-A - Waste Lines
241-A - Waste Tank Farm
252-A - Secondary Substation
291-A - Exhaust Ventilation, Filter, Fans and Stack
2501-A - Fence and Road Lighting
2503-A - Electrical Distribution System
2505-A - Fire Alarm System
2506-A - Telephone System

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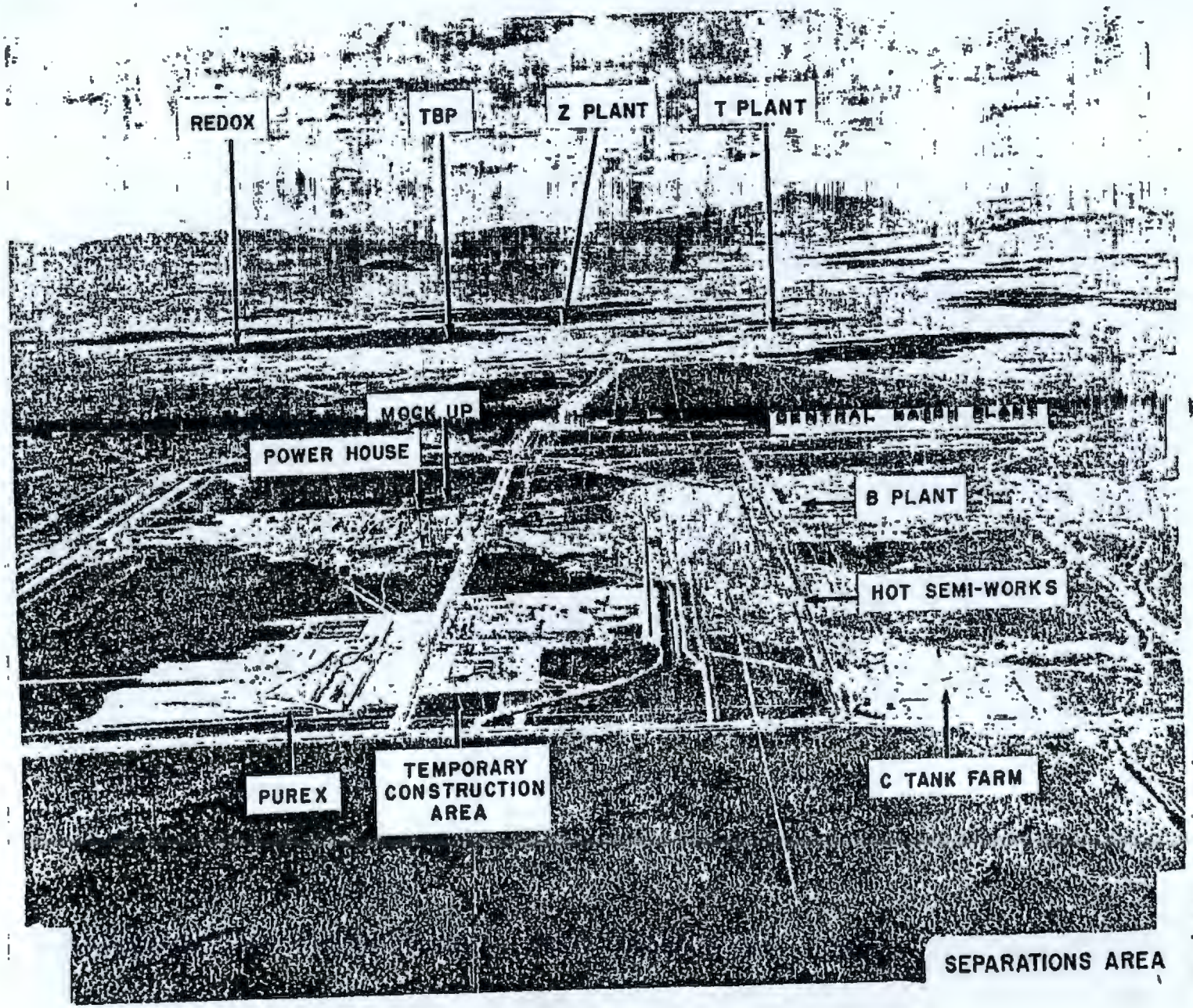

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2601-A - Railroad System
2603-A - Roads and Walks
2605-A - Fences
2607-A - Sanitary Waste Disposal System
2613 -- Parking Area
2702-A - Exclusion Area Badge House
2714-A - Sodium Nitrate Warehouse
2801-A - Overhead Pipe Support System
2802-A - Steam Distribution System
2803-A - Compressed Air Distribution System
2805-A - Process Lines
2901-A - Water Distribution System
2902-A - Fire Lines
2903-A - Sanitary Sewer System
2904-A - Process Sewer System
602 -- Casks and Cask Cars

Altered Existing Facilities

272-E - Equipment Interchangeability and Jigging Shop
282-E - Reservoir and Pump House
283-E - Filter Plant
284-E - Power House
2503-E - Electrical Distribution System
2505-E - Fire Alarm System
2506-E - Telephone system
2601-E - Railroad System
2701-E - 200 East Area Badge House
2802-E - Steam Distribution System
2901-E - Water Distribution System
2901-- Export Water System
602--- Casks and Cask Cars

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1. 202-A Process Building

The main process building is a multi-story reinforced concrete structure having overall dimensions of approximately 1,000' x 120' x 100'.

Selection of a single line longitudinal canyon arrangement was based on the recommendations of the RDA DC-4 Working Committee.(6) Although the cost of construction materials is greater for a single line canyon than the double line arrangement (Redox type canyon), it was opined that due to the simpler, repetitive, and less compact building geometry, more efficient use could be made of construction manpower resulting in earlier plant completion and a substantial savings in indirect construction overhead costs.

The Canyon Portion of the building consists of an in-line arrangement of process equipment located in cells, and includes the associated facilities of maintenance, storage and access. Also included are the galleries containing auxiliary operating and sampling equipment, a pipe trench, and an air tunnel.

The Service Section includes the operational control, chemical addition, laboratory, recovered acid and organic vaults, offices and industrial service facilities. Section III contains a more complete description of the 202-A Building.

2. 203-A Recovered UNH Storage

This facility consists of four 100,000 gallon stainless steel tanks, providing interim storage of 30 days, located in a sectionalized concrete basin. The primary purpose of interim storage is to provide for decay of U^{237} in order to meet product specifications. Other uses are for lag storage of batches of UNH with above normal zirconium,

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niobium and ruthenium content, for blending, and for surge capacity. Two fill lines from 202-A Building, routed underground in an encasement, discharge into the top of the tanks. The tanks are equipped with weight factor and temperature control instrumentation. Sump jets discharge back to storage tanks, to crib, or the loading spot. Two pumps, housed near the pit, transfer solution to the loading spot or circulate the tank contents. Two 3,000 gallon stainless steel tank trailers and one tractor transport UNH solution to the 224-U Metal Conversion Plant. Uranium solution is unloaded using a pump mounted on the tank trailer.

Two 10' x 14' stainless steel tanks are provided in the UNH storage basin to receive recovered nitric acid delivered from the UO_3 plant by tank trailer. This acid will be utilized in the head-end portion of the process.

3. 211-A Chemical Tank Farm

The chemical tank farm consists of tankage suitable for storing a minimum of two months supply of liquid chemicals at design rate usage, two unloading facilities for tank cars and one unloading facility for tank trucks, and a central pump house equipped with railroad and truck unloading docks and temporary drum storage. Tanks are provided for storage of the following solutions:

50% Sodium Hydroxide	40,000 Gallons
60% Nitric Acid	200,000 Gallons
Demineralized Water	90,000 Gallons
Hydrocarbon Diluent	60,000 Gallons
Tributyl Phosphate	25,000 Gallons
93% Sulfuric Acid	500 Gallons

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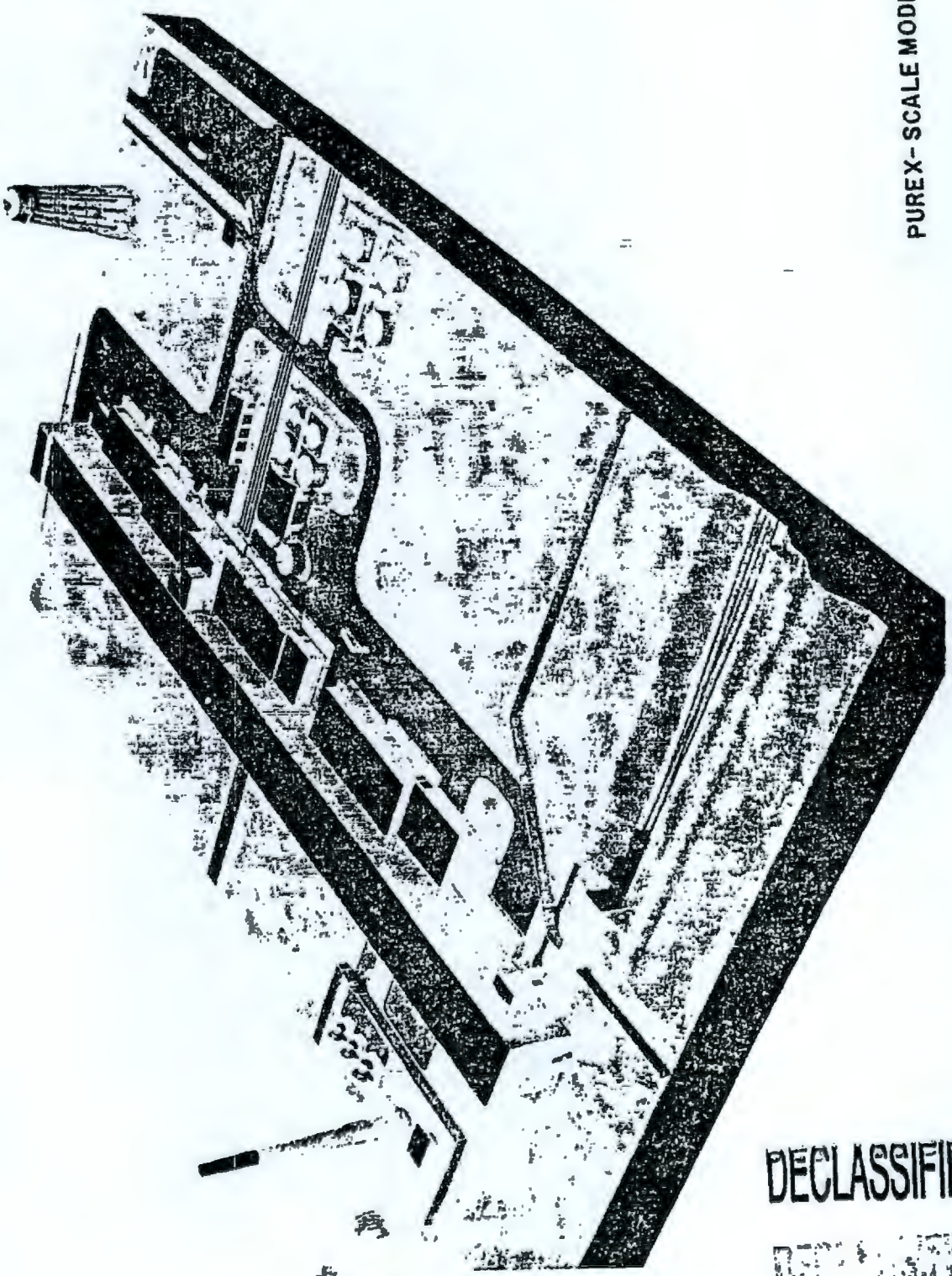
PUREX-SCALE MODEL



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Located in the central pump house are the water demineralizing equipment, sulfuric acid storage tank, unloading and transfer pumps, and the 211 Area operating panel.

To contain spillage in the event of tank rupture and as a fire protection measure, a concrete wall separates and isolates the hydrocarbon dilutent and tributyl phosphate tanks.

All pumps are equipped with mechanical seals. Valves and flanges are provided with protective polythene guards. Tank discharge piping is routed in Amercoated concrete trenches with a metal cover plate at grade level. Fill lines are routed on overhead pipe supports. An elevated walkway along the top of the tanks permits sampling and inspection.

The nitric acid and demineralized water pumping systems, which must maintain a constant pressure in feed headers in the 202-A Building, each consist of two parallel units with interlocking controls which start the non-operating pump upon failure of the pump in use.

4. 241-A Tank Farm, 240-A Waste Lines, and 216-A Cribs

Purex wastes are discharged from the 202-A Building via underground piping to the 241-A waste storage tanks or to a system of cribs. The highly radioactive wastes are routed to the 241-A tank farm via the 240-A encased waste lines and two diversion boxes. Box 241-A-151 is south of the 202-A Building, and box 241-A-152 is at the 241-A tank farm. The tank farm consists of six 1,000,000 gallon underground storage tanks, a vapor condensing system and control house.

Less active wastes are disposed of in a system of seven underground, rock-filled cribs. Streams to all cribs are monitored and measured either by sampling of batch streams in the 202-A Building

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or by use of proportional samplers in the piping to the crib. Piping to the cribs is direct buried and cathodically protected schedule 40 stainless steel pipe.

A more detailed description of this subject is given in Section III-C.

5. 272-E Equipment Inspection and Jigging

Consideration was given to providing facilities for complete mock-up of vessels and pipe jumpers prior to cell installation. Due to the lack of repetitive cell piping patterns, and the variety of cell vessels, the cost of full mock-up equipment could not be economically justified. Instead, the necessary additions and alterations were made to the existing 272-E mock-up shop to provide a Purex semi-mock-up facility. Equipment is installed for vessel and jumper checking, rotating equipment testing, equipment interference inspection, and a rework area. Emphasis will be placed on an accurate as-built program. Jigs will be used in jumper fabrication and final inspection. The inspection jig is a calibrated device with adjustable connector heads. Connectors are positioned according to jumper design and the jumper is placed on the jigs to determine accuracy of fabrication.

Following completion of construction activity, a portion of the 272-E jigging equipment will be moved to the 200-W Area mock-up shop, and the 272-E Building will be utilized as a warehouse for Purex major spare equipment.

6. 291-A Process Exhaust Ventilation

Major components of the exhaust ventilation system are the fibrous glass filter, four exhaust fans, and stack with the attendant underground ductwork, piping, and condensate tanks. Several buildings are provided for fan controls and stack gas sampling. A complete description is given in Section III-B.

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7. 2503-A and E Electrical Distribution System

The electrical distribution system feeding the 202-A exclusion area consists of two, three-conductor 13.8 kv lines: one extending from the existing 251 substation and the other from the existing 252-E substation. A secondary substation, 252-A, is provided immediately north of 202-A Building, and consists of two 13.8/2.4 kv transformers, each having an approximate capacity of 3750 kva. Thus the total installed capacity is 7500 kva. The connected load is 5250 kva and the demand load is 4500 kva. Distribution within the area is from two 2400/480 volt load centers in the 202-A Building.

Emergency power is supplied via a single line from the existing 750 kw (937 kva) generator in 284-E Building. The Purex emergency load requirement is 450 kva. If B plant is reactivated, modifications to the existing emergency power distribution will be necessary.

8. 2506-A and E Telephone System

An extension of the existing 200 East Area telephone system consisting of a 76 pair cable about one mile long is provided. About 50 additional dial telephones are provided; no new exchange equipment is necessary.

9. 2601-A and E Railroad System

Two railroad spurs from the existing 200 East railroad system totaling three miles in length are provided. One spur extends to the 202-A canyon tunnel, and the other serves the chemical tank farm.

10. 2714-A Sodium Nitrate Warehouse

As mentioned in Section X-A, the flammable properties of sodium nitrate warrants segregation of this chemical. Consideration was given to storing sodium nitrate in the 202-A Building storage

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gallery, or the 2101 Building (East Area graphite machining facility). Erection of firewalls and installation of other fire protection devices in 2101 Building was not economically feasible. In the event of fire in the 202-A storage gallery, entrance from an upper level was not deemed advisable. Also, routine transfer of chemicals to and from the storage gallery is undesirable. Therefore, a new, all steel, prefabricated building of 2000 sq. ft. floor space is provided adjacent to the 202-A unloading dock for the storage of this one chemical.

11. 2730-A Medical Facility

For reasons of economy, the existing 200 East Area First Aid Station will be utilized for routine medical services. Cases requiring more complete medical examination and treatment will be referred to 200 West Area First Aid Station or Kadlec Hospital.

12. 2802-A and E Steam Distribution

Normal steam capacity of 200 East Area was increased from 210,000 lbs/hr to 400,000 lbs/hr by the following alterations and additions:

a. Two 80,000 lb/hr normal capacity coal fired boilers were installed.
b. Additional superheater tubes were added to the three existing boilers increasing the capacity of each by 10,000 lbs/hr.
c. A single 18-inch steam line was installed from 284-E Building to the 202-A Area.

The total two to three hour peak steam requirements of the 200 East Area will be 352,300 lbs/hr with the Purex plant operating at 1.25 times the design rate. The normal steam supply of 400,000 lbs/hr

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is based on five boilers in service. However, the fifth boiler is considered as an operational spare to permit shutdown of one boiler on a rotational basis during the summer months for inspection and repairs. On this basis of operation, four boilers are adequate as shown below:

CAPACITY (lbs/hr)

	Four Boilers	Five Boilers
Normal	320,000	400,000
24 Hour Peak	360,000	450,000

DEMAND (lbs/hr)

	Summer	Winter
202-A Process	185,760*	185,760*
Other	90,940	166,540
Total	276,700	352,300

Other additions to the steam generation facility are the coal silo, car shake-out, and car puller.

The coal silo provides lag storage of 640 tons, and selective loading of coal in the silo or power house bunkers by push button switches on the firing aisle. This arrangement elimates weekend call in of the coal handling crew.

The coal car shake-out device consists of a motor driven eccentric shaft connected to a saddle strap steel frame which contacts the sides of the coal car. Induced vibration shakes the coal out of the car hopper. Previously it was necessary to use bars, etc. to pry out coal in inclement weather.

The car puller is a motor driven winch which moves empty coal cars, and positions full cars for unloading. In the past, a full time "cat" operator has been required for this service.

* Includes 1.25 capacity factor.

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13. 2901-A and E Water Distribution

Filtered Water

The filtering rate capacity of the 283-E Building was increased from 800 gpm to 3200 gpm by the following changes:

a. Two Rapid Sand Filters, two settling basins, flocculators, flash mixer, and activated silica were added.
b. Capacity of the existing retention basins was increased from 72,000 gallons to 140,000 gallons.
c. One additional 200,000 gallon clearwell was installed.
d. One 50,000 gallon overhead steel storage tank was provided.
e. One 12-inch line was installed to the 202-A Area.
f. The pumping rate was increased from 1800 gpm to 3200 gpm by adding one new pump and replacing the two original pumps with pumps of greater capacity.

The two to three hour peak filter rate requirements of the 200 East Area will be 2,190 gpm with the Purex plant operating at design rate.

Raw Water

The capacity of the raw water pump house was increased from 9,000 gpm to 17,000 gpm by the addition of two 4,000 gpm pumps in 282-E Building. Thus, raw water demands of 15,760 gpm at instantaneous peak and 10,400 gpm at 24 hour average, based on the Purex plant operating at design rate, can be readily met. A single 24-inch line was extended to the 202-A Area.

Export Water

To meet the 200 Area raw water demand of 27,800 gpm, the capacity of 100 Area export water system was increased to 33,500 gpm as follows:

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1. The outer area export water line was extended by installation of 17,000 linear feet of 30 inch pipe line.
2. One 30 inch valve was installed in the existing line.
3. One 6,000 gpm pump was installed in the 182-B pump house.
4. One 7,500 gpm steam driven pump was converted to electric drive, and one 10,000 gpm pump was installed in the 181-B pump house.
5. One 7,500 gpm steam driven pump in the 181-D pump house was replaced by one 10,000 electric driven pump.

The 200 Area requirements are given below:

Systems	Peak 24-Hour Average - GPM
202-A Process (Design Rate)	6700
Other 200-E	6000
200-W	15,100
Total	27,800

14. Casks and Cask Cars

Additional cask cars were required to handle the overall production demands resulting from the expansion program. It was economically attractive to increase the capacity of existing cars rather than purchase new rolling stock. Thus, the ten existing two-well cask cars were converted to three-well cars. In addition, two new three-well cask cars were provided. One new spare cask was purchased, making a total of three spare casks available.

Other than the economic saving from alteration of the cask cars, the time saved in dissolver charging and transportation of the metal is significant.

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II. PROCESS DESCRIPTION

A major step in the production-scale separation of plutonium was taken with the completion of the Redox plant in 1951. Although solvent-extraction processes similar to Redox were seriously considered for the recovery of uranium and plutonium as early as 1943, numerous chemical and engineering unknowns were recognized; therefore for over seven years the Bismuth Phosphate process was the only source of plutonium. An immense tonnage of slightly depleted uranium was stored underground as a waste from this process.

The savings resulting from the use of the Redox process are large compared to the Bismuth Phosphate process, but additional improvements appeared worthwhile if nitric acid could be substituted for aluminum nitrate as the salting agent.

Both the Redox and Purex processes afford major savings over the Bismuth Phosphate process, the most important of which are the recovery and decontamination of uranium, the reductions in waste volumes, and the reductions in chemical and labor costs. (The relative advantages of the Purex process over the Redox process have been detailed in Section I-B).

The isolation and decontamination of uranium and plutonium is accomplished by the preferential extraction of these products into a solvent (30 per cent by volume tributyl phosphate) immiscible with water, followed by stripping the product back into the aqueous phase. Three cycles are used to achieve the required product purity: the Precycle or Codecontamination Cycle for decontamination of both products, the Partition Cycle for separation and decontamination of the uranium and plutonium streams, and the Final Plutonium and Final Uranium Cycles for further decontamination.[3]

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A. Process Summary

Briefly the Purex process consists of the following steps: the uranium slugs are charged into a dissolver where the aluminum jacket is preferentially dissolved by a sodium hydroxide-sodium nitrate solution. The slugs are then dissolved in strong nitric acid. The concentrated uranyl nitrate-nitric acid solution is clarified by centrifugation and adjusted to proper uranium concentration and salting strength by dilution with nitric acid. The plutonium is quantitatively stabilized in the tetravalent state (the form most readily extracted by TBP) by the action of sodium nitrite and the feed is then ready for solvent extraction. Up to this point batch operation is used, subsequent extraction operations are continuous.

The prepared feed material enters the first column of the Precycle extraction battery where plutonium and uranium are extracted by countercurrent contact with 30 volume per cent tributyl phosphate in a light hydrocarbon carrier. Here conditions of flow and salting strength are regulated in such a manner that the uranium and plutonium are coextracted almost quantitatively, leaving most of the fission products and other impurities in the aqueous phase. The product bearing organic stream passes to the second column wherein the uranium and plutonium are returned to the aqueous phase by countercurrent stripping with water. After concentration, reoxidation, and increasing the salting strength, the aqueous product stream passes to the second or Partition Cycle.

The product stream is extracted to the organic phase in the first column of the Partition Cycle, as in the preceding battery. The organic product bearing stream passes to the second column wherein uranium and plutonium are separated by reducing the latter to the aqueous favoring trivalent stage by the action of ferrous ion. Salting

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strength and flow conditions are controlled in such a manner that a virtually complete separation of the two products is affected, the plutonium reverting to the aqueous phase while the uranium remains in the organic phase. Uranium is stripped to the aqueous phase in a third column.

The aqueous uranium bearing stream from the Partition or second cycle is concentrated and adjusted with nitric acid to a uranium and nitric acid composition approximating that of first cycle feed. The uranium is then extracted to the organic, and stripped back to the aqueous in a manner comparable to that in previous cycles. The product stream is concentrated prior to shipment.

The dilute plutonium stream flows directly to the second Plutonium Cycle battery (third cycle) where the material is reoxidized and the salting strength adjusted prior to the final extraction cycle. As before, the product is extracted to the organic phase, leaving the impurities in the aqueous. The plutonium is again stripped to the aqueous phase in the second column of the battery, prior to final concentration and off-site shipment.

Since the organic solvent is reused, it is sent to a solvent-recovery area after each pass through the system, where it is washed with sodium carbonate solution to remove traces of complexed radio-elements and TBP degradation products.

The aqueous wastes from the solvent-extraction cycles are concentrated with the simultaneous distillation and recovery of nitric acid. Eighty per cent of the acid used for salting purposes is recovered for ultimate reuse in the process. The main incentive, however, for acid recovery is the reduction in volume of active wastes, which must be stored indefinitely.

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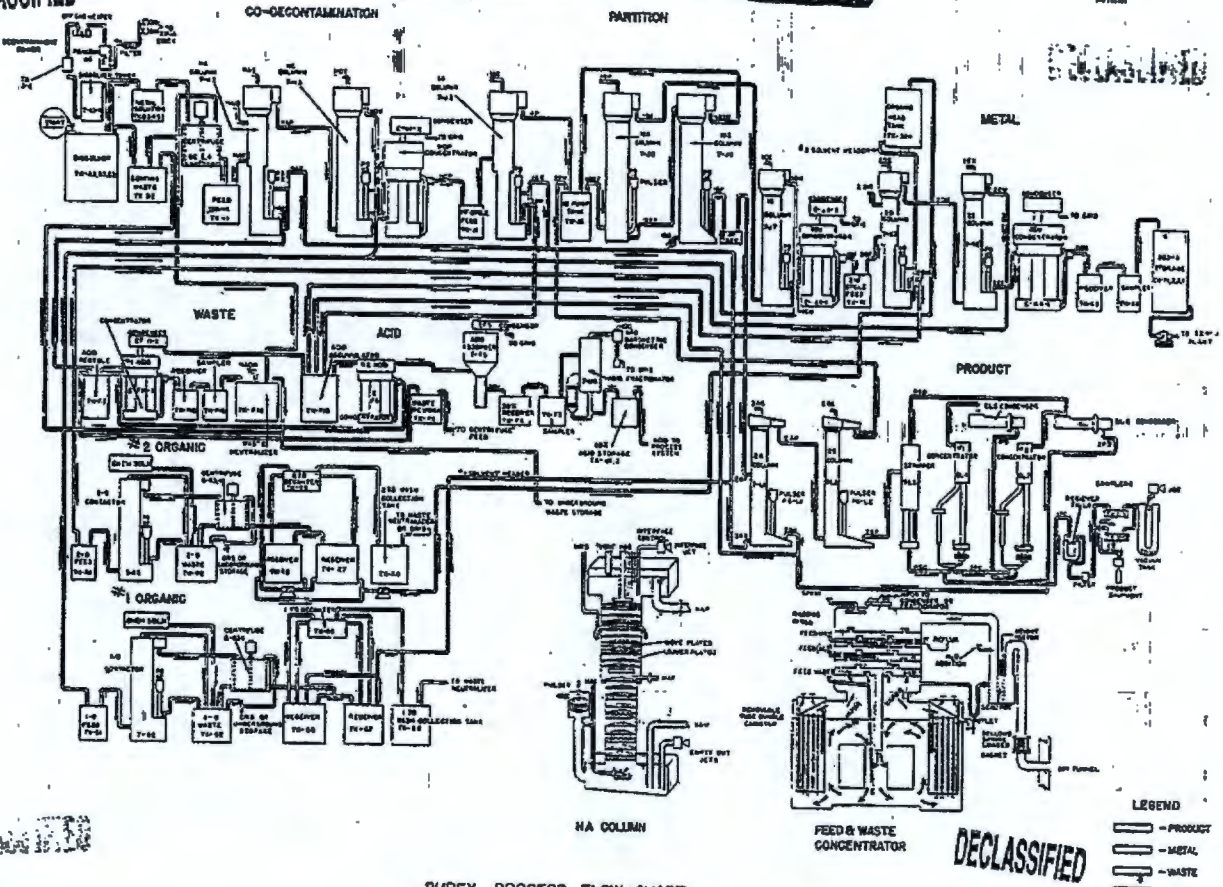

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PUREX PROCESS FLOW CHART

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Product purification by solvent extraction depends on the complexing action with TBP. For example, uranyl nitrate reacts with TBP according to the reaction

$$UO_2^{++}\ (aq) + 2NO_3^{-}\ (aq) + 2TBP\ (org) \rightarrow UO_2(NO_3)_2(TBP)_2\ (org)$$

Similarly Pu(IV) and Pu(VI) form complexes with TBP.

Although TBP is in most respects a nearly ideal organic extractant for radiochemical separations, its specific gravity (0.973 at 25 C) and viscosity (38.6 Saybolt sec at 85 F) are too high for satisfactory physical performance in the conventional types of solvent-extraction contactors. These properties are altered by blending the solvent with an inert hydrocarbon of low density and viscosity. The lowered viscosity of the mixture permits greater dispersal of solvent with the aqueous solutions, and phase disengagement is more rapid as a result of the increased interfacial tension and the greater density difference between the solvent mixture and aqueous solutions.

In the Purex application 30 volume per cent TBP in a diluent with a specific gravity of 0.788 yields a solvent of specific gravity about 0.841, which increases to 0.975 when the solvent is 85 per cent saturated with uranium. The specific gravity of the opposing aqueous stream is 1.094. Qualitative tests showed that a significantly higher solvent concentration would result in practically no gravity difference between contacting phases, which would give rise to an unstable extraction system. For these reasons 30 volume per cent TBP was felt to be maximum allowable concentration for the Purex system.

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Plutonium has three important valence states in acid solution: Pu (III), Pu (IV), and Pu (VI). Dissolver solutions may contain small amounts of either Pu (III) or Pu (VI) in addition to the predominant Pu (IV). Plutonium (V) is not stable at the acidity encountered in the Purex process.

Distribution coefficients (ratio of concentration in organic phase to concentration in aqueous phase) of Pu (IV) range from 20 to 50 per cent of those for uranium and TBP concentration, and those of Pu (VI) are less than 15 per cent (See Table I). Pu (III) is inextractable under process conditions. The most extractable state, Pu (IV), is also the most stable in strong nitrate solutions. It is obtained by the action of nitrous acid (HNO_2), added as sodium nitrite, which oxidizes Pu (III) and reduces Pu (VI).

TABLE I

Tributyl Phosphate Extraction of Uranium, Plutonium, Nitric Acid, and the Principal Fission Products from a Synthetic First-cycle Feed.

Ion	Distribution Coefficient (O/A)
U(VI)	8.1
Pu(IV)	1.55
Pu(VI)	0.62
HNO_3	0.07
Zr	0.02
Ru	0.01
Pu(III)	0.008
Nb	0.005
Total Rare Earths	0.002

Partition of uranium and plutonium depends upon the rapid reduction of solvent extractable Pu (IV) to inextractable Pu (III), by ferrous ion. As in the Redox process, sulfamic acid (HSO_3HN_2) is required to stabilize the ferrous ion and Pu (III) in the nitrate solution.

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In high nitrate concentrations in the presence of ferrous sulfamate, uranium remains in the organic while plutonium in the Pu (III) state is transferred to the aqueous phase.

After partition, the plutonium is kept in the (III) state by the excess of ferrous sulfamate. The plutonium is oxidized in order to make the plutonium extractable for second cycle decontamination. Nitrous acid again is used to oxidize Pu(III) to Pu (IV), and react with sulfamic acid to form nitrogen gas and sulfate ion.

B. Process Flow

1. Feed Preparation

In the feed preparation section, irradiated uranium slugs are dissolved, the solution is clarified by centrifugation, and chemical adjustments are made to prepare the material for insuring solvent extraction operations. Each dissolver is charged with eight and one-third tons of irradiated uranium slugs and is operated on a forty-eight hour cycle. An equilibrium heel equivalent to about eight tons of uranium is maintained in each dissolver as an aid to the rate of the dissolving reaction and to assure uniformity of uranium content in the solution.

Jacket removal is accomplished using 10 per cent sodium hydroxide - 20 per cent sodium nitrate solutions, followed by water washing. Coating removal wastes are sent to underground storage. Uranium dissolution is accomplished in two "cuts" by the use of nitric acid. (Acid strength used in the dissolvers varies from 40 - 60 per cent, controllable by dilution water, according to the process requirements, and the strength of the available acid.) Dissolution rates average about 830 pounds per hour for the first and 585 pounds per hour for the second cut. Utilization of a down draft reflux tower

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allows dissolution of uranium with 2.5 - 3.0 mols of nitric acid per mol of uranium (compared to 5.5 - 6.0 mols of nitric acid per mol of uranium in dissolvers with up draft reflux towers). Dissolver off-gases are passed through a silver reactor to remove radio iodine, and filtered to remove radioactive particles, prior to disposal.

Dissolver solutions are diluted to proper feed concentrations, and are centrifuged to remove small quantities of solid matter that may be present. (Impurities from the uranium and the silica bonding agent). Centrifugation is accomplished at 1500 G with twenty minutes residence time in the centrifuge bowl.

The clarified dissolver solution is transferred batch-wise to the HAF makeup tank where it is digested with sodium nitrite to adjust plutonium to the Pu (IV) state. Nitric acid is added to adjust the feed stream for proper column operation.

2. Precycle Decontamination

In the precycle decontamination extraction battery, uranium and plutonium are coextracted from the fission products contained in the dissolver solution. Gamma decontamination to a factor of 10^5 is accomplished when 99 per cent of the fission products are separated from the product stream in this cycle.

