Atlantic Richfield Hanford Company
Richland, Washington 99352

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QUALITY CONTROL PROGRAM PUREX THORIA PROCESSING

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MASTER

PRELIMINARY REPORT

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NOTICE

DISCLAIMER

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PUREX THORIA PROCESSING

I. INTRODUCTION

This report describes the quality control activities associated with the production of ^{233}U by separation from irradiated thoria and other radioactive contaminants. References to established documentation, such as flowsheets, specifications, and procedures, are listed as sources of detailed descriptions of the activities described herein.

II. ORGANIZATION AND FUNCTIONAL RESPONSIBILITIES

A. ORGANIZATION

The organizational structure of the Atlantic Richfield Hanford Company, showing management positions having direct impact on the quality of the thorium and ^{233}U products is shown in chart on Page 3.

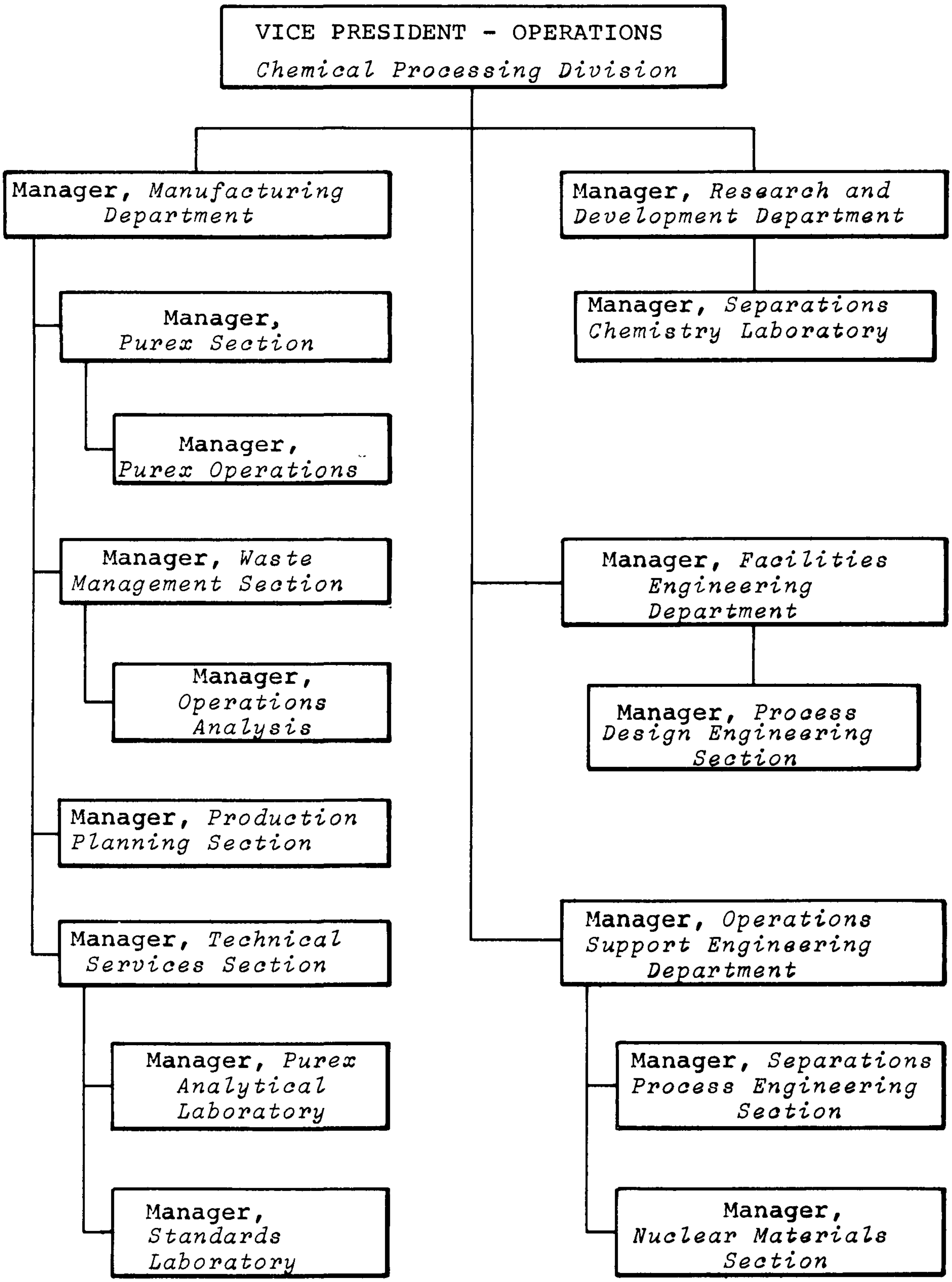
B. FUNCTIONAL RESPONSIBILITIES

The general activities and responsibilities pertaining to product quality are defined in the following Policy Guide and Operating Instruction:

Policy Guide 4.7.1, *Product Quality*, by LM Richards, President, May 28, 1969.

