NUREG-0627
Appendix B

A Safeguards Case Study of the Nuclear Materials and Equipment Corporation Uranium Processing Plant Apollo, Pennsylvania

Appendix B
With Proprietary Information Removed

W. Altman, J. Hockert, E. Quinn

Office of
Nuclear Material Safety and Safeguards

U.S. Nuclear Regulatory
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Manuscript Completed: December 1979
Date Published: April 1980

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APPENDIX B

NUMEC'S MATERIAL CONTROL AND ACCOUNTING SYSTEM

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INTRODUCTION

This appendix characterizes the material control and accounting system in place at the NUMEC Apollo Uranium Plant during the mid-1960s. The first section of this appendix provides a brief summary of the accountability requirements to which NUMEC was subject in the mid-1960s as a result of contract or lease provisions, the Code of Federal Regulations, or the AEC Manual. The summary of requirements is followed by eight chapters which present in detail a reconstruction of the material control and accounting program implemented at the NUMEC Apollo Uranium Plant in the mid-1960s. This reconstruction was based on a review of thousands of letters, reports, memoranda, licensing correspondence, etc., regarding NUMEC on file at NRC and DOE. The study group copied hundreds of these documents for their working files, and over one hundred of them were referenced directly in the preparation of this report. To assist the reader in comparing this reconstructed program with current requirements, a parallel discussion of the material control and accounting measures implemented at the Babcock and Wilcox Apollo Uranium Plant during 1977-78 (Ref. 1) is also presented in Chapters 1 through 8.[1]

The descriptions of 1977-1978 systems used for comparisons in Appendices A and B were taken from B&W plans submitted to and approved by NRC. These plans were in effect when B&W ceased its high enriched uranium operation at Apollo in 1978, and as such, provide recent points of reference for comparison of current safeguards requirements to those of the mid-1960s.[1]

In reconstructing the NUMEC safeguards program, the study group found that there was very little documentation specifically describing the program during the spring of 1964. Much more information seemed to be available describing NUMEC's safeguards in other years, such as 1962 and 1965. This was particularly true for material control and accounting. As a result, the NUMEC safeguards system described in this report necessarily is a composite picture based on available information describing NUMEC's safeguards during a period spanning several years. Therefore, the system described may not be accurate in every detail for the spring of 1964. However, the system described is consistent with the documentation reviewed and should give a reasonably complete and accurate picture, in general, of NUMEC's safeguards program in the early and mid-1960s.

In reconstructing the NUMEC safeguards program in the mid-1960s, documents dating from as early as 1957 to as late as 1973 were relied upon as primary sources. While great care was taken in interpreting those documents, certain assumptions were required in some cases to reconstruct the safeguards program. Those included assumptions that significant changes in the program would be documented in inspection reports and surveys, that procedures to which NUMEC committed itself in correspondence with the AEC were, in fact, followed (unless the AEC survey or inspection reports stated otherwise) and that all existing relevant documents were made available for this review. The reconstruction of

[1]The discussion of the Babcock & Wilcox Plant is proprietary in nature and is protected from public disclosure by 10 CFR 2.790(d). Accordingly, it is not included in this nonproprietary version of NUREG-0627, Appendix B.

the safeguards program presented is only as accurate as those assumptions. It was particularly difficult to document the absence of specific safeguards measures. This was usually accomplished by deduction from one or more of the following: (1) a survey or inspection report dated after 1964 which recommended that the specific safeguards procedure be implemented; (2) documentation of safeguards measures which were inconsistent with the implementation of the specified safeguards measure; (3) documentation of safeguards measures which would be unnecessary given the implementation of the specific safeguards measure; (4) documentation of aspects of the plant or equipment design or personnel assignments which would preclude effective implementation of the specific safeguards measures; or (5) absence of any reference to the specific safeguards measure in the documentation. It should be noted that in no case did the study group reach a conclusion based solely on condition (5).

While the discussion of the 1977-78 material control and accounting measures at B&W Apollo can serve as a useful guide to current requirements for NRC licensees processing significant quantities of highly enriched uranium and plutonium, it should be noted that the NRC safeguards comprehensive evaluation conducted at the B&W Apollo facility during the fall of 1977 found that safeguards in place at that time did not fully meet NRC standards. (A classified report detailing the deficiencies found was previously transmitted to Congressman Udall.) Because the B&W high-enriched uranium production activities were terminated before the recommendations of the safeguards comprehensive evaluation could be implemented, the discussion of their current (1977) material control and accounting measures does not fully reflect current (1979) NRC requirements.[1]

Nevertheless, it was felt that the changes in the 1977-78 material control and accounting measures required to implement the recommendations of the safeguards comprehensive evaluation were sufficiently minor, in comparison to the change in the material control and accounting program between 1964 and 1977, that the material control and accounting measures described in the 1977 plan could still serve as a useful guide to current material control and accounting requirements.[1]

[1]Note that the description of B&W Apollo's 1977-78 material control and accounting system is proprietary and is not included in this version of NUREG-0627, Appendix B.

ACCOUNTABILITY REQUIREMENTS IN THE MID-1960s

1. Material Control and Accounting Requirements

This section of Appendix B describes the material control and accounting requirements to which the NUMEC Uranium Plant was subject in the spring of 1964. These requirements differed according to the legal status of the special nuclear material held by NUMEC. In particular, NUMEC leased material from the AEC and held such material under AEC license;[1] occasionally held AEC material under cost-type (cost plus fixed fee) contracts, and NUMEC held some AEC material under fixed price contracts which required payment to the AEC for material losses (Refs. 54, 109). Special nuclear material held under license was subject to the provisions of 10 CFR 70 and the provisions of AEC lease under which it was furnished. Material held under a cost-type contract was subject to the terms and conditions of the contract which, among other provisions, required the contractor to adhere to the accountability procedures of AEC Manual Chapter 7401 and applicable supporting AEC manuals or directives. Material held under a fixed-price contract was subject to the terms of the contract but not necessarily to the provisions of AEC Manual Chapter 7401 unless they were incorporated in the contract (Ref. 54).

The following discussion outlines the material control accounting requirements in the mid-1960s for (1) leased material held under license, (2) AEC material held under cost-type contract, and (3) AEC material held under fixed price contract. The preponderance of highly enriched uranium held by NUMEC in the mid-1960s was held under fixed price contracts (Refs. 15, 18, 59, 60, 105).

2. Accountability Requirements for Leased SNM Held under AEC License

As indicated above, leased material held under license was subject to the requirements of 10 CFR 70 and the lease under which it was furnished (Ref. 54). Prior to May 1, 1960, individual agreements were used to furnish leased SNM to licensees (Ref. 54). The AEC, effective May 1, 1960, established a Standard Lease Agreement under the cognizance of the AEC's General Manager for the distribution of SNM to be used for private civilian application (i.e., SNM furnished under Section 53 of the Atomic Energy Act of 1954) (Ref. 54). Pertinent terms and conditions provided for the following:

(a) full financial responsibility for the consumption and loss of SNM;

(b) payment of use charges;

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[1]Starting in 1964, privately owned material could also be held under license; however, NUMEC held no privately owned material during the time frame under discussion.

(c) notification to the Commission of proposed or actual blending of SNM with normal or depleted uranium;

(d) AEC's right to inspect SNM, premises and facilities of the licensee;

(e) recovery of scrap at licensee expense;

(f) maintenance of adequate records pertaining to receipt, use or transfer of SNM; and

(g) reporting of transfers, losses and inventory (Ref. 54).

The Standard Lease Agreement, as originally issued, did not require the taking of a physical inventory by the lessee (Ref. 54). As revised July 1, 1963, however, the Standard Lease Agreement, in addition to continuing the conditions outlined above, provided that the lessee would make at least one physical inventory of his material per year (Ref. 54). Further, the revised Standard Lease Agreement obligated the lessee to use his best efforts to segregate SNM subject to the lease from any other source material or SNM in his possession (Ref. 54).

Requirements of 10 CFR 70 as of January 1, 1964, pertinent to a licensee's responsibility to control and account for the special nuclear material he held under license are given below.

GENERAL PROVISIONS

§70.1 Purpose.

(a) The regulations in this part establish procedures and criteria for the issuance of licenses to receive, possess, use and transfer special nuclear material and for the distribution by the Commission of special nuclear material to licensees; and establish and provide for the terms and conditions upon which the Commission will issue such licenses and distribute special nuclear material (Ref. 111).

EXEMPTIONS

§ 70.11 Persons using special nuclear material under contract with and for the account of the Commission.

The regulations in this part do not apply to any person to the extent that such person receives, possesses, uses or transfers special nuclear material under, and in accordance with, a contract with and for the account of the Commission. In any such case, such person's obligations with respect to the special nuclear material are governed by the applicable contract between such person and the Commission (Ref. 110).

LICENSES

§70.32 Conditions of licenses.

. . .

(a)(1) Title to all special nuclear material shall at all times be in the United States;

. . .

(a)(8) The license shall be subject to, and the licensee shall observe, all applicable rules, regulations and orders of the Commission.

(b) The Commission may incorporate in any license such additional conditions and requirements with respect to the licensee's receipt, possession, use and transfer of special nuclear material as it deems appropriate or necessary in order to:

(1) Promote the common defense and security;

(2) Protect health or to minimize danger to life or property;

(3) Protect Restricted Data;

(4) Guard against the loss or diversion of special nuclear material.

(5) Require such reports and the keeping of such records, and to provide for such inspections, of activities under the license as may be necessary or appropriate to effectuate the purposes of the act and regulations thereunder (Ref. 110).

ACQUISITION, USE AND TRANSFER OF SPECIAL NUCLEAR MATERIAL

§ 70.41 Authorized use of special nuclear material.

(a) Each licensee shall confine his possession and use of special nuclear material to the locations and purposes authorized in his license.

(b) The possession, use and transfer of any special nuclear material produced by a licensee, in connection with or as a result of use of special nuclear material received under his license, shall be subject to the provisions of the license and the regulations in this part.

(c) Nothing contained in the regulations in this part or in any license issued pursuant to the regulations in this part shall

authorize or be deemed to authorize (1) the distribution of any special nuclear material to any person for a use which is not under the jurisdiction of the United States or (2) the export from or import into the United States of any special nuclear material (Ref. 110).

§70.42 Transfer of special nuclear material.

(a) No licensee shall transfer special nuclear material except as authorized pursuant to this section.

(b) Any licensee may transfer special nuclear material:

(1) To the Commission;

(2) To a licensee whose license authorizes him to receive such special nuclear material:

(3) As otherwise authorized by the Commission in writing (Ref. 111).