Feed to the HA column enters near the midpoint of the tower and passes down, being contacted by the HAX extractant stream (30 volume per cent TBP - 70 per cent inert hydrocarbon) entering from the bottom. A dual scrub is used in the HA column. HAS entering at the top is water and its primary purpose is to reduce the acidity of the organic phase leaving the tower, to decrease corrosion rates in the HC column. HAIS scrub solutions enter the column at an intermediate point between the top and the feed inlet point. The HAIS

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scrub provides nitric acid for use as a salting agent in the transfer of uranium and plutonium to the organic phase. Careful flow ratio control is maintained on all feed, extractant, and scrub streams.

The aqueous phase (HAW), containing the fission products, is routed from the tower bottom to waste treatment.

The product bearing organic stream (HAP) leaves the top of the HA column, enters the bottom of the HC column, and contacts the low nitrate extractant stream (HCX) entering from the top. The plutonium and uranium are stripped back to the aqueous, and the organic stream (HCW) is routed to organic treatment. The product stream (HCP) passes continuously to the HCP concentrator where its volume is reduced by a factor of eight. After leaving the concentrator, the solution is reoxidized with sodium nitrite and nitric acid is added to increase the salting strength prior to partition.

3. Partition Cycle

The Partition Cycle effects further decontamination from fission products and separates the uranium and plutonium products. The 1A column functions identically to the HA column, transferring the uranium and plutonium products from the aqueous to the organic phase. A single, high nitrate scrub is used, and the same feed-to-extractant-to-scrub flow ratios used in the HA tower, are utilized. Aqueous waste (2AW) is routed to the waste treatment and the product stream (1AP) passes to the 1BX feed tank.

Since overall height requirements of a compound B type column are excessive for cell installation, two simple columns designated as 1BX and 1BS are provided. In the 1BX column the product bearing organic stream is contacted with an aqueous solution of ferrous sulfamate, which reduces the plutonium to the inextractable Pu (III) state, and returns it to the aqueous phase.

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The 1BXF stream enters the bottom of the 1BX tower while the extractant (1BX) enters the top. The aqueous phase leaving the tower bottom contains the plutonium in a reduced state and serves as a feed stream to the 1BS column. The uranium leaves the 1BX column in the organic phase and is fed to the 1C column.

In the 1BS column, the aqueous stream containing the plutonium is scrubbed with fresh organic solution to further separate the uranium and plutonium. The organic discharge from the 1BS column is routed back and combined with the 1BX feed stream, while the plutonium in the aqueous phase (1BP) is routed to the oxidizer tank (2AF) for further processing.

The uranium stream from the 1BX column is stripped to the aqueous phase in the 1C column by countercurrent extraction with a low nitrate extractant stream. The organic stream from column 1C is routed to the organic treatment section of the building, while the aqueous uranium stream (1CU) passes to the 1CU concentrator.

The 1BP feed stream enters the compartmented oxidizer tank (2AF), which is designed for sequential chemical adjustment while maintaining continuous flow. In this tank plutonium is oxidized to the extractable Pu (IV) state, while the excess ferrous sulfamate is destroyed by the action of nitrous acid, and the salting strength of the solution is adjusted with nitric acid.

The 2A and 2B columns function identically to the 1A and 1C columns, but differ in physical size due to differences in flow requirements and critical mass considerations. Waste from the 2A column (2AW) is routed to waste treatment while the organic waste stream (2BW) is returned to the 1BX feed tank.

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The aqueous plutonium stream (2BP) is fed continuously to the plutonium stripper for initial concentration, and removal of entrained organic solvent, prior to final concentration. Condensed stripper overheads are routed to waste treatment while the product stream passes to the plutonium concentrators. Concentrated plutonium solution (75 grams per liter) is transferred batch-wise from the product receiver to sample tanks, prior to shipment in special PR cans.

The uranium stream is concentrated by a factor of eight in the 1CU concentrator and is passed to the 2DF tank for chemical adjustment prior to processing in the final uranium cycle.

4. Second Uranium Cycle

In the Second Uranium Cycle, the product stream is further decontaminated from fission products and plutonium to the degree that specifications for off-site shipment can be met. Uranium recovery efficiency through the three extraction cycles is expected to be 98.75 per cent.

The 2D and 2E columns are identical in size, function, and flow rate to the HA and HC columns. The 2DW waste stream is routed to the waste treatment section of the building and the 2EW organic waste passes to the organic treatment section. The product stream from the 2E column is routed through the 2EU concentrator for final volume reduction. The concentrated product stream (60 per cent UNH) is transferred to storage tanks in the 203-A Area, and shipped by tank truck to the 224-U metal conversion facility.

5. Second Plutonium Cycle

In the Second Plutonium Cycle the product stream is further decontaminated from fission products and uranium in order to meet specifications. The material is shipped to the metal fabrication building at 75 grams per liter concentration. Plutonium recovery efficiency through the three extraction cycles is expected to be 98.75 per cent.

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6. Organic Treatment

Entrained fission product material, as well as organic decomposition products, are removed from solvent streams by scrubbing with sodium carbonate solution. Treated solvent streams are centrifuged to remove solids and any emulsified aqueous material that may be present, prior to return to the plant solvent headers. Two identical organic treatment batteries, each consisting of a pulse column contactor and two specially designed liquid-liquid-solid centrifuges, are provided to accomplish this treatment.

Feed to the 1-O organic treatment battery is provided by the HCW, 1CW, and 2BW streams. This material is contacted in a 3 to 1 (organic to aqueous) ratio with sodium carbonate scrub solution in the 1-O pulse column. The organic stream leaving the 1-O column passes through one of two centrifuges, operating in parallel, to remove solids and emulsified aqueous material prior to its return to the organic header system.

A small fraction of the fission products entering the solvent remains in that phase even after being washed. While the level of activity is low (up to thirty times natural uranium activity) the presence of this activity decreases the probability that product specifications can be met routinely. For this reason, a separate (2-O) organic treatment battery is provided for supplying the final uranium cycle. Feed to the second cycle organic system is the 2EW stream. Fixed piping is provided for future operation of the final plutonium cycle on the 2-O organic treatment battery.

7. Waste Treatment and Acid Recovery

The waste treatment section of the Purex process is utilized to receive, concentrate, neutralize, and dispose of salt waste streams, and to recover approximately eighty per cent of the nitric acid used as a salting agent in the process for ultimate reuse.

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The HAW waste stream, containing 99 per cent of the fission products introduced to the system from the dissolver solution, is fed to the number one acid (waste) concentrator. This stream is reduced by a volume factor of eight prior to neutralization and underground storage.

The condensed overheads from the number one concentrator are routed to the F-10 acid accumulator tank where they are combined with 2AW, 2DW, and 1AW waste streams, as well as with the condensed overheads from the plutonium stripper and the number two plutonium concentrator. This combined material makes up the feed stream to the number two acid (waste) concentrator, wherein it is reduced in volume by a factor of twenty-seven. Bottoms from the number two acid concentrator are routed to the number one concentrator feed tank.

Overheads from the number two acid concentrator are discharged as vapor to the acid absorption tower. Nitric acid in the vapors are absorbed in the T-F5 atmospheric pressure fractionation tower (operated as a stripper, normally, without steam on the reboiler), using a fixed reflux, to produce a 30 per cent acid product. This acid is used as feed material to the low pressure fractionation unit located in a contact maintenance zone. In this unit, the 30 per cent acid is fractionated under 26 inches (Hg) vacuum to produce the 60 per cent recovered nitric acid which is reused in the process.

All tank leakage, spills, etc. in the canyon cells are accumulated in local cell sumps, and transferred to the cell drain collection tank in the waste treatment cell. Analytical determination dictates final disposition of this material to the waste neutralizer, to rework, or to crib.

8. Waste Rework

The rework of an off-standard product or concentrated acid waste stream is accomplished by recycling the stream through the solvent-extraction batteries. Since little economic advantage can be realized by introducing the rework stream at intermediate points in the process, all such streams are returned to the feed preparation facilities.[7]

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The uranium product stream may be off-standard through excessive plutonium or fission product content. The off-standard material is returned to the feed preparation facilities for reprocessing as normal dissolver solution.

The plutonium product stream may be off-standard through excessive uranium, organic, or fission product content. Off-standard plutonium stream is returned to the precycle for rework.

The acid waste streams and scrub material from the organic treatment cycle may be off-standard through excessive uranium, or plutonium content. As these streams usually contain quantities of TBP and its decomposition products, they are hydrolyzed to phosphoric acid prior to reintroducing into the solvent extraction system. Hydrolysis is accomplished by boiling under total reflux for 10 - 15 hours at an acidity of 8 molar nitric acid or greater, in the waste rework tank, F8.

Recovered acid streams may be off-standard through low acid content or through excessive fission product content. This rework stream is returned to the number two acid concentrator.

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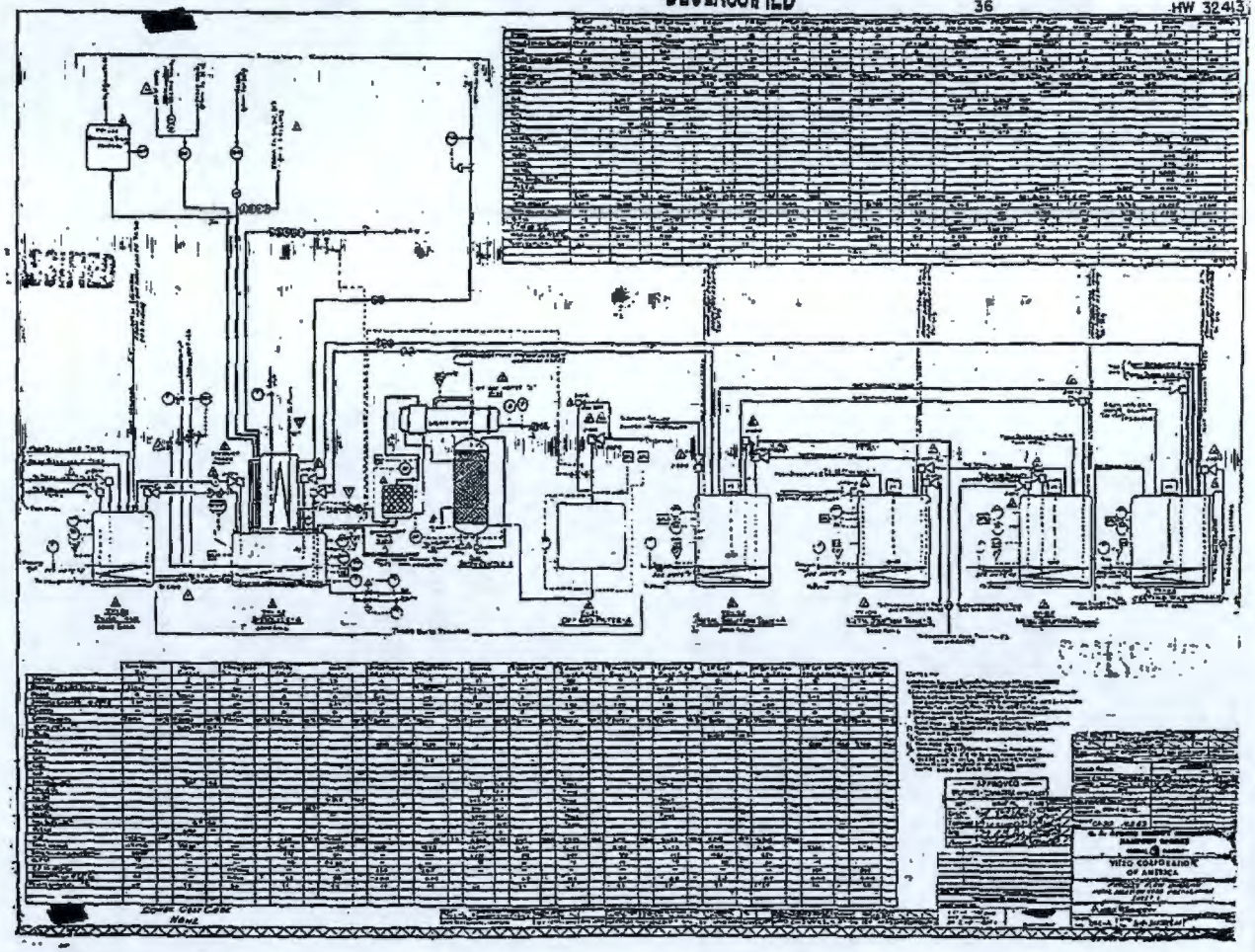

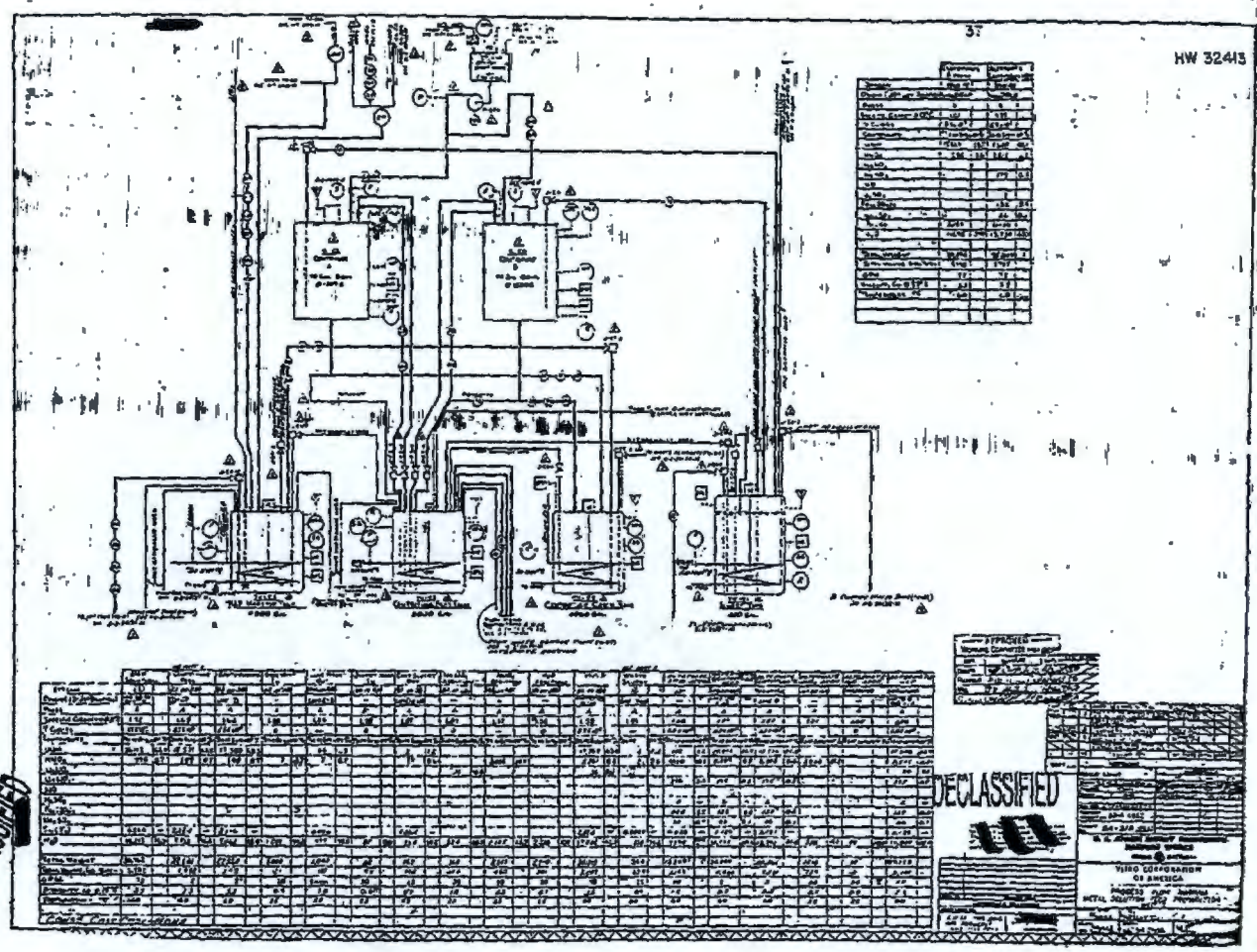

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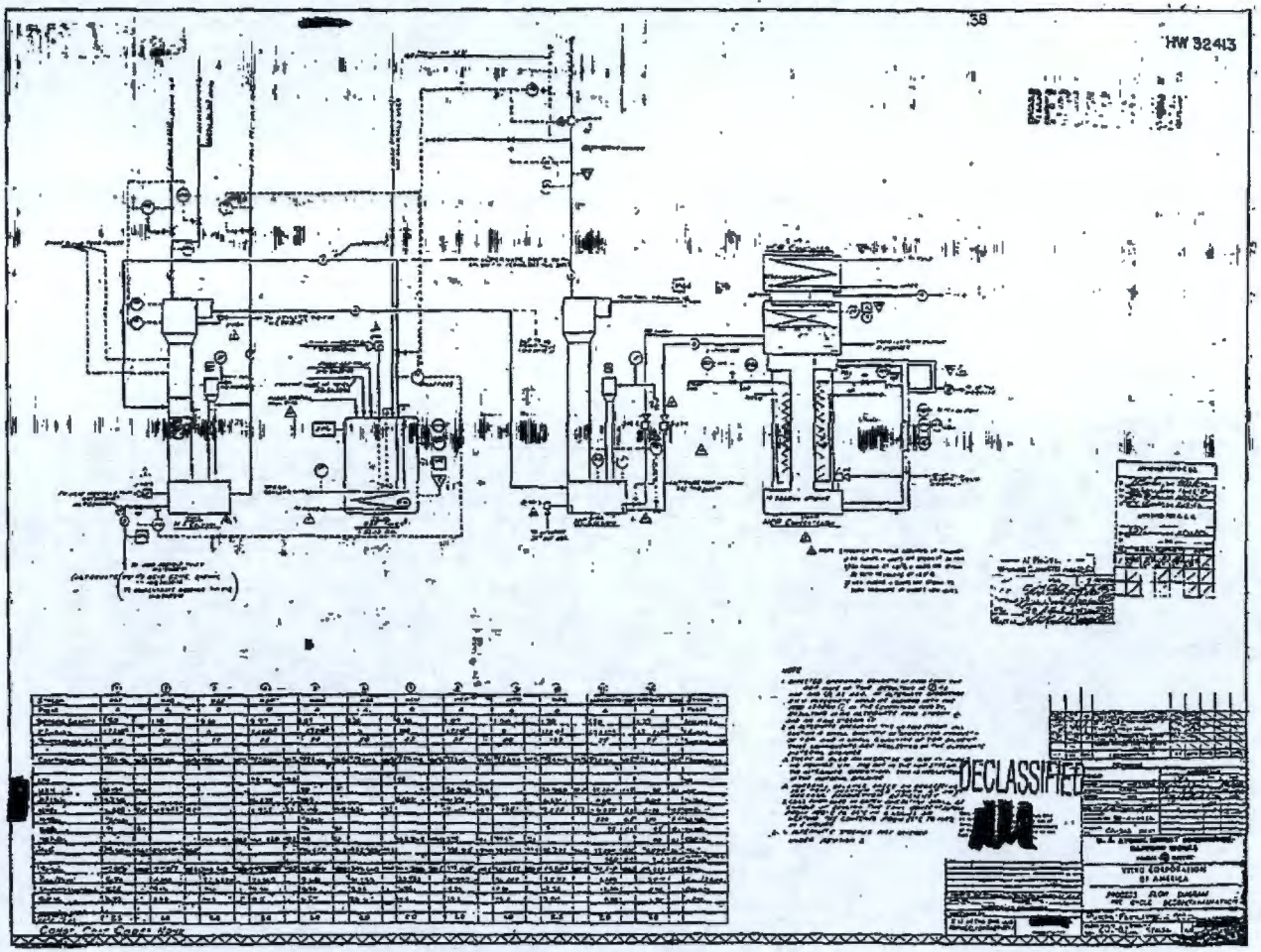

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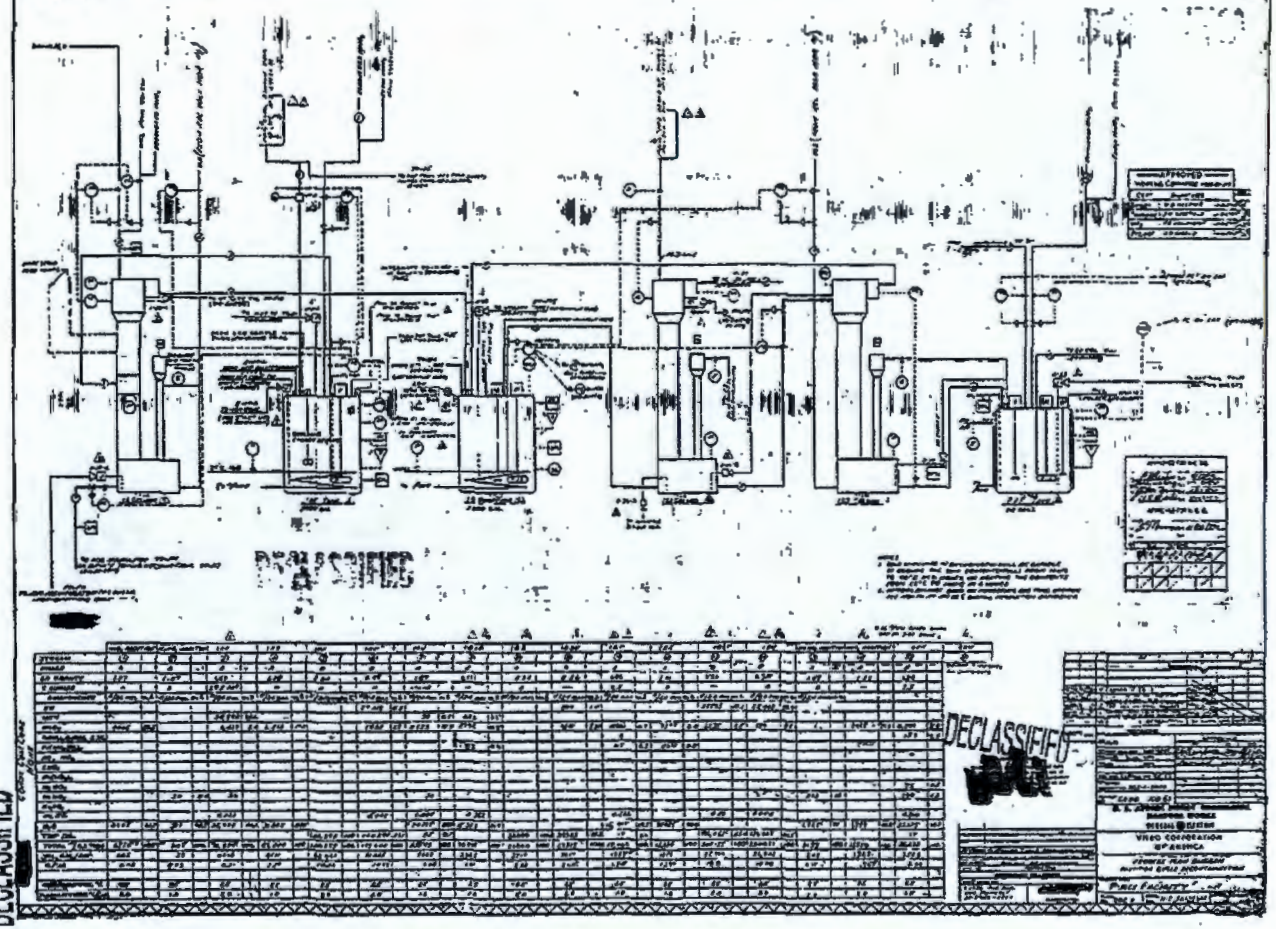

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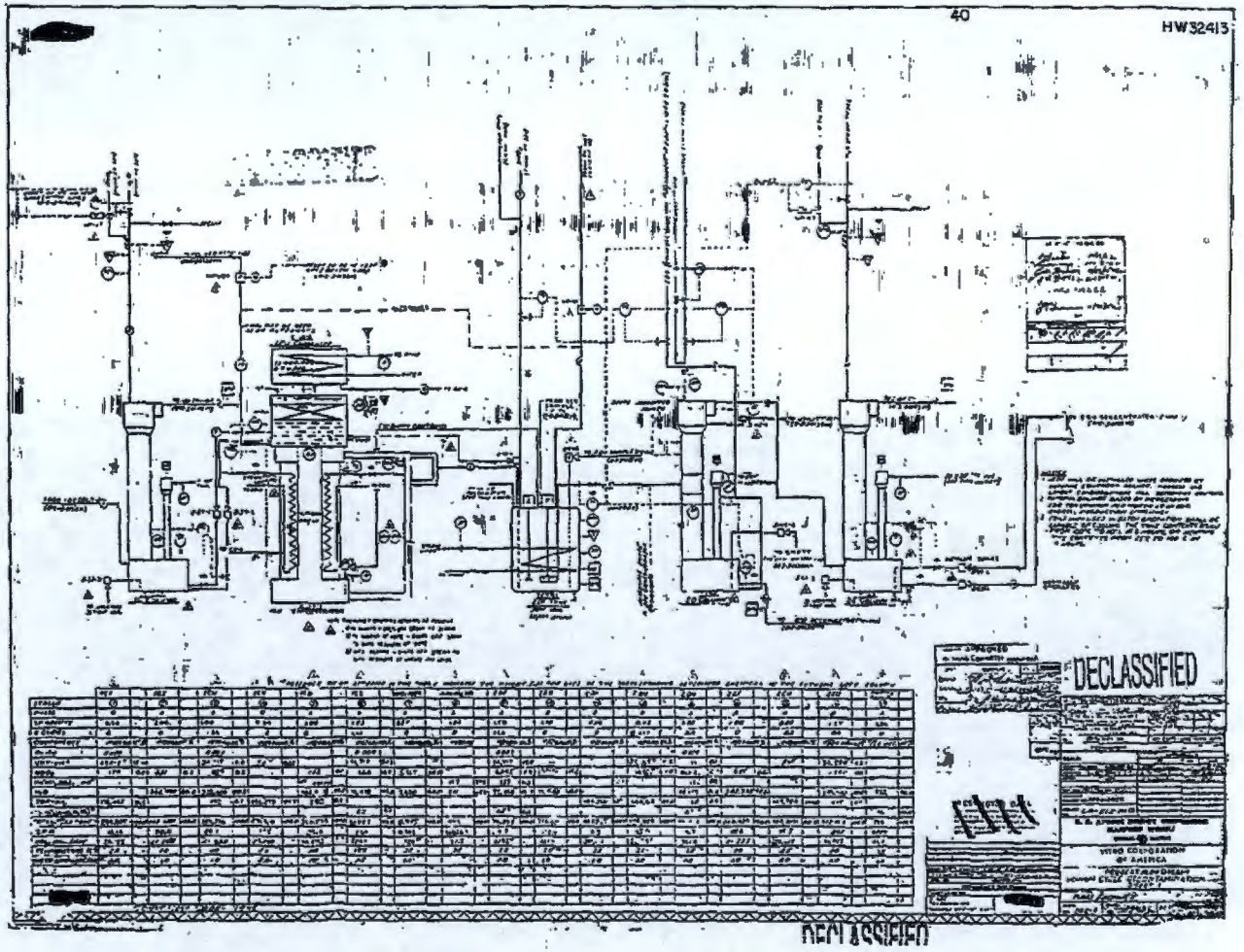

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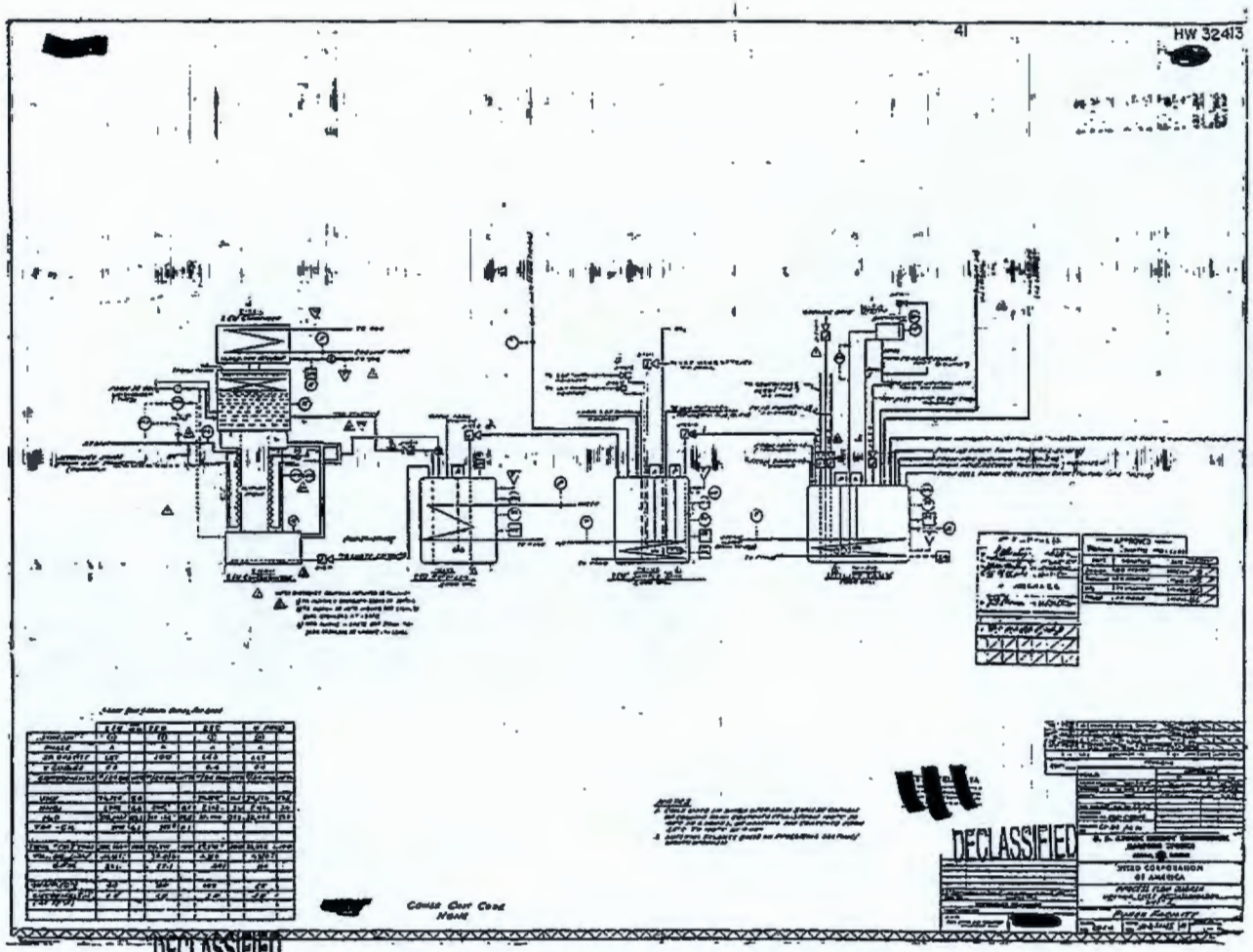