Operating Instruction 4.7.1.1, *Product Quality*, by RP Corlew, Vice President, Operations, May 28, 1969.

A listing of management positions having responsibility and authority, and the functions for which they are responsible, for quality control at the Purex Plant is shown commencing on Page 4. Authorities for issuing and approving waivers to product specifications are not included in this listing. For this function refer to Paragraph V-G.


VICE PRESIDENT - OPERATIONS
Chemical Processing Division
Manager, Manufacturing Department
Manager, Purex Section
Manager, Purex Operations
Manager, Waste Management Section
Manager, Operations Analysis
Manager, Production Planning Section
Manager, Technical Services Section
Manager, Purex Analytical Laboratory
Manager, Standards Laboratory
Manager, Research and Development Department
Manager, Separations Chemistry Laboratory
Manager, Facilities Engineering Department
Manager, Process Design Engineering Section
Manager, Operations Support Engineering Department
Manager, Separations Process Engineering Section
Manager, Nuclear Materials Section

Equipment Design and Testing

Manager, Facilities Engineering Design Sections	Establishes and implements programs for design, testing, and installation of new equipment and spare parts; administer the Facilities Change Notice (FCN) system; provide drafting and engineering standards.

Essential Materials

Manager, Production Planning (PPS)	Orders bulk materials; orders, receives, samples and stores packaged materials and, depending on results of the analyses, approves packaged materials for process use.
Manager, Separations Chemistry Laboratory (SCL)	Establishes specifications and acceptance sampling requirements and analytical methods.
Manager, Separations Process Engineering (SPE)	Establishes material quality requirements and approves waivers permitting process use of any material not conforming to the specifications.
Manager, Purex Operations	Receives, stores, samples and approves bulk material for process use. Maintains inventory of bulk material.

Irradiated Thoria Target Elements

Manager, SPE	Establishes basis for quality requirements for thoria target feed material. Establishes minimum cooling time for irradiated target elements. Provides the basis for scheduling the receipt of irradiated thoria targets at Purex.
Manager, PPS	Provides liaison with DUN, AEC-RL and customer in establishing mutually agreeable specifications.

Manager, Purex Operations	Accepts irradiated target elements; samples dissolved thoria for inventory and process control information.
Manager, Purex Analytical Laboratory (PAL)	Analyzes feed solution samples.

<u>Process Control</u>

Manager, SPE	Issues and revises, as necessary, feed, product and effluent specifications; issues process standards and operating limits; prepares Standard Operating Procedures; prepares and issues safety analysis reports and criticality and chemical safety specifications. Provides continuous process control technical support and process engineering services. Provides schedule of target shipments for optimum blending of product.
Manager, PPS	Arranges for irradiated target shipments from reactors to Purex to provide a timely source of feed and uniform impurity (^{232}U and ^{238}U) content.
Manager, Purex Operations	Issues Standard Operating Procedures; monitors process operations for operating performance and conformance to standard operating procedures. Initiates responsive action for maintaining control of product quality and unit cost, provides for control of nuclear materials accountability and nuclear criticality safety.
Manager, PAL	Determines the characteristics of Purex Plant samples. Controls laboratory operations to assure the highest practicable quality of services. Prepares appropriate samples for special analyses by other laboratories. Provides sample composites for shipment to customers.

Product Certification

Manager, SPE	Establishes product specifications consistent with the requirements of the customer. Audits for conformance to these specifications. Reviews requests for waivers to specification limits.
Manager, SCL	Establishes the analytical procedures required for measuring product quality.
Manager, PPS	Negotiates with the customer, waivers to the minimum technical requirements for the product.
Manager, Purex Analytical Laboratory	Certifies product sample quality characteristics. Provides analytical measurement uncertainties.
Manager, Purex Operations	Packages, samples, stores, and prepares product for shipment, maintaining its measured characteristics. Provides total measurement uncertainty; certifies quality of product shipped and assures that processing is accomplished in conformance to this plan.

III. DESCRIPTION OF THE PROCESS

A. THORIA RECEIPT AND FEED PREPARATION

Irradiated thoria target elements are received from DUN via the standard slug buckets, casks, and well cars used for transporting low pressure reactor (aluminum-clad) fuels. Loading of the buckets into the transfer casks will be in accordance with closely supervised procedures [redacted]. The thoria target elements are accompanied by transfer papers, identifying the material by irradiation history and listing the quantity of thoria contained in each bucket. The quantity of irradiation products specifically ^{233}U and ^{232}U will also be shown, but will be the average value for the reactor "push" of which the bucket is only a portion.

Upon receipt at the Purex Plant of a shipment of thoria elements, verification will be made that:

1. the material described in the shipping papers is the material ordered;

2. the cask cars containing the thoria are marked with a red "T" placard at each end and on top of the well; and

3. the target elements are all standing on end in the buckets and no cored (I and E) elements are visible.

After verification of material identity, as described above, the thoria elements are charged to one of the three Purex multipurpose dissolvers. The target elements are processed in the Purex Plant in accordance with the approved chemical flowsheet using chemical reagents that are of acceptable purity. The processing operations are conducted in conformance with the recommended process parameters and safety specifications. Following is a brief summary of the chemical process in use at the Hanford Purex Plant for recovering and purifying ^{233}U and thorium from the irradiated thoria target elements.