§ 70.43 Licensee's responsibility for special nuclear material.

(a) Any licensee who receives special nuclear material from the Commission shall be responsible and shall reimburse the Commission for any loss, consumption or contamination of, or damage to, such special nuclear material occurring from the time of delivery of such material to the licensee or to a carrier for delivery to the licensee and until such material has been returned to the Commission by delivery at the laboratory, plant or office designated for the return of the material in his license or other written instruction from the Commission.

(b) The transfer of special nuclear material by a licensee to another licensee shall not relieve the transferor of responsibility to the Commission for loss, consumption or contamination of, or damage to, such special nuclear material unless, upon receiving an agreement signed by the transferee assuming such responsibility, the Commission shall give its consent in writing. The Commission will not unreasonably withhold its consent. Such arrangements may be made with the Commission in advance for a series of anticipated transfers (Ref. 110).

RECORDS, REPORTS AND INSPECTIONS

§ 70.51 Records.

Each licensee shall keep records showing the receipt, inventory and transfer of special nuclear material (Ref. 110).

§70.52 Reports of accidental criticality or loss of special nuclear material.

Each licenses shall promptly report to the Commission any case of accidental criticality and any loss, other than normal operating loss, of special nuclear material (Ref. 110).

§70.53 Material Status Reports.

Each licensee shall submit to the Commission on Form AEC-578 reports concerning special nuclear material distributed by the Commission pursuant to section 53 of the Act and received, transferred or possessed by the licensee or for which the licensee is financially responsible. Such reports shall be made as of December 31, and June 30 of each year and shall be filed with the Commission within 30 days after the end of the period covered by the report, except that any licensee who during the six months preceding June 30 had losses or burnup of less than ten grams of special nuclear material and did not receive or transfer any special nuclear material or financial responsibility therefor, is required to file only an annual report as of December 31. The Commission may permit a licensee to submit Material Status Reports at other times when good cause is shown [25 F.R. 1607, Feb. 25, 1960] (Ref. 110).

§ 70.54 Material Transfer Reports.

Each licensee who transfers and each licensee who receives special nuclear material shall submit to the Commission on Form AEC-388,[1] in accordance with instructions set out therein, reports concerning each transfer of special nuclear material which has been distributed by the Commission pursuant to section 53 of the Act. Such reports shall be transmitted to the Commission promptly after the transfer takes place. [25 F.R. 12730, Dec. 13, 1960] (Ref. 110).

§ 70.55 Inspections.

(a). Each licensee shall afford to the Commission at all reasonable times opportunity to inspect special nuclear material and the premises and facilities wherein special nuclear material is used, produced, or stored.

(b) Each licensee shall make available to the Commission for inspection, upon reasonable notice, records kept by the licensee pertaining to his receipt, possession, use, or transfer of special nuclear material.
[21 F.R. 764, Feb. 3, 1956. Redesignated at 25 F.R. 1607, Feb, 25, 1960 and 25 F.R. 12730, Dec. 13, 1960] (Ref. 110).

[1]Filed as part of original document.

§ 70.56 Tests.

Each licensee shall perform, or permit the Commission to perform, such tests as the Commission deems appropriate or necessary for the administration of the regulations in this part, including tests of (a) special nuclear material, (b) facilities wherein special nuclear material is utilized, produced or stored, (c) radiation detection and monitoring instruments, and (d) other equipment and devices used in connection with the production, utilization or storage of special nuclear material.
[21 F.R. 764, Feb. 3, 1956. Redesignated at 25 F.R. 1607, Feb. 25, 1960 and 25 F.R. 12730, Dec. 13, 1960] (Ref. 110).

3. Accountability Requirements for SNM Held under Cost-Type Contracts

As indicated above, special nuclear material held under a cost-type contract was subject to the provisions of AEC Manual Chapter 7401 and supporting AEC policy manuals and directives (Ref. 54). AEC Manual Chapter 7401 became effective November 7, 1960, and its provisions applied to cost-type contracts at least through 1967 (Ref. 54). Its provisions relevant to this discussion were as follows:

7401-01 POLICY

It is the policy of the AEC to establish and maintain a system of control over its SS[1] material. The degree of control shall be appropriate to the value of the SS material (Ref. 10).

7401-02 PROGRAM OBJECTIVES

The objectives of the control of SS material are to conserve the SS material and to provide current and accurate quantitative information concerning the disposition and availability of such material (Ref. 10).

7401-04 SS STATIONS

041 Concept. The system to control SS material is based upon the concept that responsibility for SS material rests wherever SS material is located physically. When a physical transfer of SS material occurs, there is a concomitant transfer of responsibility for that material; likewise, unless there is a physical transfer of SS material, responsibility for it cannot be transferred (Ref. 10).

043 b.(5)

Prior to authorizing receipt of SS material by a newly established SS Station, the appropriate Manager of Operations shall...require that an SS material management representative (SS Representative) be appointed who

[1]Source and special nuclear material. See Glossary.

will be responsible for implementing SS material inventory, measurement, record, and reporting procedures at the SS Station and who will be the principal contact regarding those procedures (Ref. 10).

7401-06 CONTRACTS PROVIDING FOR PAYMENT FOR LOSSES OF SS MATERIAL

For SS Stations operating under a contract, or subcontract, having provisions resulting effectively in an obligation to pay the AEC for losses of SS material, a Manager of Operations may determine that the objectives of this chapter can be met with procedures different from those required in Section 7401-07. In such cases, provided losses are determined by the AEC at appropriate intervals, each Manager of Operations is authorized to establish such requirements as he deems necessary, except that, under all circumstances, the requirements of subsections 7401-071 and 7401-072 shall apply (Ref. 10).

7401-07 BASIC REQUIREMENTS

071 Transfers of SS Material. All SS material received from or shipped to any "person" or AEC office shall be documented in accordance with the procedures described in Appendix 7401, "Control of SS Material" (Ref. 10).

072 Reporting Requirements. Detailed procedures for the preparation and submission of the following reports to the Director, Division of Nuclear Materials Management, Headquarters, are contained in appendix 7401, section F.

a. Material Balance Report. One copy (use of form AEC 577 is optional) shall be submitted for each SS Station by the fifteenth working day of the month subsequent to the one being reported.

b. Consolidated Material Balance Report. One copy on form AEC 577 shall be submitted by the fifteenth working day of the month subsequent to the one being reported.

c. Report of Composition of Ending Inventory. One copy shall be submitted for each SS Station by the fifteenth working day of the month subsequent to the one being reported. There is no prescribed form.

d. Consolidated Report of Composition of Ending Inventory. One copy shall be submitted by the fifteenth working day of the month subsequent to the one being reported. There is no prescribed form.

e. Material Status Report. One copy on form AEC 578 shall be submitted each June 30 and December 31 for each SS Station by the fifteenth working day of the month subsequent to the one being reported (Ref. 10).

073 Physical Inventories.

a. physical inventories shall be taken of SS material with the frequency and scope authorized by the Manager of Operations,

but in no case at intervals greater than twelve months for any SS Station. In establishing the frequency and scope of the physical inventory, managers shall ensure that inventory procedures provide routine control and periodic verification of the SS material content;

b. the results of the physical inventories shall be reflected in the records and reports of the SS Station (Ref. 10).

074 Measurement of SS Material. Receipts, removals, and inventory of SS material shall be measured in accordance with methods approved by the Manager of Operations; such measurements shall be the bases for the entry of SS material quantity data in the records. In approving such measurement methods, Managers should be guided by the fact that the appropriateness and practicality of accurate measurement are affected by such factors as the quantity and value of SS material, difficulties and cost of measurement, extent of measurement data on like material, availability of personnel and facilities, and contribution of the total error of a particular measurement to the entire measurement error of the SS Station. Statistical analysis of the measurement data will aid in reaching a conclusion as to the appropriateness and practicality of the measurement method (Ref. 10).

075 Records. Records, as approved by the Manager of Operations, of SS material transactions shall be maintained by each SS Station in such detail as will disclose fully all such transactions. In approving such records, Managers of Operations should be guided by the many uses of SS material quantity data and ensure that a single system for collection of such data is devised which also will meet such needs as those for production control, cost accounting, contractual payments, etc. (Ref. 10).

076 Scope. This chapter applies to all source and special nuclear materials and to such other materials as the General Manager may direct from time to time, which are owned by the United States and administered and controlled by the Commission as agent of and on behalf of the United States, and are in the possession of or in use by SS Stations (Ref. 10).

Other manual chapters and directives published before 1966 setting forth AEC policies and standards with regard to cost-type contracts included the following:

1. AEC Manual Chapter 7402 - "SS Surveys and Headquarters Reviews." This manual chapter was issued on October 29, 1959, and it set forth the AEC policy and program for ascertaining the effectiveness of accountability control exercised by AEC contractors over source and special nuclear materials (Refs. 54, 107).

2. AEC Immediate Action Directive 7400-5 - "Process Losses, Wastes, Write-offs and Material Unaccounted For." This directive required AEC contractors to change the way they reported losses to the AEC. The former categories of Process Losses and Wastes were roughly replaced by the categories of Accidental Losses and Normal Operational Losses (Refs. 54, 108).

4. Accountability Requirements for SNM Held under Fixed-Price Contracts

As part of the AEC program of developing a private nuclear industry, AEC Field Office (Operations Offices) and their operating contractors were encouraged to contract with private industry for AEC work -- primarily for UF_6 conversion, fuel element fabrication and scrap recovery (Ref 54). Since 10 CFR 70 provided that contractors "with and for the account of the Commission" were exempt from licensing, Field Offices and their prime contractors entered into contracts and subcontracts with licensed facilities which provided for the furnishing of the material as non-Section 53 material; i.e., SNM not for private use and not subject to licensing (Ref. 54). The contracts and subcontracts differed from the terms of the Standard Lease Agreement in that they generally did not provide for full financial responsibility or for the payment of use charges or recovery of scrap (Ref. 54). Consequently, there developed the phenomenon of "mixed facilities" in which a licensee possessed SNM under varying terms and conditions, including varying degrees of financial responsibility ranging from 0% to 100% (Ref. 54). The "mixed facilities" situation was further complicated by varying practices of Field Offices in contracting with licensees both on a cost-type and fixed-price basis (Ref. 54). Under fixed-price contracts, requirements to adhere to AECM 7401 applied only if they were incorporated in the contract (Ref. 54). As a result of the "mixed facilities" situation and a lack of uniformity in fixed-price contracts, the AEC in 1962 developed a set of uniform terms and conditions and instructed its Field Offices to use them to the "maximum feasible extent" in connection with the furnishing of non-section 53 material (i.e., non-leased material) under fixed-price contracts (Ref. 54). These terms and conditions were essentially the same as those set forth in the Standard Lease Agreement except for the requirement for payment of a use charge (Ref. 54). Research contracts and contracts for testing and analytical services, both of which were generally cost-type contracts, were excluded from these conditions (Ref. 54). The AEC, on July 22, 1964, adopted the use of a Standard Supply Agreement, following closely the terms and conditions of the Standard Lease Agreement, for the supply of non-Section 53 enriched uranium to the industry for use under AEC fixed-price contracts (Ref. 54).