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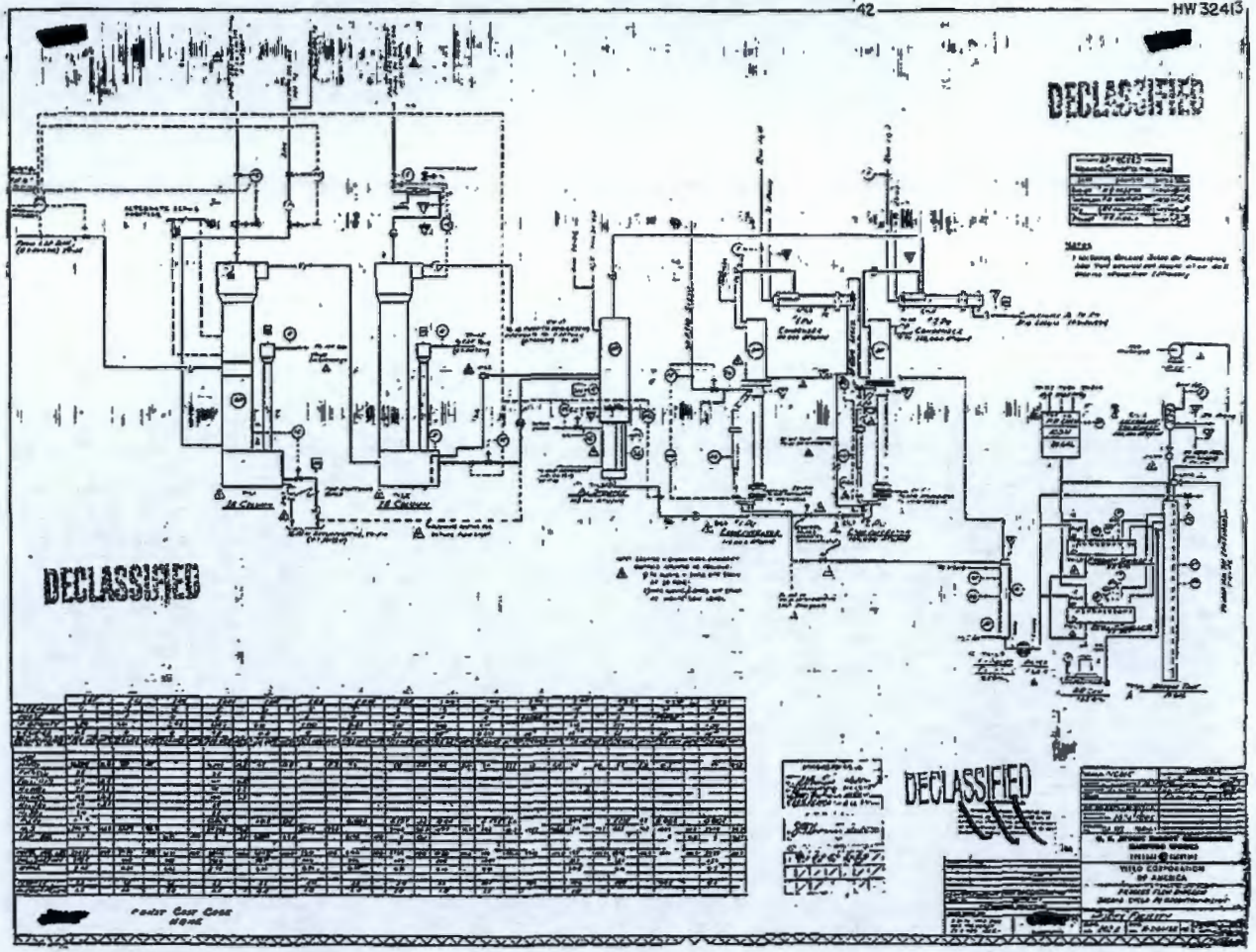
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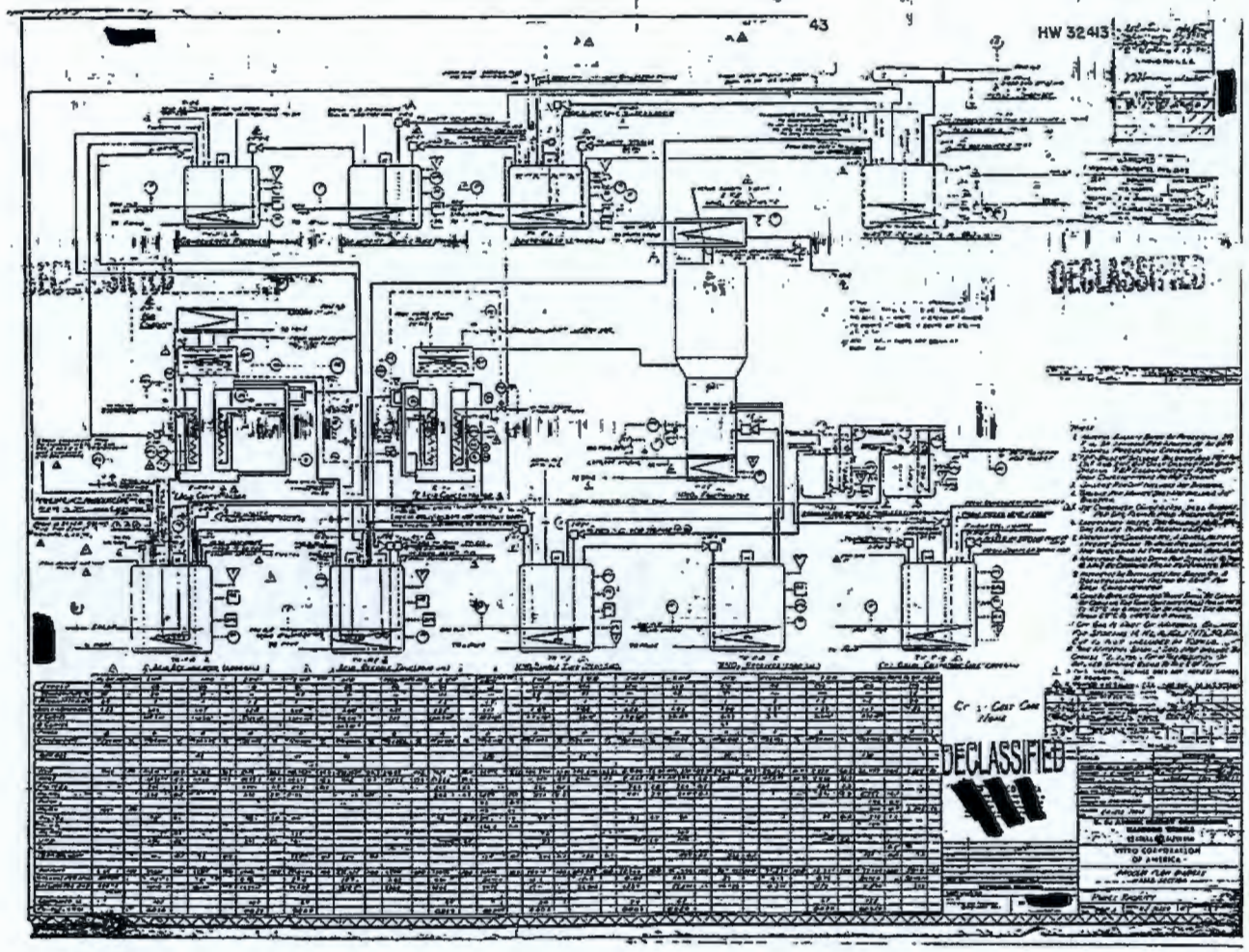

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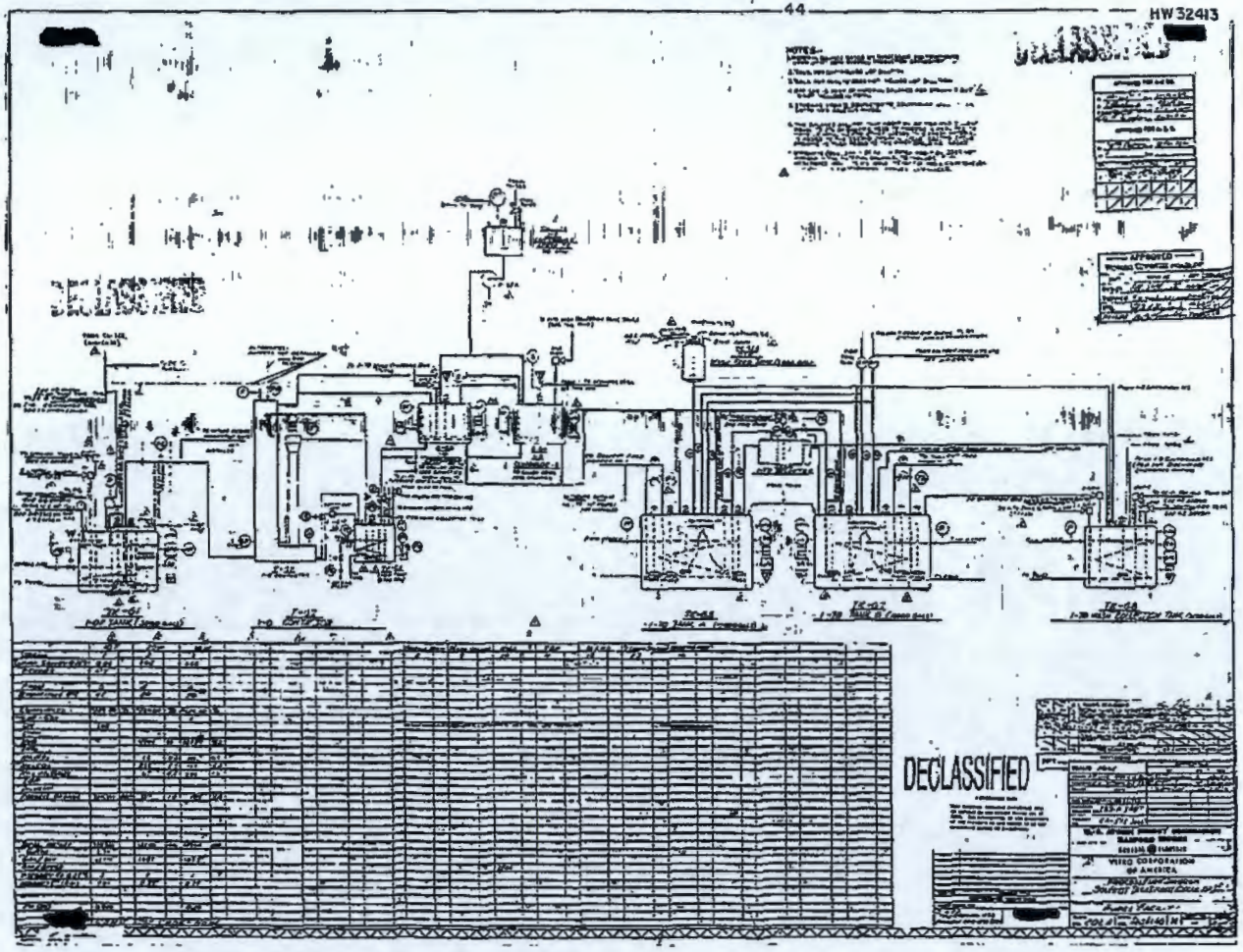
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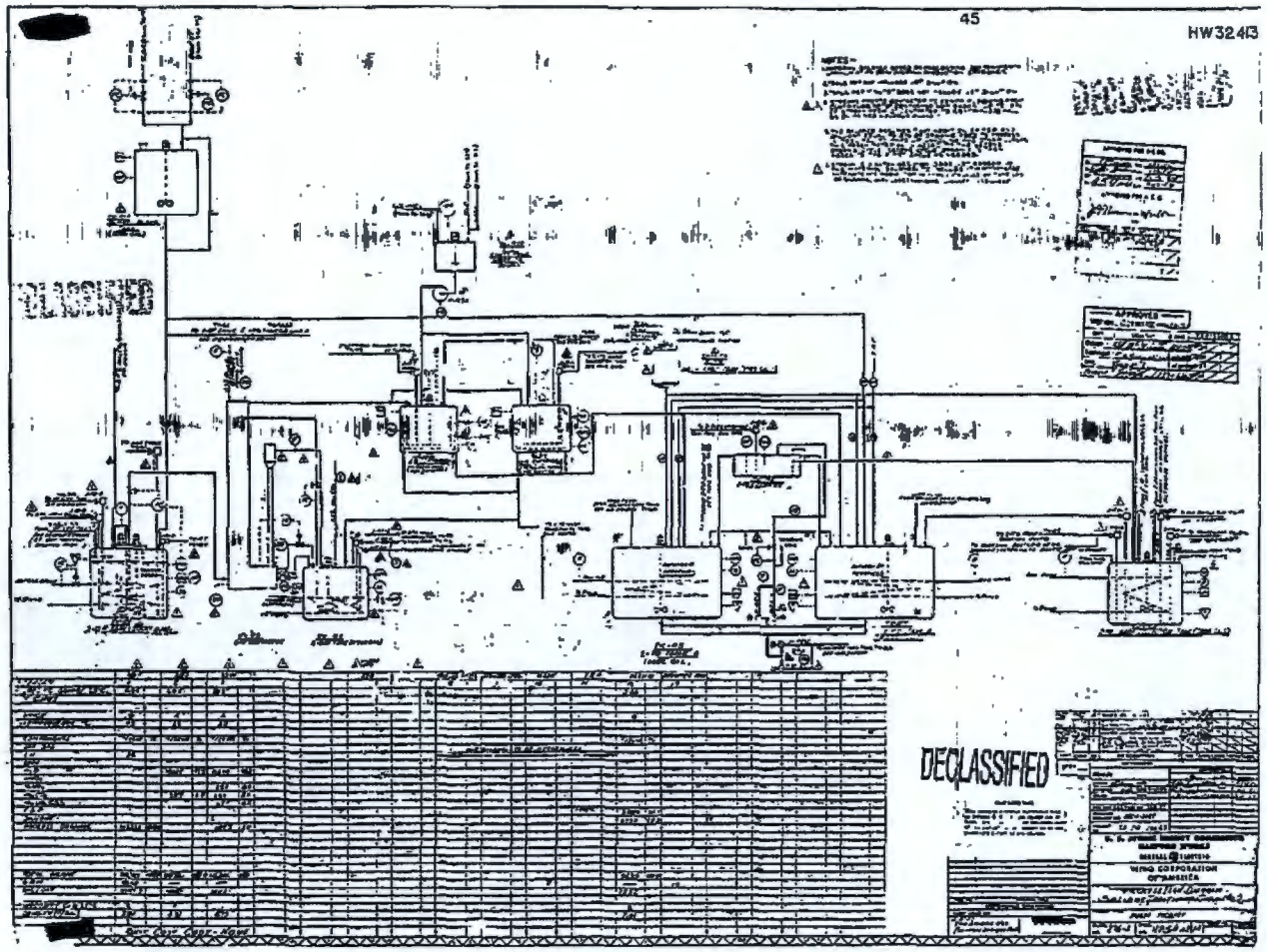
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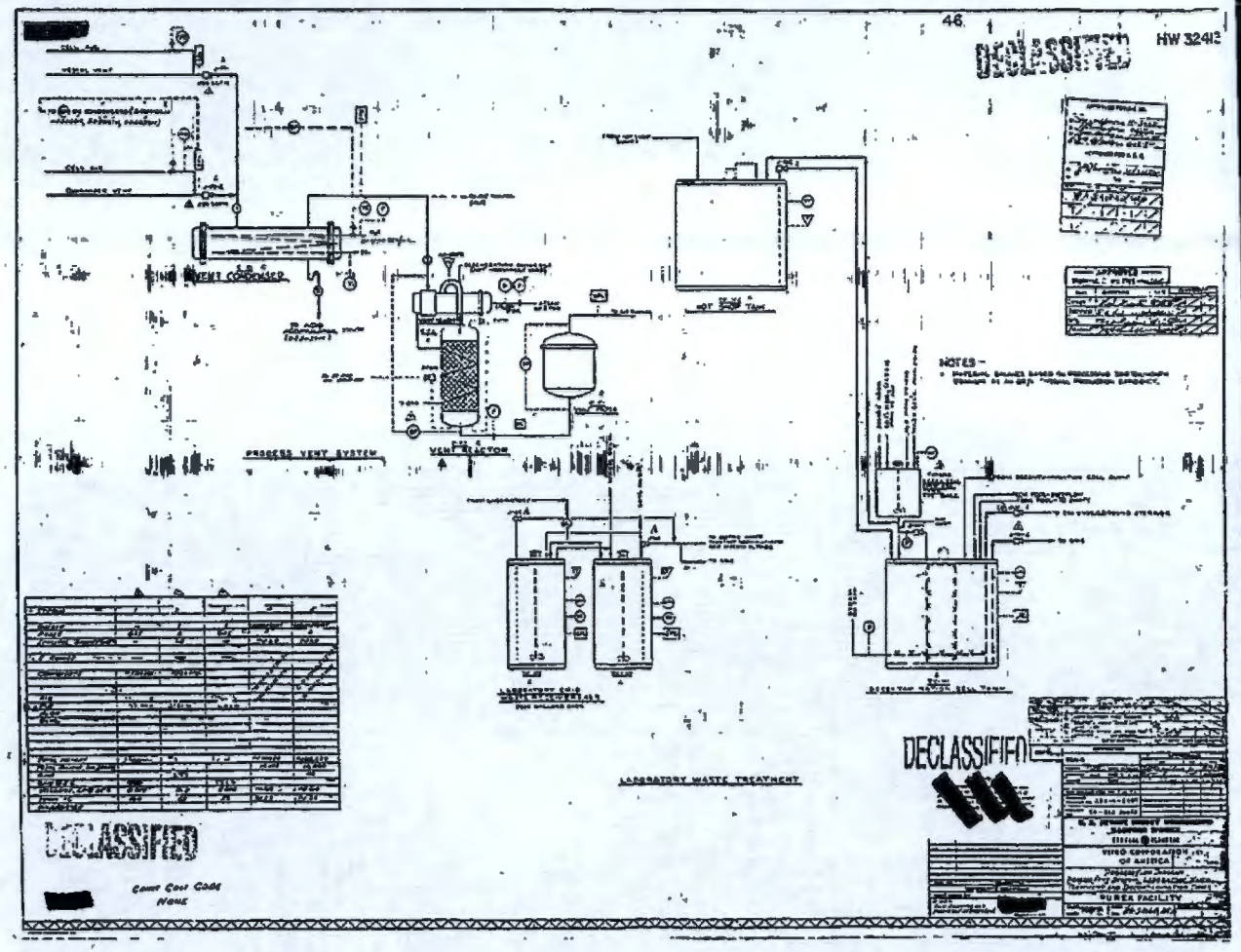

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III. PRODUCTION PLANT AND MAJOR FACILITIES

A. 202-A Building - Description by Structure

1. Canyon Section

a. Slug Handling Area

A Storage Basin for storing loaded slug buckets is located at the east end of the canyon. The storage area has a nominal capacity of forty yoke suspended buckets on one level, and a maximum capacity of 76 buckets on two levels. The basin is serviced by a raw water fill line with overflow to the steam condensate header. A jet out line discharges to the 216-A-6 crib via the steam condensate header. Liquid level is determined by visual inspection.

The Railroad Tunnel is located between the storage basin and the first dissolver cell, and is sized to accomodate a total of three modified cask cars. The tunnel extension permits initial spotting of three cars by the train crew and subsequent movement of cask cars by the crane operator utilizing a remotely operated car puller. A sliding metal ventilation cover at canyon deck level provides an air lock when the tunnel door is open. The ventilation cover is electrically operated from the Dispatcher's office. The railroad tunnel is accessible from the sample gallery and the outer tunnel door. Floor drains are provided from the railroad tunnel to the steam condensate header.

A roadway paralleling the tracks, at the same level, originates at the railroad cut outer gate and terminates at the tunnel door. A concrete pad adjacent to the tunnel door provides an area (45' x 85') for turning a semi-truck and trailer.

b. Regulated Work Area

A Decontamination and Equipment Storage Cell, Pool Cell, and Hot Maintenance Shop are located at the west end of the canyon. The Decontamination and Storage Cell is equipped with a stainless steel

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floor liner, wall spray nozzles, connectors, and flexible jumpers to facilitate remote decontamination of faulty canyon equipment. A vessel, TK-M1, is provided for cleanup of pumps, agitators, etc. Removable equipment storage racks are positioned on one wall. Personnel may enter the decontamination and storage cell via a shielded door from the hot maintenance shop. Leaded glass viewing windows are located in the wall separating the Hot Shop from the Decontamination and Storage Cell to allow visual observation of failed equipment. In order to conserve floor space this wall is constructed of high density aggregate.

The Hot Shop is provided for maintenance of canyon equipment by semi-remote and contact methods. That portion of the hot shop accessible from the crane is furnished with metal ventilation covers. The remaining portion of the hot shop roof is located below the canyon lobby. Handling of equipment in this area is accomplished by a monorail and a jib crane. A decontamination sink and hood is provided for cleaning small tools and equipment. A shielded vessel, TK-M2, is located in the hot shop to facilitate additional decontamination and disassembly of pumps and agitators.

A Pool Cell 36' deep, containing a stainless steel floor liner, is provided for underwater maintenance. When the pool cell is drained, it can be used for equipment storage. A Regulated Shop, at the storage gallery level, is located adjacent to the hot shop for maintenance of small decontaminated process equipment. The shop is furnished with a rotameter and valve test bench, portable work bench, welding machine, drill press and grinder.

c. Main Process Cell Area

Process cells are located in-line on the longitudinal axis of the building and are designated as follows:

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A, B, C,	Metal Dissolution
D	Metal Storage
E	Metal Preparation
F	Waste Treatment and Process Ventilation
G	First Cycle Solvent Recovery
H	Precycle
J	Partition Cycle
K	Uranium Decontamination
L	Plutonium Decontamination
M	Equipment Decontamination and Storage

The final plutonium concentration equipment is located in L cell in preference to a gallery installation. The plutonium concentration equipment package is described in Section IV.

All cells are 14' wide and 42' 6" deep. Distance from cell floor to underside of coverblock is 39' 6". That portion of the canyon occupied by process cells is approximately 860' long.

Cell partition walls are located on the basis of ventilation requirements, being placed as necessary in the vicinity of high temperature equipment, to maintain cell exit temperature at a maximum of 125° F. For example, a "ventilation wall" is provided between TK-F12 and TK-F13. Dissolver cell cover blocks are arranged so that removal of one block permits dissolver charging. The cell floor is sloped to a small trench in the center of the cell which drains to a sump. Cell drainage is jetted from the sump to a cell drain collection tank, TK-F18.

Paralleling the process cells is the Hot Pipe Trench with varying levels of permanently installed (welded) transfer piping and spare routings supported by pipe racks. At the upper level of the trench, connectors are provided for future use; therefore, trench cover blocks are used rather than a permanent cover. Overall dimensions of the pipe trench are 860' x 12' x 33'. Immediately

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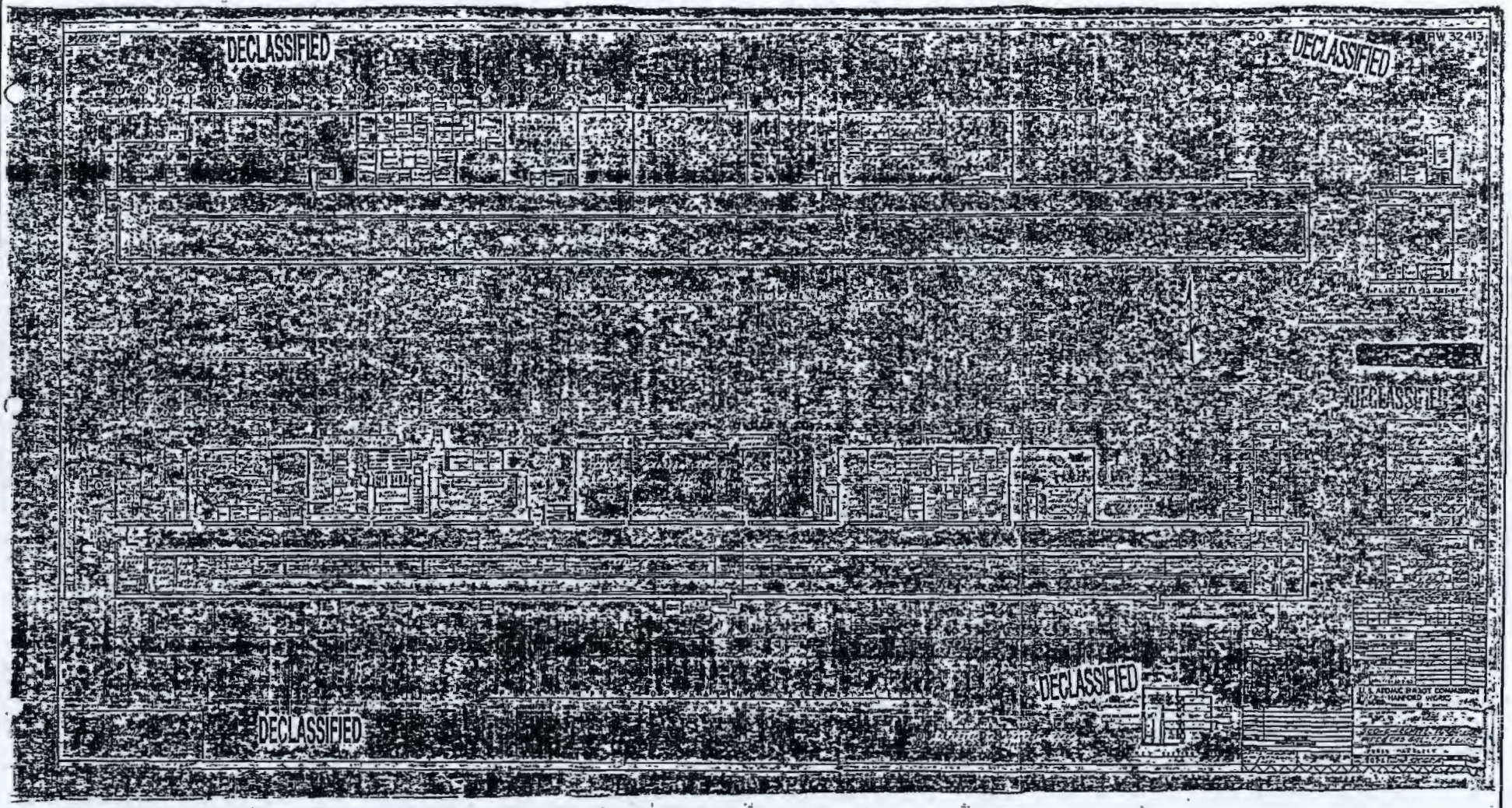
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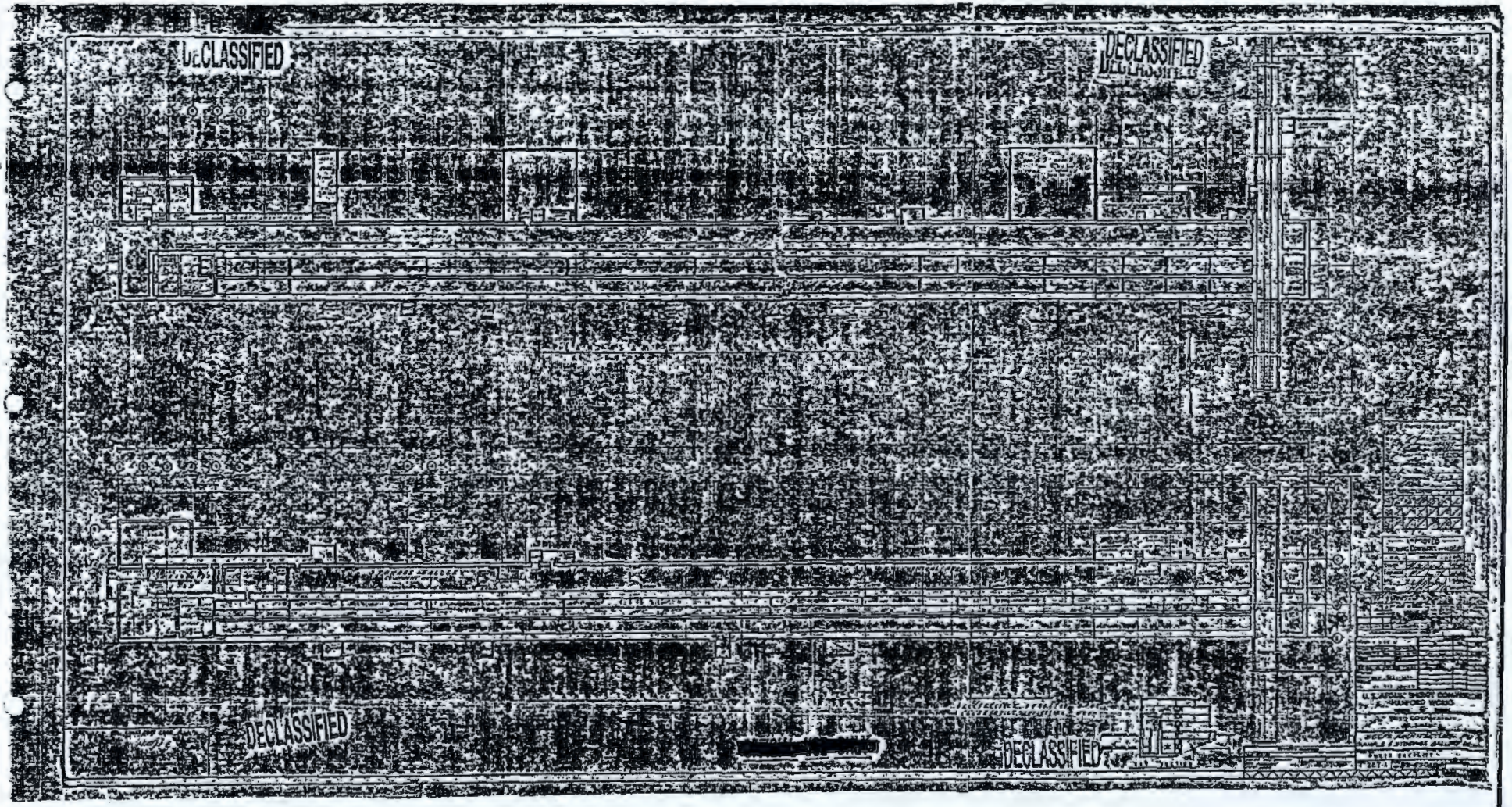
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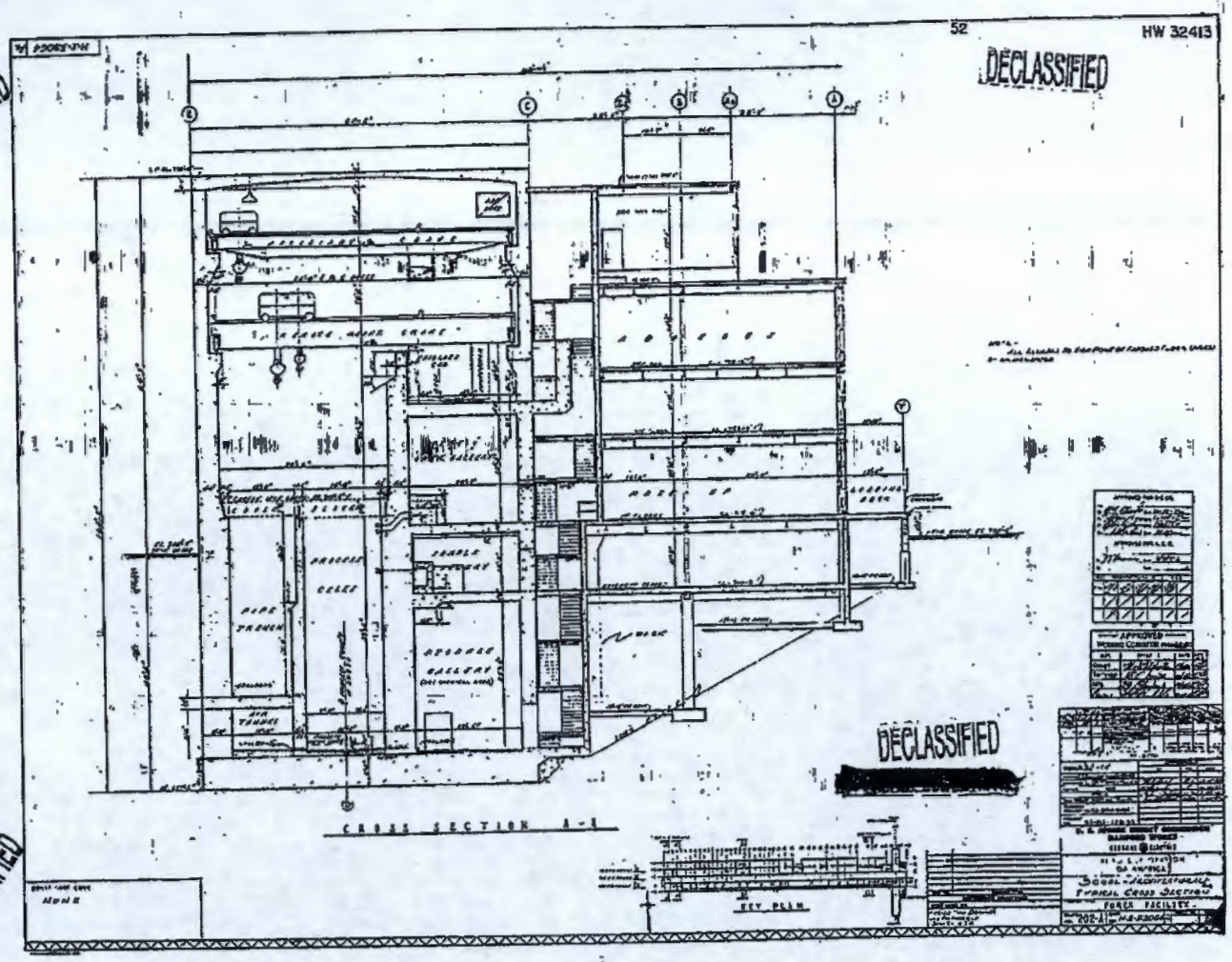

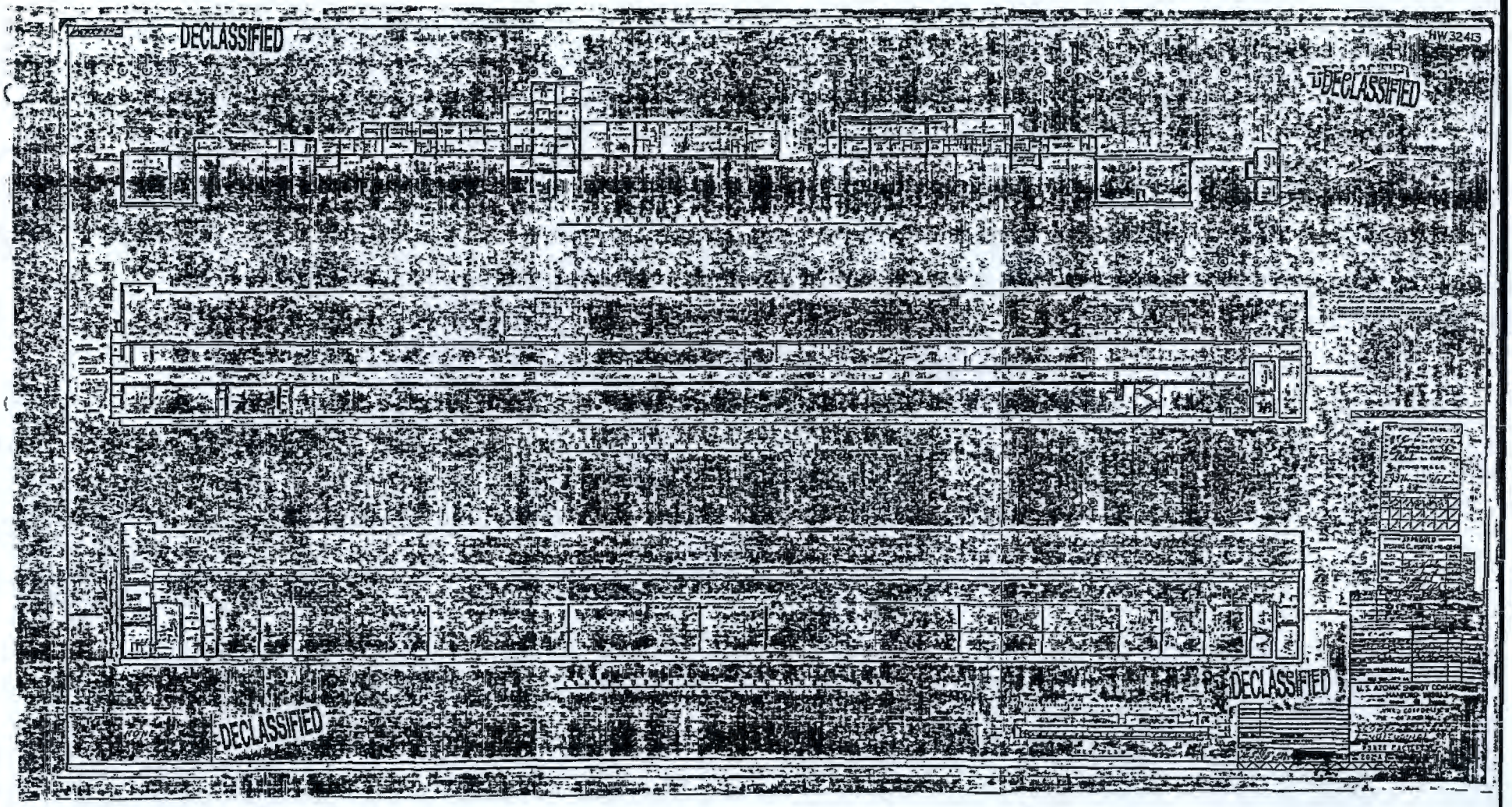
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below the pipe trench is the air tunnel through which exhaust air passes from the canyon proper and the process ventilation system to the fiber glass filter and the 291-A stack. The floors of the pipe trench and air tunnel are sloped to weep holes and are curbed to segregate floor drainage with respect to cell sumps. The hot pipe trench drains to the air tunnel which drains to the cells. Overall dimensions of the air tunnel are 860' x 11' x 7' 6".

d. Gallery Section

Paralleling the cells, on the side opposite the hot pipe trench, are the crane cab gallery, pipe and operating gallery, sample gallery and storage gallery.