The thoria elements are charged to the three Purex dissolvers and the aluminum cans are removed with a solution of sodium hydroxide and sodium nitrate. The decladding waste solution is centrifuged to remove the small amount of suspended, fine granular thoria, sampled for accountability, and transferred to underground storage.

The thoria is dissolved in 13M HNO_3, 0.025M KF, 0.10M Al $(NO_3)_3$ solution. It is dispersed during dissolution by means of airlift recirculators. The dissolved $Th(NO_3)_4$ solution is transferred to a storage tank and the dissolver is water flushed in preparation for the succeeding charge.

The thorium nitrate solution from the three dissolvers is blended and transferred to a large thermosyphon evaporator for acid removal. The acid deficient, concentrated thorium nitrate solution is simultaneously transferred and diluted by water jet to a receiver tank. The solution is then transferred to successive tanks for sampling and accountability measurements, feed adjustment, and finally for feed to the solvent extraction system.

B. SOLVENT EXTRACTION PROCESSING

The solvent extraction system for processing the thorium - ^{233}U solution consists of:

1. a codecontamination and partitioning cycle for removal of >99.9 percent of the fission products and separation of the ^{233}U from the thorium;
2. two additional cycles for decontaminating ^{233}U from residual fission products, thorium and plutonium;
3. a single additional thorium decontamination cycle;
4. two separate solvent treatment systems for removing degradation products (DBP and MBP) and fission products from the organic solvent; and
5. a waste treatment and acid recovery system.

Codecontamination and Partition Cycle

The dissolved thoria feed solution is pumped to the HA Column where the thorium and uranium-233 are extracted into an organic solvent (30 volume percent tributyl phosphate in normal paraffin hydrocarbon diluent). The major portion of the fission products and ^{233}Pa remain in the aqueous waste stream which is routed to the Waste Concentration and Acid Recovery System for further processing. The uranium-233 and thorium are separated in the 1BX and 1BS Columns. The aqueous product stream from the 1BS Column, containing thorium is concentrated to feed composition for the Second Thorium Cycle. The organic product stream from the 1BX Column, containing uranium-233, is transferred to the 1C Column where the uranium is "stripped" or back-extracted, into an aqueous phase which is concentrated to feed composition for the Second Uranium Cycle.

Second Thorium Cycle

The concentrated thorium product from the first cycle overflows continuously to the 2DF feed tank where it is cooled (30°C), butted with ferrous sulfamate (for plutonium decontamination) and pumped to the 2D Column. In the 2D Column, the thorium is extracted into organic solvent from the No. 2 Solvent Treatment System. Further decontamination from ^{233}Pa and fission products is achieved by scrubbing the thorium-bearing organic phase with a phosphoric-nitric acid solution, and, finally the acidity is reduced by scrubbing with a demineralized water "terminal" scrub stream.

The thorium-bearing organic product stream is routed to the 2E Column where the thorium is stripped into the aqueous phase. The aqueous product (2ET) stream is then concentrated to approximately 1.9 molar thorium, sampled and measured for accountability, and pumped into a tank trailer for transport to storage tanks.

Second and Third Uranium Cycles

The flowsheets for the Second and Third Uranium Cycles are very similar. No chemical adjustment is made to the feed for either the second or third cycle extraction columns. The organic solvent used in both uranium decontamination cycles is supplied from the No. 1 Solvent Treatment System. The only significant flowsheet difference between the two cycles is the addition of ferrous sulfamate to the second cycle scrub (2DS) stream for decontamination from residual plutonium.

The product stream from the Third Uranium Cycle is pumped through a cation exchange column for thorium removal, concentrated to 1.5M in uranium in a tantalum-lined product concentrator, sampled, and loaded into three-liter polyethylene bottles [redacted].

Solvent Treatment

Two separate solvent treatment systems are used to wash and decontaminate the organic solvent used in the solvent extraction system. Solvent from the No. 1 Solvent Treatment System is used in the Codecontamination and Partition Cycle and in the Second and Third Uranium Cycles. Solvent from the No. 2 Solvent Treatment System is used in the Second Thorium Cycle.

The flowsheets for the two systems are essentially the same in - consisting of a carbonate-permanganate wash followed by a dilute nitric wash of the solvent "waste" streams from the solvent extraction system. The No. 1 system provides, in addition, a second carbonate wash and re-acidification of the solvent before it is reused in the solvent extraction columns. The carbonate-permanganate treatment effectively removes organic degradation products (primarily dibutyl phosphate) and fission products from the solvent.

Waste Treatment and Acid Recovery

The function of the Waste Treatment and Acid Recovery System is to:

1. concentrate all of the aqueous waste from the solvent extraction cycles;
2. boil off the nitric acid and recover it by absorption in demineralized water;
3. concentrate the recovered acid to 13M (60%);
4. denitrate the concentrated waste by reaction with sugar; and
5. neutralize the waste and transfer it to underground storage tanks.