FUNDAMENTAL NUCLEAR MATERIAL CONTROL

1.0 ORGANIZATION

1.1 Organization Structure

1.1.1 Corporate Organization

The Nuclear Materials and Equipment Company (NUMEC) was a stock corporation incorporated under the laws of the Commonwealth of Pennsylvania (Ref. 2). Its "Pennsylvania division" was itself the parent company, so it makes no sense to speak of autonomy from the parent company. The pertinent corporate chain of command was: Board of Directors, President and General Manager (same person) (Ref. 2). Figure 1.1.2.3 shows the corporate organization chart.

1.1.2 Site Organization

Figure 1.1.2.3 shows the 1964 corporate organization chart. The Hafnium Plant, Metals Plant, and Plutonium Plant were located in Leechburg, Pa. Corporate offices and the Uranium Plant were located in Apollo, Pa. Figure 1.1.2.3 indicates that the Accountability Representative (the 1964 version of the 1977 Manager of Nuclear Material Control and Accountability and several subordinate positions) reported to a corporate vice president and was officially on a staff level equivalent to the production, engineering and quality control managers. NUMEC's 1964 License Renewal Application stated, "The Accountability organization shall be independent of the production departments so that it can provide management with an unbiased appraisal of the production groups' handling (of) SS[2]-materials" (Ref. 2).

Other information, however, indicates that the Accountability Representative was not independent of production (see Paragraph 1.1.2.2). Moreover, AEC interviews of NUMEC employees in 1966 revealed that the Accountability Representative, while technically reporting to a vice president, actually reported to the Manager, Metals and Plant Services (Ref. 3).

The documentation reviewed does not provide a 1964 organization chart for the Accountability Organization. The organization chart shown in Figure 1.1.2.5 was drawn based on information contained in Reference 5.

NUMEC's 1964 License Renewal Application and NUMEC's November 1957 License Application (Ref. 7) do contain resumes of key personnel; however, neither they nor other documentation provide explicit job

[2]Source and Special Nuclear Material. See Glossary.

descriptions for key accountability personnel in the mid-1960s. Appendix B-IV contains pertinent information drawn from several sources and organized in the format of job descriptions.

1.1.2.1 Internal Organization (Refer to Figures 1.1.2.3 and 1.1.2.5)

(a) The Accountability Representative had the overall responsibility for control of and accounting for special nuclear material (Refs. 8, 9, 10). However, pre-1966 NUMEC manuals and licensing submittals did not address individual responsibility for the control of or accounting for special nuclear material with much specificity (Refs. 2, 7, 11). NUMEC's 1964 License Renewal Application describes the duties of the Accountability Representative in the following manner:

"The Accountability Representative...shall be the person authorized by the officers of the company to sign SS-transfer forms and SS-reports and, in addition, shall represent the company in all matters of accountability assigned to him. His position shall be analogous to a treasurer of a company authorized to sign checks up to a specified amount" (Ref. 2).

(b) Accountability measurements were the responsibility of the Accountability Representative (Ref. 11). However, choice of the appropriate measurement methods was at the discretion of the Production Manager or his designated representative (Ref. 11).

(c) The Accountability Representative was responsible for special nuclear material accounting (Refs. 9, 10, 11).

(d) Material Balance Area (MBA) supervisors were responsible for the custodians for their MBAs (Ref. 11). The storage vault operation was the responsibility of the Accountability Representative (Ref. 11), so presumably the vault custodians reported to him. By 1966, NUMEC had four vault custodians and they reported to the Accountability Representative through the SS Material Accountability Foreman (Ref. 3), who was also referred to in 1966 as the Accountability Clerk (Ref. 5).

(e) The Plant Services Group was reponsible for several functions including plant maintenance and shipping and receiving (Refs. 2, 12). A 1962 NUMEC organization chart indicates the individual in charge of shipping and receiving, who reported in this capacity to the Plant Services manager, was also the Accountability Representative (Ref. 12). NUMEC's 1964 License Renewal Application (Ref. 2) indicated that shipping and receiving was to "be done under the cognizance of GPA." GPA, or "General Plant - Physical Accountability" was the physical accountability section of the Accountability Organization (Ref. 2), and it reported to the Accountability Representative (Ref. 12).

(f) The AEC as early as 1960 pressed NUMEC to designate a single individual to be responsible for physical inventories (Ref. 13). Later documentation (1962, 1964) stated that inventory planning was to be the joint responsibility of the Accountability and Production Departments (Refs. 2, 11). It indicated that inventory procedures were the province of the Production Manager (Ref. 11) and that the accountability group was to reconcile Book-Physical Inventory Differences (BPID) (Refs. 2, 11). In 1962 the Manager of Production was responsible for disposition of significant unresolved BPIDs (Ref. 11). In 1964 book-physical inventory differences were to be jointly resolved by the Accountability Department and the supervisor in whose MBA the difference appeared (Ref. 2). However, "unresolved and/or unreasonable BPIDs" were still "to be reported to the Production Manager and/or Contract Administrator immediately" (Ref. 2).

(g) Measurements were performed by Production, Quality Control, the Analytical Laboratories, and Accountability personnel (Refs. 2, 3). The nearest program NUMEC had to a measurement control program for accountability purposes was a scale and balance program which provided for biweekly checks of scales and balances used in determination of material quantities for shipments and receipts (Refs. 2, 21). This program was administered by Quality Control (Ref. 2). Calibrations and inspections were performed quarterly by an outside firm (Refs. 2, 15).

(h) NUMEC maintained no formal statistical programs for accountability purposes (Ref. 15, 44).

(i) The Manager of Quality Control was responsible for the Quality Control Department (Ref. 2), and presumably, for production quality assurance.

(j) Since the scale and balance program referred to in (g) above was administered by Quality Control, presumably the Manager of Quality Control was responsible for the quality assurance of accountability measurements performed on the scales and balances covered by the program.

(k) In 1964, the Manager of Quality Control was responsible for the Quality Control Laboratory (Ref. 2). However, the Instrumental Analysis Laboratory and the Wet Chemical Analysis Laboratory were the responsibilities of other laboratory supervisors (Ref. 2). These other supervisors reported to the President and General Manager through a corporate vice president different from the vice president through whom the Manager of Quality Control reported (Ref. 2).

(l) The documentation reviewed does not indicate that anyone was responsible for auditing the performance of the accountability

system's effectiveness. Indeed, the documentation does not indicate that audits were performed on any aspect of the accountability program prior to 1967 (Refs. 20, 22). See paragraph 1.2.9.

(m) The documentation reviewed does not indicate that NUMEC had a designated position whose incumbent was responsible for maintaining the currency of NUMEC licenses.

(n) The documentation reviewed does not indicate that NUMEC had a designated position whose incumbent was responsible for license administration.

(o) The overall responsibility for execution of policy and procedures relative to ensuring compliance with NUMEC's license lay with the General Manager (Ref. 2). Assisting him in the area of accountability was the Accountability Representative (Ref. 2).

1.1.2.2 <u>Separation of Functions</u>

NUMEC's 1964 License Renewal Application (Ref. 2) stated, "the Accountability organization shall be independent of the production departments so that it can provide management with an unbiased appraisal of the performance of the production groups' handling (of) SS-materials." However, the organizational separation of the Accountability group from the Production group was not so great as this statement might suggest. In 1962, the Accountability Representative officially reported to the vice president in charge of production (Ref. 12). In March 1964, the Accountability Representative reported to the same vice president, and later in 1964, due to personnel changes, the Manager of Engineering also became the manager of Production and Accountability (Refs. 2, 3). By 1966, NUMEC had a new Accountability Representative, a former AEC employee (Refs. 3, 16), but he still reported to the general manager through the manager of Engineering and Production (Ref. 5). In addition to being organizationally superior to Accountability, Production also apparently made the final decisions in such matters as scheduling of inventories and resolution of resulting inventory differences (Refs. 2, 11).

(a) Custody. Upon release of special nuclear material by the storage vault operation, which was responsible to the Accountability Representative (Ref. 11), overall material custody officially was the responsibility of the appropriate MBA supervisor (i.e., production or processing manager) (Refs. 2, 5, 11). However, MBA supervisors delegated custodial responsibility to their MBA material custodians (Ref. 11). Although Accountability was to provide MBAs with forms used for recording and reporting of material quantities (Ref. 11), there is no indication in the documentation reviewed that Accountability approved custodial procedures for material physically located in MBAs.

(b) Measurement. Application of special components of the measurement system was the function of the processing, quality control, analytical laboratory, and accounting personnel (Refs. 2, 3, 11). The nearest program NUMEC had to a measurement control program for accountability measurements was a scale and balance program covering scales and balances used for shipments and receipts and administered by the Quality Control Department (Refs. 2, 21).

(c) Accounting. The bookkeeping or accounting function was the responsibility of the Accountability Representative (Refs. 5, 7, 10, 11). In late 1962, it was NUMEC's intention to have their Accounting Department (financial) keep the central material accountability records (Ref. 17). While documentation dated in 1963 indicates that some effort was made to have (financial) Accounting keep the records (Refs. 17, 18), and NUMEC's 1964 License Renewal Application was written as if this were an accomplished fact (Ref. 2), no confirmation was found in the AEC-generated inspection and survey reports reviewed that this shift actually took place. Certainly by late 1965 (financial) Accounting was not keeping the central records: they were maintained by the SS Material Accountability Foreman, who reported to the Accountability Representative (Refs. 3, 19). NUMEC did not use an automated data processing system for accountability purposes prior to 1967 (Ref. 20). At that time it was used for inventory listings (Ref. 20). There was no indication in the documentation reviewed that accounting source data were audited. The findings of several AEC material control and accounting surveys suggest that if such auditing indeed were done, it was neither routine nor effective (Refs. 15, 18, 21).