The Crane Cab Gallery affords a shielded area by virtue of its parapet wall so that the cab or the operator, when entering or leaving the cab, is protected from direct radiation emanating from the canyon area. The cabway extends full length of the canyon and is 20' wide. Distance from crane gallery floor to canyon roof is 39' 6". The slave crane rail is located 17' above the remote crane rail. The normal point of entry to the crane gallery and the remote crane is from stairwell No. 2 near the west end of K cell. Six emergency exit stairwells are distributed full length of the cabway.

Floor drains are provided from the cabway and the crane maintenance platform to individual cell sumps. The crane maintenance platform does not have a parapet wall. This work area is located at the west end of the canyon, in a low radiation zone compared to the dissolver cells which are at the east end of the canyon. The crane maintenance platform is accessible from the SWP elevator and stairwell.

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The Pipe and Operating Gallery is located directly below the crane gallery and contains the non-radioactive piping and service headers, canyon motor control centers, instrument transmitters, and other related equipment. This level extends full length of the building, is 20' wide and 20' 3" high. The majority of cold piping and services to cell equipment originate in this gallery and terminate in connectors at various levels in the cells. Operating equipment such as centrifuge bowl spray pumps, organic blend tank, and dissolver drowning water tanks are located in this gallery. A high pressure steam reducing station is located at each end of the gallery in a ventilated enclosure.

The Sample Gallery extends full length of the building below the pipe and operating gallery. It is 19' 6" wide and 10' 3" high. A hot pipe trench adjacent to the canyon wall provides shielding for process piping to the samplers, the sampler drain piping, and the recovered nitric acid and organic distribution piping to cell equipment. The sample gallery hot pipe trench has a permanent concrete cover, facilities for water flushing, and floor drains to the cell sumps. A hood is installed adjacent to the hot pipe trench at B cell and F cell for sampling of process off-gases. The product recycle hood is located near the west end of E cell, which provides jetting facilities from recycle cans into the feed make-up tank. A decontamination sink and hood is provided near the center of the gallery, on the canyon side, for cleaning of sampling equipment. The "C" type samplers are located along the gallery wall opposite the hot pipe trench for convenience in sampling the acid and organic vault vessels. Building air sampling compressors are installed in the west end of the sample gallery. "A" and "B" type samplers are located along the gallery wall adjacent to the hot pipe trench.

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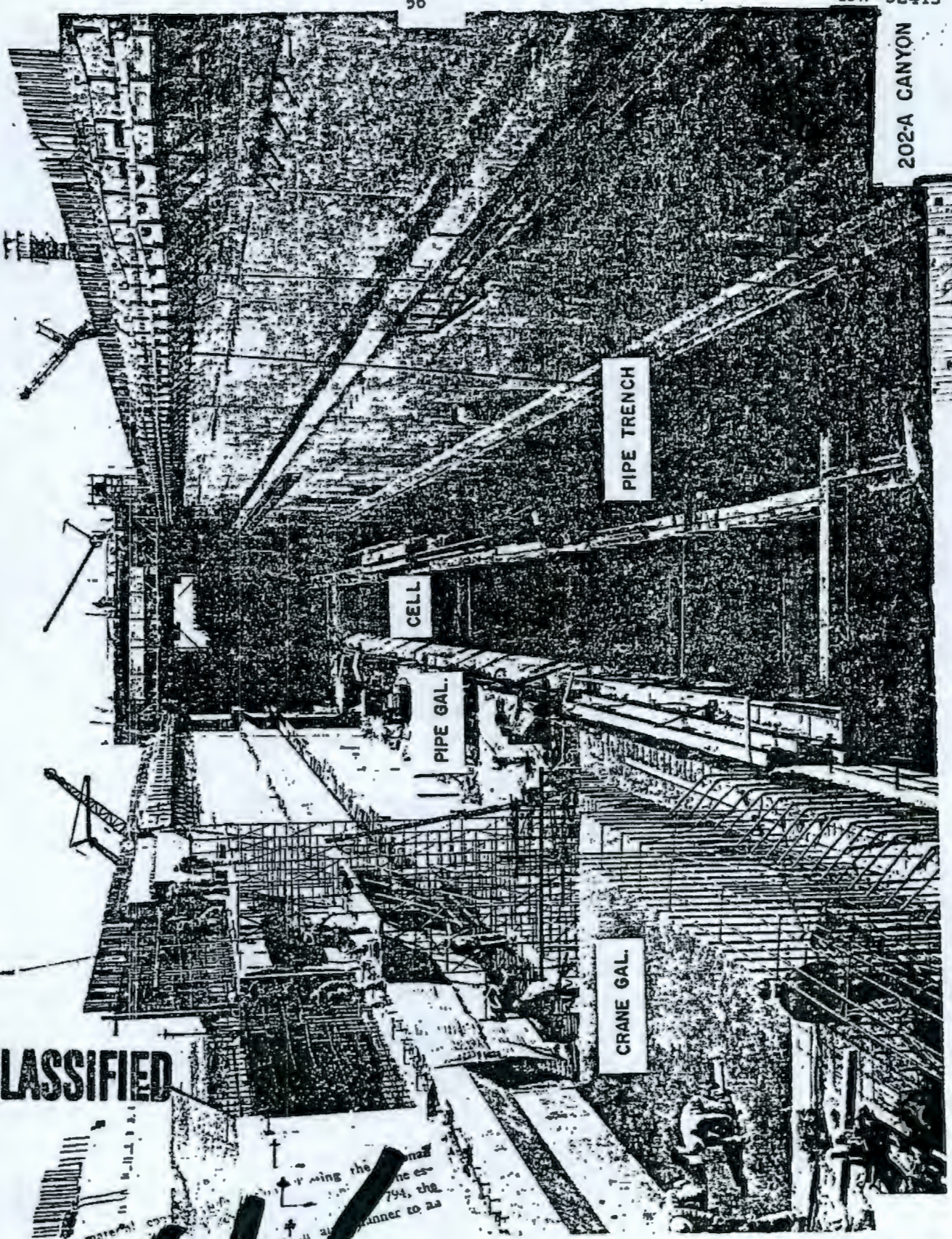

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The stairway from the SWP change room serves as the normal entrance to this level. To minimize the possibility of spreading contamination into the stairwell and the SWP change room, a personnel monitoring station is located in the stairwell. At the west end of the gallery the SWP elevator provides entry from zones other than the SWP change room, and a stairwell serves as emergency exit. At the east end of the gallery the stairwell can be used as personnel entrance to the railroad tunnel, or emergency exit from the sample gallery. The sample gallery is connected to the analytical laboratory by a stairway and dumbwaiter. The dumbwaiter is normally used by sampling teams for delivery of samples to the laboratory. The stairway is provided to allow flexibility in sample routing and for emergency use in the event of failure of the dumbwaiter. A second dumbwaiter is provided for removal of contaminated waste from the sample gallery.

Samplers are described in Section XI-B.

The space below the sample gallery is used as a Storage Gallery for dry chemicals and operating supplies. It is 19' 6" wide and 25' 2" high. Pulse generator alternator controls and the telephone exchange are located in this gallery. The PR room and Regulated Maintenance Shop are at the west end of the storage gallery level. Sumps are provided along the outside wall of the storage gallery for collection of water. Individual sumps are emptied by a portable pump which discharges to a collection header terminating in the AMU pipe chase. From this point an installed pump discharges to the chemical sewer. Entrance to the storage gallery is by way of the AMU elevator and stairway. Emergency exits are located at each end of the gallery.

2. Non-Canyon Section

Adjoining the north wall of the canyon section of the 202-A Building is the Service or Non-Canyon Area. It is about 60' wide and 750' long with varying roof levels. For reasons of economy, the walls are corregated asbestos cement siding and insulation board supported by

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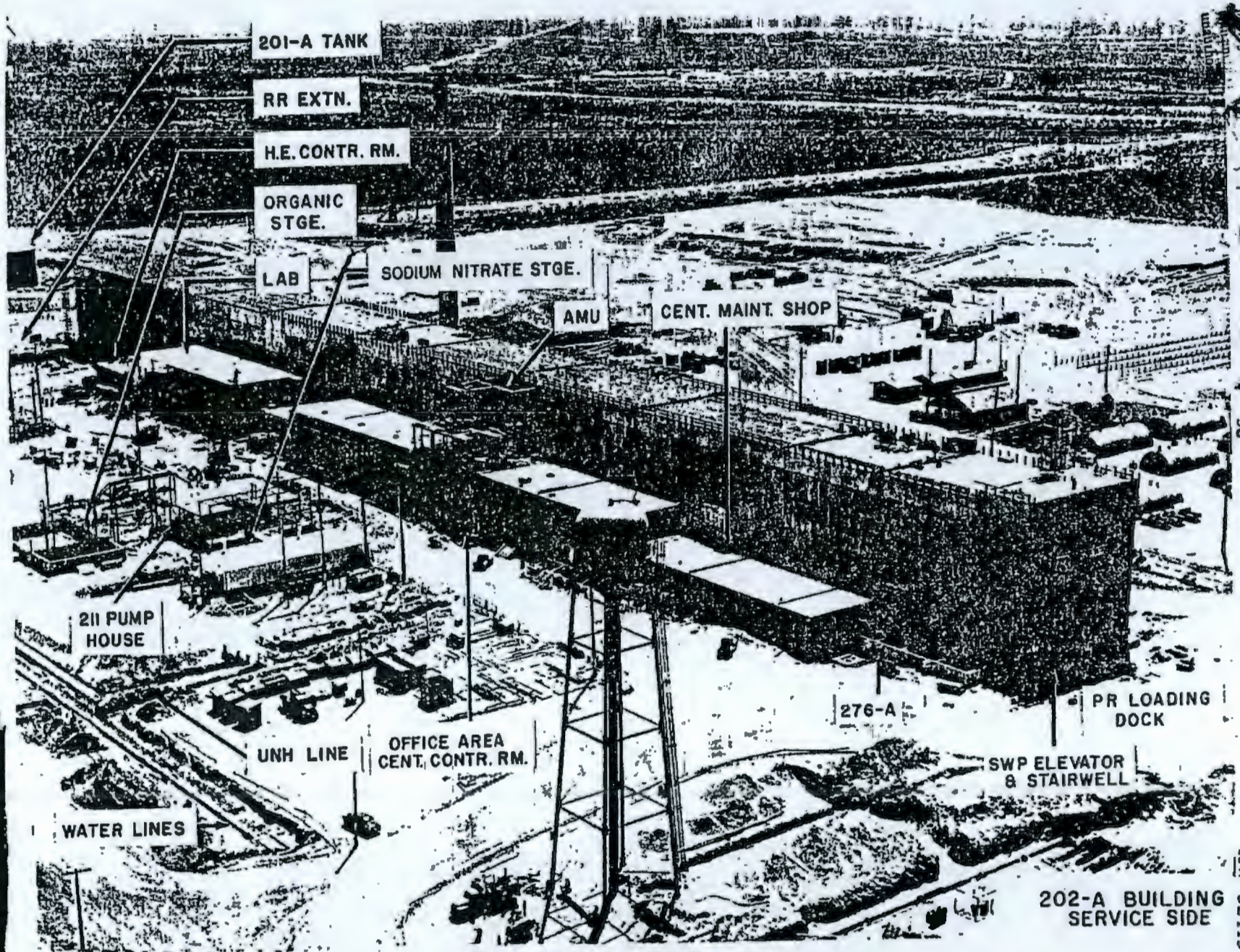

202-A BUILDING SERVICE SIDE

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structural steel. The roof is a poured gypsum slab covered with insulation and waterproofing. The exception to this construction is the aqueous makeup facility and the first floor of the laboratory which retain the reinforced concrete construction partition walls. The main floor level is common with the pipe gallery and accessible from numerous outside loading docks. Major components of the non-canyon section are the operating control rooms, acid and organic vaults, aqueous makeup, and industrial services and offices.

a. Control Rooms

Three control rooms containing diagrammatic picture graphic panel boards are provided for process and ventilation control. Centralization of controls for a continuous process in contrast to decentralized locations and control is of particular importance in prompt detection of instrument malfunctions and system upsets. This arrangement is of notable significance in a process which has a high through put and a small surge capacity between cycles. Pictorial graphic panels aid in quick appraisal of process difficulties since the various pieces of operating equipment with inter-connecting flow lines are portrayed in their relative positions. The control instrumentation is graphically represented at the points where the corresponding control of the process is actually affected. The background of graphic panels is gray-green. Identifying process and service lines contrast with the color of the panel board. A false ceiling with recessed, direct lighting is designed to eliminate reflection at eye level. Instrument repair is performed at the rear of the panels in an enclosed cubicle. The two process control rooms are rectangular in shape with the primary panel boards installed along three walls in a modified "U" arrangement. Miniature instruments are used to conserve panel space and to portray a realistic proportion to the graphic picture. For example, a standard recorder instrument is 6" x 6" as compared to the former 12" x 14" size. Thirty-day strip charts are provided instead of 24-hour circular charts.

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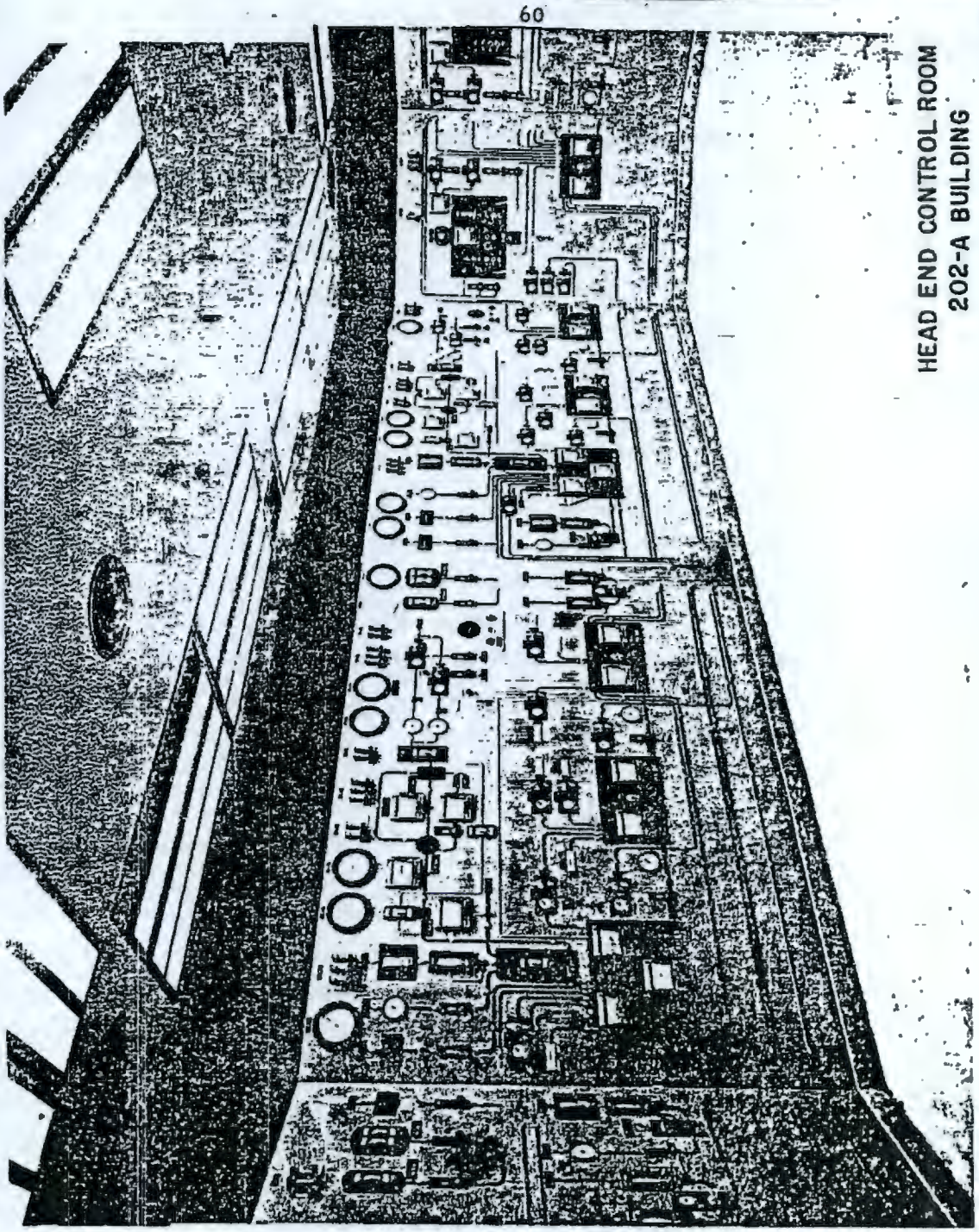

HEAD END CONTROL ROOM
202-A BUILDING

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The Head End Control Room, containing the graphic panels for the batch section of the process, is located centrally with respect to the batch type cell equipment.

The Central Control Room, containing the graphic panels for the continuous portion of the process, is located as centrally as possible with respect to the related canyon equipment.

A Power Unit Control Room is located in the Process Blower Room. The straight line graphic panels contain controls for the building ventilation systems, laboratory ventilation systems, compressor equipment, and instruments for utility metering.

b. Aqueous Make-Up Area

Four levels comprise the AMU area. Pumps are located in the basement. The first floor is utilized for dry chemical storage and all solids dissolution. Solids make-up tanks are recessed in the floor for convenience in solids addition. Chemical and service piping and headers are in the second level. The third floor contains head tanks and vessels for liquid make-up. The second cycle recovered organic head tank is located on the fourth floor in a regulated work area.

This arrangement of cold process feed tanks, with the attendant diaphragm valves and flow control instrumentation operated from the Control Room, eliminates the installation and operation of feed tanks in the pipe and operating gallery.

c. Maintenance Area

A Centralized Industrial Shop, located at pipe and operating gallery level at the west end of the service area, is equipped to handle all normal building maintenance. A central tool crib minimizes tool

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and equipment inventory. A clerical office is provided for control of maintenance materials and shop facilities. All compressed gases are grouped on the loading dock with a manifold piping system to the shop proper, the regulated and hot maintenance shops, and the crane maintenance platform. An overhead monorail system services the loading docks and the valve, electrical, and instrument test benches.

d. Laboratory Section

The analytical laboratory is located on the service side of the building adjacent to E and F cells. It is a two story structure, approximately 145' long and 55' wide. The structure is an integral part of 202-A Building in order to provide convenient access to both the sample gallery and aqueous make-up. Further economic saving is realized by utilizing many of the mechanical and electrical services of the main building. This laboratory is for analytical control only, and does not have facilities for research and development. Because of the hazards involved in handling radioactive material in open hoods, and because of the desirability of continuous laboratory operation through periods of shutdown in the main building, the laboratory ventilation system is complete and separate from that of the 202-A Building. The first floor of the laboratory contains the various shops, change rooms, lunch room, and analytical equipment. The upper floor houses heating and ventilating equipment. The room requirements of the laboratory are tabulated below:

Number	Type Room	Approximate Size
2	Hot Laboratories	20 x 24
1	Hot Laboratory	24 x 28
1	Cold Laboratory	15 x 28
1	Decontamination Room	17 x 28
1	Counting Room	10 x 12
1	Instrument Repair Shop	10 x 17
1	Glass Shop	10 x 12

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Number	Type Room	Approximate Size
1	Sample Storage Room	12 x 20
1	Sample Receiving Room	14 x 17
1	Hot Waste Storage	5 x 8
5	Offices	10 x 12
1	X-Ray Photometer Room	7 1/2 x 10
1	Fluorimeter Room	10 x 12
1	Infra Red Room	10 x 10
1	Storage Room	10 x 12
1	Personnel Decontamination Room	7 x 9

e. Elevators

The 202-A Building is serviced by three elevators for passenger or freight service and one dumbwaiter for sample movement. The function of these elevators is as follows:

(1) Elevator No. 1 - West End Passenger and Freight Elevator (SWP)

This elevator, located at the west end of the canyon building is provided mainly to facilitate movement of personnel and equipment (PR cans). It serves four floor levels from the regulated shop to the crane maintenance platform. An outside access door is provided at dock level. This elevator is rated at 2500 pounds capacity and is a "high speed" type (200 fpm). The outside opening is interlocked with controls located at the dispatcher's office.

(2) Elevator No. 2 - Aqueous Make-Up Passenger and Freight Elevator

This elevator facilitates the movement of personnel and chemicals through five floor levels extending from the building basement to the third floor aqueous make-up. It is located on the south side of the service side of the 202-A Building at approximately the midpoint of the building. The elevator has a capacity of 10,000 pounds.

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(3) Elevator No. 3 - Waste Handling Freight Elevator

This is a "dumbwaiter" type elevator which is referred to as an elevator because of code classification. The elevator is provided for removal of contaminated waste and laundry from the sample gallery to the loading dock at the north side of the 202-A Building. It is located approximately 200' east of Elevator No. 2. It is approximately 4' 6" x 4' 4" in floor area and is rated at 1000 pounds capacity.

(4) Sample Handling Dumbwaiter

This dumbwaiter is provided for transfer of samples from the sample gallery to the laboratory sample receiving room. It is an electrically operated hoist 3' x 3' in floor area, rated at 500 pounds capacity. It is located on the north side of the 202-A Building approximately 50' east of Elevator No. 3.

f. Acid and Organic Vaults

The function of the Recovered Acid and Laboratory Waste Storage Vault is to provide storage for recovered nitric acid and laboratory wastes prior to reuse and disposal. This facility is located at the east end of the service area, and the equipment is operated from the Head End Control Room. Entrance to the vault is by means of a stairwell from the sample gallery.

The function of the Solvent Recovery and Storage Vault (276-A) is to provide decontamination and storage of recovered second cycle solvent. Located at the west end of the service area, this facility is operated from the Central Control room. Access is provided to the vault floor from the regulated shop air lock, and to the centrifuge platform via the sample gallery.

Because of similarity in structure and equipment, the following description applies to each of the two vaults:

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(1) Structure is reinforced concrete. Base of the vault is at the same elevation as 202-A structural mat because of process hydraulics and equipment requirements. Curb and door sills are provided to confine leakage within specific areas. Removable concrete cover blocks at grade level are designed to provide radiation shielding and to facilitate replacement of equipment by motor crane. Emergency exit is provided via caged ladder and escape hatch in the vault roof.

(2) Equipment in general is designed with the same physical dimensions as its canyon counterpart, but fabricated to commercial tolerances with conventional flanges and supporting structures. In addition to the canyon deep well pumps, provided in the organic vault, horizontal centrifugal pumps are installed to transfer recovered organic to the head tank. Since the organic storage tank design is unlike other vessels, a standard type industrial pump was selected rather than a special deep well pump. The centrifuges are identical to the G-Cell units. All equipment maintenance is to be performed by contact methods under regulated work procedures.

(3) Piping from the canyon hot pipe trench is routed to the vault via a pipe chase. Piping returning to the cells is routed through the sample gallery hot pipe trench. Samples are taken from the sample gallery utilizing a Type C sampler.

(4) Vessel ventilation is provided by a blower which discharges to the air tunnel.

As mentioned in Section II, final nitric acid recovery is accomplished by an outside vacuum fractionation facility. Since this approach was pursued in the final stages of Purex design, when the corrosion experience of U Plant fractionation equipment became known, the Purex vacuum fractionation building will be installed on an individual project, not as part of CA-513.

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B. 291-A Building

1. General

The 291-A facilities for handling process exhaust ventilation air and off-gases consist of underground ductwork and piping, a fibrous glass filter, exhaust fans, and stack.

2. Fibrous Glass Filter

Provision of a Purex main ventilation air filter was deferred after it was established late in 1952 that the average radioactivity content of the Redox ventilation air stream entering the sand filter was one-tenth, or less, than that leaving the B and T plant sand filters.

During 1952, however, the particulate activity of the Redox exhaust ventilation air entering the sand filter increased substantially, resulting in the decision to install a Purex ventilation air filter. A comparative study of fibrous glass filter versus sand[8] revealed that the collection efficiency of the fibrous glass filter is superior to sand filter (99.9% compared to 99.5%), and that the total project cost could be reduced by approximately $500,000 by substitution of fibrous glass. Possessing overall dimensions of 83' x 53' x 15', the filter is divided into two main areas. The major section, or pre-filter, is bulk loaded with fiber glass Owens-Corning Type 115K, contained by upper and lower stainless steel screens. Air flows downward at 50 fpm through the 7' layer of fiber glass which removes most of the condensate and particulate matter. The smaller section, or cleanup filter, contains 132 American Air Filter Deep Bed Filter Units. These packaged filters, hung in racks, consist of "V" shaped screens covered with a 1 inch layer of types B and AA fiber glass. Air flows upward at 20 fpm through these units for final cleanup. The fiber glass filter is designed for an initial pressure drop of four inches of water and a maximum pressure drop of nine inches of water.

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The canyon vacuum cleaner discharges to the fibre glass filter supply duct. A system of removable concrete plugs provide for filter by-pass and future installations.

3. Exhaust Fans

Four stainless steel process exhaust fans are provided with suction from the fan inlet plenum and discharge in parallel to the main duct to the stack. Three fans are driven by electric motors through belt drives and have a capacity of 42,000 cfm each at 15 inches water static pressure. The fourth fan is sized for 63,000 cfm at nine inches water static pressure. Power to this standby unit is provided by a direct-driven steam turbine.

The fans are not designed for remote removal or maintenance. A recorder is provided for bearing temperature and high temperature alarm. Plexiglass inspection ports are provided at the individual fan on-off dampers and the main modulating control damper.

4. Stack

The 291-A stack is a 200' concrete structure containing a free standing stainless steel liner sized for an air velocity of 3500 fpm. Dissolver off-gas lines enter near the base of the stack liner. Three spare entry stubs extend from the liner for future installation.

In July of 1954, when spread of contamination from the Redox stack to the 200 East and West Areas reached serious proportions, design changes were initated and work started to provide means and tools for control of this problem at the Purex Stack. Facilities to be provided are as follows:

a. Installation of a duct stub connection for the future addition of a second stack.

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b. Revision of the stack washdown facilities to provide better distribution of the water than originally designed.

c. Revision of the stack sampling facilities by provision of an improved isokinetic stack gas sampler in lieu of the previous design.

d. Provision of a cable and pulley system within the stack liner for possible future use with a portable high velocity, rotating spray head for stack wash down.

e. Provision of a cable and pulley in the stack annulus to permit survey of the full length of the stack liner with a portable radiation instrument.

f. Revision of Stack Gas Sample House piping to change the sampler system for the top of the stack from 5 to 50 cfm. The sampler at the top of the stack will be made the continuous sampler instead of the 50' level sampler. The stack spray pump piping will be revised as required by the new spray system.

Two items which were also recommended will require issuance of a Revision Request by the Design Section. These are:

a. Installation of the ammonia gas scrubbers in the dissolver cells as part of the project instead of waiting until the plant is operating to determine the need.[9]

b. Provision of an alternate routing to a new crib (or at least for connection to a new crib in the future) for disposal of stack drainage and stack wash water.

5. Condensate System

Liquid wastes in the 291 area drain by gravity to a collection tank and are jetted to the 216-A-4 crib. The stack liner drains to a calcium carbonate neutralization tank which overflows to the collection

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tank. Sources of drainage are the fiber glass filter, fan plenum, and floor drains in the 291 buildings.

The collection tank sampler and jets are located below grade in a small concrete vault.

6. Auxiliary Buildings

Four buildings are provided for air sampling and control of exhaust fans as follows:

a. Two small buildings are provided at the fiber glass filter to house equipment utilized for ventilation air sampling, differential pressure, and dew point determinations. In order to eliminate long runs of piping, which tend to negate sampling data, the buildings are located adjacent to the filter inlet and outlet ducts.
b. A stack gas sampling house affords means for monitoring emission of radioactive materials from the stack. Facilities are provided for stack sampling at 50' and 200' levels, stack flushing, air flow measurement, and continuous iodine monitoring and recording.
c. A fan control house contains the emergency steam turbine, motor switchgear, and related instrumentation.

C. 241-A Area

Purex wastes are disposed of in one of three ways: to permanent underground storage tanks, to subsoil via cribs, and to ground via a surface swamp. The activity of the waste stream determines the method of disposal. Highly radioactive waste streams from the 202-A Building waste neutralizer and coating waste tanks require permanent storage and are routed to the underground storage tanks in the 241-A tank farm. Effluents of relatively low actual or potential radioactive content are routed to underground cribs for disposal in the subsoil.

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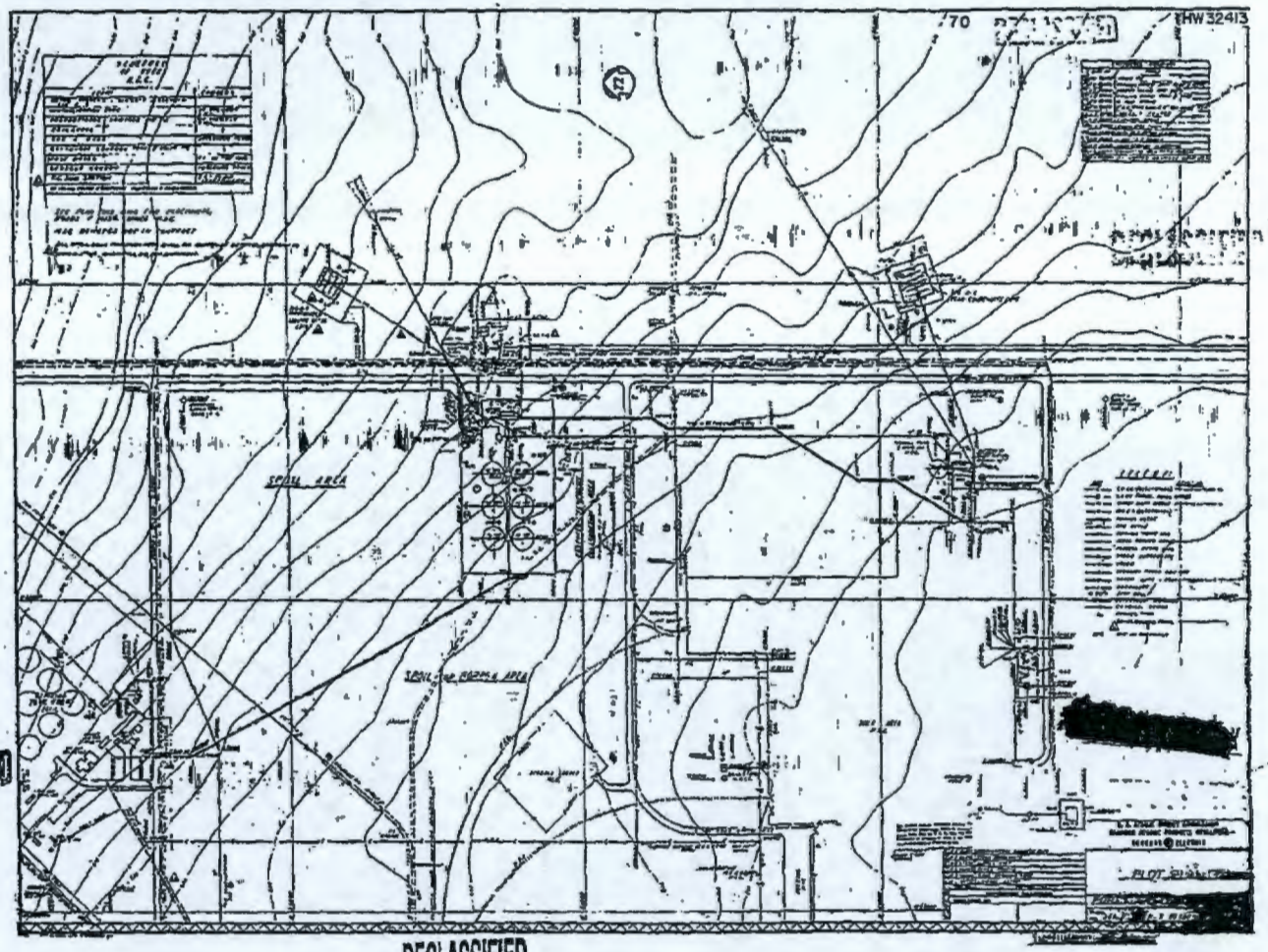

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Other large volume waste streams containing little or no actual or potential activity are sent to surface swamps for ultimate disposal to the ground. At design operating rates, waste volumes from the process building are as follows: 5990 gallons per day to underground storage tanks, 2,434,100 gallons per day to cribs, and 7,200,000 gallons per day to the swamp.