The aqueous waste streams from all of the "A-type" extraction columns are combined and concentrated in a large thermosyphon evaporator equipped with two vertical tube heat exchangers and tantalum wire mesh mist eliminators. The acidic overhead vapors from the waste evaporator pass through an absorption tower for removal of the nitric acid. The recovered acid, nominally 4.7M concentration, is routed to the acid fractionator, operating at 360 inches of water vacuum, where it is further concentrated to 13M for recycle to the process. The concentrated salt waste solution overflows from the evaporator at a nominal concentration of 4M HNO_3 and 8M total nitrate ion. After sampling for accountability and acid concentration, the concentrated salt waste is reacted with sugar to destroy excess acid (to ~1.0M free acid) neutralized, and transferred to underground storage tanks.

IV. DESCRIPTION OF THE FACILITIES

Processing of the irradiated thoria target elements will be accomplished in the equipment and facilities of the Hanford Purex Plant. A description of the facilities and originally installed equipment is provided in the Purex Technical Manual.[redacted] Major equipment modifications and additions since plant startup, not included in reference [redacted] are summarized below:

MULTIPURPOSE DISSOLVERS

Annular dissolvers, equipped with special airlift circulators to facilitate suspension of thoria, were installed in the plant in 1965 and 1966. These dissolvers are described in reference [redacted].

SECTIONALIZED CONCENTRATORS

Two-piece concentrators [redacted] have been installed in the Purex Plant for: a) waste concentration and acid boiloff, (E-F6); b) acid boiloff from the dissolved thoria solution (E-F11; and c) concentration of the U-233 product solution from the 1BX Partition Column (E-H4). The acid boiloff concentrators are equipped with "acid towers" for particle deentrainment and the uranium concentrator is equipped with a bubble cap "stripping" tower for removal of dissolved and entrained organic from the feed stream. In addition, the reboiler sections of the E-H4 uranium concentrator and the E-F11, acid boiloff concentrator were modified as described in references ([redacted] and ([redacted], respectively. The E-H4 concentrator reboiler was modified for improved criticality safety; the E-F11 concentrator reboiler was modified to permit quick removal of the de-acidified "bottoms" without extensive cooling.

J CELL PACKAGE

A single solvent extraction cycle system was installed in the "J2" canyon position in 1962 to permit the continuous recovery of neptunium. This system, described in the Purex Neptunium Recovery and Purification Information Manual, [redacted] is used for the second uranium solvent extraction cycle during thorium processing.

PRODUCT CONCENTRATOR

The final product concentrator, E-N6, described in reference [redacted] is a tantalum-lined thermosyphon evaporator of geometrically favorable design for safe processing of U-233.

PRODUCT SAMPLING AND LOADOUT FACILITIES

New facilities have recently been installed in the PR Room for improved safety and accountability and will be used for product sampling and loadout during thorium processing. The facilities include a vertical, three-barrel sampling tank with a nominal capacity of ten gallons, [redacted] a new product loadout head tank [redacted] and a new loadout hood. [redacted]

Equipment modifications and changeouts specifically for thoria-uranium-233 processing include:

1. installation of the acid boiloff concentrator in the F11 canyon position;

2. installation of a new concentrator in the H4 canyon position (for use as a first cycle uranium concentrator);

3. provision of airlift circulators in the multipurpose dissolvers;

4. changing of cartridges in two large pulse columns;

5. sizing of the product concentrator, product sample tank, and product loadout head tank to be geometrically favorable for use with ^{233}U solutions at concentrations up to 450 grams per liter; and

6. approximately 100 remote canyon jumper changes - required to make equipment interties compatible with the thorium processing flowsheet.

V. QUALITY CONTROL BASES

Routine processing operations in the Purex Plant during thorium-uranium-233 processing involve the following general areas of activity or concern, over which close control must be maintained.

- Process and Operational Safety
- Product Quality
- Feed and Chemicals
- Effluents
- Equipment - Modifications or Replacements

The bases for maintaining the required degree of control in the above areas are provided by policy guides, specifications, and technical requirements. These bases are summarized and referenced in this section.

A. SAFETY SPECIFICATIONS

General

The general bases for promoting and maintaining safe practices, including responsibilities, are described in ARHCO Policy Guides, [redacted] Operating Instructions [redacted] and Accident Prevention Standards. [redacted]

Chemical and Criticality Safety

Limits and restrictions required to maintain criticality and chemical safety at acceptable levels are defined in the Criticality Prevention Specifications [redacted] and the Process Specifications and Standards, [redacted] respectively. These specification limits are based on engineering analyses discussed in references [redacted] and [redacted].

B. PRODUCT QUALITY REQUIREMENTS

Uranium-233

A primary purity requirement for the uranium-233 product is minimal ^{238}U contamination. Uranium-238 contamination is of major concern to the customer because of its effect on the nuclear physics measurements and tests in which the product will be used. Uranium-238 contamination is, in turn, of major concern to ARHCO during thorium processing because it cannot be removed from the product by conventional chemical processing techniques.