(d) Auditing. In 1964, NUMEC did not provide for internal or external audits of its nuclear material control organization (Ref. 22). It was not until 1967 that NUMEC, in response to an AEC material control and accounting survey recommendation, started performing audits of the accountability and materials management function (Ref. 20). See paragraph 6.3.

1.1.2.3 Outside Support

Some outside support was necessary for NUMEC's normal routine operation.

(a) The documentation reviewed does not indicate that NUMEC engaged outside management consultants to assist in the development of procedures, nor does it indicate that private auditors were engaged prior to 1966 (Ref. 23). In 1966 NUMEC engaged Price-Waterhouse Company to observe the October inventory and the AEC verification of it (Ref. 23). The GAO also witnessed this inventory, which was the first since the November 1965 inventory, that established the magnitude of NUMEC's loss on the Westinghouse Astronuclear Laboratory (WANL) contract (Ref. 23).

(b) NUMEC's onsite measurement of isotopic content of uranium was by an emission (optical) spectrographic technique (Refs. 7, 15, 21). This was not a "means of performing precise measurements of isotopic content" (Ref. 18), so NUMEC engaged "the services of a qualified commercial laboratory to perform isotopic analyses for them on a sample charge basis, when the accuracy of the mass spectrometer is desirable" (Ref. 24).

Mass spectrometers were expensive (about $150,000 in 1968), and most licensees, including NUMEC, did not have one (Ref. 24).

1.2 Responsibilities and Authorities

The Plant Manager (i.e., General Manager) was responsible for establishing assignments for the control of special nuclear material at the staff level (Ref. 2). The Plant Manager was to designate Material Balance Areas upon recommendation of the Accountability Representative (Ref. 2). The MBA supervisors in turn would assign material control and accounting responsibilities to individuals reporting to them (Ref. 11). The documentation reviewed does not indicate whether there were any formal procedures for obtaining changes in assignments.

This section describes the assigned duties, responsibilities, and authority of organizational units responsible for the custody or control of special nuclear material. The Accountability Representative approved (in fact, signed) reports of material transfers and material status to the AEC (Ref. 2). Since selection of appropriate measurement methods, changes to inventory procedures, and disposition of inventory differences were responsibilities of the Production Manager (Ref. 11), it can be surmised that (in 1962, at least) the Accountabilty Representative did not have to approve MBA accounting procedures. It was not until 1968 that a NUMEC procedure manual stated that the Accountability Representative (then called Manager, Nuclear Materials Control Department) had approval responsibility for nuclear material control procedures (Refs. 2, 5, 6, 11, 25). Source data documents for the custody, measurement, control, and accounting of special nuclear material were generated by the MBA and vault custodians, Quality Control, and the analytical laboratories (Refs. 2, 3, 11).

1.2.1 Overall Program Management

Title 10, Part 70, Section 70.58(b)(1) was first published in 1974 (Ref. 4) so NUMEC was not subject to its provisions. However, AEC Manual Chapter 7401 (Source and Special Nuclear) did require that each AEC contractor appoint an SS material management representative who would "be responsible for implementing SS material inventory, measurement, record, and reporting procedures at the SS station and who will be the principal contact regarding those procedures" (Ref. 10). In NUMEC's case the designated representative was the Accountability Representative. Appendix B-IV contains a description of the duties of this position.

1.2.1.1 Functional Relationships

The Accountability Representative position was not "functionally separate from others having responsibilities for the custody and measurement of special nuclear material." While the documentation reviewed does not suggest that the Accountability Representative actually performed measurements or routinely handled material, it does indicate that he was responsible for the custody of nuclear material in nonprocess areas (such as storage vaults and shipping and receiving) and that he was responsible for accountability measurements (Refs. 2, 5, 7, 11).

1.2.1.2 Independence of Action

In the mid-1960s, NUMEC's organization did not ensure independence of action on the part of the Accountability Representative from the Production group (Refs. 2, 3, 5, 12). (See paragraph 1.1.2.2). Moreover, the accountability function was not independent of plant management functions: the Accountability Representative served at the pleasure of the General Manager (Refs. 2, 3).

1.2.2 Nuclear Material Control

Primary responsibility for the control of special nuclear material in NUMEC's possession lay with the Accountability Representative (Refs. 5, 8, 9). The documentation reviewed is not specific with regard to "authorizing, planning, coordinating, and administering;" however, the Accountability Representative surely was a key figure in these matters. By 1968, NUMEC's procedure manual spoke of the Manager of Nuclear Materials Control's (Accountability Representative) having "responsibility for the development, approval, and management of an overall system of nuclear materials control..." (Ref. 25). See Appendix B-IV for a position description for the Accountability Representative.

1.2.3 Accounting Management

The Accountability Representative was responsible for the maintenance of records, including central accounting records (Refs. 5, 7, 11). This does not mean that he always personally maintained the records. Certainly there were periods when the bookkeeping function was delegated to subordinates (Refs. 2, 3, 19, 44). See Appendix B-IV for a job description.

1.2.4 Special Nuclear Material Custodial Units

The physical units (MBAs) which contained special nuclear material were the responsibility of the respective MBA supervisors, or foremen (Refs. 2, 11). The Quality Control Manager was the supervisor of the Quality Control MBA (Ref. 2). NUMEC did not have Item Control Areas (ICAs); rather, they had storage vaults. These vaults were under the control of vault custodians, who were responsible to the Accountability Representative (Refs. 2, 3, 11).

1.2.5 Special Nuclear Material Custodians

The MBA supervisors delegated responsibility for the custody and control of special nuclear material in their MBAs to SS material custodians (Ref. 11). The duties of the custodians are listed in Appendix B-IV. Each MBA did not have a separate custodian: in some cases two MBAs had the same custodian (Ref. 26). The documentation does not indicate whether each MBA had a single custodian or not; presumably there were alternates since NUMEC worked multiple shifts and weekends (Ref. 11). For the storage vaults, the vault custodians, who worked for Accountability, had actual custody of the material (Refs. 2, 3, 11). However, since the vaults were not MBAs, and all material was assigned to one MBA or another, accountability for the material in the vaults resided with the MBAs that checked the material into vault storage (Refs. 2, 11). Each vault did not require a separate custodian (Ref. 26), and there were sufficiently many vault custodians to maintain coverage three shifts a day and seven days a week (Refs. 3, 11). It does not appear that the same individual was simultaneously a vault custodian and an MBA custodian. Since two MBAs could have the same custodian (Ref. 26), presumably the same individual could act as shipper and receiver on an internal transfer between MBAs.

1.2.6 Special Nuclear Material Control Technicians

The 1964 version of the SNM Control Technicians was a group reporting to the Accountability Representative called GPA, for General Plant-Physical Accountability (Refs. 2, 11, 12). This group was responsible for monitoring internal transfers (even signing the transfer document) and for "accountability surveillance of all operations involving SNM" (Ref. 2). See Appendix B-IV for a description of duties performed by GPA personnel.

1.2.7 Scrap Technician

NUMEC had no position similar to that of Scrap Technician. In 1964, the group organizationally responsible for burials was the Special Plant Services Group (Ref. 2). NUMEC buried its uranium wastes at its Parks Township site (Refs. 2, 27) and the records that were kept of burials were incomplete and were based on estimates, not measured values (Refs. 3, 27). See paragraph 7.5.5 for a more complete discussion of waste disposal at NUMEC.

1.2.8 Special Nuclear Material Control and Accounting Units

(a) NUMEC had no position similar to that of Special Nuclear Material Inventories Specialist. Physical inventories were the joint responsibility of Production and Accountability (Refs. 2, 11). It was not until at least 1966 that Accountability determined the schedule and procedures for inventories, and assumed the authority to determine when processing activities could restart (Refs. 2, 5, 11).

(b) NUMEC had no formal statistical programs for accountability purposes (Refs. 15, 44). Consequently, NUMEC had no position similar to that of Nuclear Materials Control Statistician and no routine program to determine the variability of measurement techniques utilized for the control of special nuclear material (Refs. 15, 28).

(c) NUMEC's Manager of Quality Control was not responsible for Production or the analytical laboratories (Ref. 2). He was responsible for the Quality Control Department and the Quality Control Laboratory (Ref. 2). The duties of the Quality Control Department included maintaining a scale and balance program (Ref. 2). Presumably this department also maintained the quality of intermediate and final product and released material through various points in the process on meeting certain predetermined standards. Since NUMEC had no formal measurement control program for accountability measurements (Refs. 2, 14, 15, 21), it seems unlikely that the Manager of Quality Control would have known when an accountability measurement system (other than possibly a scale or balance) was out of control, much less have curtailed the measurement process in such a situation. In 1964, the incumbent manager of Quality Control was a college graduate, and he had had at least two years of quality control experience (Refs. 2, 3).

(d) NUMEC had no position similar to that of Performance Analyst (Refs. 2, 5, 6). Moreover, NUMEC had no one responsible for evaluating the effectiveness of material control and accounting practices, at least prior to 1966. In 1966, at the AEC's urging, NUMEC initiated a program to improve the effectiveness of their material control and accounting system (Refs. 3, 29). In this case, the Accountability Representative was the person primarily responsible for evaluating the system's effectiveness and recommending improvements (Ref. 3).

1.2.9 Audits and Reviews

(a) Prior to 1967, NUMEC did not have a program providing for reviews and/or audits of the accountability program (Refs. 20,

22). As a result of an AEC materials management survey of NUMEC conducted in late 1966, the AEC recommended that NUMEC verify, through internal audits, that their accountability system was operating in accordance with written plans (Ref. 22). By the time of the next AEC material control survey in October 1967, NUMEC had initiated an internal audit program of the accountability function (Ref. 20).

(b) See 1.2.9 (a) above.

(c) Since NUMEC had no formal measurement control program (Refs. 2, 14, 15, 21) for accountability measurements, no one was responsible for reviewing its adequacy.

NUMEC's scale and balance program, which covered only a small fraction of their measurement systems, provided for periodic inspections and calibrations by an outside firm (Refs. 2, 15). However, such checks were narrow in scope and could not be considered reviews of the adequacy of the scale and balance program.

(d) See 1.2.9(c) above.

1.2.10 Delegation of Authority

There is no indication in the documentation reviewed that delegations of authority in the Accountability organization had to be in writing. The first NUMEC accountability manual containing an organization chart (the earliest Accountability organization chart found in the documentation) was dated March 30, 1966, and it showed positions only, not names (Ref. 5). The next NUMEC accountability manual found in the documentation was dated May 1, 1967, and it did contain an Accountability organization chart showing positions and names (Ref. 6).