Process flow, system and equipment details on the three types of waste disposal are presented below.

1. Underground Storage System

Due to acid recovery within the 202-A Building, the volume of highly radioactive waste resulting from the Purex process is small compared to that of existing plants, the design basis being 685 gallons of waste per ton of uranium processed. Because of the increased fission product concentration of the waste, the heat generated per unit volume of waste is appreciably greater than that previously encountered in Separations plants. The Purex tank farm has therefore been designed to control the heat generated, allow the tank contents to boil, condense the resultant vapors, and achieve as much self-concentration of the wastes as may be possible. Features which are incorporated into 241-A tank farm to accomplish these requirements are: (a) a vapor header system with a deentrainment vessel leading to direct buried, contact condensers using water as the condensing medium, (b) means of introducing metered raw water into the waste storage tanks to control the rate and degree of self-concentration, and (c) a ventilation system to vent the condensers and maintain a negative pressure on the tanks and vapor system.

The tank farm design is based on the following information relative to heat generation. During normal tank farm operation, heat generation is expected to be 15×10^6 Btu per hour per filled tank.

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Sufficient heat is available to evaporate five or six times the quantity of water present in the waste. Provision for adding water to the tanks to keep the waste from evaporating to dryness is therefore necessary. Frequent but irregular emissions of heat as great as 75×10^6 Btu per hour may occur based on as yet unexplained eruption phenomena occurring in the Redox waste tank farm. It is predicted that the tank farm will be operated to self-concentrate the wastes by a factor of three. Boiling of the tank contents is expected to occur about two weeks after the start of tank filling. Normal evaporation rate from a boiling tank is about 15 gallons per minute.

The underground waste storage system consists of diversion boxes, waste lines, tie lines, underground storage tanks, vapor lines, vapor condensing facilities, and related service utilities.

Waste flow is from the neutralizer and coating waste in the 202-A Building through a diversion box (241-A-151) at the rear of the 202-A Building, an encased line to the tank farm diversion box (241-A-152), and to one of six underground, waste storage tanks. Vapors from the boiling wastes in the tanks are routed through a vapor header and deentrainment vessel to a direct buried, contact condenser. Condensed vapors and condenser cooling water are jointly disposed to an underground crib (216-A-8).

The waste distribution and diversion system consists of two diversion boxes, a pipe encasement from the 202-A Building pipe trench to the 241-A-151 box, a five line pipe encasement between the 241-A-151 and 241-A-152 diversion boxes, and fill lines to tanks and cribs. Two direct buried, stainless steel lines connect the 241-A-152 box to the 241-CR facility and the existing inter area underground piping system. All encased piping is 3 1/2" o.d., 0.120" wall stainless steel tubing. The diversion boxes are of two designs: the A-151 box uses

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wall-to-floor jumpers similar to those utilized in the TBP facility, and the A-152 box uses standard wall to wall jumpers similar to those utilized in the original diversion boxes. Both diversion boxes are equipped with modified Redox connectors. The A-151 diversion box drains to a catch tank for accumulation of process leaks and wash down material. The A-152 box has a sump in the pipe pit portion which syphons to a crib (216-A-7) in lieu of a catch tank. The sump is equipped with liquid level instrumentation, a sample riser, an overflow and an automatic sewer type syphon. Spare stubbed lines are provided at both boxes for new routings and tank farm expansion.

The 241-A tank farm is located approximately 1500' northeast of the mid-point of the 202-A Building. Desirable downgrade space is available on the north side for expansion of the waste storage facilities. Included in the tank farm are: (a) six waste storage tanks connected through a vapor header and deentrainment vessel to two contact condensers, (b) a ventilation and pressure relief system terminating in a fan house and stack, (c) the 152-A diversion box and associated tank and crib fill lines, and (d) a control house and associated tank farm instrumentation.

The six waste storage tanks are each 75' diameter and 1,000,000 gallon capacity tanks. The total waste storage capacity will be used in approximately three and one half years with the Purex plant operating at design capacity and no self-concentration of the waste. With self-concentration by a factor of three, the tank storage capacity will be depleted in approximately eleven years. The tanks are individually filled, but located so that five of the tanks each overflow to a succeeding tank. The sixth tank (TK-106) has no overflow provision but may later be connected to a future tank farm. The Purex waste storage tanks differ from presently used 750,000 gallon tanks in the following features:

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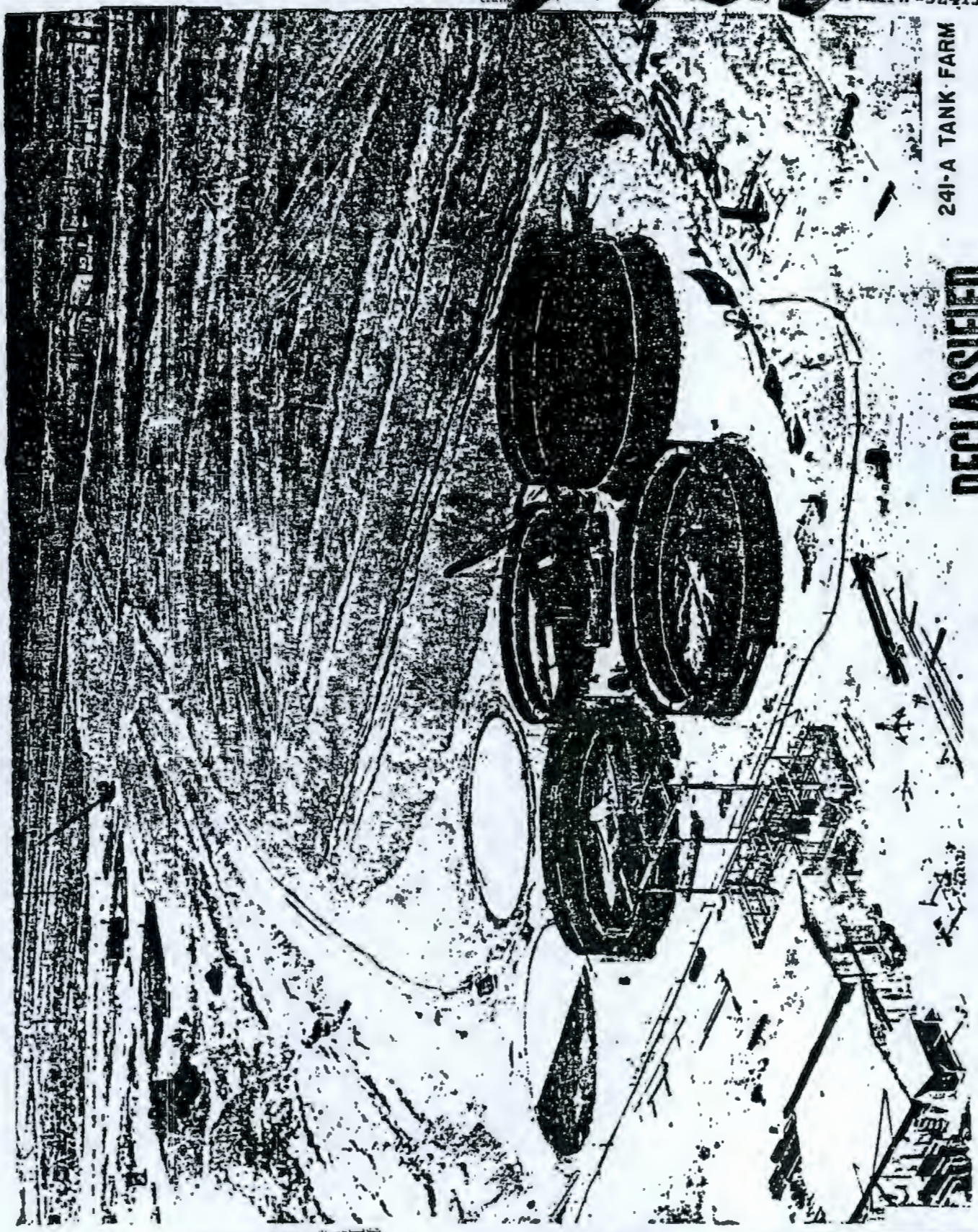

241-A TANK FARM

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a. The tanks are deeper to provide a capacity of 1,000,000 gallons.
b. The tank bottom is flat with a "T" joint between the wall and bottom instead of the four foot radius knuckle.
c. Radiographic inspection of welds is on a spot check basis only.
d. The waterproofing membrane is eliminated.

The tanks are each equipped with a pump pit to provide means for installation of a sludge pump in case it is necessary to transfer the tank contents. Tank pump pits are connected to the A-152 diversion box by a four-inch header.

Each waste tank is vented through a 20-inch vent line to a 24-inch vapor collection header which passes between the two rows of storage tanks to a buried deentrainment vessel and to the condensers. The entire vapor collection system is stainless steel as a precaution against corrosion failure. The vent lines are sealed with a six-inch water leg for system isolation. Tank overflows are also sealed by water filled traps. Raw water is supplied to all seal traps for filling. Traps are also equipped with liquid level instrumentation and remote drain valves. At times of eruption, tank pressure may increase to approximately 40-inches of water in the erupting tank. Since the tank seals are only six-inch water seals, these may be blown allowing vapors to enter inactive tanks forming condensate and a vacuum. Each tank is therefore equipped with a four-inch riser and valve for vacuum breaking purposes so that the water seals may be refilled. Pumps are provided, but not installed, for removing condensate from the tanks.

The deentrainment vessel is primarily a cyclone separator designed to remove entrained liquid carried by the vapor during violent boiling or eruptions. The deentrainer drains by gravity flow through a seal loop to waste storage tank TK-106. Condensate may be pumped out on a periodic or routine basis. A pressure relief system is installed

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to limit tank and vapor system pressures. The vapor header vents to the ventilation stack via a 24-inch emergency relief header which is connected to the vapor header between the waste and deetrainment tanks. A water seal is provided in the relief header. It will blow at 42-inches water pressure and admit air at six-inches water vacuum.

The limits adopted are based on the design pressure limits of the waste storage tanks which are as follows:

	Pressure	Vacuum
Full tanks	6.5 psig	-3.7 psig
Empty tanks	9.1 psig	-6 inches water

Contact condensers are installed instead of surface condensers on the basis of capital cost, economy of water use, ease of installation, operation and control, and flexibility with respect to capacity.[10] Two condensers are installed, each of which has sufficient capacity to carry the entire load. The installed spare principle was adopted because of the impossibility of shutting down the tank farm in case of maintenance requirements. The condensers may be isolated from the vapor header by filling a 48-inch water seal which is remotely drainable.

The condensers are baffled chambers wherein the vapors directly contact the cooling water and are condensed, as in a barometric type condenser. Vapors enter the bottom and contact water flowing from the top. The condensers are vented by exhaust fans connecting the top of the condensers through a packed deentrainment vessel and discharging to a local stack. Cooling water and condensate are discharged to a crib (216-A-8).

The source of condenser cooling water is a 16-inch gravity flow line which takes water from the 201-A head tank east of the 202-A Building. An alternate emergency water supply is provided by an

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eight inch, raw water, supply line from 241-C Area. Water flow to each condenser is controlled by two diaphragm operated valves on each inlet water line. One valve regulates normal water flow to the condenser and is controlled by the temperature of the condenser effluent water. Normal water rate is approximately 400 gallons per minute. At times of waste tank eruptions and consequent pressure rise in the erupting tank, a pressure sensing element will rapidly open the second diaphragm operated valve on the condenser water inlet line. This will allow a total of approximately 3000 gallons per minute of water to enter the condenser to condense the increased volume of vapor emitted during the surge.

A control building located on the north edge of the tank farm, houses instrumentation, ventilation fans, and an instrument air compressor.

The ventilation building, located in the south east corner of the tank farm, houses two exhaust fans, a vapor deentrainment vessel and a stack. One fan is an installed spare. The fans are designed to provide a slight vacuum in the waste tanks and develop a maximum shut-off vacuum of six-inches of water. The vent deentrainment vessel is a 6' 6" O.D. x 8' 9" tank packed with ceramic Raschig rings and located within a shielded portion of the fan house. It is normally operated dry; however, spray rings are provided to wash out the vessel.

2. Crib Disposal

Seven cribs are utilized in the Purex Waste Disposal system for subsoil disposal of effluent streams which may be contaminated. The cribs are of a rock design and are filled to a minimum depth of seven feet with coarse (3" or larger) aggregate below the distribution header. Distribution in the cribs is made by tile distributors sized

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to handle the required flow and to distribute it evenly over the total area of the crib. Following is a list of Purex cribs, their approximate size and location:

Crib	Service	Approximate Size	Approximate Location
216-A-1	(Abandoned)		
216-A-2	Organic Crib	20' x 20'	200' south of 202-A
216-A-3*	203-A Drainage	20' x 20'	200' north of 203-A
216-A-4	Lab Waste and Cell Drain	20' x 20'	100' south of 291-A
216-A-5	Process Condensate	35' x 35'	South of west end of 202-A
216-A-6	Steam Condensate	100' x 100'	1000' east of 202-A
216-A-7	152-A Diversion Box Drain	10' x 10'	200' east of 152-A
216-A-8	Waste Tank Condenser Disposal	80' x 80'	700' northeast of 241-A

* As part of the vacuum nitric acid fractionator installation, this crib will be increased to 30' x 200' to receive barometric condenser condensate and cooling water from the acid fractionator.

a. Waste Tank Condensate (216-A-1 Crib)

When the design of the waste tank condensers was changed from the shell and tube type to the contact type, construction of the A-1 crib was abandoned since it is inadequate for disposal of the increased flow rate.

b. Organic Waste Disposal (216-A-2 Crib)

Facilities are provided for intermittent disposal of organic streams from the 202-A Building. Organic streams requiring disposal originate from routine solvent treatment operation and from the waste disposal cell as a result of system irregularities. Disposal to the 216-A-2 crib is made by infrequent batch transfer through the 241-A-151 diversion box. The crib was sized for a 75 gallon per minute flow.

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c. 203-A Drainage Crib (216-A-3)

Uranium bearing wash and rain water from the 203-A tank farm and loadout area are routed to the 216-A-3 crib for disposal. Flow to this crib is small and intermittent. The crib is about as small as was practical to construct.

As part of the vacuum acid fractionator addition to the Purex facility, this crib will be enlarged to 30' x 200' to continuously receive overhead condensate and cooling water from the fractionator barometric condenser. A proportional sampler will also be installed on this stream to meter and sample the flow from the fractionator condenser. Fractionator wastes will be neutralized with sodium carbonate prior to disposal. Crib size is based on a minimum flow rate of 400 gallons per minute.

d. Laboratory and Cell Drainage Disposal (216-A-4 Crib)

Waste solutions routed to this crib originate from the decontamination and hot shop cells, from the laboratory waste receiver tanks, and from the cell drainage collection tank. Disposal of all of these streams is controlled by batch sampling and neutralization. Crib design is based on an intermittent flow rate of 75 gallons per minute.

e. Process Condensate Disposal (216-A-5 Crib)

Process condensate from the canyon concentrator units is collected in a six-inch condensate header located in the hot pipe trench and routed out of the building through a calcium carbonate neutralizer to a proportional sampler prior to its disposal in the 216-A-5 crib.

The calcium carbonate neutralizer is similar to those employed in the TBP condensate disposal system, and utilizes the percolation system for continuous neutralization of low acidity streams. A small calcium carbonate warehouse is provided at the site for storage purposes.

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The proportional sampler is located in a pit downstream from the neutralizer and contains a new type multiple weir sampler for measuring flow as well as continuously diverting a portion of the material to a sampler tank. Samples will be taken periodically from the sampler tank for routine analytical determination. The 216-A-5 crib is designed to receive a continuous flow of 140 gallons per minute.

f. Steam Condensate Disposal (216-A-6 Crib)

A steam condensate disposal system is provided to handle 1150 gallons per minute on a sustained basis. This system wil handle all steam condensate from the 202-A Building. In addition, cooling water from the 2EU concentrator condenser will normally enter the steam condensate header to provide cooling below the flashing temperature. Water from the raw water header can also be added if necessary. Overflow from the slug storage basin and railroad tunnel drains enter this header east of the scintillation counter. Activity levels of this stream will be continuously recorded and samples for periodic analytical determination will be taken.

Steam condensate from process vessels discharges through lines from the cells through the south wall of the 202-A Building. With few exceptions, the condensate discharge lines pass through one of five trap pits located outside and adjacent to the south wall of the canyon building. When elevation permits, the condensate passes directly from the traps located in "jumpers" in the trap pit to the 16-inch condensate header. Condensate discharge from major process concentrators leaves the cell at such a low elevation that heating efficiency will be seriously impaired when operating under low steam pressure unless special means of condensate disposal are used. In these cases the condensate discharges to the trap pit where it is discharged by gravity to a condensate pump pit. From the pump pit the condensate is pumped

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to the disposal header. Two pump pits are provided for this concentrator condensate system. All equipment in the trap and condensate pump pits is designed for remote removability and semi-remote installation.

The condensate header is a 16-inch carbon steel line paralleling the south side of the 202-A Building. The line slopes from the west to the 216-A-6 crib located approximately 1000' east of the canyon. A scintillation counter probe is located in the condensate stream near the east end of the canyon building and a proportional sampler is located in the line near the crib. A continuous gamma recorder and alarm in the control room is actuated by the scintillation probe when abnormal activity is encountered. The source of the unusual activity can be discovered by means of probe risers located on each individual vessel discharge line.

g. Diversion Box 152-A Drain (216-A-7 Crib)

Due to an adjustment of tolerances for cribbable materials by Radiological Sciences, a crib was installed rather than a catch tank. The initial cost of a crib is less, and the problem of disposal of the catch tank waste collection is eliminated. Liquid level instrumentation, a sample riser, and a conductivity alarm to the 202-A Building control room is provided at the crib.

h. Waste Tank Condenser Disposal (216-A-8 Crib)

Condenser cooling water and condensate from the boiling waste tanks are routed through a sixteen inch line to the 216-A-8 crib. Flows vary from a nominal of 400 to a maximum of 3000 gallons per minute. A proportional sampler and metering facilities are located in the line upstream from the crib so that required records on the material being cribbed can be maintained.

3. Surface or Swamp Disposal

The process vessel cooling water and the chemical sewer wastes are disposed of to an open ditch or swamp. Surface disposal is utilized for

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this disposal due to volume consideration and the fact that radioactive contamination will be sufficiently below tolerance to permit this type of disposal.

a. Cooling Water Disposal

The raw water employed in process equipment for cooling and general utility purposes discharges through branch lines which pass through the south wall of the canyon building and enter a 30-inch buried collection header running parallel to the building. The header slopes from the west end of 202-A to the cooling water pump pit located east of the 202-A Building. In this pit a portion of the total flow is pumped into the 201-A water storage tank which is used to supply the cooling water to the 241-A contact condensers. The balance of the flow continues through a 30-inch vitrified clay line to the swamp. Normal swamp discharge is about twenty-five acre feet per day.

The cooling water pump pit is a vault structure approximately thirty feet deep, containing a baffle chamber and a weir for flow rate determination. The pit is equipped with two pumps each rated at 1200 gallons per minute which can be operated individually or in parallel. The pumps discharge to a steel tank of 750,000 gallon capacity located adjacent to the pump pit at grade level. The pump pit also contains a continuous proportional sample unit for metering flow and from which samples are taken for periodic analytical determination.

Instrument risers are located on the cooling water line a short distance upstream from the pump pit. Temperature elements and a scintillation counter probe are located in these risers. When activity levels determined by the probe exceed a predetermined safe level, an alarm is sounded in the 202-A central control room, and power to the cooling water pumps is automatically disconnected. The source of high activity can be isolated by use of the probe risers located on each vessel discharge line prior to entry into the header.

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The 201-A tank serves as a head tank and as emergency storage in case of interruptions to the raw water supply to the tank farm condensers. This tank is a carbon steel vessel 60' in diameter with a working depth of 36'. Steam injection heating is provided to prevent freezing, and instrument control is utilized to actuate or deenergize the feed pumps at predetermined low or high liquid levels. A supplementary eight-inch raw water line is provided to the 201-A tank for filling the system when high activity levels prevail in the canyon coolant system. The 201-A tank is sized for an emergency supply equivalent to 30 hours normal demand for the tank farm condensers in case of a failure to the plant raw water system.

b. Chemical Sewer Disposal

The chemical sewer system is comprised of floor drainage from non-radioactive areas in the service side of the building, chemical make-up tank overflows, and 211-A tank farm drainage. This material is collected in a header at the north side of the building and disposed of to the main 202-A swamp.

All floor drain and chemical overflow drain lines in the 202-A service side are stainless steel or duriron. The header system is twelve-inch vitrified clay pipe.

Organic liquid drains in the 211-A Area are routed to a large french drain in this area for disposal.

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IV. MAJOR CANYON AND CELL EQUIPMENT

A. Vessels

Design criteria for vessel fabrication were based on process requirements, service conditions, replaceability, safety, and overall economy.[11] Specifications were formulated for vessel fabrication by defining three groups as follows:

Class I vessels are those specifically designed for process service in a remotely maintained area.[12] This group is further divided into the so-called "critical" and "non-critical" categories. "Critical" units include the concentrators, fractionator, and dissolver system; construction is of type 304-L stainless steel welded with 347 rod using the Heliarc method. Weld craters are removed by hot chipping or grinding to base metal. "Non-critical" units include all other canyon pieces and are fabricated of 304-L welded with type 308-L rod.

Class II vessels are fabricated of type 304-L and are designed for service where contact maintenance can be utilized.

Class III vessels are fabricated of materials other than stainless steel and are used for process service functions.

1. Standard Vessels

The standard vessel used in the canyon is a 10' x 9' 3", 5000 gallon unit equipped with 2" coils 520 feet in length. Two flanges are provided for pump or agitator supports. Twenty-five such units are provided for pump tanks, receiver tanks, etc.

2. Dissolvers (A3, B3, C3)

Dissolver design is similar to existing units except that the reflux tower is separate from the dissolver pot and is designed for downdraft flow in order to improve acid recovery. The dissolver is 8' x 12' 4", equipped with 813 linear feet of 2" coils. The coils are completely

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submerged during normal dissolving cycles. A basket crib assembly fabricated of stainless steel bars protects the coils against damage from uranium slugs during charging. The slug crib also serves to support the charged material above the tank bottom permitting maximum contact of process fluids with charged material. Separation of the dissolver tower from the pot resulted in location of the charging port near the center of the dissolver.

Because of hydraulic considerations, transfer of dissolver solution by means of a conventional top entry jet promises to be erratic and uncertain. Therefore, a permanent dip leg (and spare) with nozzle located 8' 4" from the tank bottom is installed for metal solution transfer.

3. Dissolver Reflux Condenser A3-1, B3-1, C3-1

Dissolver off-gases pass through a 16" line from the dissolver to the top of the dissolver tower. This unit is a vertical tube heat exchanger approximately four feet in diameter and 18 feet long, containing 511 tubes. The exchanger tubes are fin type, 1" outside diameter, through which is inserted a three-quarter inch plug restricting the flow of water through a 0.042" annulus at high velocity.

Demineralized water may be added as reflux through a distributor at the top of the tower. The dissolver tower is supported on dunnage above the dissolver tank.

4. Deentrainment Tower (Knockout Pot) A3-2, B3-2, C3-2

The deentrainment tower is connected to the reflux condenser by a 10" gas line which joins the bottoms of the two towers, and by the two condensate lines which join prior to returning to the dissolver. Neither of these lines are remotely removable, thus, the reflux condenser and the deentrainment tower are handled as a unit (total weight about 22 tons).

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The deentrainment tower is 4' x 4' 6" and is packed with one inch stainless steel Raschig rings. The tower traps entrained liquid from the gas flow prior to entry into the silver reactor system. Condensate is returned to the dissolver from the deentrainment tower and the reflux condenser.

5. Silver Reactor and Heater (A2, B2, C2)

Dissolver off-gases pass from the top of the deentrainment tower to the top of a horizontal heat exchanger located above the silver reactor. The heater increases the temperature of the gases from 110 F to 325-400 F prior to passing through the silver reactor.

The silver reactor heater is a tube and shell heat exchanger 2' 8" x 8', with 185 psig steam pressure supplied to the tube with process gases on the shell side. Steam discharge from the heater tubes passes through an external coil on the silver reactor tower (High pressure steam promises to give more reliable service than electrical units currently in use in other plants).

The silver reactor is a vertical tower, 4' 6" x 10' 6", packed with 1/2" ceramic intalox saddles impregnated with silver nitrate. The heater is remotely removable from the reactor to facilitate repair or replacement. Facilities are provided for regeneration of the saddles in place.

6. Vent Filter (A1, B1 C1)

The vent filter receives gases from the silver reactor for filtration prior to final disposal to the ventilation stack. The vent filter is a vertical vessel nine feet in diameter and six feet high; gases enter the bottom and discharge at the top. The filter is packed with fiber glass in the following manner:

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(Layers numbering from the bottom to the top).

Layer 1	Type 115K Fiberglas	1.5 lb/cu ft	12" thick
Layer 2	Type 115K Fiberglas	3.0 lb/cu ft	6" thick
Layer 3	Type 115K Fiberglas	6.0 lb/cu ft	12" thick
Layer 4	Type "AA" Fiberglas	1.2 lb/cu ft	1" thick

Dissolver system vacuum is supplied by two jets installed in parallel at the discharge side of the vent filter. While these jets are normally steam actuated, the smaller can be operated on either steam or air. The utilization of two vacuum jets for this service was adopted to conserve steam, since the small jet is normally adequate for the system, and to insure adequate system vacuum when dissolving is conducted by use of acid varying in strength from 45 to 60 per cent.

7. Vessel and Condenser Vent System

The vessel and condenser vent systems utilize a common silver reactor (F2), heater (E-F2), and filter (F1) similar to those of the dissolver system. In addition, a surface vent condenser (E-F1), 3' x 9', is provided for condensation of steam from the two different sized jets. The discharge from the vent jets passes successively through: the vent condenser, the reactor heater, the silver reactor, and the fiber glass filter and is finally discharged to the air tunnel.

8. Concentration Equipment

Two distinct concentration systems are provided in the Purex process, defined as process and plutonium concentration systems. Due to differences in the nuclear safety requirements, flow requirements, and volume reductions, these systems are described separately.

a. Waste and Uranium Concentration Equipment

Five process concentrators are installed in the Purex plant for waste and uranium concentration. Due to the nature of the process, volume reduction up to 27 to 1 is required at certain points in the system. Heat

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transfer up to 20,000,000 Btu/hr is required to maintain flow sheet conditions on some of these units, e.g., E-F6, #2 acid concentrator.

(1) Concentrators (F6, F11-1, H4-1, J8-1, K4-1)

The concentrators are vertical tube, thermal recirculation type, equipped with a seven tray bubble cap tower for stripping and a packed section for deentrainment. Due to the potential high rate of corrosion and the large heating surface required, the evaporator is equipped with two remotely replaceable heat exchanger tube bundles. The tube bundles are designed for 25,000,000 Btu/hr; steam traps are located in trap pits outside the building. Heating is accomplished with steam on the shell side of the tubes at 30 psig pressure in uranium service and 40 psig in waste service, in keeping with safety requirements recently adopted to prevent high temperature organic-nitric acid vapor explosion.[13] Improved seal pots are utilized on the system to provide a more positive seal of the pot vent to the air tunnel and to limit excessive pressure or vacuum.

The concentrator is approximately 28 feet high and requires a floor space of approximately 200 sq ft. The tower or upper section containing the bubble cap trays is 9 feet in diameter and 12 feet tall. The three ball heat exchange or lower section containing two remotely replaceable vertical tube bundles is 16 feet tall. This integral unit (less tube bundles) weighs approximately 42 tons. In order to withstand prolonged corrosive action the lower section is fabricated from 1/2" plate. The upper section and removable tube bundles are fabricated from 3/8" plate.

(2) Concentrator Condenser (F11-2, J8-2, K4-2)

The condensers are shell and tube surface condensers located in a horizontal position at the top of the concentrators. They are three feet in diameter and nine feet long and are designed to transfer 25,200,000 Btu/hr.

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The vessel vent condenser, E-F1, and the fractionator condenser, E-F5, are identical in design to the concentrator condensers. The #2 acid concentrator, F6, does not utilize a condenser as the overheads from that unit are routed in the vapor phase to the F5 acid fractionator as feed material.

b. Plutonium Concentration Equipment

The Purex plutonium concentration equipment is designed to meet nuclear safety requirements.[14] In keeping with these requirements unusual geometric patterns characterize the design of some equipment pieces. The plutonium concentration equipment is installed in L Cell as a "package", i.e., all the equipment pieces are supported by the same dunnage and are attached to each other by contact flanges. The unit can be removed by the remote crane and moved to the regulated shop for repairs.

Radiation levels should allow contact maintenance in the plutonium concentrator portion of L cell. A radiation shielding wall separates the 2B extraction tower from the remaining equipment in L cell. Flood lights are installed in the cell walls and an access door is provided for entry into the cell via an air lock from the PR room.

(1) Plutonium Stripper (L-3)

The plutonium stripper is provided to concentrate the plutonium product stream and strip entrained organic solvents prior to final concentration.

The stripper is a double loop structure resembling, in elevation, an elongated figure eight with the upper and lower loops separated by a stripper section. The lower loop of the structure contains a heat exchanger and serves as a thermal recirculation passage way through the heater. The heater is a vertical tube bundle exchanger heated with 30 psig steam in the shell. The stripper section is packed with stainless steel Raschig rings. The upper loop consists of two parallel deentrainment columns packed with Raschig rings.

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The stripper column is made of seven-inch tubing and is twenty-eight feet in height. The stripper section is packed for a height of eight feet and the deentrainment columns each contain four feet of packing.

(2) Plutonium Concentrators (L4, L7)

The plutonium concentrators are of the same geometric configuration as the stripper; however, the loops on the concentrators are larger and the center section is shorter.

The heater exchanger in the lower loop of the plutonium concentrator is identical to that of the stripper and the units are interchangeable. The concentrator has no packed stripping section, but has parallel packed deentrainment columns in the upper loop. The concentrator is fabricated from seven-inch tubing; the #1 concentrator (L4) is twenty-three feet high and the #2 concentrator (L7) is twenty feet high. The deentrainment columns are packed to a depth of seven feet with stainless steel Raschig rings.

(3) Plutonium Condensers (L5, L8)

The units are horizontal tube and shell surface condensers, approximately six inches in diameter and six feet long and are located on the top of the two concentrators.

Condenser L12 is identical to the two plutonium concentrator condensers and serves as a vacuum jet condenser for the L11 vacuum tank in the product cage. See Section X for description of PR room facilities.

9. Acid Recovery Equipment

The initial fractionator design in Purex was a canyon installed unit operating at atmospheric pressure very similar to the unit presently in operation at 224-U. With the very poor experience of this 224-U fractionator due to weld crater corrosion, crevice corrosion, and general corrosion of trays and risers, the design has been altered so that the initially designed,

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canyon installed Purex fractionator will operate as an absorber, utilizing no additional steam heat, and will produce a 30 per cent acid. This acid will then be pumped as feed acid to a vacuum fractionator unit located in an outside vault and designed for contact maintenance. The design of the vault fractionator for 100 mm vacuum will result in a decrease in temperature from 120 C to 80 C. A 10 C drop in temperature is estimated to decrease corrosion three-fold.[15]

a. Atmospheric Pressure Acid Fractionator (T-F5)

The T-F5 acid fractionator is an atmospheric pressure 15 tray bubble cap tower approximately 28 feet in height; the upper section is ten feet in diameter and the lower section three feet-six inches. The reboiler is an internal vertical tube bundle with a large center annulus to allow thermal recirculation.