The "minimum technical requirements," which have been established by mutual agreement between the customer and ARHCO in lieu of firm specifications, are described in detail in references [redacted] and [redacted] and summarized in the following table:

TABLE I
TECHNICAL REQUIREMENTS - ^{233}U

Component	Specification	Suggested Analytical Method
Uranium	300-375 g/l	UC-2A
Uranium Isotopic(1)		Mass Spec.
^{232}U	8 ppm, max.	
^{233}U	97 wt. %, max.	
^{234}U	2.5 wt. %, max.	
^{235}U	0.5 wt. %, max.	
^{236}U	0.1 wt. %, max.	
^{238}U	0.5 wt. %, max.	
Gamma Activity (Time Corrected to Completion of Purification)	<0.9 Ci ^{228}Th/g ^{233}U <0.54 Ci ^{224}Ra daughters(2) plus FPs per g ^{233}U	GE-1A
Alpha Activity (At Time of Separation)	≤125% of Calculated α Activity from all U Isotopes	PuA-6b
Impurities(3)		
Np	113 ppm parts U	NpA-6c
Pu	170 ppm parts U	PuA-6b, AEA-1A

The average impurity of the total order quantity of purified material shall not exceed a total neutron poison equivalence of 260.[redacted]

NOTES:

(1) *Based on total uranium*
(2) *^{220}Ra, ^{212}Pb, ^{212}Bi, ^{208}Tl*
(3) *For the complete list of requirements, refer to the Process Specifications and Standards,* [redacted]
(4) *Refer to the Process Specifications and Standards,* [redacted], *for definition.*

Thorium Nitrate (TNT)

No firm specifications have been established governing the purity of the thorium nitrate product, as no customer or disposition, other than storage is anticipated. The "technical requirements" for the TNT product, listed in the process specifications [redacted] and shown in the following table, are designated to permit its use for possible future U-233 production without additional purification.

TABLE II
TECHNICAL REQUIREMENTS - THORIUM NITRATE

Component	Target Limit	Suggested Analytical Method
Th	3.5 ± 0.5 #/gal	ThXR-1A
HNO_3	0.5 ± 0.3 #/gal	HVC-2A
Radiochemical Impurities	(Thorium Weight Basis)	
Pu	<10 ppb	PuA-20a
^{233}U	<20 ppm	U-1X (AT Mount)
Total U (Excl. ^{233}U)	<10 ppm	U-1X (UF Mount)
^{95}Zr-Nb	<50 µCi/lb	GE-1A
^{103}Ru, ^{106}Ru-Rh	<50 µCi/lb	GE-1A
^{233}Pa	<300 µCi/lb	GE-1A
TMI*	<1000 ppm	Emission Spec.
Si	<50 ppm	Emission Spec.
Fe	<100 ppm	Emission Spec.
Cl^-	<50 ppm	To be Determined
$SO_4^=$	<200 ppm	SO_4-1A

*Al, B, Be, Bi, C, Ca, Cd, Co, Cr, Cu, Fe, K, Li, Mg, Mn, Na, Ni, P, Pb, Si, Sn, Zn

C. FEED SPECIFICATIONS

1. Purity requirements for the thoria powder used in the manufacture of the thoria target elements were established by Douglas United Nuclear, Inc. with the concurrence of ARHCO and are specified in reference [redacted].

2. Irradiation exposures of the target elements, also the responsibility of DUN, are summarized in reference (26).

3. Thoria target identification, handling, and information transmittal procedures and responsibilities are specified in appropriately documented and signed Intercontractor Agreements. [redacted]

4. Specific requirements of the Purex Section governing target element receipt and identification are specified in the Process Specifications and Standards, [redacted] the Criticality Prevention Specifications, [redacted] and the Intercontractor Agreement. [redacted]

D. ESSENTIAL MATERIALS SPECIFICATIONS

The essential materials to be used during the thoria processing campaign are listed in the process specifications and standards. [redacted] The purity requirements, sampling and analytical methods are specified in the essential materials specifications. [redacted]

E. EFFLUENT AND WASTE SPECIFICATIONS

Gaseous Effluents and Low Level Liquid Wastes

Firm specifications have not been established for the Purex Plant. In lieu of formal specifications, discharges of gaseous effluents are limited to ten percent of the guidelines established by the AEC. [redacted]) Low level liquid waste discharges are limited to the values established by the AEC. [redacted] Administrative actions and responsibilities are governed by ARHCO Policy Guide 1.6.4 [redacted] and Operating Instruction 1.6.4.1. [redacted]

High Level Liquid Waste

Disposal of the high level liquid waste generated in the Purex Plant during the thorium processing campaign is governed by the appropriate Process Specifications and Standards [redacted] issued by Waste Management Process Engineering.