1.3 Training Program

All NUMEC personnel were supposed to receive training or indoctrination in nuclear safety procedures, health and safety rules, fire prevention rules, and the security of classified matter (Ref. 2). However, there is no indication in the documentation reviewed that NUMEC maintained a training and qualification program for personnel involved in accountability functions. Indeed, on-the-job training seemed to be the customary practice (Ref. 3). The nearest program to a formal training program in accountability was a companywide educational program, begun in 1966 at the AEC's instigation, which aimed at stressing the high intrinsic and strategic value of special nuclear material and emphasizing the health and safety implications of careful handling practices (Refs. 22, 29).

1.3.1 Procedures

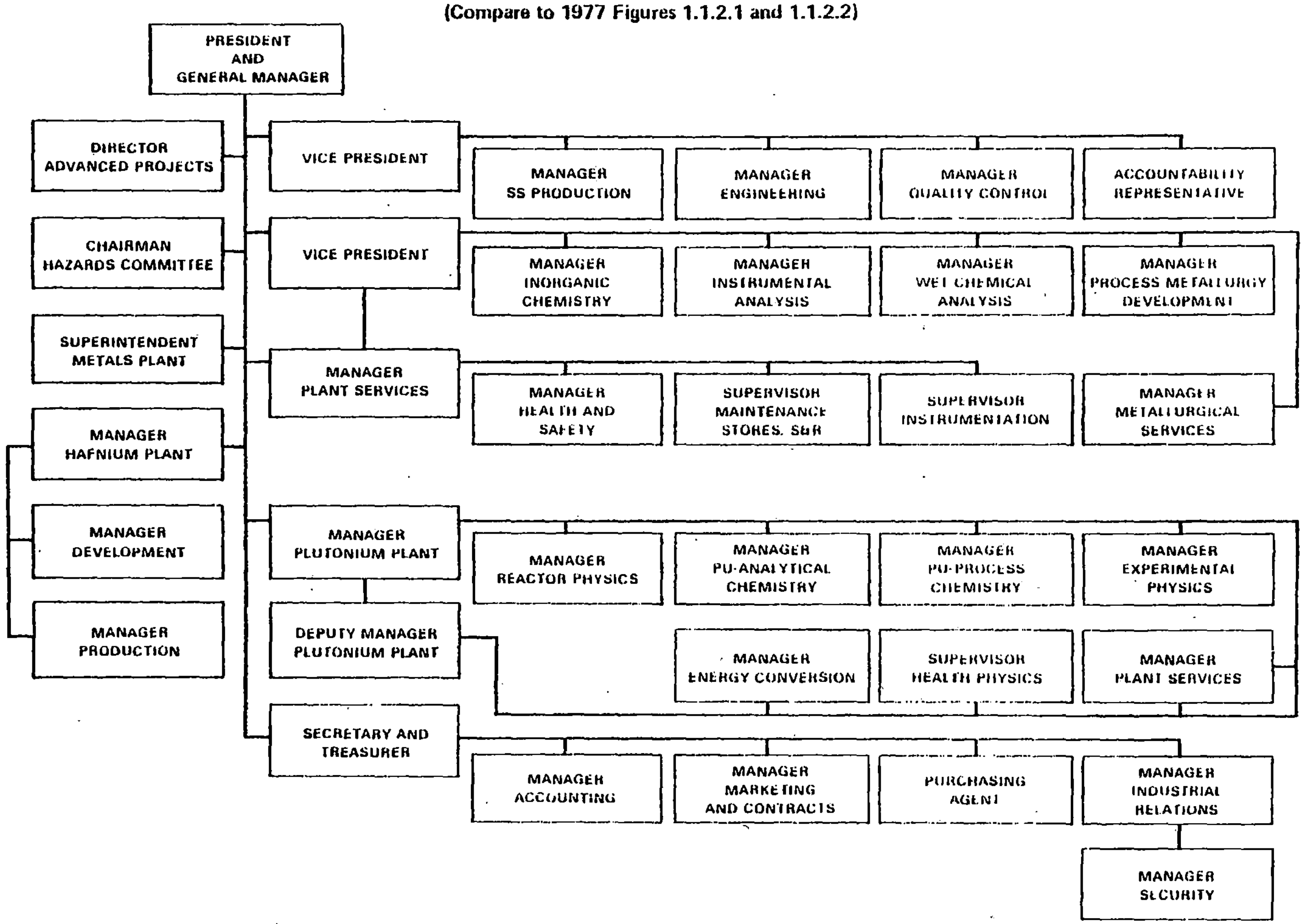
Does not apply. See paragraph 1.3.

1.3.2 Periodic Briefings

Does not apply. See paragraph 1.3.

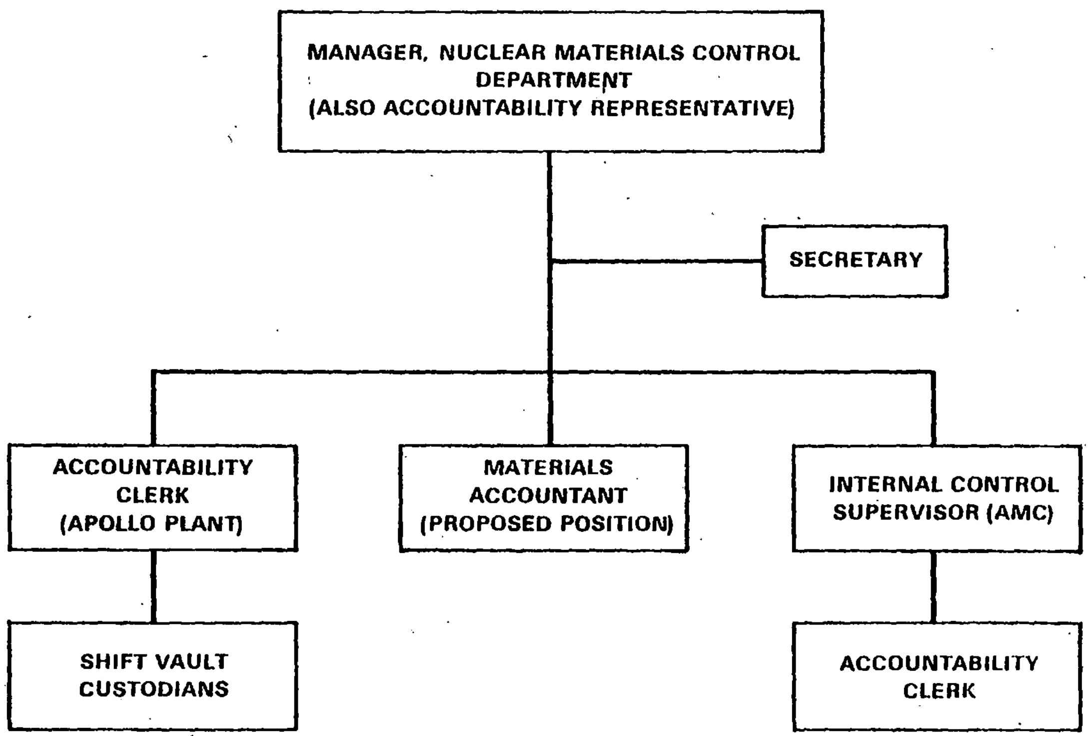
1.3.2.1 Does not apply. See paragraph 1.3.

(1964)
Figure 1.1.2.3
NUMEC Corporate Organization
(Compare to 1977 Figures 1.1.2.1 and 1.1.2.2)



SOURCE: REFERENCE 2

(1964)
Figure 1.1.2.5
NUMEC Accountability Organization
(Compare to 1977 Figure 1.1.2.4)



SOURCE: REFERENCE 5 (1966)

2.0 MATERIAL CONTROL AREAS

2.1 Identification of Control Areas

(1964)

2.1.1 Plant Areas

For accountability purposes, the NUMEC Apollo plant consisted of one plant in 1964. This one plant included the laboratories, the low enriched uranium conversion and scrap recovery operations, and the high enriched uranium operations (Ref. 2). Drawings L-1042 and L-1043 in Appendix B-I show the physical layout of the Apollo Facility (Ref. 2).

2.1.1.1 Plant I

The high enriched uranium operation was part of the total facility operation and was not considered a separate plant. In 1964, NUMEC did not conduct part of their high enriched uranium processing operation at their Parks Township (Leechburg) site (Ref. 2). However, incoming uranium-bearing scrap material awaiting recovery at the Apollo facility was stored at NUMEC's Advanced Materials Center located in Parks Township (Ref. 30). In addition, solid uranium-bearing waste materials generated at the Apollo site were buried at the Parks Township site (Ref. 27).

2.1.2 Internal Control Areas

Table 2.1.2 lists the MBAs that were in operation in 1964 and provides some additional information about them (Ref. 2).

Department	Designation	Usual Enrichments	Operation
Chemical Processing	CP-1	low	UF_6 conversion
Chemical Processing	CP-2	high	UF_6 conversion
Chemical Reprocessing	CRP-1	low	Scrap recovery
Chemical Reprocessing	CRP-2	high	Metal scrap recovery
Chemical Reprocessing	CRP-3	high	Oxide scrap recovery
Process Chemistry	PC-1	high	Liquid processes
Process Chemistry	PC-2	high	Metal coating
Process Chemistry	PC-3	high	Carbon coating
Ceramic Fabrication	CF-1	all	Pelletizing
Ceramic Fabrication	CF-2	all	Spherical particles
General Fabrication	GF-1	all	Tube loading
Processes Metallurgy	PM-1	all	Carbides and alloys
Quality Control	Q.C.	all	Inspection and testing

TABLE 2.1.2

NUMEC'S MBAs IN 1964 (Ref. 2)

In 1964, any functional organization unit at NUMEC could be designated an MBA (Ref. 2). Presumably, the MBA boundaries corresponded roughly to the perimeters of the working spaces occupied by the departments listed in Table 2.1.2. Drawings L-1042 and L-1043 in Appendix-B-I indicate the location of the departments listed above, except PM-1 (Ref. 2).

Neither the vaults nor the laboratories were MBAs (or ICAs) in 1964 (Refs. 2, 20, 22). As a result of a recommendation made by the AEC, both the Analytical Laboratory and the vaults controlled by Accountability (Nuclear Materials Control Department) became MBAs in 1967 (Ref. 20). Incoming uranium-bearing scrap for the Apollo recovery operation was stored at the Leechburg site (Ref. 30), and solid uranium-bearing scrap generated by the Apollo plant was buried at Leechburg (Ref. 27). Used but unrecovered uranium-bearing filters were stored on the mezzanine of the second floor of the Apollo plant overlooking the low enriched uranium operation and in an out- building on the Apollo site called the "Blue Building" (Refs. 27, 31).