Reflux is normally supplied by a fixed weir on the condenser, routing a portion of the condensate back to the fractionator. Chloride purge lines are provided to three trays in the tower covering the expected 10-20 per cent acid composition range.

b. Vacuum Fractionator (T-U6)

The T-U6 vacuum fractionator is a 12 tray bubble cap tower, eight feet in diameter and 28 feet tall. This fractionator is equipped with an external vertical tube reboiler section designed for thermal recirculation. Heat to the reboiler is supplied by 40 psig steam pressure supplied to the steam chest. The system is designed to operate at 100 mm of mercury absolute pressure at the top of the tower. This reduced pressure is supplied by vacuum steam jets discharging into a barometric condenser. Nitric acid from the T-F5 stripper (30 per cent strength) is introduced at the sixth plate. Purge facilities are provided for chloride removal from plates covering the 7 to 30 per cent composition range. Reflux to the tower is added from a demineralized water line at the top of the unit.

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10. Reflux Condenser (F9)

Process waste to be reworked is accumulated in tank F8 where the organic material is hydrolyzed prior to rework. The reflux condenser is provided on this rework tank to condense the vapors evolved during hydrolysis.

The reflux condenser is a standard horizontal tube and shell surface condenser. The condenser is 18 inches in diameter and 9 feet long and is designed for a heat transfer duty of 5,772,000 Btu/hr.

11. Process Vessel 2AF(TK-J5)

This small vessel, essentially an in-line oxidizer, affords means of continuous preferential chemical addition to the IBP stream. Chemical adjustment is performed in the first two compartments. The adjusted solution is pumped from the third compartment. The overall unit is sized such that 99.9 per cent of the IBP stream is statistically retained at least three minutes before feeding to the 2A column.

This horizontal tank is 30 inches in diameter and 6 feet, 7 inches long, and is divided into three separate compartments by baffle plates. It is equipped with a jacket for heating and cooling purposes. The unit is equipped with agitators in the first two compartments and a pump in the third.

12. Decanter Tank (F14 and G6)

The decanter is provided for separation of aqueous from the recovered organic stream in the event of 0 column and centrifuge irregularities. Under normal continuous operating conditions, the decanter will not be used. The decanter is 4' in diameter and 5' 10" tall. It is equipped with aqueous and organic diverter lines, and a 24" diameter plate distributor.

13. 1T0 Tank (Bath Tub) (G5 and G7)

The recovered organic receiver bath tub design is essentially the same as the TBP bath tub vessels. It affords maximum storage capacity in the alloted cell space. The bath tub is 10' 6" in diameter, 16' long, and 14' tall. It contains six rows of coils, and five agitator-pump mounting flanges.

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B. Columns

Adoption of pulsed, perforated plate columns for the Purex plant resulted in reduction of overall column heights by about one-half that estimated for simple packed columns.

Purex columns are of three general types; A, C, and O. The A type column is used to extract the desired product from the aqueous to the organic phase. The C type column is used to extract the product stream from the organic back to the aqueous phase. The O type column is used for scrub treatment of recovered organic.

The A columns have seven louver type distributor plates equally spaced throughout the extraction and scrub sections to prevent channeling. Pilot plant work demonstrated the ability of these plates to introduce a "swirl" to the passing fluid thereby preventing channeling and resulting in improved extraction efficiency. Ring distributors in the A column inlets are jet mixer distributors which accomplish positive mixing of the feed and scrub streams. The organic feed distributor in the uranium stripping column is a seven nozzle ring distributor.

The Purex partition cycle, like that in the Redox plant, uses a B type column to selectively strip the plutonium from the organic stream without removing the uranium. This column does not fall in the same general classification as the A, C, and O columns. The height requirement for a single compound B column in Purex service is so great that two simple columns are installed. In the Purex plant the B type scrub column (1BS) will operate in series with the extraction (1BS) column.

Experimental work has shown the greater efficiency of a continuous organic phase for C and O type columns (and for 2A column) provided that the pulse plates can be "wetted" with the continuous phase material. Perforated fluorothene plates (or packing) will accomplish the required preferential wetting.

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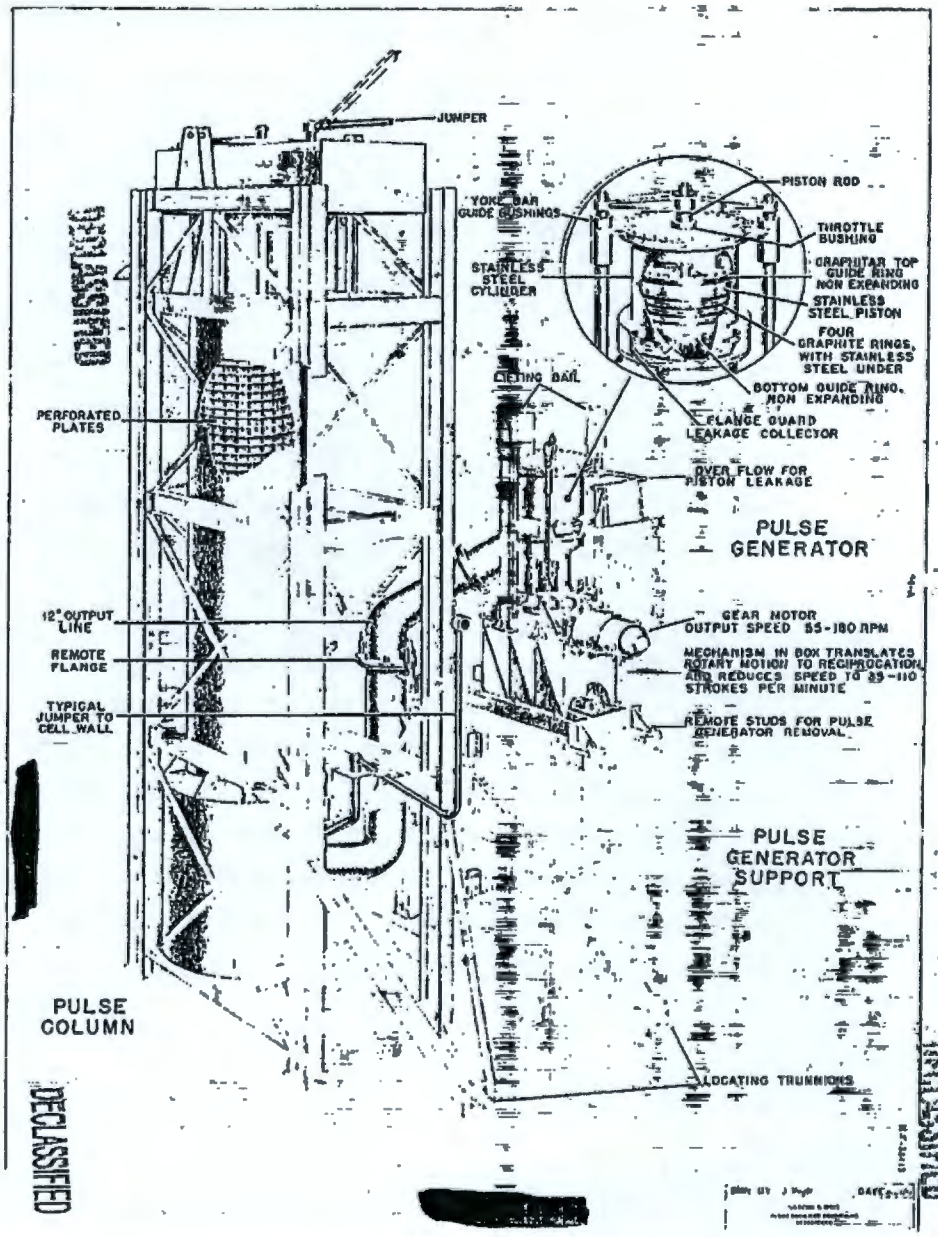
JUMPER
YOKE BAR GUIDE BUSHINGS
STAINLESS STEEL CYLINDER
PISTON ROD
THROTTLE BUSHING
GRAPHITAR TOP GUIDE RING NON EXPANDING
STAINLESS STEEL PISTON
FOUR GRAPHITE RINGS, WITH STAINLESS STEEL UNDER
BOTTOM GUIDE RING, NON EXPANDING
LIFTING BAIL
FLANGE GUARD LEAKAGE COLLECTOR
OVER FLOW FOR PISTON LEAKAGE
PERFORATED PLATES
PULSE GENERATOR
12" OUTPUT LINE
REMOTE FLANGE
TYPICAL JUMPER TO CELL WALL
GEAR MOTOR OUTPUT SPEED 55-180 RPM
MECHANISM IN BOX TRANSLATES ROTARY MOTION TO RECIPROCATION AND REDUCES SPEED TO 25-110 STROKES PER MINUTE
REMOTE STUDS FOR PULSE GENERATOR REMOVAL
PULSE GENERATOR SUPPORT
PULSE COLUMN
LOCATING TRUNNIONS
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Phase disengagement sections in all columns have been sized to hold up the effluent phase for at least 10 minutes (varies from 10 minutes in 2A to 28 minutes in 2B, at design rate).

Purex plant pulse column data is as follows:

Column	Over-all Height	Internal Diameter	Continuous Phase	Interface Location	Plate or Packing
HA, 1A, 2D	33'	24" (Ext.) 32" (Scrub)	Aqueous	Top	Stainless Steel Perforated Plates
HC, 1C, 2E	27'	34"	Organic	Bottom	Fluorothene Perforated Plates
1O, 2O	33'	34"	Organic	Bottom	Fluorothene Perforated Plates
1BX	33'	27"	Aqueous	Top	Stainless Steel Perforated Plates
1BS	19'	8"	Aqueous	Top	Stainless Steel Perforated Plates
2A	40'	7"	Organic	Bottom	Fluorothene Raschig Rings
2B	30'	7"	Aqueous	Top	Stainless Steel Perforated Plates

A removable steel shield 2 1/2" thick approximately 30" wide and 20' tall is provided to protect HC column fluorothene plates from radiation damage originating in the extraction section of the adjacent HA column.

C. Pulse Generators

Pulse generators provide a surge agitation to the process liquid by forcing it back and forth through the column plates (or packing) thereby providing maximum contact between the two distinct phases. The Purex pulse generators are basically the same as those in use at the TBP facility. The generator is a fixed amplitude, variable frequency, piston unit powered by an electric motor. The frequency variation is accomplished by varying the frequency of the alternating current supplied to drive the motor. The variable frequency current is provided by an alternator which is a function

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of the building electrical equipment. The current frequency variation is accomplished by changing the speed of the alternator (generator) by adjustment of a variable speed mechanical drive coupling between the generator and its drive motor.

Two sizes of pulse generator will be used in the Purex plant, the smaller being a scaled down replica of the larger.

Unit	Displacement	Outlet Size	Motor Size
#1	44 cu in	4" IPS	2 hp (300 per cent of theoretical requirement)
#2	485 cu in	12" IPS	15 hp (200 per cent of theoroetical requirement)

The actual amplitude of the pulse is governed by the column geometry as the piston displacement is fixed. Frequencies can be varied from 25 to 110 cycles per minute. Design displacement volumes allow for leakage past the piston and through an air weep hole; this leakage rate is measured. The piston is equipped with graphitar rings which are uniformly spring loaded.

D. Centrifuges

Centrifuges are used in the Purex system to separate solids from liquids in the feed preparation section of the plant, and for liquid-liquid-solid separation in the organic treatment section.

To obtain the required holdup time for the flow requirements through the minimum number of centrifuges, it was necessary to increase the standard 40" bowl to 48". A centrifugal force equivalent to 1500 times gravity was the maximum that the vendor would recommend for the structural safety of the enlarged forty-eight inch bowl. The problem of reducing the normal motor speeds of 1750 rpm to 1500 rpm was resolved by operation of the drive motors on 550 volt three phase 75 cycle current which is supplied by generator sets included in the building power supply. Under these conditions, normal

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operating speeds of 1500 and 750 rpm can be realized. These units are designed to operate for indefinite periods on standard 440 volt 60 cycle current at 1200/600 rpm speeds in case of failure to the special power supply. (Two 550 volt motor generator sets are provided; each will power three centrifuges. A third prototype generator of smaller size, used in vendor testing, is installed in the regulated shop area for use during maintenance of equipment).

The liquid-liquid-solid centrifuges function by selectively baffling the lighter organic phase from the aqueous at the upper edge of the bowl. Controlled air circulation within the case and the discharge lines prevent intermixing the two phases after leaving the bowl.

Braking is accomplished by direct current which stops the bowl in 90 seconds from a speed of 750 rpm, and precludes the possibility of reversing the direction of rotation. Skimmers and plows are installed; however, cake removal is normally accomplished by means of bowl sprays operating at 800 psi pressure at a 20 gpm flow rate. Continuous drip lubrication is installed to assure lubrication of the upper bearings at all speeds of centrifuge operation.

E. Pumps

The movement of process liquids is made by means of jets and pumps, taking full advantage of gravity flow when possible.

Of the 29 process pumps, 18 are considered remote maintenance items while the remaining 11 are contact maintained. The process pumps are vertical "deep well" units supplied by the Johnston Pump Company and are similar to the units currently in use at 221-U Building. Modifications have been made in an endeavor to decrease leakage at the seal bearing and to simplify maintenance of these units. All process pumps are equipped with pile graphite bearings. The slinger ring and throw out hole below the mounting flange have been enlarged; the discharge line passes through the adapter flange at a point several inches away from the pump seal bearing.

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Experience has shown that the motors normally last longer than the pumps and manufacturer's claims of hand packed motor bearings lasting 3 to 5 years have been verified by Hanford operating experience. Therefore, lubrication jumpers to the pumps have been eliminated and all motors are equipped with hand packed bearings. The pump bearings are process lubricated.

In an attempt to simplify maintenance and reduce exposure to personnel working on these pumps, two additional changes were made. The electrical receptacle is fastened to the motor frame instead of the mounting plate, as an aid in motor removal. The motors have hollow shafts; pump to motor couplings and adjustments are made at the top of the motor. These design changes allow for ease in motor replacement by semi-contact means and should substantially reduce the cost of process pump maintenance and replacements.

So that the number of different pumps could be minimized, the 18 remote pumps are subdivided into four groups. These four groups are based on shaft length, capacity, and head requirements. Each pump of these four basic types is interchangeable with others in the same group; flow rates are controlled instrumentally, sparing philosophy is based upon the criticality of the service and the expected radiation levels involved; sparing varies from 50 per cent to 200 per cent.

F. Agitators

For the sake of simplicity and ease of maintenance, all remotely maintained agitators are vertical, direct drive, comparatively high speed units; no foot or torque tube alignment bearings are employed, instead all guide and support is supplied by the two motor bearings. No lubrication jumpers are required since motor lubrication is provided by hand-packed bearings. Remote agitators operate at 600RPM. The agitator power supply is jumpered to a receptacle attached to the motor frame instead of the mounting flange.

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Standardization is again the keyword in the procurement of canyon agitators so that interchangeability of equipment can be facilitated. The 30 remote agitators are classified in three groups according to shaft length and degree of agitation required: 24 are of Type I, nine feet shaft length and 15 hp motors; four are of Type II, 13 feet shaft length and 15 hp motors; and two are of Type III, two feet shaft length and 1 hp motors. Standardization of agitators, elimination of gear reduction units and lubrication jumpers resulted in substantial cost savings over that previously expended for process agitators.

G. Valves and Rotameters

Although not a major equipment item, the process flow transmitters and diaphragm operated valves are critical to continuity of operation. These items are similar to those currently used in separations plants with some design improvements.

A Hammel-Dahl control valve with a welded leaf "accordion" bellows and open yoke superstructure is used in process service. The welded leaf bellows gives added strength and maintains the process solution on the outside of the bellows which aids in a self-cleaning action. An open yoke permits process leakage (from bellows rupture) to spill into the cell rather than travel up instrument tubing to the nonregulated pipe gallery.

The Fisher-Porter rotameter electrical conduit and junction box was modified for ease of maintenance and accessibility. Formerly, wiring or conductor failures in this assembly were difficult to repair.

H. Canyon Cranes

The 202-A canyon is serviced by two 40-ton overhead cranes. The primary or remote crane is the same basic design as remote cranes currently in service at 202-S, 221-U, and 221-T. The second or auxiliary "slave" crane operates on a level 17 feet above the remote crane. Since a major portion of the crane work requires lifts of less than 25 feet above

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deck level, and since it is desirable to minimize the total lift for viewing purposes and reduction of cable twist and swing, the main crane was set at this lower level. The slave crane is designed to handle the tall pieces of equipment requiring lifts exceeding 25 feet above deck level. The maximum height attainable by the slave crane hook is 43 feet above deck level. Even with this clearance, the length of the 2A extraction column requires special handling by both cranes.

The remote crane is equipped with an amplidyne direct current control system which functions similarly to the Redox crane system. Ventilation is supplied to the crane cab through a fire resistant glass wool filter and air conditioning control is provided. Electrical switchgear is air tight and is installed in a cabinet located on the outside of the crane cab for ready accessibility. The 221-B crane periscopes were installed on the Purex remote crane; binocular type eyepieces and other modifications were added for improved operator comfort and visibility. Also, the crane is provided with two closed-circuit color television cameras with viewing screens in the crane cab. Crane communications are supplied by a three station teletalk and two building circuit telephones.

The auxiliary or slave crane is equipped with a single 40-ton hook and a single impact wrench. A suspended cab with lucite panels for direct viewing by the operator is provided on the auxiliary crane. A few simple controls are provided in the crane cab and remote controls are installed so the unit can be operated from the remote crane. When operated from the remote crane, only one speed can be attained on the auxiliary crane, as compared to variable speeds when direct control is employed. Control of the slave crane from the remote crane is maintained by means of a "plug in" cable between the two cabs. This cable limits the operability range of the slave crane to a maximum distance of 75 feet from the remote crane. Both cranes are equipped with non-twist wire rope on all hooks. (The two process cranes are made by the Shaw-Box Division of the Manning, Maxwell, and Moore Equipment Company).

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I. Operational Spare Requirements

Operating difficulties experienced in the Redox and Metal Recovery plants due to canyon equipment failures have emphasized the importance of the availability of adequate spare units for the critical equipment. A basic policy of "10 per cent spares or one, whichever is greater" was adopted except for concentrators, off-gas headers, centrifuges, pumps and agitators. For this equipment additional spares are provided. The total estimated cost of the spare equipment is $2,000,000 as compared to the total procured canyon equipment and jumper cost of $6,300,000.

Units	Total Installed	No. of Spares
Concentrators	5	4
Off-Gas Heaters	4	2
Centrifuges - Head End	2	2
Centrifuges - Three Phase	4	3
Pumps	20	16
Agitators	30	8

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V. VENTILATION

A. Building Ventilation

The Purex ventilation system was initially patterned after that of the Redox plant. When, by operating experience, the Redox system was found to be inadequate, the Purex design was improved to the extent that original design and construction plans would permit. The system as designed has recognized inadequacies which can be overcome by care and adequate procedures. The purpose of the ventilation system is to control contamination by selective static pressure zones, and to control ambient temperature affecting process and personnel. Four major components of the system routinely supply and exhaust approximately 325,000 cfm of air. All instrumentation and control of the 202-A Building ventilation is located in the Power Control Room near the process blower room. One group of people will be responsible for the complete ventilation control of the Purex facility.

To insure proper air flow and decrease inleakage to the canyon during dissolver charging, a roller door is installed over the railroad tunnel opening at canyon deck level. This door will be sealed against air inleakage as tightly as possible. The controls to the canyon level tunnel door will be actuated by the Dispatcher, and will be interlocked with controls to the external railroad tunnel door. This interlock prevents opening the deck level door until the external door is closed, and also prevents opening the outer door until the deck level door is closed.

1. Process Supply and Exhaust Ventilation

Ventilation air to the process portions of the building is supplied by two fans located in the process blower room and rated at 57,750 cfm each when operating in parallel and 70,000 cfm each when operated singly. The fans will normally operate in parallel supplying approximately 100,000 cfm. However, the 70,000 cfm supply is adequate for canyon ventilation

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with all cell blocks installed, which allows one fan to be down for required maintenance periods. The flow pattern of filtered, washed, and tempered air is to the crane cab gallery, canyon, cell and pipe trench, air tunnel, 291-A filter and stack. A portion of the supply air is diverted to the hot shop and the recovered organic head tank room. The hot shop exhausts to the air tunnel; air is exhausted from the organic head tank enclosure by a local exhauster and stack.

Direction of air flow is maintained by static pressure control. Design static pressures in equivalent inches of water are: -0.2 canyon, -0.8 cells, and -1.0 to -1.4 air tunnel. The air enters the cells and pipe trench through slots provided around the edges of the cover blocks. Air is exhausted from the pipe trench to the cell and from each cell through a series of ports in the wall between the cell and the air tunnel. The above range of air tunnel pressure reflects allowance for removal of cell cover blocks. When all cell blocks are installed the entire supply is controlled and the system balanced by the slot area around the blocks, resulting in the -1.4 static presssure in the air tunnel. When cover blocks are removed the estimated excess of 40,000 cfm supply air will be routed through the cell opening and the system is controlled and balanced by orifices located in the cell exhaust parts with a consequent -1.0 static pressure in the air tunnel. It is estimated that the available 40,000 cfm air is adequate for two cell covers to be removed and still prevent any contaminated air from rising into the canyon proper while the process equipment is thermally hot and in operation.

Air quantities for the particular canyon cells were determined by the internal cell heat loads so as not to exceed a maximum air temperature of 125 F. The normal air flow, controlled by cover block slot size, is itemized:

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Cell	Air Flow - cfm	Air Changes Per Hour
Hot Pipe Trench	9515	2.0
A, B, C (each)	3750	11.8
D	1500	2.5
E	1620	2.5
F	12,525	6.5
G	5000	5.0
H-J	6250	5.7
J-K	6730	8.3
K-L	3750	12.2
M	4240	8.4

The main supply of canyon air will exhaust through a tunnel, through the fiber glass filter, to the 291-A exhaust plenum where three electric driven exhaust fans operating in parallel, each rated at 42,000 cfm, and one emergency steam turbine driven exhaust fan rated at 63,000 cfm discharge the air through the 291-A stack. See Section III B for description of the equipment components.

The primary instrument controls for the process ventilation system consist of the Temperature and Humidity Control System and the Static Pressure Control System.

The Temperature and Humidity Control System through temperature controllers and steam valves control the heat (dry bulb temperature) added and the moisture added (wet bulb temperature) to the ventilation supply air during the winter months. During the summer months when no heating is required, maximum evaporative cooling is obtained from the water spray washer.

The Static Pressure Control System consists of two separate control systems whose primary function is to maintain flow through the cells and limit contamination to the cell. First, the static pressure in the canyon is controlled through a static pressure controller and throttling damper on the supply fan suction side. Second, static pressure in the

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PROCESS AREA VENTILATION SYSTEM

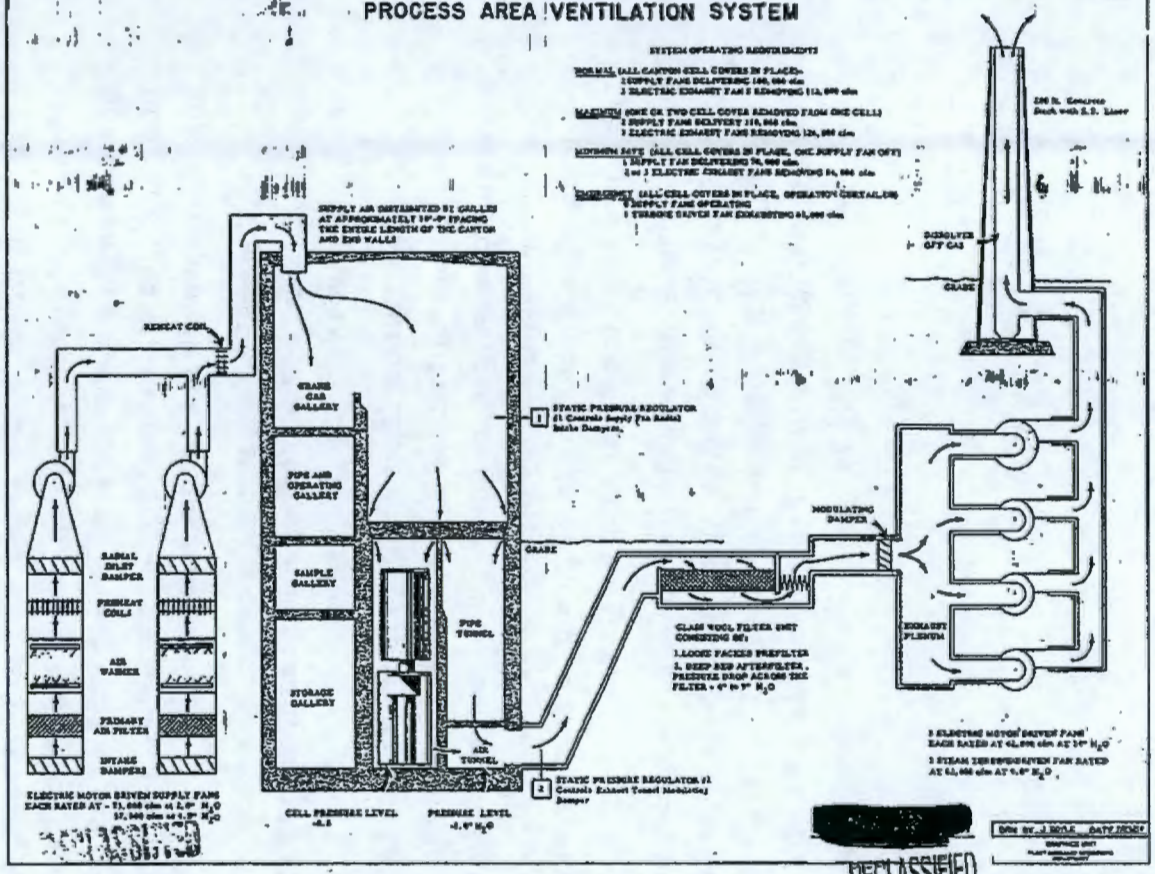
SYSTEM OPERATING ARRANGEMENTS

NORMAL (ALL CANYON CELL COVERS IN PLACE)
2 SUPPLY FANS DELIVERING 180,000 cfm
2 ELECTRIC EXHAUST FAN S REMOVING 112,000 cfm

MAXIMUM (ONE OR TWO CELL COVER REMOVED FROM ONE CELL)
2 SUPPLY FANS DELIVERY 216,000 cfm
2 ELECTRIC EXHAUST FANS REMOVING 126,000 cfm

MINIMUM DUTY (ALL CELL COVERS IN PLACE, ONE SUPPLY FAN OFF)
1 SUPPLY FAN DELIVERING 90,000 cfm
2 or 3 ELECTRIC EXHAUST FANS REMOVING 84,000 cfm

EMERGENCY (ALL CELL COVERS IN PLACE, OPERATION CONTAIN.ON)
2 SUPPLY FANS OPERATING
1 TURBINE DRIVEN FAN EXHAUSTING 63,000 cfm



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exhaust air tunnel is controlled through a static pressure controller and a large single throttling damper in the concrete exhaust duct leading to the 291-A exhaust fan plenum. By controlling the static pressure both above the cells in the canyon and below the cells in the exhaust tunnel at the cell exhaust, a uniform and controlled quantity of ventilation air moves through the cells.

2. Sample Gallery Ventilation

This system ventilates the sample gallery and other associated regulated areas. The supply air is provided by one of two installed fans located in the blower room rated at 36,500 cfm of air. The air is distributed according to the following table which also lists the basic ventilation criteria for the various zones:

Location	Static Pressure Inches of Water	Air Changes Per Hour	Total Air Flow
Sample Gallery	-0.20	2.0	25,200
PR Room	-0.20	9.8	3,555
Regulated Shop	-0.10	8.0	3,760
PR Corridor	-0.10	10.8	1,360
Canyon Lobby	-0.10	5.0	2,660

As shown above approximately two-thirds of the air is distributed to the sample gallery through two primary supply ducts which enter the gallery at midpoint and extend to each end of the gallery. The other one-third of the total flow is diverted through a separate supply duct to the west end of the building for distribution through four reheat zones to facilities at that location, i.e., PR room, regulated shop, etc.

The main sample gallery ventilation system is exhausted by two centrifugal fans located outside the building at each end of the gallery. These fans discharge into stacks which extend ten feet above the building roof.

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The fifty-five sampler and miscellaneous hoods, located in the sampler gallery, have an independent exhaust system. Air supplied by the main sample gallery system will flow into the hoods and out an exhaust ventilation duct which is sectionalized by a damper located approximately at the midpoint of the gallery. An exhauster is provided for each section of the duct, simulating two separate systems. The system is designed to handle, simultaneously, flow through any two hoods in each half of the gallery with the doors open, at a space velocity of 150 fpm, plus an inleakage of ten per cent per hood at the other hoods. This insures unidirectional ventilation into the hoods.

This air, which is exhausted by an outside centrifugal fan, passes through a fiber glass filter and local roof stack.

The PR corridor is supplied with air from the supply duct leading to the regulated shop, and exhausts to the air lock adjacent to the hot shop. The PR area is supplied from the main supply duct leading to the regulated shop. The PR facilities are maintained at a static pressure equal to, but independent of, that in the sample gallery. All the air to the PR facilities is exhausted through the PR cage at a face velocity of 150 fpm through the maximum operational opening by a centrifugal fan located outside the building at grade level. This air passes through fireproof fiber glass filters prior to disposal to a local roof stack.

The regulated shop and canyon lobby are supplied with primary air through the main supply duct. Exhaust is by means of the west sample gallery exhaust fan.

The 276-A organic and recovered acid vaults have independent supply systems but are connected to the main sample gallery exhaust system.

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Evaporative cooling towers provide filtered, washed, and tempered air to the 276-A organic vault, (6340 cfm) and the recovered acid vault (7300 cfm). The cooling towers are located outside, above grade level. The air from the two vaults is exhausted by duct connection to the sample gallery exhaust fans.

A resumé of the supply and exhaust motorized equipment utilized in the sample gallery ventilation system is as follows:

Eq. Pc. No.	Service	Rated (cfm)	Normal Service	Motor Size-hp
202-A-902.1-1	Supply Fan	38,365	36,535	40
202-A-902.1-2	Supply Fan	38,365	(standby)	40
202-A-902.2-1	Sample Gallery Exhaust (east)	19,130	18,220	10
202-A-902.2-2	Sample Gallery Exhaust (west)	27,625	26,335	15
202-A-902.2-3	Sample Gallery Hood Exhaust	4,600	4,400	7 1/2
202-A-902.2-4	Sample Gallery Hood Exhaust	4,600	4,400	7 1/2
202-A-902.2-5	PR Room Exhaust	4,100	3,910	5

3. Service Ventilation

The service ventilation system is an air conditioning system designed to maintain a static pressure equivalent to 0.10 inches of water above atmospheric. Reheat zones are utilized, as required, to regulate temperature, and damper controls are used to maintain the required air flow. The system provides service for the storage gallery, pipe and operating gallery, four floors of aqueous make-up, offices, control rooms, locker rooms, blower rooms, and shops.

The normally required flow of 135,440 cfm for the service ventilation system is provided by two supply fans, located in the service blower room, operating in parallel. The supply stream is distributed through 16 reheat zones to maintain proper temperature control. The pipe and operating gallery is ventilated by 45,100 cubic feet per minute of air distributed through grills located at 20' intervals in the supply duct along the ceiling of the gallery. This quanity of air provides eight air changes per hour.

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Approximately 13,000 cfm is introduced into the storage gallery, which provides two air changes per hour. The balance of the supplied air is distributed throughout the offices, shops, control rooms, and locker rooms, as well as to the process and service blower rooms and to the compressor room. A total of 36 motorized fans and local exhausters, as well as numerous counter weighted gravity flow type louvers discharging through wall openings, are utilized to exhaust the ventilation air from the service areas. The exhaust fans are strategically located to maintain the proper flow of air.

The service area ventilation system has simplified control circuits, the majority of which consist of thermostatic temperature controllers. These controllers regulate temperatures by adjusting steam flow to the zone reheaters. As an aid to service ventilation temperature control, the primary pressure reducing valve stations on the building steam supply system are isolated. These PRV rooms are located at each end of the pipe and operating gallery separate from the gallery proper. Approximately 25 per cent of the ventilation air supplied to the pipe and operating gallery is exhausted through these PRV rooms, discharging excess heat to the atmosphere.

As the service ventilation system serves no contamination control functions, none of its equipment is supplied from the emergency power system. In case of a power failure, the supply and exhaust fans shut down and the dampers open.

4. Laboratory Ventilation System

Because of the special hazards involved in handling radioactive material in open hoods, and because of the desirability of continuous laboratory operations through periods of shutdown in the process building, the operation of this system is independent of the other 202-A Building systems. The system provided is a self-contained unit using critical static pressure differential to maintain the flow of air from "cold" to "hot" zones with positive prevention of flow reversals.

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Supply air to the laboratory ventilation system is provided by one of two installed fans located in the laboratory blower room. Inlet air is filtered, washed, and heated. The instrument and counting rooms require strict air conditions to be maintained year around. In this area the air is conditioned by a refrigeration unit and maintained at 75 ± 1 F dry bulb and a relative humidity of 45 ± 5 per cent. The supply flow is distributed to the various offices, laboratories, and service rooms through nine reheat zones for added temperature control. The laboratory ventilation system is operated as a pressurized system with normally non-regulated zones maintained at a static pressure equivalent to 0.30 inch of water. The volume of air distributed to any particular location is controlled by dampers to maintain the proper number of air changes. This requirement is from nine changes per hour in the lobby area, to 45 changes per hour in the decontamination room. With the exception of relatively small flows that are removed from the change room area and redistributed to the blower room, and small volumes discharged locally from lunch and rest rooms, exhaust from the laboratory facilities is from the hoods.