Solid Waste

Packaging and disposition of solid wastes generated in the Purex Plant during the thorium processing campaign is governed by appropriate Process Specifications and Standards ([redacted] issued by Waste Management Process Engineering. Additional requirements are specified in an AEC Directive, IAD 0511-21. ([redacted]

F. EQUIPMENT MODIFICATIONS AND REPLACEMENTS

Design, testing and engineering review of all equipment installed in the Purex Plant is the primary responsibility of the Facilities Engineering Department, with the concurrence of the managers of the Purex Section and the Separations Process Engineering Section. The authorities and functions for those activities are described in references [redacted], [redacted] In addition, certain facilities and individual equipment pieces described in the Criticality Prevention Specifications [redacted] require the review and approval of the Manager, Separations Process Engineering prior to any changes. The authority for and implementation of this requirement is described in references [redacted] and [redacted])

The mechanism for securing the required review and approval before changes are accomplished and recording all changes in facility and equipment design (after changes are accomplished) is the Facilities Change Notice (FCN) System. [redacted])

G. WAIVERS TO SPECIFICATIONS

Authority for processing waivers of specifications is established by the Process Specifications and Standards [redacted] as follows:

Essential Materials

Approved by the Manager, Separations Process Engineering.

Feed

Requested by the Manager, Purex Section; approved by the Manager, OSE.

Thorium Product

Waivers of the technical requirements do not require formal approval; however, the Manager, SPE should be notified of material not meeting the technical requirements.

Uranium Product

Waivers to the technical requirements established by the customer require negotiation between ARHCO and the customer. This will be initiated by the Manager, Production Planning Section, with the concurrence of the Managers of OSE and Manufacturing. Request will be made by the Manager, Purex.

Safety Specifications

Waivers to chemical or criticality safety specifications are not permitted. Supplements or revisions to safety specifications require the same level of review, approval, and acceptance as the original specifications.

VI. PROCESS AND OPERATIONAL QUALITY CONTROL

The quality control bases discussed in the previous section are implemented, during routine processing operations in the Purex Plant, by use of the process and operational control "tools" described in this section.

A. PROCESS STANDARDS

Process standards define the conditions that will permit operation and the production of materials within the limits or restrictions prescribed in the specifications.

B. PROCESS AND OPERATIONAL GUIDELINES

Process and operational control guidelines are informal limits and conditions that are established to provide necessary flexibility of operation, yet maintain the maximum practical assurance of control within the limits or restrictions of the specifications and standards. Process control guidelines are established covering the following "flowsheet" and operating conditions:

- chemical makeups,
- batch sizes,
- continuous stream flow rates,
- solution temperatures,
- dissolver operation,
- pulse column operation, and
- concentrator operation.

C. PRE-CAMPAIGN FLUSHING

Special criteria (reference [redacted] have been established for product removal and chemical flushing of the entire processing system prior to commencing the thorium processing campaign. Pre-campaign chemical flushing, to remove residual traces of uranium-238, is of paramount importance to product quality control.

D. STANDARD OPERATING PROCEDURES

Detailed procedures [redacted] covering startup, steady state, and shutdown operation of all process equipment and all routine operations in the Purex Plant are issued by the Manager, Purex Operations. Each S.O.P. is divided into four sections, providing information in the following areas:

- process and equipment description,
- safety considerations (including applicable limits),
- detailed procedures, and
- pertinent references (and sketches, as appropriate).

Standard Operating Procedures are issued for the following activities:

Pre-Campaign Flushing

1. Dissolver Flushes
2. D Cell Flushes
3. E Cell Flushes
4. Solvent Extraction Flushes
5. N Cell Flushes
6. PR Room Flushes
7. 203 Area Piping Flush
8. Miscellaneous Flushes

Thorium Operation

1. General Description and Special Procedures
2. Dissolver Operation
3. E Cell Operation
4. Feed Preparation
5. Aqueous Makeup
6. Codecontamination Cycle
7. Partition Cycle
8. Final Thorium Cycle
9. Second Uranium Cycle
10. Third Uranium Cycle
11. No. 1 Solvent Treatment System
12. No. 2 Solvent Treatment System
13. Waste Concentration and Acid Recovery
14. Product Finishing
15. Product Handling

Post-Campaign Flushing

1. Dissolver Flushes
2. D Cell Flushes
3. E Cell Flushes
4. Solvent Extraction Flushes
5. N Cell Flushes
6. 203 Area Flushes
7. Miscellaneous and Special Flushes

Miscellaneous Routine and Special Operations

1. Sampling

E. SAMPLE SCHEDULE

The primary measurement for conformance to specifications, standards and process control criteria is laboratory analysis of selected samples of process solutions. Quality control of the analytical function is discussed in Section VII. Quality control of the sampling function is maintained by the use of Standard Operating Procedures [redacted] and a routine sample schedule [redacted] issued by the Manager, Purex Operations.

The sample schedule designates the samples to be taken, sampling frequency, and analyses required. In addition to the samples taken for process control and product quality measurements, certain samples are required, at specified minimum frequencies, for criticality control. The sample schedule thus requires the approval, for criticality prevention considerations, of the Manager, Separations Process Engineering.

F. PROCESS CONTROL

The process control function involves the continuous monitoring of process equipment and sample analyses for conformance to the chemical flowsheet, process specifications and standards, and criticality safety specifications. Responsive action to a process deviation depends upon the nature and magnitude of the deviation, but minor process and instrument adjustments are generally adequate. A complete listing of operations and process control actions used in the Purex Plant is too extensive for inclusion in this document.