Since neither laboratories nor vaults were MBAs (or ICAs) (Ref. 2), some SNM not in transit was not physically within any of the MBAs.

2.1.2.1 Process Boundaries

Appendix B-I describes NUMEC processes and operations in use in the mid-1960s for which sufficient information was found to warrant their inclusion in this report. The descriptions provided include the main material flows, and where information was available, the flow of material within and between Material Balance Areas.

2.1.2.2 Physical Boundaries

Figures L-1042 and L-1043 in Appendix B-I show locations of the various departments that were MBAs in 1964 (Ref. 2). From these figures, one can infer roughly what the physical boundaries of the MBAs were. However, it should be noted that in 1964 the criteria for MBA boundaries were not well defined: the regulation that requires MBAs and ICAs to be identifiable physical areas was not yet published (Ref. 4).

2.1.2.3 Selection Criteria

Any functional organizational unit at NUMEC having a supervisor could be designated as an MBA (Ref. 2). Designation was to be made by the Plant Manager (General Manager) upon recommendation by the Accountability Representative (Ref. 2). However, the MBAs did generally correspond to a discrete processing step or series of steps, but not to storage areas (Ref. 2).

While NUMEC was capable of quality measurements in the mid-1960s, it appears that they did not exercise this capability for measurements of material transferred between process steps (Ref. 15). NUMEC's analytical measurement facilities and techniques were rated very

good by the AEC in 1962 (Ref. 21); however, the AEC also observed at that time that intermediate process materials were not measured carefully (Ref. 21). The AEC observed in 1965 that "intraplant flows receive the minimum of measurement needed for production purposes." (Ref. 15).

LICENSE CONDITIONS

2.2 Facility Operation

2.1 The AEC first published requirements for licensees to submit full descriptions of their procedures to control and account for SNM in 1967 (Ref. 30). These descriptions (plans) were to identify the "fundamental material controls" which the licensee considered essential for adequately safeguarding SNM in his possession (Ref. 30). Upon review of the plan, the AEC would determine what additional conditions should be incorporated in the license pursuant to 10 CFR 70.32(c) (Ref. 30). Apparently in response to this new requirement, which amended 10 CFR 70.51, NUMEC submitted new procedure manuals to the AEC in 1967 and 1968 (Refs. 6, 25).

2.2 Not applicable in 1964.

2.3 Not applicable in 1964.

2.4 In 1964, NUMEC did not recover or have recovered offsite, on a current basis, scrap generated at NUMEC (Refs. 15, 18, 21, 22, 29). Indeed, even for scrap sent by others to NUMEC for recovery, NUMEC retained unrecovered residues (dissolver solutions) indefinitely (Ref. 37).

3.0 MEASUREMENTS

3.1 General Description

(1964)

3.1.1 Measurement Points

The measurement points for some processes are identified in Appendix B-I. The documentation reviewed which was dated prior to 1968 contained little detailed information on measurement points. The report of the AEC survey conducted in April and May, 1965, recommended that "NUMEC revise their procedures manual so that it will completely and accurately portray current SS material safeguards procedures. . . . The procedures named should set forth . . . SS material flows and points of measurement, analytical methods, . . ." (Ref. 15).

However, the revised procedures manual, which was dated March 30, 1966, (Reference 5), did not describe SS material flows, points of measurement, or analytical methods. NUMEC's 1967 Procedures Manual, (Reference 6), did describe analytical methods, but not material flows or measurement points.

NUMEC's 1968 accountability manual, (Reference 25), contains a much greater level of detail concerning most of NUMEC's process than did earlier documentation which was reviewed. This manual apparently was written to comply with 10 CFR 70.51, amended in Feb. 1967, to require, among other things, that licensees submit to the AEC a full description of their procedures for controlling SNM in process (Ref. 32).

3.1.2 Materials and Measurements

Figure 5.1.4, (1964), which formed part of NUMEC's 1964 License Renewal Application, lists the types of materials NUMEC received in 1964, and the uses they made, or proposed to make, of these materials at that time.

3.1.2.1 Measurements of uranium and uranium-235 content were generally performed to establish the special nuclear material content of shipments (Refs. 15, 33). However, NUMEC did not always make independent analyses of incoming material, particularly uranium hexafluoride (UF_6) received from the AEC (Refs. 3, 5). Accountability measurements were not made of waste discards prior to 1966 (Refs. 5, 22, 29). Large portions of NUMEC's inventory values were based on estimates or shipper's values which had not been independently verified by NUMEC (Refs. 21, 37). (For one inventory in 1962, based on total uranium content, only 50% of the material was listed using NUMEC measured values, 20% was estimated and 30% was listed on shipper's values (Refs. 21, 37)). Internal transfers received the minimum of measurement necessary for production purposes, often only

an NDA determination of uranium content based partially on an estimated uranium-235 assay (Ref. 15).

3.1.2.1.1 In addition to several categories of materials mentioned in 3.1.2.1 which were not measured, NUMEC did not perform measurements on:

1) Samples intended for analysis or testing (Refs. 2, 5, 11, 21; see also Appendix B-I).

2) Filters. The fact that NUMEC did not measure their filters was reported by four AEC materials management survey teams that visited NUMEC between 1962 and 1966 (Refs. 15, 21, 22, 29). Generally the filters were not carried on the inventory listing (Refs. 15, 22), and the records of them that did exist were usually based on estimates (Ref. 3). These statements apply both to used filters in storage and filters still in use (Ref. 29).

3.1.2.1.2 Solid noncombustible wastes, such as pipes and old equipment, were, after removal of gross contamination, disposed of by burial (Ref. 2). However, scrap and waste materials unsuitable for chemical assay were not, in general, measured by NUMEC (Refs. 15, 21, 29).

3.1.2.1.3 Gaseous effluents were not measured for elemental or isotopic content (Refs. 19, 27, 37). NUMEC occasionally monitored its gaseous effluents for health and safety reasons, but no effluent data were entered in the accountability records (Refs. 19, 29, 34). NUMEC's monitoring program was minimal: as late as 1966, NUMEC said that they monitored each of their 120 or so stacks (Ref. 29) once every three months for four hours (Ref. 35).

3.1.2.1.4 The only measurements that were made of liquid effluents were to determine the concentration (μC/ml) of liquid in the holding tanks to be sure it did not exceed allowable limits for discharge to the nearby Kiskiminetas River (Ref. 36). In particular, accountability measurements were not made of liquid effluents, and the discharges were not reflected in the accountability records (Ref. 29, 34).

3.1.2.2 NUMEC had a nondestructive assay capability (gamma spectrometry) at least as early as 1962 (Refs. 30, 37); however, they did not routinely use this capability for accountability purposes (Refs. 15, 21, 22, 29). When this capability was used (e.g., for internal transfers), the uranium element content was often based on estimates, not measurements, of isotopic content (Ref. 15).

3.1.2.3 In 1964, NUMEC did not have a "dry" scrap recovery process (Ref. 2), so they did not produce UF_6 for shipment back to the AEC. The end product of their scrap recovery operation would have been one of the following: uranyl nitrate solution, uranyl nitrate hexahydrate, ammonium diurnate, or uranuim oxide (Ref. 2).

3.2 Mass Measurement

In 1964 NUMEC did not have any program comparable to a measurement control program currently required for licensees by 10 CFR 70.57 (Refs. 2, 14). The nearest program NUMEC had to a measurement control program for accountability measurements was a scale and balance program administered by Quality Control (Ref. 2). Under this program scales and balances used for receiving and shipping were calibrated and maintained by an outside firm (Ref. 21), which made quarterly scale checks (Refs. 2, 15).

3.2.1 Samples

The documentation reviewed was not clear with respect to which, if any, samples were weighed for accountability purposes. Apparently process control samples were not routinely weighed: the AEC described NUMEC's procedures for the transfer of their samples to be "informal" (Ref. 21). Except for retainer and referee samples required by contract terms and transferred to Quality Control or the Production Service Department, internal transfer forms were not required (Ref. 2). None of the accountability scales at NUMEC in 1962 (Ref. 11), 1964 (Ref. 2), or 1966 (Ref. 5) was located in the analytical laboratories. Unless the analytical laboratory samples were weighed on the vault scales (none of the documentation reviewed indicates they were), it appears that the samples for the analytical laboratory were not weighed for accountability purposes. It should be noted that the analytical laboratories first became an MBA in 1967 (Ref. 20).

3.2.2 Low Enriched UF_6

In 1964, NUMEC had a 1,000 lb capacity Detecto scale used in the low enriched receiving area (Ref. 2). Its sensitivity was not given in Reference 2.

In 1966, NUMEC had a Sauter scale, capacity 50 kg, sensitivity 20 g, which was located in the CP-1/CRP-1 area and was used to weigh low enriched materials (Ref. 5).

3.2.3 Solid Low Enriched Scrap and Recycle

In 1964, NUMEC had a 30 kg capacity Sauter scale which was used for vault transfers, in-process storage, and shipping (Ref. 2). They also had a 4.5 kg capacity Sauter scale for the same uses (see 3.2.4). In 1964, the Chemical Reprocessing Area also had a 30 kg capacity Sauter scale (Ref. 2). It may have been used for high or low enriched dissolver solutions, or for both. Reference 2 did give the sensitivity of either scale.

In 1966, NUMEC had a Sauter scale with a 30 kg capacity and 5 g sensitivity located in the H-vault working area which was used for internal transfers and for shipments of low enriched UO_2 products (Ref. 5).

3.2.4 UNH Solutions

In 1964, NUMEC had a 4.5 kg capacity Sauter scale used for vault transfers, in-process storage, and shipping (Ref. 2). Reference 2 did not give its sensitivity.

In 1966, NUMEC had a Howe scale, with capacity of 5 kg and sensitivity of one gram. It was located in the vault office and was used for scrap receipts, internal transfers and shipments of UNH crystals (Ref. 5).

3.2.5 High Enriched UF_6

In 1964, NUMEC had a 60 kg capacity Sauter scale used in the high enriched receiving area (Ref. 2). Reference 2 did not give its sensitivity. It appears that NUMEC used this scale for measuring high enriched UF_6 receipts (Ref. 2).