Hoods provided in the laboratories and decontamination room are of two types, those with fixed openings maintaining a continuous air flow, and those with variable opening allowing intermittent air flow. Twenty-four fixed opening hoods and eighteen variable opening hoods are employed in the laboratory system. Air from the "cold" zones, i.e., offices, service rooms and corridors pass into the rooms containing hoods at minimum rates of 50 fpm through louvered doors, or through open doorways to the "hot" labs. Exhaust from the laboratory ventilation system is filtered through fiber glass filters located in the laboratory blower room. The filters are located on the suction side of the exhaust fans and discharge to a roof stack.

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All supply and exhaust fans in the laboratory ventilation system are installed on a parallel basis, with the 100 per cent installed sparing philosophy observed. Each system is manifolded so that failure or maintenance of any one unit will not interfere with the ventilation, analytical operation, or the maintenance of the failed unit. By the same reasons, all filters, (six separate filter units installed) are so placed that they are readily accessible and can be replaced without interruption of all analytical operations.

The supply fans are rated at 31,000 cfm and are powered by 40 hp electrical motors. The exhaust fans are rated at 21,000 cfm and powered by 40 hp motors. The booster fan redistributing air from the change room area to the blower room is rated at 3600 cfm.

The laboratory ventilation system like the canyon system has two basic control systems: a Temperature and Humidity Control System and a Static Pressure Control System. Temperature and humidity are controlled in the same manner as in the canyon system.

The Static Pressure Control System has two separate control systems controlling static pressure in the supply air plenum and the static pressure in the exhaust plenum. This is accomplished through static pressure controlling instruments and throttling dampers on the fans.

By controlling the static pressure in the supply air plenum and exhaust plenum and by maintaining relative static pressure zones, a controlled flow of air moves through the building from non-contaminated areas toward contaminated areas which in most cases are the laboratory hoods. The S.P. differential between the change room area and the lab hood area is maintained by manual balancing dampers. Static pressure in the hot lab rooms is controlled by a hood by-pass control system in each laboratory.

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B. Process Vessel Ventilation

Six separate process vessel ventilation systems are provided: condenser vent system, vessel vent system, dissolver system, recovered organic vault system, recovered acid and laboratory vault system, and PR room system. Initial design of the vessel ventilation system included canyon vessels, acid and organic vault vessels, and PR room vessels. In order to eliminate the possibility of contaminating remotely maintained equipment from a pressurized vessel vent system, the vaults and PR room were removed from the canyon ventilation system and provided with separate, individual ventilation systems. This arrangement is also advantageous since it reduces the load on the canyon vessel vent system.

1. Canyon Vessel Ventilation

Emphasis was placed on the design of this system in order to provide sufficient vacuum at individual process vessels to overcome moderate leaks. Thus, air will flow into the vessel at the source of a moderate leak, such as an improperly impacted connector head, around a pump shaft, etc. In this manner, escape of process vapors to the cell and subsequently to the canyon deck, etc., is prevented.

The source of vacuum is a six inch steam-air ejector rated at 800 scfm capacity. See table for additional jet data. The capacity of this jet is three times that of the jet in similar service in the Redox plant. The jet and a cell air bleed valve are located in a remote jumper in F cell. The bleed valve is a diaphragm operated valve which may be set to automatically control the desired pressure at the suction side of the jet. Manual control of the D.O.V. permits regulation to suit unusual conditions. Design pressure of the vessel vent header is -5 inch water gage.

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2. Condenser Ventilation

The source of condenser ventilation is a steam-air ejector of 250 scfm capacity. A jet-D.O.V. jumper assembly is provided in F cell similar to the vessel vent assembly. Design pressure of the condenser vent header is -40 inch water gage. The condenser and vessel vent jets discharge to a manifold which routes the gases through a common condenser, heater and silver reactor, and off-gas filter. The filter discharges to the air tunnel. The installation of the silver reactor in this system is based on the quantity of radioactive iodine which will be liberated during the normal processing and jet transfer of solutions.

3. Dissolver Off-Gas Ventilation

The dissolver and associated off-gas equipment in the dissolver cell is ventilated by two steam-air ejectors. The normally used jet is sized for 460 scfm; the emergency jet is sized for 1600 scfm. The large jet is provided to maintain dissolver pot vacuum under abnormal conditions such as excessive inleakage of air, or high reaction rates (use of 60 per cent nitric acid for dissolving requires the large jet). The small jet may be operated on steam or air; steam only is provided for the large jet.

When a pressurized pot condition arises which is in excess of the small jet capacity, automatic controls supply steam to the large jet and turn off steam to the small jet. When normal dissolver conditions are restored, the reverse jet action occurs automatically. A diaphragm operated valve is installed on the suction side of each jet. Gang valve control permits throttling of the valve. Both jets and valves are contained in a single remote jumper in the dissolver cell.

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Table of Off-Gas Jets

Number	Service	Capacity scfm	Suction Pressure in. Hg. abs.	Back Pressure psig	Steam Usage lb/hr	size - in.*
J-F1-1	Vessel Vent	800	28.0	1.5	3600	8 x 8 x 2
J-F1-2	Condenser Vent	250	25.0	1.5	1125	4 x 4 x 2
J-A1-1	Dissolver	460	27.5	1.5	2100	6 x 6 x 2
J-A1-2	Dissolver	1600	25.5	4.0	7676	10 x 10 x 2

* Small dimension is steam inlet pipe. Jet connections are butt welded.

4. Acid and Organic Vaults and Product Removal Room

The process equipment in each of these locations in ventilated identically. A direct drive centrifugal non-overloading blower, constructed from 300 series stainless steel, is the source of ventilation. A locally mounted, contact maintained blower is installed in each location. The suction piping of the blower is connected to each vessel. A hand operated gate valve is used to bleed in air for regulation of optimum negative pressure of the system. The blower discharges to the 202-A Building air tunnel. Blower capacity is 550 scfm at -9.0 inch water gage.

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VI. PROCESS PIPING

A. Canyon Piping (Hot)

Canyon piping is defined as piping in the canyon cells, in the hot pipe trench, and in the shielding wall from the last flange on the gallery side (including stainless steel block valves and strainers) through the wall. Buried piping such as dissolver off-gas lines to the stack, and process waste lines to underground storage is also classified as "hot" piping. Fixed piping is that piping which is encased in concrete and which cannot be repaired or replaced subsequent to plant operation. Stainless steel type 304-L or 347 seamless piping was specified; however scarcity of material and the construction schedules dictated the use of welded piping in most cases.

1. Gallery Wall Piping

All piping through the gallery shielding wall is designed with offset bends to minimize radiation in the galleries, and in most cases terminates at remote connectors on flush mounted kickplates in the cell. All kickplate piping, with the exception of electrical conduit, is wrapped with heavy corrugated paper and bound with waterproof tape to provide an annulus for pipe expansion. Piping designated for steam service has a double layer of wrapping and a gallery wall plate which will prevent creepage toward the cell. Cell electrical receptacles have been waterproofed by the addition of a gasket to the contactor plate, and by application of glyptal at the flanged connection to the kickplate.

Connector spacing in the cell is maintained 12 inches minimum, in plan view on any one level. Where a supplementary connector level is required, the connector positions are offset six inches in plan from the primary level. Because of the variation in function as well as size of the cell equipment, it is impractical to establish a single pattern or arrangement of wall connectors compatible with all equipment requirements.

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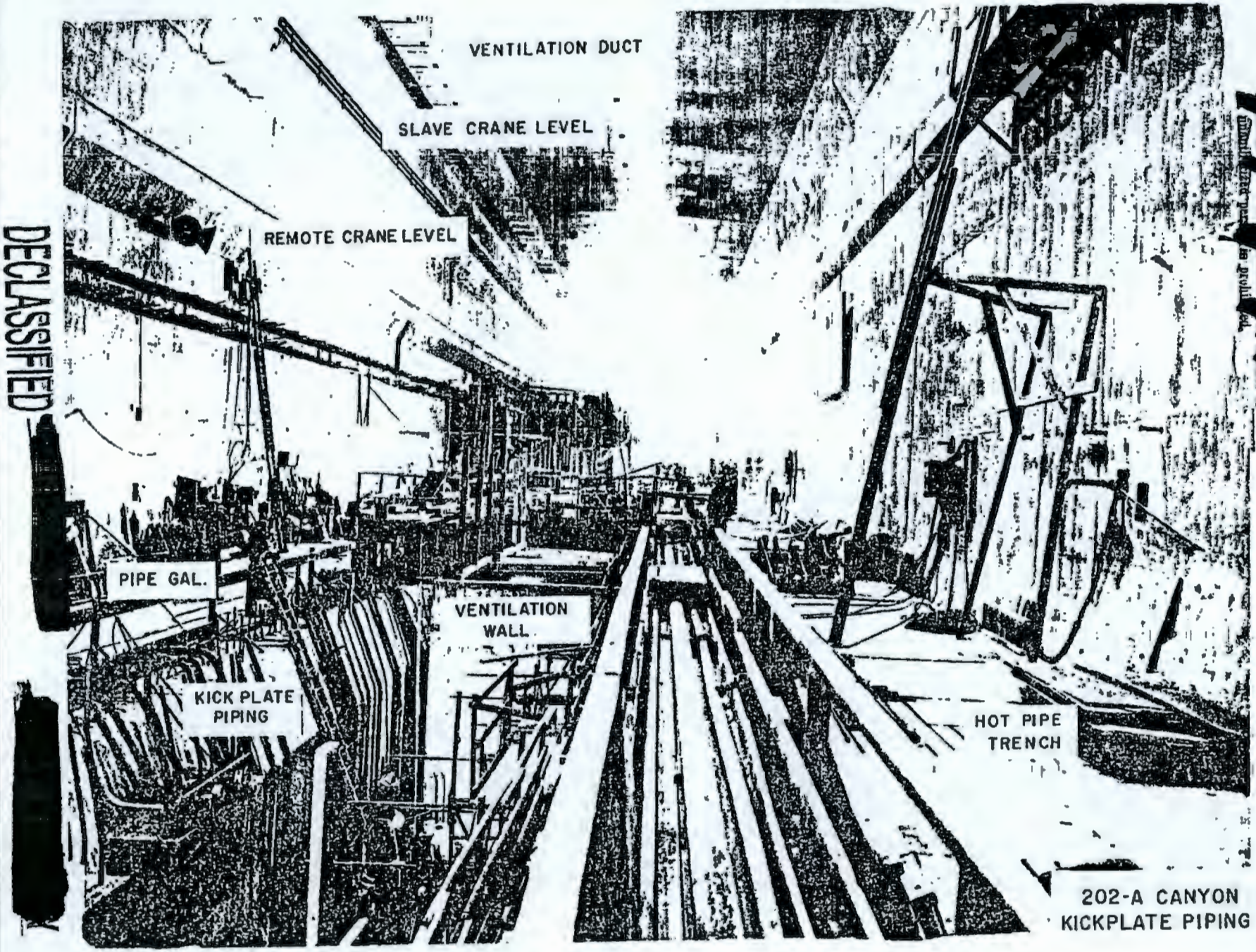

202-A CANYON KICKPLATE PIPING

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However, it is possible to establish similar connector patterns for groups of cell equipment either identical or of similar function, thus obtaining considerable economy in the cost of kickplates and remote pipe jumpers. For example, a 14 foot connector pattern with the same sequential arrangement of the various types of pipe connectors is provided for all standard vessels.

Three basic levels of pipe connectors are provided on the gallery cell walls:

a. The first basic level is required 38 feet above cell floor to service tall equipment. An auxiliary level is provided at 36 feet above cell floor when there is insufficient space for connectors on the first level.

b. The second basic level is required at 29 feet for remote sampling of cascading process streams.

c. A third basic level is required at 26 feet for short cell equipment. An auxiliary level is provided at 24 feet where there is insufficient room for the piping in the basic level. These two levels are utilized for standard vessels and other small equipment resulting in reduction of the length of jumpers.

d. A special gallery wall pipe connector level is required for the 2A column in L cell. This level is 43 feet above the cell floor.

2. Hot Pipe Trench Wall Piping

Because of considerable variation in process function of individual cell vessels, it is impractical to establish a standard trench wall pattern. There are three primary connector levels on the trench cell wall: a 38 foot level for tall equipment, a 37 foot level for spare trench piping systems, and a 36 foot level for process headers and pressurized transfer systems. Numerous other individual levels of pipe connectors are required because of cascade hydraulics. Some spare piping terminates at connector nozzles in the trench. This system will be further discussed under Sparing.

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3. Jumper Piping

Jumper piping includes all remotely maintainable piping and electrical conduit within the canyon. The modified Redox type connectors in the two, three, and four inch sizes are used for electrical, multiple pipe, and individual pipe jumpers. For jumper piping exceeding four inches in size, remote type flanges are used. Where sizes over four inches are required for the trench or gallery walls, multiple four inch lines are used.

Jumpers are designed to permit remote handling by means of a single bail which is oriented in a plane parallel to the major axis of the canyon. Of the 1300 installed jumpers, approximately 30 are in excess of 26 feet in length. These will require remote handling by the "slave" crane in the same manner as tall equipment.

In order to minimize jumper requirements for decontamination of all types of failed equipment, flexible jumpers are used in the decontamination cell. Two types of flexible jumpers are provided: those fabricated with short lengths of stainless steel pipe coupled with Chicksan joints, and others made with rubber or plastic hose.

4. Hot Pipe Trench Piping

All normal routings in the pipe trench are through permanently installed, welded piping supported on "Unistrut" pipe racks. Levels of piping in the trench are determined by the process function as noted below.

a. Pressurized Transfer Piping System

This system services streams which are transferred by pumps and jets. Located in the upper level of the trench, these lines slope in both directions from the piping system high point located at the mid point of the trench.

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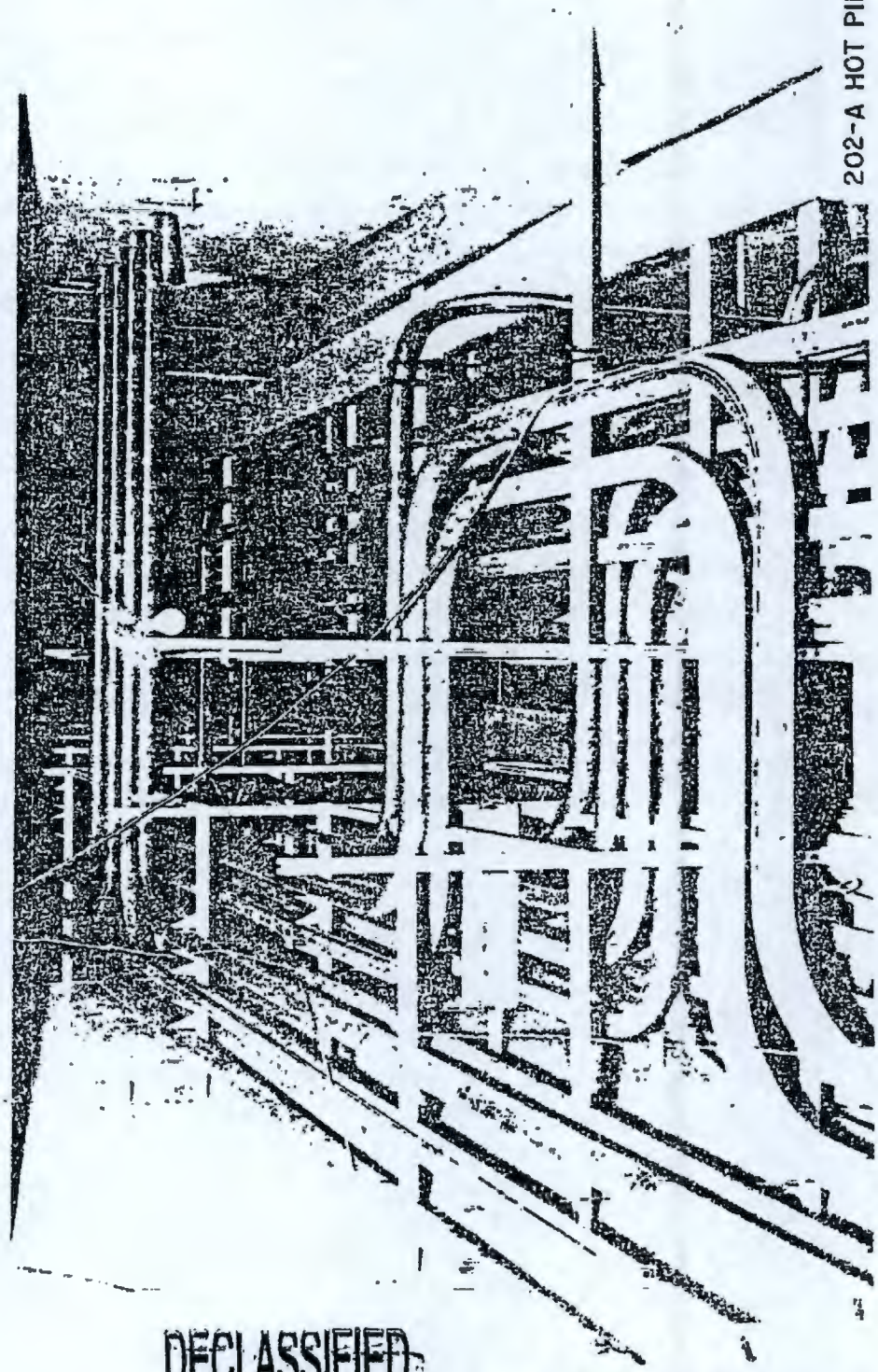

202-A HOT PIPE TRENCH

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b. Collection Header Systems

The collection header systems are dependent upon gravity for motivation of liquids below the pressurized transfer system. Exceptions are the cooling water and steam condensate headers which are located outside the canyon about 15 feet from the south wall and 20 feet below grade level. Process cooling water and steam condensate have been segregated with cooling water being disposed to a swamp and process steam condensate routed to the 216-A crib due to its potential source of contamination from coil leaks.

All vessel cooling and heating lines are routed directly to headers outside the building. Lines from vessels used primarily for cooling service are connected to the cooling water header. Discharge lines from heat transfer tube bundles and dual-service coils pass through trap pits located outside the building and enter into the steam condensate header. Refer to Section III C for functional description of trap pits.

c. Process Waste Lines

Process waste piping to either underground storage or cribs leaves the pipe trench through a single opening in the rear canyon wall about 200 feet west of the railroad tunnel. These lines enter an encasement and terminate in a diversion box near the building.

d. Acid Vault Transfer Lines

The recovered acid lines from F cell are routed through a pipe chase between C and D cells, through an encasement in the storage gallery and enter into the acid recovery vault.

e. Organic Vault (276-A) Transfer Line

Interconnecting line between the hot pipe trench and the organic vault are routed through L cell as exposed piping, through a pipe chase between the PR room and the regulated shop at storage gallery level and continue above the PR corridor to the organic vault.

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f. Dissolver Off-Gas Lines

Three dissolver off-gas lines are routed across the hot pipe trench through the south wall of the building and then through an encasement to the base of the 291-A stack.

5. Spare Piping

In remotely operated and maintained plants, it has been shown that installed spare piping is necessary to assure continuity of operation and to provide means for future process changes and expansion of facilities.

a. Gallery Side Spares

The degree of sparing of gallery to cell piping varies depending upon the function of the specific equipment. A typical example of the sparing for the standard vessels which includes the minimum number of wall connectors is as follows:

(1) One spare electrical connector
(2) Two spare instrument connectors
(3) One spare sampler connector
(4) One spare two-inch pipe connector from the pipe gallery
(5) One spare two-inch pipe connector from the sample gallery for each vessel that initially requires service from the sample gallery.

b. Trench Spares

Spare piping in the hot pipe trench consists of three major systems.

(1) Spare Headers

The following major header systems and branch lines are spared:

(a) First Organic Waste Header
(b) Second Organic Waste Header
(c) First Acid Waste Header
(d) Second Acid Waste Header
(e) Process Condensate Header
(f) First Solvent Feed Header

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(2) Individual Line Spares

All gravity flow routings through the pipe trench requiring specific elevations due to process hydraulics are spared.

(3) General Sparing Systems

Three general spare systems are provided in the hot pipe trench for the required flexibility in routings between cells, and from canyon to future outside facilities.

(a) General Spare System No. 1

The purpose of this system is to provide spare routings for pressurized transfer lines between non-adjacent canyon equipment. It consists of a net work of relatively short loops of permanently installed trench piping terminating in the various cells. Wall connectors are arranged so that each piece of canyon equipment has access to the spare piping system.

(b) General Spare System No. 2

This system provides for major process stream rerouting within the hot pipe trench. A minimum of two lines are provided for each cell. The piping originates at a cell wall connector and terminates at a vertical pipe trench connector above the permanently installed pipe. Rerouting within the trench is accomplished by removal of trench cover blocks and installation of jumpers between hot pipe trench connectors.

(c) General Spare System No. 3

A third spare system is provided for routing of process solutions between the canyon and future outside facilities. Piping is installed at intervals of approximately 40 feet for the length of the pipe trench. Lines originate in a vertical connector at the upper level of the pipe trench and terminate outside the building wall at a blind flange about eight feet below grade.

This system is activated by jumpering to general spare system number 2 in the manner described above.

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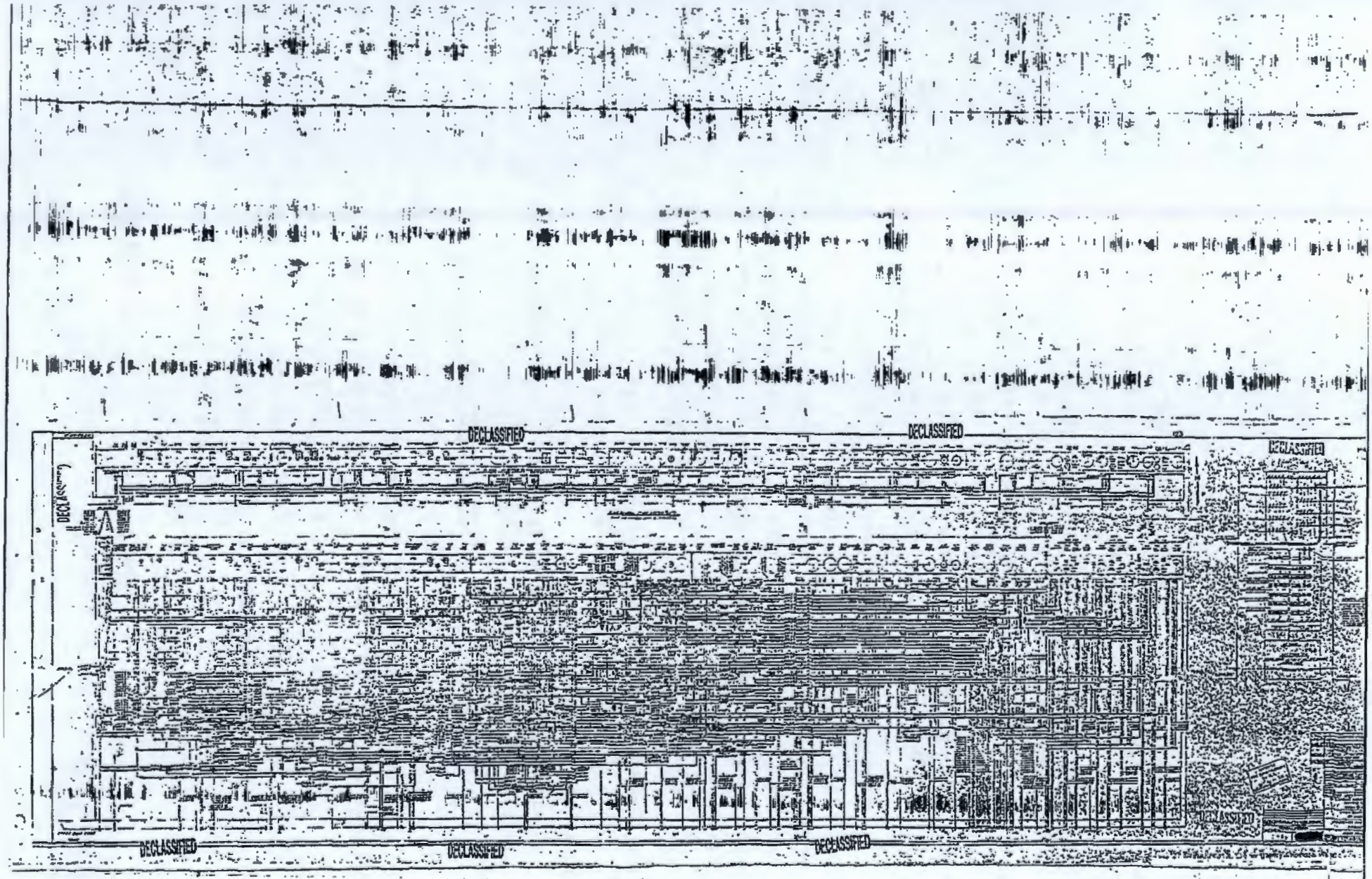
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(d) Dissolver Off-Gas Spare Piping

One spare off-gas line from each dissolver cell is routed through the pipe trench and stubbed off outside the building.

c. Spare Pipe Jumpers

A total of 47 fully equipped operational spare jumpers are provided to back up approximately 1300 installed jumpers. The jumpers to be spared are based on the criticality of the jumper to the process, and the vulnerability to failure. The majority of spare jumpers are the rotameter - diaphragm valve type; others are electrical, jet transfer, sampler, and specific gravity-weight factor types. In addition to the above spare jumpers are alternate process routing jumpers which are fabricated, but not installed.

d. Spare Sample Gallery Piping

Transfer lines and headers in the sample gallery are spared as follows:

(1) One spare recovered nitric acid distribution header in the sample gallery hot pipe trench with flanged branch lines for future use.
(2) One spare recovered second cycle solvent distribution header in the sample gallery hot pipe trench with flanged branch lines for future use.
(3) One spare UNH transfer line to outside storage. A portion of the line is encased in the sample gallery floor.
(4) One spare hot laboratory waste line to the acid accumulator (F10) encased in the sample gallery floor.

B. Canyon Service Piping (Cold)

Canyon service piping is defined as that piping installed on the personnel side of shielding walls, excluding stainless steel strainers and block valves. In general, "cold" piping consists of utility distribution systems such as steam, air, water, chemical feed lines, and gang valve systems.

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Some piping, however, although classified as "cold" piping, by virtue of its location, is utilized in radioactive solution service. Examples of this are the recovered acid and organic distribution headers in the sample gallery hot pipe trench.

Other exceptions to the definition are those systems such as cell washdown and fire fog systems originating in the pipe gallery and terminating in the cells and/or canyon hot pipe trench.

C. Buried Drain Piping

1. Crane gallery and sample gallery floor drains, sample gallery hot pipe trench drains, and gang valve vent manifolds terminate in individual cell sumps.

2. Sample box drain headers manifold into the sampler drain collection header in the canyon hot pipe trench.

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VII. PROCESS INSTRUMENTATION

Instrumentation for the Purex process combines the best features of Redox and TBP plants with almost the entire process controlled from two centralized Graphic panel control rooms. The tendency is toward improved instruments and completely automatic continuous process controls. New type replaceable miniaturized recording and controlling instruments are used to conserve panel space and improve maintenance. All heating and ventilating controls are located on a graphic panel in a separate control room.

A separate Purex Instrument Manual (Official Use Only) covers in detail instrument control systems, one line diagrams, and instrument data.

A. Summary of Special Instruments

1. Dissolver Operation Controls

Automatic controls are provided for evacuation of the off-gases and maintenance of pot vacuum, and preset integrator-displacement meter controls are provided for cold chemical addition, so that once set, volume control and shut off are automatic.

2. Gang Valves

The gang valves used for jets are of the automatic delay air purge sequence type, similar to those used at the Redox plant. The gang valve controllers are all mounted on the graphic panel in their proper process location.

3. Interface Controls

Interface controls are of the three dip tube sp. gr type for both top and bottom interfaces, with one exception. The 2A column, bottom interface type, has a slab so constructed that it is necessary to use a capacitance probe - electrical bridge instrument for measurement because of the restricted space. Two concentric probes are inserted into the solutions, one for measuring, the other for reference. As the interface height varies

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over the probe length, the capacity between the inner and outer elements varies, and it can be compared with the capacity of the reference probe and measured as a level.

4. Continuous Section Controls

The use of automatic controls for continuous process sections has been greatly expanded in the Purex plant. Electric rotameters and air operated diaphragm valves are used for flow control. The input flow to a continuous section is measured and fed to a master controller. The air signal from this controller is used to establish the flows throughout several stages of the section by the use of panel mounted set point adjusters. The use of control instruments with pneumatically controlled set points has made it possible to control several related flows in ratio to each other.

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VIII. COMMUNICATIONS

The Purex Facility is serviced by three communication systems and by three additional call or emergency alarm circuits. These systems are designed to allow internal and external communications at all normal operating stations, and to allow maximum coverage at infrequently utilized stations by the judicious installation of jacks for portable phone service. Emergency audible alarms are strategically located inside and outside the building for complete area coverage.

The Purex communication system consists of: (1) plant or "outside" telephone system, (2) internal or PAX dial type telephone system (3) primary and secondary "teletalk" type system, (4) call bell system, (5) emergency evacuation or air raid warning audible alarm system, and (6) fire alarm system.

A. Plant or "Outside" Telephone System

The Purex Facility is serviced by a telephone cable comprising 76 pairs of lines. Thirty-nine telephones with twelve extensions will be initially installed. This will provide outside communication for all primary control locations as well as offices allocated to operating and utility personnel within the Purex facility.

B. Internal (PAX) Dial Type Telephone System

A PAX type telephone system provides internal communication throughout the Purex facility. This system is sized to accomodate one hundred stations. For most efficient utilization and plant coverage, three types of installation are used. Forty-nine standard dial phones (with 18 extensions) will be installed in offices and primary control points. Twenty-three dial type phones equipped with jacks, will be located in strategic positions where maintenance will be routinely accomplished. Twenty-five phone jacks will be located throughout the processing area at points where personnel entrance is infrequent. Eight portable hand telephone sets with fifty-foot

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extension cable are provided for "plug-in" service to the phone jacks. All installed plant telephones are wall mounted sets except those installed in offices which are desk type.

C. "Teletalk" System

A twelve station teletalk system is installed in the Purex plant for direct communication between primary control points within the 202-A Building. Eleven stations are connected to the teletalk system, locations of which are as follows:

1. Railroad Tunnel Door
2. PR Room
3. Air Lock between Storage Gallery and Hot Shop
4. Dispatcher's Control Room
5. Central Control Room
6. Head End Control Room
7. SWP Change Room
8. Aqueous Make-up 1st Floor
9. Aqueous Make-up 3rd Floor
10. 211-A Pump House
11. Storage Gallery Column 13

A secondary teletalk system of three stations provides communication between the dispatcher's desk, the remote crane cab, and the railroad tunnel door.

D. Call Bell System

A call bell system is installed in the 202-A Building providing audible code signal transmission for use in locating personnel throughout the facility. Twenty-seven bells are utilized in this system located throughout the building for complete coverage. Bells used in this system have a characteristic tone to differentiate them from other building alarms. Signals are transmitted from the dispatcher's office.

E. Emergency Evacuation "Howlers"

Evacuation "howler" type audible alarms are located in fifty-eight places inside and outside the 202-A Building for complete facility coverage during periods of emergency. These alarms are controlled by switches at

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the dispatcher's control desk.

The evacuation "howlers" are paralleled by a second alarm of distinctly different sound for use as an air raid warning. Two systems are utilized for the two distinct services, the first requires all personnel to leave the building due to an emergency condition within the area; the second requires all personnel to remain in the building at a prearranged place of safety, against potential external hazards.

F. Fire Alarm Boxes

Fire alarm boxes in the area fire alarm system are located at the following places:

a. Master Alarm Box with an auxiliary located outside the main entrance to the 202-A Building.
b. Master Alarm Box outside main entrance to the laboratory with auxiliary boxes located in the corridor and lobby.
c. A standard coding alarm box located on the south side of the building between 291-A and the 151-A diversion box.
d. A standard coding alarm box located at east end of 211-A.
e. A coding bell - six inches in size - located in the 202-A main lobby.
f. A standard coding fire alarm box located at 241-A.

Cell fires are detected by "fire eye" detectors positioned in cell jumpers. These detectors sound appropriate alarms in the central control room and the fire location dictates action to be taken.

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IX. SERVICE SYSTEMS

The Purex Facility has six utility service systems. These utilities consist of (a) Electricity, (b) Compressed Air, (c) Steam, (d) Raw Water, (e) Sanitary Water, and (f) Demineralized Water.

Normal electrical service is supplied to the area by two independent parallel supply lines. Compressed air is supplied internally by compressors which are an integral part of the plant system. Steam, raw and sanitary water are supplied to the Purex area by single service lines due to proximity of power house, and the accessibility of these supply lines for maintenance. Loop distribution headers are utilized within the exclusion area for the latter three services.

All utilities supplied from outside the exclusion area are metered.

Demineralized water is used in the Purex process to insure product purity.