VII. ANALYTICAL QUALITY CONTROL

The analytical control plan for the thorium processing campaign is discussed in detail in reference [redacted]. Included in the reference are brief descriptions of the analytical methods used for the feed and product analyses, the methods (by code number) to be used for all other routine analyses, and the standards requirement schedule.

Laboratory performance is reviewed routinely by the Supervisor, Standard Laboratory. Reports and analytical statements, issued at least quarterly, are described in reference [redacted]. Additional audits are made by the Standards Laboratory of standard and referee input data and minimum frequency requirements.

VIII. NUCLEAR MATERIALS MEASUREMENT

The nuclear materials measurement program and system used routinely at the Purex Plant are described in references [redacted] and [redacted] respectively. The general measurement and accounting methods to be used for the thorium processing campaign are essentially the same as those employed for uranium-plutonium processing. Reference [redacted] outlines methods of receiving material into the system, SS materials balance areas, measurement points and accounting records for the materials processed, including thorium and uranium-233. The reference also includes procedures for physical inventory of all nuclear materials held within the Purex Plant complex.

IX. WASTE AND EFFLUENTS CONTROL

A. LOW LEVEL AQUEOUS EFFLUENTS

All low level aqueous effluent streams from the Purex Plant are sampled and volumes are either measured or estimated from the related input water streams. Proportional or representative samples are taken once per week and composited for monthly and bimonthly analyses, as described in reference [redacted] Periodic reports of volumes and quantity of radioactivity discharged are submitted by the Manager, Purex Operations to the Manager, Operations Analysis.

B. HIGH LEVEL WASTES

The high level waste generated during the thorium processing campaign is neutralized by "reverse strike" with caustic soda, and transferred to non-boiling waste storage. The operation is conducted in accordance with the applicable specifications. [redacted]

C. SOLID WASTES

Solid, contaminated (or potentially contaminated) wastes are accumulated in fiber boxes and disposed to burial trenches in accordance with the requirements of reference [redacted]. In addition, wastes which may contain plutonium or other transuranic elements are sealed in coated metal drums for long-term containment, in compliance with AEC IAD. [redacted]

D. GASEOUS EFFLUENTS

Gaseous effluent streams from the Purex Plant processing areas, which are, or have a high potential for becoming, contaminated with radioactivity are sampled routinely and filtered prior to discharge to the atmosphere. Periodic reports of radioactivity discharged are submitted by the Manager, Radiation Monitoring to the Manager, Operations Analysis.

X. PRODUCT CERTIFICATION

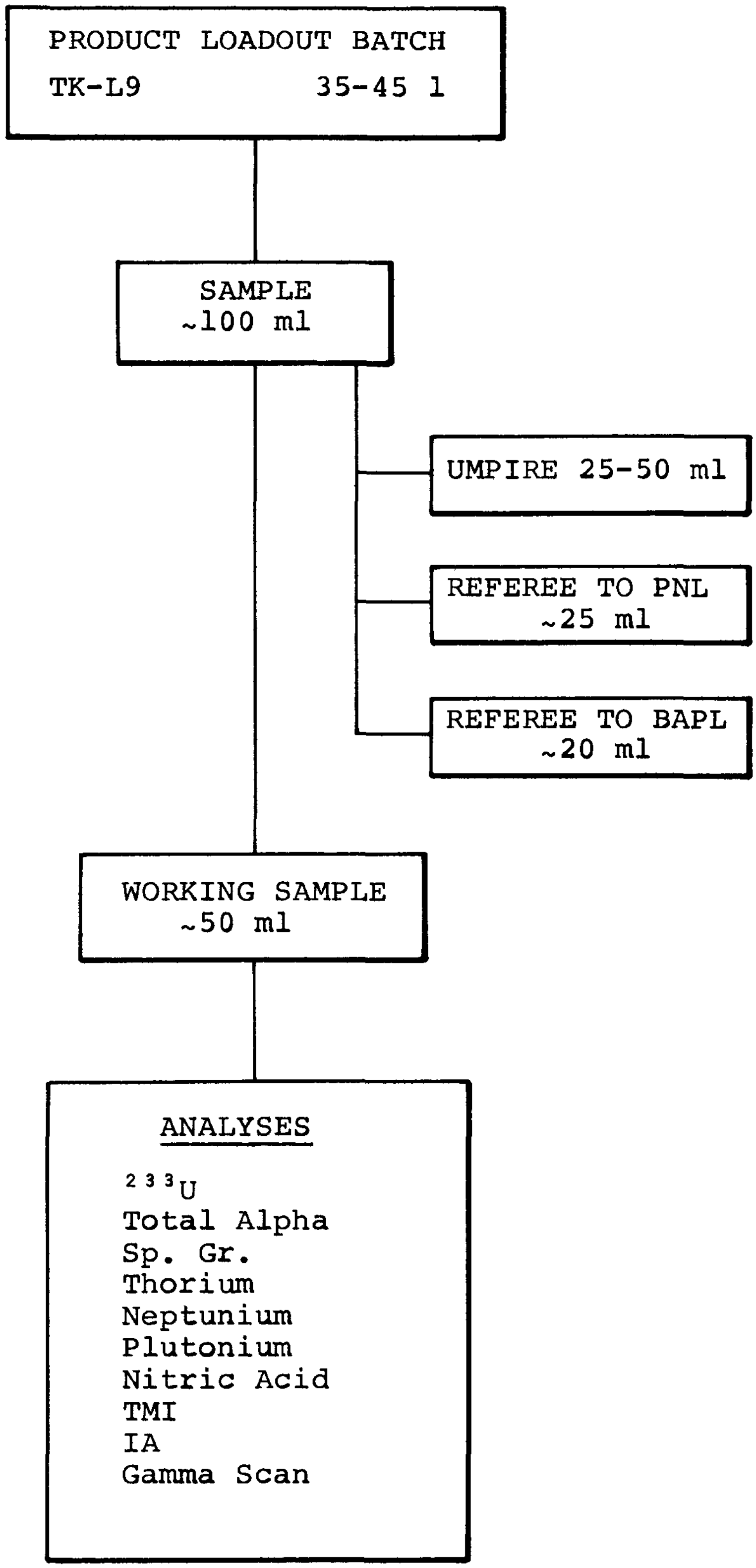
Product certification is the final action resulting from the various quality control activities designed to provide: (a) a product of maximum purity and (b) the maximum knowledge of the quantity and quality of the product. Analytical reports for each product batch are reviewed and certified for accuracy by the responsible laboratory manager. The analytical information is then included, with volume and quantity data in the certified shipping reports which are transmitted to the customer with each shipment.