In 1966, NUMEC had a 60 kg capacity Sauter scale with a sensitivity of 10 grams (Ref. 5). It was located in area CP-2/CRP-2 (high enriched) and it was used for UF_6 cylinders and dissolver solutions (Ref. 5).

3.2.6 Solid High Enriched Scrap and Recycle

It appears that in 1964 NUMEC used the 4.5 kg capacity Sauter scale (used for weighing vault transfers and in-process storage (See 3.2.4)) for weighing high enriched scrap and recycle (Ref. 2).

In 1966, the 5 kg capacity Howe scale located in the vault office (see 3.2.4) was used for weighing scrap receipts and shipments of UNH crystals (Ref. 5).

3.2.7 Uranium Solutions

The documentation reviewed does not indicate which of NUMEC's scales were used in 1964, or in 1966, for the measurement of high enriched uranium solutions contained in 10 liter polyethylene bottles.

3.3 Volume Measurements

The nearest program NUMEC had in 1964 to a measurement control program was a scale and balance program, and volume calibration and measurements did not fall under it (Refs. 2, 14, 21). Solution tanks were calibrated on the basis of actual or nominal fabrication dimensions and the calibration marks frequently were as much as ten to twelve inches apart (Ref. 21).

3.3.1 Uranyl Nitrate

Weight measurements were used by NUMEC, at least in 1962 and 1968, to determine the amount of uranyl nitrate resulting from scrap recovery (Refs. 25, 30). The documentation reviewed does not suggest that NUMEC changed from weight to volume measurements during the intervening years.

3.3.2 Raffinate, Condensate and Filtrate Discards

Liquid waste discards were measured by volume rather than weight, with the normal discard quantity being the volume of the tank (Ref. 5). In early 1966, the normal discard quantities were 11 gallons for high enriched condensates and raffinates, 40 gallons for low enriched raffinates, and 120 gallons for low enriched condensates (Ref. 5).

3.3.3 Incinerator Scrubber

Reference 2 said that incinerator scrubber water was to be sampled every hour for uranium concentration; however, this reference gave no indication that the volume of scrubber discharge was measured. It appears that the scrubber discharge was routed to treatment tanks for eventual discharge to the river with no separate volume measurement being made (Ref. 2).

3.4 Sampling Systems

The documentation reviewed provides few details concerning the sampling systems used by NUMEC in 1964. However, NUMEC's 1968 Procedure Manual (Ref. 25) contains some specific information on sampling UF_6 and low enriched UO_2 powder. This information is contained in 3.4.1 and 3.4.2. Paragraphs 3.4.3 to 3.4.6, while not directly comparable to their counterparts in Reference 1, do give some additional details on sampling done by NUMEC in the mid-1960s.

3.4.1 UF_6 (High and Low Enriched)

NUMEC did not generally make independent elemental and isotopic measurements on incoming UF_6 (Refs. 3, 5). Hence they had no sampling procedure for UF_6 (Ref. 25).

3.4.2 UO_2 Powder-Low Enriched

Two bottles selected randomly from a blend of 118 bottles (max. 18 kg/bottle) were each shell blended and sampled for uranium, U-235, and specification analysis (Ref. 25).

3.4.3 UO_2.BeO Dissolver Solutions

Reference 38, a letter from the AEC to NUMEC dated Dec. 15, 1963, contained the following AEC observations regarding NUMEC's sampling procedures for UO_2.BeO dissolver solutions:

"UO_2.BeO dissolver solutions at NUMEC are combined, for purposes of sampling, in batches of about 35-40 liters. This volume in a 5" I.D. column is air sparged to ensure proper mixing and is then drawn off into three 5" I.D. bottles for weighing. During the "drawing off" process a portion of each bottle is taken as a sample; these are combined to give one 500 ml sample for each 35-40 liter batch."

"The data clearly show that NUMEC's air sparge is not adequate to keep suspended solid matter in uniform suspension. Not only is there a definite settling out, but Batch 1, which stood for about 30 hours before sampling, shows twice as much settling."

"The data do show a fairly linear relationship between percent solids and vertical height up the column. Thus, NUMEC's practice of taking a portion of the sample from top, middle, and bottom is a definite improvement over taking just one sample" (Ref. 38).

3.4.4 Liquid Waste Effluent

Reference 29, an AEC report dated April 6, 1966, contains the following information about NUMEC's sampling procedures for liquid waste effluents prior to 1966:

"The survey team noted that samples of liquid waste effluent consistently have a pH of 9-11, and usually are cloudy. Samples are taken at a point approximately 10-20% of the vertical height from the true tank bottom. These factors led the survey team to surmise that actual liquid waste concentrations may even be somewhat greater than calculated" (Ref. 29).

It should be noted that NUMEC took samples of liquid waste effluents for health and safety reasons and that accountability measurements of these discharges were not made prior to 1966 (Ref. 39).

3.4.5 Carbon Coated UC_2 Particles

Reference 29 also contained the following information on NUMEC's sampling procedure for carbon coated UC_2 particles produced by NUMEC for the Westinghouse Astronuclear Laboratory (WANL):

"We investigated the possibility that measurements of carbon coated UC_2 prepared and delivered by NUMEC to WANL for NERVA fuel elements might be biased."

"NUMEC took grab samples for each batch for uranium analysis. This could possibly lead to a sample richer in uranium than the parent batch.* On a series of seventy-five batches, however, the average NUMEC analysis was 0.6657 g U/g sample, while the average WANL analysis (on their own samples) was 0.6643 g U/g sample. These two averages are not statistically different, but even if it is assumed that the difference is due to biased NUMEC samples, the magnitude of the bias is only 0.2%" (Ref. 29).

3.4.6 Batch Sampling - Scrap Reprocessing

NUMEC's 1962 Scrap Reprocessing Manual (Ref. 30) described how NUMEC sampled batches of material after dissolution in the scrap recovery operation:

"Mixing is accomplished by means of an air sparge for about 45 minutes. After mixing, the solution is drained into tared 3 gallon, 5-inch diameter, polyethylene bottles. This procedure allows for 500 ml sample to be taken from solution at the bottom, middle and top of the column."

...

". . . thus samples are taken at three different equivalent heights in the mixing column. Since the 5" diameter columns have a unit volume of approximately 1 gal/foot, the samples are taken at the 3 foot, 6 foot and 9 foot level after mixing the batch and combined as a representative sample of the solution batch. These batch samples are transferred, together with NUMEC Form CRP-2-J, to the Analytical Laboratory for the preparation of the assay composites.

Based on the weights reported on CRP-2-J, the batch samples are composited on a weight basis to prepare an assay composite" (Ref. 30).

*Qualitatively, the thickness of the carbon coating on a particle is constant, regardless of particle size. This means that the average uranium concentration is greater in large particles than in small ones. Like all mixtures of particles (sand, for example) the finer particles tend to settle to the bottom. Thus, a grab sample from the top of a container may be rich in large particles, and correspondingly rich in uranium. (Ref. 29).

3.5 Analytical Measurements

NUMEC's 1964 License Renewal Application (Ref. 2) stated NUMEC wished to be licensed to perform, among others, the following types of analytical measurements: gravimetric, volumetric, titrimetric, spectrophotometric, spectrographic and x-ray diffraction. This document did not describe how NUMEC performed these measurements. However, NUMEC's 1967 Procedure Manual (Reference 6) did describe how some of these analyses were performed and also how some other analytical measurements were made. Presumably, it may be assumed that NUMEC's procedure for the gravimetric and titrimetric analyses did not change measurably from 1964 to 1967. The following descriptions are based on information in the 1967 Procedure Manual:

3.5.1 "Gravimetric Determination of U in UO_2, U_3O_8, UNH, or other nominally pure compounds

An accurately weighed sample of about five grams is fired for a minimum of four hours at 900° C, and the uranium is calculated from the weight loss or gain. In the case of UNH, the sample is placed in a cold furnace which is then heated in steps to 900° C. If necessary, a correction for impurities is made based on a spectrographic analysis" (Ref. 6).

3.5.2 "Titrimetric determination of U in scrap dissolver solutions

AL $(NO_3)_3$ is added to the dissolver solution and a quadruple extraction made with 15% TBP. The U is back extracted from the TBP by a quadruple extraction of 5% H_2SO_4 and the solution evaporated to dryness.

Following redissolution with HNO_3 the U is precipitated with NH_4OH. The ammonium diuranate is filtered off, and ignited at 900 degrees C overnight. The U_3O_8 from the diuranate ignition is dissolved in HNO_3, fused with H_2SO_4, diluted and placed in a Hg cathode electrolytic cell for two hours. This solution is passed through a Jones Reducter and aerated to oxidize U (III) to U (IV). An excess of ferric chloride is added, and the U concentration is determined by titrating the Fe (II) formed in the oxidation of U (IV) and U (VI). The titrant is potassium dichromate and the indicator is ferroin (Ref. 6).

The aqueous wastes from the TBP extraction and the diuranate precipitation are combined and the U concentration determined by gamma ray spectrometry or x-ray fluorescence. The U found is added to the total U determined in a titration procedure" (Ref. 6).

a. Titrimetric determination of U in Solid Samples - A weighed sample is dissolved in HNO_3 and fumed with H_2SO_4, or, if necessary, with $Na_2S_2O_7$. The sample is passed through a Jones Reducter, and titrated as described...above (Ref. 6).

b. Titrimetric determination of U in the presence of Niobium - An accurately weighed sample of about 0.5 grams is fused with Na_2SO_4 and dissolved in dilute H_2SO_4. The U (VI) is reduced to U (IV) with chromous acid, and excess Cr (II) and U (III) are destroyed by aeration. An excess of ferric chloride is added, and the U concentration is determined by titration as ...above (Ref. 6).

3.5.3 "X-ray Fluorescence determination of U, combined with Gamma Spectrometric determination of U-235

This combination procedure is used to estimate the U concentration and enrichment of a variety of materials. The results are considered accurate to ±15% relative. A 0.1 ml sample is exposed to X-rays, and the U concentration is determined from the uranium fluorescence. The natural decay gamma rays of 184 kev are determined on a separate 50 ml sample. After corrections for system background and high energy gamma errors, this gamma count rate is converted to U-235 concentration by reference to comparative standards on a standard curve. Enrichment is estimated by the ratio $\frac{\text{U-235 (100)}}{\text{U}}$" (Ref. 6).