A. Electricity

The Purex Building electrical distribution system centers around two primary and one emergency 2.4 kv busses. The emergency bus serves as a third primary distribution system, and as an emergency system only at such times as an interruption occurs in the primary feeder lines.

The area is supplied by two 13.8 kv normal and one 2.4 kv emergency feeder lines. The two 13.8 kva lines supply two 3750 kva transformers located near the laboratory structure of the 202-A Building. The transformers energize the primary 2.4 kv distribution busses. The emergency bus is supplied normally through a cross-tie switch from the secondary side of the main transformers. In case of power interruptions to the main 13.8 kv supply, under-voltage relays open the switch connecting emergency bus to the normal system, and close a switch connecting this bus to the emergency power supply line from generators at the power house.

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The 2.4 kv distribution busses supply 2300 volt power to a number of large motors in the process building and serve as supply sources for the 480 volt distribution system which is commonly utilized in the building. Two banks of three transformers each are used in the 480 volt distribution system. Three of these transformers are located on the pad outside the laboratory structure adjacent to the main 3750 kva transformers. The second bank is located on a pad near the maintenance shop portion of the 202-A building. These transformers are rated at 1000 kva when employed in 2400/480 volt service.

Distribution from the 480 volt system is through motor control centers located throughout the building as close to their load as possible.

Switch gear for the distribution system is located in the 2400/480 volt switch gear room, adjacent to the head end control room, or in the 480 volt switch gear room near the maintenance shop portion of the service building.

All transformers in the Purex electrical system have provision for fans to be installed at a later date, if increased capacity is required.

Two features of the Purex electrical system which are new in Separations Section usage are direct current braking for centrifuges, and 550 volt, 75 cycle alternating current for centrifuge operation. The power for the braking system is supplied by rectifiers operating from the 480 volt emergency busses. The 550 volt, 75 cycle alternating current is provided by two 250 kw motor generator sets, each of which will supply power to three centrifuges. These generator sets will be powered by 400 hp synchronous motors operating on 2300 volt supply. (A third generator set rated at 100 kw on 550 volt, 75 cycle output is located in the regulated shop for equipment testing and run-in).

About 20 per cent of the building lighting, all the perimeter lighting, and the instrument power panels, are connected to the emergency power system. In addition to this load, motors in critical ventilation and agitation

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service totaling a connected load of 525 hp, are supplied from the emergency electrical system.

B. Compressed Air

The Purex Facility utilizes three separate compressed air systems in the 202-A Building: process air, instrument air and breathing air. Each component stream has its own compressor as well as separate distribution headers. In case of failure of either of the instrument air or breathing air supply sources, it is possible to supply all air requirements from the process air compressor system. All compressors are located in the compressor room near the process blower room on the first floor of the service building.

1. Process Air System

The process compressed air system supplies requirements for jet air blow systems, process coil purging, air sparger systems, air operated tools, and other special features.

One unusual feature of the Purex Plant design utilizes compressed air to pressurize coils and concentrator and fractionator tube bundles automatically in case of a steam shut down to any of these equipment pieces. This prevents leakage of radioactive material into the tubes or coils in case of leaks during shutdown periods. The steam trap system provides an automatic cut-off at the discharge of the equipment, and approximately 20 psig is maintained in the coils during the period of shutdown.

The process air system is supplied by two, two-stage compressors rated at 1000 cfm each at 100 psig pressure, and powered by 200 hp synchronous motors. The compressors discharge through an after cooler and water separator to a single 4' x 12' vertical receiver tank. Discharge from the receiver tank to the header system passes through an oil separator system prior to its distribution. Process air is distributed to the process area by way of a six-inch header extending the length of the building in the pipe and operating gallery. Process air headers will be maintained at 100 psig pressure.

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2. Instrument Air System

Instrument compressed air facilities for the Purex plant are separate and distinct from the process air supply. Instrument air is used for pneumatic signal transmission, for purge air instrumentation, for air motor controls on ventilation equipment, and for specialized calibration requirements.

Instrument air is supplied by a centrifugal compressor rated at 370 scfm at 80 psig (minimum) pressure, powered by a 200 hp synchronous motor. The instrument air compressor is a rotary water sealed unit to minimize entry of oil into the air stream. Flow from the compressor passes to a 4' x 12' vertical receiver tank and discharges through dryers to the header system.

The instrument air header is a three-inch line extending the length of the building located in the pipe and operating gallery. Header pressure is maintained at 80-85 psig and pressure reducing stations, as required, are installed locally.

3. Breathing Air System

Compressed air for "fresh air" masks is provided in the Purex plant. A header system is installed for distribution of clean air at 50 psig pressure to zones where contact type operation and maintenance work is required semi-routinely, and to the decontamination cell, hot shop, and the regulated shop.

The breathing air header is supplied by a centrifugal, rotary water seal compressor powered by a 40 hp electric motor. This unit is the same type as used for the instrument air supply system.

Flow from the compressor passes to a 3' 6" x 9' vertical receiver tank and through a filter prior to its entry into the distribution header.

C. Steam

Steam is supplied to the Purex exclusion area at a minimum of 185 psig through an 18-inch overground line. Steam enters the process building at

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three points from an area loop distribution header. The north loop is an eight-inch line which enters the building at the process blower room. The south loop is a 16-inch line which branches to two 14-inch lines near the west end of the pipe and operating gallery. One branch enters the building at this point and the other supplies 291-A Area and enters the east end of the pipe and operating gallery. The loop is completed by a two-inch line from the east entry point, through the pipe gallery, connecting with the north loop line in the process blower room.

The north loop provides steam service to 203 and 211-A Area as well as the heating requirements for the air conditioning and ventilation system.

The south loop provides process steam to the west pressure reducing station, to the 291 exhaust turbine, and to the 201-A storage tank as well as the east pressure reducing station in the pipe and operating gallery.

The two-inch connecting header in the pipe gallery supplies steam at 185 psig to the silver reactors and heaters in the dissolver and F cells. As mentioned in Section V, precedence is given to the south distribution header supplying 185 psig steam to the 291-A turbine and silver reactors during periods of emergency. This is accomplished at the expense of the other canyon process steam users (if necessary), by control valves at the east and west pressure reducing stations, which maintain 185 psig in the south service loop. This system is utilized to maintain the turbine at maximum speed, and continuity of the silver reactor off-gas treatment, during emergency periods, without unduly overloading the power house facilities.

With the exception of the two-inch high pressure loop line supplying steam to the canyon silver reactors, all distribution of steam within the process building is 100 or 25 psig pressure. Pressure reducing stations are located at each end of the pipe and operating gallery. These stations are isolated as an aid to building ventilation control, and are sized so that either

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can supply the entire demanded load. The two pressure reducing stations are connected by a 16-inch header in 100 psig service and a two-inch header in 25 psig service which supply lines to the cells and service areas.

Steam at 100 psig pressure is used for process transfer jets, vessel coils, and concentrating equipment. Steam to concentrators passes through local pressure reducing valves and is utilized in the canyon at 30 psig pressure. (40 pounds on acid concentrators and fractionators)

The 25 pound steam service header supplies low pressure steam to ventilation zone reheaters, canyon spargers, and canyon and gallery service "drops" for steam cleaner service.

Sectionalizing valves are installed throughout the steam distribution header system for the most efficient method of system isolation, with minimum process shutdown, during periods of header maintenance.

D. Raw Water

Raw water is supplied to the Purex exclusion area by a 24-inch iron line entering near the northwest corner of the building. This 24-inch line branches to two 20-inch lines forming a loop for the area facility services.

The raw water loop parallels the steam loop to a certain extent; however, the north segment of the 20-inch loop enters the building at a point near the railroad tunnel. The other portion of the raw water loop, passes south to the west end of the building where it branches and feeds the building at the west end of the pipe gallery. The remaining portion, which is reduced to a 6-inch line, continues in a loop paralleling the south wall of the canyon to re-enter the building at the east end of the pipe and operating gallery. The south loop also supplies water for the 241-A-201 tank.

An 18-inch line in the pipe and operating gallery completes the loop by connecting the lines entering the east and west end of the building. The north service loop entering near the railroad tunnel also services this pipe gallery header.

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The principal usage of raw water is for process cooling in condensers and vessels, supply for the slug storage and decontamination pools, cell sprays, and as compressor coolant. Normal water flow in the raw water system is approximately 6000 gpm at design rate.

As an operability feature, all raw water lines are adequately supplied with sectionalizing valves for segment isolation during periods of maintenance.

E. Sanitary Water

Sanitary water headers parallel the raw water system almost in its entirety. Sanitary water enters the Purex exclusion area near the northwest corner of the 202-A Building. The 12-inch supply line bifurcates inside the area to form an 8-inch loop around the 202-A Building.

The north line of the sanitary water loop parallels the north loop of the raw water line and enters the building near the railroad tunnel. This line services the 211 water demineralizer and 203-A Areas as well as three fire hydrants on the north side of the building.

The remaining line runs south, divides, and one line enters the 202-A Building at the west end of the pipe gallery, while the other branch continues around the south side of the building parallel to the raw water line and again enters at the east end of the pipe gallery. The line supplies the high tank (2901-A), three fire hydrants south of the building, and the 291-A Area as well as the main process building. The service loop is completed by a six-inch header in the pipe gallery to which all three inlet supply lines are connected.

The principal usage for sanitary water is for demineralized water make-up, ventilation system, safety showers, fire hydrants, drinking, and sanitary facilities.

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In case of failure to the sanitary water supply line, operations can continue at a reduced rate until the available stored supply of demineralized water is exhausted. The 2901-A high tank contains an adequate supply of emergency water for fire hydrant service.

As in steam and raw water headers, sectionalizing valves are installed at frequent intervals throughout the system for segment isolation for maintenance purposes.

F. Demineralized Water

All solution additives to the Purex process are made up with demineralized water to improve chemical purity. To satisfy the demand for process demineralized water by the Purex operation at normal design rate, a maximum continuous supply of 157,000 gallons per day is provided.

To meet the requirements of the process, two demineralizer units, each with a normal rated capacity of 150,000 gallons per day are provided. These treatment units are located in the 211-A pump house. Feed to the demineralizer units is supplied from the north loop of the area sanitary water header. The demineralizers are of standard anion-cation ion exchange bed design to produce water with the following maximum impurities:

Impurity	Feed Stream (Sanitary Water)	Demineralized Stream
Total Hardness (As $CaCO_3$)	60-80 ppm	2 ppm (max)
Calcium	20-24 ppm	1 ppm
Magnesium	4-5.5 ppm	1 ppm
Silica (As SiO_2)	4-7.5 ppm	7.5 ppm
Total Dissolved Solids (grav) (Excludes SiO_2)	90-110 ppm	4.5 ppm
Free CO_2	0-2 ppm	100 ppm
pH	7.9-8.1 ppm	5-8

The demineralizer is instrumentally controlled by alarms activated on the Power Control panel for regeneration.

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Flow from the demineralizer units is routed to a 90,000 gallon aluminum storage tank located in the 211-A area. Two pumps are provided to transfer demineralized water at the required 110 gpm rate to the head tank located on the third floor of aqueous makeup. Only one pump is required at a time, the other is a standby and is automatically actuated in case of a failure of the first unit.

Demineralized water is distributed by gravity flow from the head tank to pipe gallery and aqueous makeup headers for process service.

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X. SAFETY AND RADIATION CONTROL

A. Fire and Explosion

1. General

Chemicals utilized in the Purex plant which require special control measures are sodium nitrate and hydrocarbon diluent (Deobase). Sodium nitrate is classified in literature as a common hazardous chemical[16] and as a powerful oxidizing agent and a dangerous fire and explosion hazard.[17] Deobase is a deodorized hydrocarbon diluent similar in appearance and characteristics to commercial kerosene. Because it has a flash point of 150 F, Deobase is classified as a Class III Flammable Solvent. A mixture of 70 per cent Deobase and 30 per cent TBP by volume is used as the process solvent. Tributyl Phosphate (TBP) is a colorless, mildy sweet smelling organic liquid used commercially as a plasticizer for lacquers. Since its flash point is 294 F, no fire or explosion hazard arises from its use.

2. Handling and Storage

Sodium nitrate is received and stored in 100 pound bags. A special steel warehouse is provided to meet safety requirements. Refer to Section I E for description of storage facilities. Deobase is received in tank cars and stored in an outside tank which is enclosed in a diked area to control spread of liquid. The fill line extends to the bottom of the tank to prevent buildup of static charge and consequent spark discharge. The diluent storage tank is provided with a steam smothering system above the liquid level which is operated from outside the diked area in case of fire. Curbs are provided around the organic tanks in the operating gallery, head tank room, and the organic vault to control spills. Non-sparking materials will be used for dip tubes and measuring rods used for unloading tank cars and inventory of storage tanks. In handling diluent or mixtures

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of diluent and TBP, "No Smoking" and "No Welding" regulations are followed. Contact of diluent with the skin is to be avoided. Inhalation of the vapor causes irritation to the mucous membrane of the nose.

Fires are to be detected and controlled by Fireye detectors, cell temperature recorders, and a fire fog system. Fireye detectors are essentially photoelectric devices which "see" a fire and sound an alarm. The canyon cells, the organic vault, head tank room, and the organic make-up tank in the operating gallery have Fireye detectors suitably located for fire detection. These elements transmit signals to alarms in the Central Control Room. As a supplementary system, temperature elements are located in the cells to measure cell air temperature. A multiple temperature recorder, with an alarm, is located in the Central Control Room.

A fire fog system, suitably sectionalized, is provided in the cell, organic vault, organic head tank room, and operating gallery organic make-up tank area. Controls for the remotely operated valves in the fire fog system are located in the Central Control Room.

3. Process Control

Considering the facts that Deobase has a flash point of about 70 F higher than hexone, that mixing with TBP in specified amounts raises the flash point of the mixture an additional 40 F, and that the diluent affords greater stability than hexone, the fire and explosion hazard in the Purex plant at normal processing conditions is not critical. It has been demonstrated, however, that in an acid medium the combination of poor operating control and mechanical failure can result in explosive reactions.

A Purex type concentrator was demolished at duPont's TNX Semi-Works while concentrating a uranyl nitrate-nitric acid solution.[18] The incident was attributed to gross over-concentration and instrument failure. Amsco (140 F flash point) - TBP was the process solvent used. Major facts observed during the investigation were as follows:

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a. Mixtures of TBP, UNH, HNO_3 and water will react exothermically with varying degrees of vigor depending on the heating rate and composition, but no reaction will take place at atmospheric pressure until enough water and nitric acid have been distilled to permit the temperature of the charge to rise above 135 C. (78 per cent UNH).

b. The system TBP/UNH/water will yield a self-sustained reaction, but when nitric acid is present the reaction is more vigorous.

c. The system TBP/HNO_3/water will react with considerable violence if heated rapidly to temperatures above 150 C.

In the initial uranium solution testing of the Purex prototype uranium evaporator at Hanford, failure of the concentrator feed pump resulted in over-concentration of uranyl nitrate solution to the point of incipient denitration.[19] A 30/70 TBP-Deobase solvent was used.

As a result of these incidents the following safety features are incorporated into Purex concentrator control systems:

Instrumentation	Critical Control Points
a. Temperature Alarm	250 F in UNH concentrator 265 F in waste concentrator
b. Temperature Shut-Off of Steam Supply	265 F in UNH concentrator 280 F in waste concentrator
c. Pressure Shut-Off in Steam Supply	30 psig in UNH concentrator 40 psig in waste concentrator
d. Weight Factor Shut-Off on Steam Supply	When liquid level is below end of upper specific gravity dip tube (60 inches from base of cannister).

The same instrumentation and controls that are specified for the UNH concentrators are provided for the plutonium concentrators and waste rework tank.

B. Radiation and Contamination

1. General

Previously established criteria for the protection of personnel, practiced in the existing separations plants, are followed in the Purex facility. Some of the major controls are: structural shielding, building

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and process ventilation, underground waste disposal, remote radiation monitoring and air sampling, vessel off-gas filtration, remote decontamination and maintenance, and controlled, centralized entry to radiation zones.

2. Shielding

Radiation levels are reduced by placing a shield between the primary source, i.e., the process equipment, and personnel who are operating or maintaining the plant. Shield barriers are constructed primarily of reinforced concrete. Other special types of shields utilized in the Purex plant are steel, lead, and leaded glass.

All personnel areas are designed for a radiation level of 0.1 mr/hr except the sample gallery, regulated shop, hot maintenance shop, and PR room which are designed for a radiation level of 1.0 mr/hr. The canyon roof is designed for a radiation level of 1.0 mr/hr at ground level.

Cell cover blocks (3' thick) and trench cover blocks (2' 6" thick) are designed for a maximum radiation level of 100 mr/hr at the surface of the canyon deck. Actually, this level may be approached in local zones such as directly over concentrated waste equipment, but is not contemplated as a general background condition. (This criterion was established as a compromise between no cover blocks and cover blocks of standard thickness, prior to the Redox canyon ventilation and contamination incidents. By reducing cover block thickness 50 per cent, the overall building height was decreased with resultant construction economy.)

In order to conserve floor space for equipment handling, a special shielding wall separates the decontamination and storage cell from the maintenance hot shop. When a magnetite aggregate could not be readily obtained to make high density concrete, pieces of reinforcing steel were used as aggregate in wall construction. Shielding requirements for this wall were based on extremely high radiation levels associated with failed Redox equipment.

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A concrete shielding wall separates the 2A and 2B columns in L cell. This barrier is provided to reduce the radiation level in the vicinity of the plutonium concentration equipment which is designed for contact maintenance.

PR room vessels are shielded by a 16" thick concrete barrier. Based on a product gamma decontamination factor of 1×10^6, the maximum radiation in the PR room work area is expected to be 1.0 mr/hr.

Lead glass is utilized to provide visual inspection without sacrificing shielding requirements at the following locations:

a. Wall between decontamination cell and hot maintenance shop.
b. Wall between stairwell and crane maintenance platform.
c. Lead shield at face of "A" type samplers.
d. Steel shield in front of PR loadout head tank.

3. Other

New design features which have been developed to cope with recent problems associated with process ventilation, underground waste storage, and equipment decontamination and burial are discussed individually in other sections of this manual.

Total radio-iodine emission will be continuously monitored and recorded in the 291-A stack gas sampling building and will transmit a high level alarm signal to the dispatcher's office. Radiation Monitoring will provide equipment which can be used for monitoring radio-ruthenium in the stack gas. Facilities are provided in the sample gallery for intermittent sampling of the dissolver, vessel ventilation, and condenser ventilation off-gas systems.

The limitations of the process ventilation system and the significance of canyon deck and crane contamination is recognized as a problem which can limit continuity of production. Procedures will be established to minimize and control spread of canyon contamination. The Purex design was

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re-examined when the problems arising from canyon deck and crane contamination of the Redox plant were made known insofar as construction progress allowed. The facilities provided to combat the contamination problem are as follows:

a. A vessel and condenser ventilation system of sufficient capacity to assure inleakage rather than permit escape of vapors from vessel to cell atmosphere.

b. A spring-loaded, gasketed, bellows connection from the concentrator seal pot to the air tunnel pipe connection. This device prevents vapor emission to the cell when the seal pot "blows". Instrumentation is provided to indicate liquid level in the seal pot.

c. Cell floor and equipment washdown systems to remove loose contamination from equipment prior to its removal from the cell. Fire fog sprays in all process cells to wet the under side of cover blocks, to cool equipment and minimize thermal air currents in the cells.

d. An industrial vacuum cleaning system for cleaning of the canyon deck and the crane maintenance platform.

e. A canyon ventilation system designed with sufficient capacity to add 40,000 cfm air (in addition to normal requirements) to any one cell with one or two cover blocks removed.

C. Nuclear Safety

1. General

Nuclear safety in the Purex plant is controlled by association of plutonium with uranium, dilution, geometry of equipment, and batch size control.[7]

2. Association with Uranium

In all equipment containing materials with a uranium to plutonium weight ratio greater than 1000, criticality is impossible.

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3. Dilution

The volume of combined aqueous and organic waste streams from the columns is such that waste streams are critically safe even though all of the plutonium were concentrated in any one stream. No size limitation is placed on waste handling equipment.

4. Geometry of Equipment

For critical mass considerations at Hanford, a conservative 400 MWD/T was originally assumed, with moderators equal to water present in the solution, and surrounding the vessel.[14] On this basis, an infinitely long cylinder of 5.7 inches inside diameter, or less, is described as the "always safe" or critically safe vessel.

In the final stages of design, the equipment was examined for criticality based on processing 200 MWD/T material. The "always safe" vessel design remained unchanged, but the inside diameter of the plutonium stripper and concentrators was reduced. Thus, in this application criticality is controlled by limiting the diameter of columns and special concentrating equipment.

Special design considerations are necessary in the location of supporting framework (dunnage) and shielding walls in the vicinity of the various equipment pieces which are designed to be infinitely safe from a slow-neutron chain reaction. The 1B scrub, 2A, and 2B columns are positioned so that the three-inch thick slabs (beaver tail) and the column proper is at least two feet from the cell walls, floor, and cover blocks. The column "beaver tail" disengaging section is a geometrically safe design. Critical mass considerations do not permit a large diameter column disengagement section. Other design details dictated by neutron interaction considerations are as follows:

a. Free space between Pr can positions in PR room decontamination hood.
b. Free space between Pr room vessels and concrete shielding walls.

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c. Free space between PR can and outer jacket.

d. Addition of 4 per cent cadmium alloy to the lead shield of PR can to assure safe storage conditions in PR room vault regardless of quantity or "nest" arrangement of filled PR cans.

5. Batch Size Control

Although little opportunity exists to exceed batch size limits using the conventional plutonium decontamination cycle flowsheet, special operating and analytical control methods will be required to prevent exceeding batch size limits if the reflux plutonium cycle flowsheet is adopted. Using the recycle flowsheet, undetected operating errors could transfer three to four kilograms of plutonium from the 2A and 2B columns to the aqueous waste equipment or the 1-0 contactor in a few hours. This product concentration violates the equipment geometrical design.

Since vessels utilized for rework are of standard design, it is the responsibility of supervision to exercise critical mass control by special procedure and careful planning during the rework periods.

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XI. SPECIAL FEATURES

A. Product Removal Room

Facilities for sampling, loadout, decontamination, and storage of product containers are provided in the PR room.

The product stream is transferred from the product receiver in L cell to either of two sample tanks in the PR room by means of vacuum from the vacuum tank steam jet. Solution is fed by gravity from the sample tank to a glass head tank in the loadout hood. The PR Can is positioned in the loadout hood, and filled from the glass head tank by gravity. Since the geometry of the sample tank is not conducive to accurate measurement of small volumes (horizontal tank, three inch to six inch diameter), the calibrated glass tank provides an intermediate measurement. By this method, the possibility of exceeding batch size in the PR Can is minimized. Before loadout, contents of the sample tank are circulated by pump and sampled using a modified 231 Building P-1 sampler.

In order to keep PR Cans clean, and control contamination during the filling operation, the loadout hood is divided physically into two sections. The upper or "hot" section contains the glass head tank, valves, loadout nozzle, and drip cup. The PR Can loading position is in the lower or "cold" section. Filling is accomplished by remotely passing a flexible loadout nozzle through a small opening separating the two sections. Air flow is from lower to upper section. The decontamination hood provides the desired facilities of lighting, drainage, and ventilation control for survey and decontamination of PR Cans.

A portable Toledo scale, 1000 gram Over and Under indicating dial type, is provided for product accountability. Minor division scale graduations of 50 grams permit interpretation of tare and gross weights to ± 25 grams. PR Cans are handled by a jib crane at the building loading

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dock and transported between dock and PR room by dolly. Two electric hoist monorail systems facilitate handling of Cans in the PR room. The first is utilized for weighing and loadout, the second services the decontamination hood.

All vessels and valves in process service in the PR room are totally enclosed in ventilated hoods. The hoods consist of a structural wall, removable lucite panels, and a stainless catch pan. Since process valves are normally inaccessible, those in routine service are air-operated Saunders patent valves (no packing gland, Kel-F seating diaphragms). All hoods drain to a critically safe sump. Off-standard batches of plutonium and sump collection are jetted from the vacuum tank to HAF Make-Up (TK-E6).

Since small volumes and a long length of piping are involved, a water jet is used for this transfer. A micro metallic filter is installed in the incoming line from L cell to remove any solids from the product stream. This filter is located in the vacuum tank hood and is equipped for chemical addition and backflushing.

B. Process Samplers

Three types of samplers are installed in the sample gallery. Their design and use is dictated by the radioactivity of the streams sampled.

1. Type "A" - Hanford Remote Pipetter

This unit is designed to replace the trombone-doorstop method. Developed and tested on a small scale by the Process Analytical Control Unit, application of this sampling technique to plant use is unprecedented. Adoption of existing sampling methods was not advisable, since a 1 cc sample of some Purex solutions required a doorstop weighing approximately 300 pounds. In addition to overall shielding requirements and the handling problem, related personnel exposure levels could not be tolerated. Hence,

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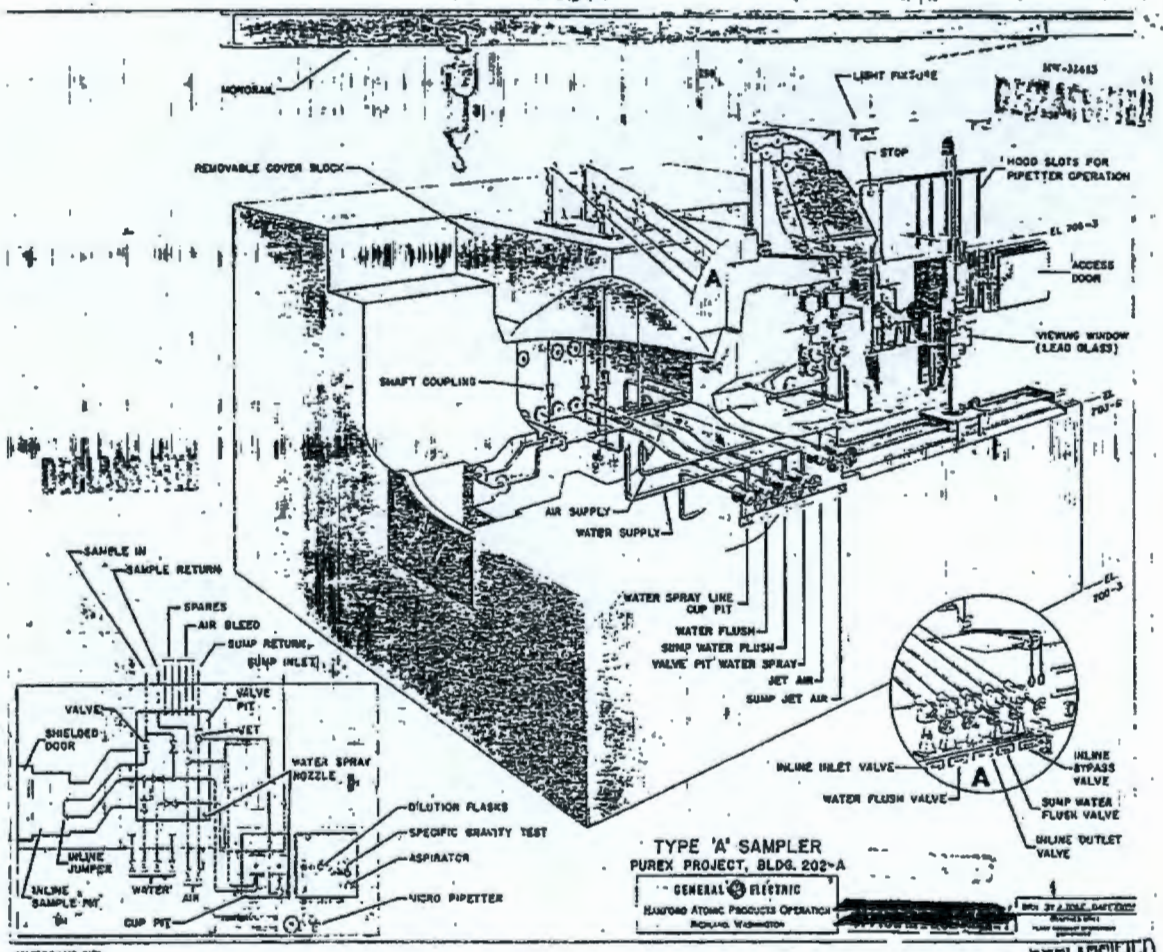

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the primary advantages of the type "A" sampler are: minimized exposure to the operator and laboratory technicians, reduction in weight of the sample carrier, contamination control, and savings accrued from reduced laboratory manpower requirements (fewer analytical steps and less equipment decontamination).

Three separate shielded compartments constitute the sampler assembly: recirculation jet pit, recirculation cup and riser compartment, and sampling bench and hood. The jet pit, which is the terminal point of sample piping from the canyon, is accessible by removal of a concrete cover block using an overhead monorail system. The recirculation cup compartment and sampling bench are accessible by hinged, lead filled doors. Sampling steps are performed in front of a lead barricade at the face of the sampling bench, and observed through leaded glass windows in the barricade. A small raw sample (approximately 0.050 c.c.) is withdrawn from the recirculation cup into the pipette with a micropiston operated hydraulic system. The pipette holder travels through slots in the sampler hood, over the top of the lead barricade. The controls are mounted on a track at the front of the sampler. Metered increments of the raw sample are discharged to dilution flasks. Specific gravity data are taken by timing the travel of a drop of sample through a "falling drop" tube.

2. Type "B" - Bayonet

This unit is in general similar in construction and operation to existing bayonet type samplers.

3. Type "C" - Bottle

The purpose of this installation is to provide a larger volume (4 ounce) of low activity streams at a nominal fabrication cost. It consists of two valved dip tubes and a recirculation jet enclosed in a small hood.

A sample is procured by inserting the dip tubes in a stoppered bottle and turning on the jet.

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The following design features are common with the "A" and "B" type samplers:

(a) A plug valve is installed on the top of the sampler riser to prevent blow-back of contamination from the process vessel.

(b) Valve and piping arrangement in the jet pit facilitates flushing of the recirculation cup, jet, and all sampler piping.

(c) A concrete plug on the side of the jet pit provides for future installation of in-line monitoring devices.

All samplers are totally enclosed and ventilated. See Section V for description of ventilation. "A" type samplers are furnished with a recessed lighting fixture, servicable from outside the hood. Sample gallery lighting is adequate for "B" and "C" type units. In-line scintillation counters (beta-gamma monitors) are installed on "B" type samplers in process condensate and final uranium service. In-line pH meters are installed on samplers servicing the waste neutralizer, and the first and second cycle organic feed and aqueous receiver tanks.

C. Equipment Handling and Disposal

Tall equipment such as columns, concentrators, fractionator, dissolver towers, and some pipe jumpers require handling by the auxiliary crane. In these cases, the height of equipment plus the lifting yoke is in excess of 26' which is the total lift of the remote crane. Operation of the auxiliary crane independently of, or as a "slave" to the remote crane will be governed by the radiation level in the zone of remote maintenance.

To remove or install the 2A column (40' long), both cranes will engage and transport the column. The column is partially removed from the cell using the slave crane and tilted toward the horizontal by moving the crane bridge in the direction of the railroad tunnel. The column pivots on the reinforced edge of the adjacent cover block. Scuff plates are provided

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on the column framework to withstand the rocking. Using the remote crane and a special yoke, the column lower trunnions are engaged. By careful manipulation of the controls of both cranes, the column is removed from the cell and transported to the railroad tunnel (or decontamination cell) in a position about 45 degrees from horizontal. At the tunnel the procedure is reversed. The remote crane lowers the load into the tunnel until the column pivots against the top of the railroad tunnel wall. After the remote crane disengages the column, the auxiliary crane positions the column vertically on the flat car. The column is then lifted by the remote crane (for better visibility and control) and placed in special trunnion guides on one end of the flat car. Final horizontal positioning of the column on the flat car is accomplished by lowering the load while moving the flat car and the remote crane trolley in opposite directions. The column is then ready for disposal.

A study has been completed and a revision request is being prepared at the time of this writing to extend the south end of the railroad tunnel. The tunnel extension will provide internal burial for large and/or extremely radioactive failed equipment. This method of equipment disposal is very attractive from the standpoint of outside contamination problems, and elimination of costly and hazardous (high exposure to personnel) methods currently devised. An outside burial ground will be used, however, for disposal of small equipment pieces. The proposed tunnel extension is 500' long and is equipped with a shielded door, sloped rails, and removable plugs at grade level for addition of earth, concrete, etc. Expendable flat cars will be used for disposal of equipment in the tunnel extension.

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XII. ACKNOWLEDGEMENT

The authors wish to acknowledge the cooperation and assistance of other members of the Purex Contact Engineer's Group in the preparation of this document.

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JJC:BEC:jw

B. E. Clark, Jr.

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Long, Leslie B

From: Hildebrand, R D (Doug)
Sent: Thursday, February 02, 2017 3:51 PM
To: Habel, Leonard, D
Cc: Day, Roberta E; Long, Leslie B
Subject: RE: 200-EA-1 designation calculations

I am ok with placing these references into the AR.

Doug Hildebrand

From: Habel, Leonard, D
Sent: Thursday, February 02, 2017 11:47 AM
To: Hildebrand, R D (Doug)
Cc: Day, Roberta E ; Long, Leslie B
Subject: 200-EA-1 designation calculations

Doug,

This email seeks your approval to add the following references to the Administrative Record (AR). These were referenced by the four calculations I presented to you this morning but are missing from the AR.

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Thanks,

Len

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