A schematic of the sampling and analytical plan for the U-233 product solution is shown on Page 22. Samples are taken of each loadout batch (35 to 45 liters) of product solution for complete analysis as outlined. The total metallic impurity (TMI) and uranium isotopic (IA) analyses are performed by the Plutonium Analytical Laboratory, ARHCO. All other analyses are performed by the Purex Analytical Laboratory. Referee analyses for certain critical qualities, including ^{233}U and uranium isotopic content, will be performed by the Pacific Northwest Laboratory (BNW-PNL) on sample aliquots from the first, third, tenth, twentieth, thirtieth, and other, randomly selected batches of product intended for the DNR program. In addition, referee sample aliquots from the third, tenth, twentieth, and thirtieth batches of product intended for the DNR program will be sent to the Bettis Atomic Power Laboratory (BAPL) for analysis, in accordance with the agreement with the customer.

XI. QUALITY ASSURANCE

A system of audits is established to monitor quality of performance of the plant and laboratory operations. These audits, both formal and informal, are used as a means of information feedback for improving the quality effort. Areas of major quality control concern are safety, nuclear material measurements, laboratory performance, and materials control. Audits in these areas are described below.

SAMPLING PLAN - ^{233}U PRODUCT



A. CRITICALITY SAFETY AUDITS

Criticality prevention in the Purex Plant is audited routinely by Operations Support Engineering. A continuing audit of process and operational control is performed informally by the process control engineers on shift and by the process engineer responsible for criticality prevention. Informal feedback is furnished to the Manager, Purex Operations Subsection for corrective action. In addition, formal audits are performed and reported on a quarterly basis in accordance with the requirements of references [redacted] Inspections are made by members of the Nuclear Materials Section, Separations Process Engineering Section, and the Advanced Process Development Section.

Annual audits of criticality prevention effectiveness are performed by AEC-RL personnel and by "third party" teams requested and scheduled by the Manager, Research and Development. Formal reports of these audits are issued to ARHCO for action by the appropriate managers.

B. NUCLEAR MATERIALS MEASUREMENT AUDITS

A system of audits of the nuclear materials measurements program is described in reference [redacted] Random, informal audits of sampling and measuring procedures are performed and quarterly reports are issued by the Analyst, Measurements and Auditing, Purex Operations Subsection.

Annual audits of the total measurement system (both plant and laboratory operations) are performed, and reports issued, by the Nuclear Materials Section.

Annual audits of the ARHCO performance in nuclear materials accountability and control are made by AEC-RL personnel. Formal reports of the findings are issued to the responsible managers and corrective action is taken.

C. LABORATORY PERFORMANCE AUDITS

Laboratory performance is reviewed routinely by the Supervisor, Standards Laboratory. His reports and analytical statements are issued at least quarterly. These reports are described in reference [redacted] Additional audits made by the Standards Laboratory personnel are audits of standard and referee input data and standard and referee minimum frequency requirements.

D. ESSENTIAL MATERIALS CONTROL

The essential materials control function, including receipt, sampling, analysis and acceptance, is audited annually on an informal basis by the Operations Support Engineering Department. Informal reports are submitted to the appropriate, responsible managers for information and action.

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XIII. APPROVALS AND CONCURRENCES

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Purex Section
Date

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Manager
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Date

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Date