3.5.4 "Colorimetric determination of U in very dilute solutions (1-100 ppm)

Uranium is extracted from an acid solution of raffinate or other waste with a 2% solution of TOPO in cyclohexane. Dibenzoylmethane and pyridine are added to the TOPO extract to develop a yellow color. Color intensity is determined with a Beckman Model B spectrophotometer, and U concentration is determined from a standardization curve. This method is the "official" analysis of process wastes to be discarded, but results are verified by gamma spectrometry" (Ref 6).

Note that prior to 1966, NUMEC did not perform accountability measurements on process wastes to be discarded (Ref. 39).

3.6 Nondestructive Assay Measurements

3.6.1 Gamma Counter Solids

NUMEC had a single channel gamma ray spectrometer at least as early as 1962 (Refs. 30, 37). One of the uses of this instrument was to confirm previous NUMEC analyses (to ± 5% or so) as part of an AEC inventory verification (Ref. 37). However, NUMEC did not routinely use the gamma counter for accountability measurements (Refs. 15, 21, 22, 29).

3.6.2 Gamma Counter Liquids

The measurement of traces of uranium in plant effluents (such as incinerator scrubber water (Ref. 2)) was made by either X-ray

fluoresence measurements using the Norelco X-ray spectrometer or gamma ray spectroscopy using a single channel gamma ray spectrometer (Ref. 30). The choice between the two methods depended on the enrichment involved. For enrichments greater than 2%, the gamma ray spectrometer was used but cross checks were to be routinely performed on both instruments as assurance checks (Ref. 30).

It should be noted that NUMEC did not routinely use the gamma counter for accountability measurements (Refs. 15, 21, 22, 29).

3.6.3 Isotopic Source Assay System (ISAS)

NUMEC neither had nor proposed to use an Isotopic Source Assay System in 1964 (Ref. 2).

3.6.4 Segmented Gamma Scanner (SGS)

NUMEC neither had nor proposed to use a Segmented Gamma Scanner in 1964 (Ref. 2). This instrument did not become available commercially until the mid-1970s.

3.7 Measurement Uncertainties

A statistical program to determine measurement uncertainties for accountability measurements was not a requirement in 1964, and NUMEC did not maintain such a program on their own initiative (Ref. 15). The report of the AEC survey of NUMEC in April and May 1965 stated, "No formal statistical programs are maintained by NUMEC for accountability purposes" (Ref. 15).

Therefore, data reflecting NUMEC's measurement uncertainties in 1964 apparently were not calculated, nor could they have been. Consequently, no meaningful 1964 comparison can be made with the data in Table 3.7.3 (taken from Reference 1).[1] (Two other similar 1977 tables for low enriched uranium are not included in this part since their inclusion would make no additional safeguards point.)

TABLE 3.7.3

TYPICAL LIMITS OF ERROR
HIGH ENRICHED URANIUM OPERATIONS (CONVERSION & SCRAP RECOVERY)

In 1964, a measurement control program adequate to permit computation of data comparable to that in Table 3.7.3 of Reference 1 was neither required by the AEC nor maintained by NUMEC (Refs. 4, 15, 18, 19, 21, 29, 44). Therefore, it is unlikely that data for 1964 similar to that in Table 3.7.3 of Reference 1 exist.

[1]Table 3.7.3 is proprietary and is not included in this nonproprietary version of NUREG-0627, Appendix B.

(1964)

FIGURE 5.1.4
TYPICAL MATERIAL TYPES AND USES[1]

DESCRIPTION OF MATERIAL		USE AT NUMEC	INVENTORY AS URANIUM	ANNUAL REQUIREMENTS
Chemical or Physical Nature	Enrichment Wt. % U-235			
UF_6	>5	Conversion to UO_2 and all intermediates (UO_2F_2, $(NH_4)_2U_2O_7$, UO_3, U_3O_8) including fabrication of ceramic fuel shapes as pure oxide and mixed oxide.	500 kg	Unlimited
UF_6	<5	Conversion to UO_2 and all intermediates (UO_2F_2, $(NH_4)_2U_2O_7$, UO_3, U_3O_8) including fabrication of ceramic fuel shapes as pure oxide and mixed oxide.	30,000 kg	Unlimited
UF_6	>5	Conversion to UF_4, uranium metal, and metal alloys.	500 kg	Unlimited
UF_6	<5	Conversion to UF_4, uranium metal, and metal alloys.	50,000 kg	Unlimited
UF_6	>5	Conversion to UC, UC_2 including fabrication into fuel elements.	500 kg	Unlimited
UF_6	<5	Conversion to UC, UC_2 including fabrication into fuel elements.	30,000 kg	Unlimited
Scrap	>5	Recovery of uranium as $UO_2(NO_3)_2$ soln., $UO_2(NO_3)_2 \cdot 6\,H_2O$, $(NH_4)_2U_2O_7$, UO_3, U_3O_8, UO_2.	500 kg	Unlimited
Scrap	<5	Recovery of uranium as $UO_2(NO_3)_2$ soln., $UO_2(NO_3)_2 \cdot 6\,H_2O$, $(NH_4)_2U_2O_7$, UO_3, U_3O_8, UO_2.	5,000 kg	Unlimited
UF_6	All Enrichments	R & D	100 kg	500 kg

[1] Source: Reference 2.

Detailed information comparable to that in Figure 5.1.4 of Reference 1 was not required by the AEC in 1964, and it did not appear in the documentation reviewed.

Figure 5.1.4 of this reconstruction of NUMEC's circa 1964 material control and accounting program shows, in a somewhat different format, the types of materials for which NUMEC wished to be licensed in 1964 and the uses NUMEC proposed for them. This table formed part of NUMEC's 1964 License Renewal Application, Reference 2. While this table does not contain exactly the same information as Figure 5.1.4 of the 1977 plan, it does summarize the actual or expected extent of the NUMEC operation in 1964. (Seven other figures similar to Figure 5.1.4 of Reference 1 were not included in this report since their inclusion would make no additional safeguards point.)

LICENSE CONDITIONS

3.8 Measurements

3.1 Numec would not have met this license condition. Many of NUMEC's values at inventory time were based on estimates, not measurements (Refs. 21, 37). Moreover, the nearest program NUMEC had to a measurement control program covered only some of their scales and balances, and NUMEC had no statistics program for accountability purposes (Refs. 2, 15). Therefore, even if NUMEC had based inventory values on measurements, they could not have determined whether the measurements were accurate to 0.5% or not.

4.0 MEASUREMENT CONTROL PROGRAM

(1964)

The nearest program NUMEC had to a measurement control program for accountability measurements was a scale and balance program administered by the Quality Control Department (Refs. 2, 3). This program was to provide for periodic (approximately biweekly) checks by Quality Control of all scales used in determination of SS-material quantities (Ref. 2). Scales were to be checked at 0, 1/4, 1/2, 3/4 and full capacity for accuracy and sensitivity (Ref. 2). Results were to be recorded and a copy submitted to the area supervisor (Ref. 2). In addition, a contract was to be arranged with an outside firm that would provide for quarterly scale checks and scale maintenance (Ref. 2).

Several AEC materials management survey reports commented on NUMEC's scale and balance program. The 1961 survey found that NUMEC did not have a scale and balance program in effect before the survey was made; however, "the program was inaugurated by NUMEC during the survey," and put under the supervision of the Production Manager (Ref. 44). The 1962 survey found that the scales and balances used for shipping and receiving were calibrated and maintained by an outside firm which inspected the scales every three months (Ref. 21). The same survey found that intermediate process materials were not weighed as carefully and that, in some cases, nominal or target weights, rather than actual weights, were recorded (Ref. 21). The 1963 survey found that high quality scales had been installed since the last survey and that the program of maintenance, test weighing, and calibration appeared adequate (Ref. 18). Guidance for the program was provided by the Quality Control Department (Ref. 18). The April 1965, survey originally rejected NUMEC's (physical) inventory because AEC check-weighings of a statistical sample of items previously weighed by NUMEC produced an unusually large number of rejects (Ref. 15). The AEC considered this phenomenon "an illustration of the fact that NUMEC weighs product and high grade material on scales which have a higher precision than the scales which are used to weigh materials in the process areas" (Ref. 15). The 1966 survey found NUMEC's weighing equipment to be of an acceptable quality and maintained in an acceptable manner (Ref. 22).

Based on the documentation reviewed, it does not appear that NUMEC had a formal measurement control program for any accountability measurements other than for the scales and balances used for shipping and receiving (Refs. 15, 18). It also appears that this limited program would not have been in compliance with the requirements currently set forth in 10 CFR 70.57.

4.1 As indicated in paragraph 4.0 the nearest program NUMEC had to a measurement control program was a scale and balance program which emphasized weighing instruments used for shipments and receipts (Refs. 2, 15, 18). In particular, it does not appear that a formal measurement control program was maintained for other accounting measurement systems.

4.1.1 The scales and balances included in NUMEC's program were to be checked at 0, 1/4, 1/2, 3/4, and full capacity; i.e., at five points over the range of operation (Ref. 2).

4.1.1.1 Paragraph 3.6.2 explained how trace analyses were to be performed in 1962 by X-ray or gamma-ray spectrometers. NUMEC indicated that "a regular program of standard sample measurements are made during each shift on both instruments." (Ref. 30). It is unlikely that this program, as implemented, contained the features mentioned in the 1978 license condition. In any event, NDA measurements were not routinely used by NUMEC for accountability purposes (Refs. 15, 21, 22, 29), so the question is somewhat academic.

4.1.2 Reference 2 indicated that the scales and balances were to be checked on approximately a biweekly, not semiweekly, basis. Thus the 1978 license condition (opposite) would require approximately four times as many measurements of standards as NUMEC said they required in 1964.

4.1.3 The purpose of a program of replicate sampling is to determine the random error associated with a measurement system. Since NUMEC had no formal statistical programs for accountability measurements (Refs. 15, 44) it is very unlikely that they performed replicate measurements as part of any formal program.

4.2 Since NUMEC had no formal statistical program for accountability purposes (Refs. 15, 44) it can reasonably be concluded that they did not determine the biases, systematic errors and random errors associated with their sampling and measurement systems. Nor could they have determined LEMUF (Refs. 15, 44).

4.3 The statement in 4.2 applies here also.

4.4 Presumably the data generated by the scale and balance program was used to monitor and control the measurement performance of scales and balances.

4.5 Responsibility for the scale and balance program in 1964 resided with the Quality Control Department (Ref. 2). However, there is no indication in the documentation reviewed that the program was reviewed by the Quality Control Manager, the Accountability Representative, or anyone else. It should be noted, however, that periodic checks and/or calibrations were made by an outside firm (Refs. 2, 3, 15). While not formal reviews, these periodic independent checks presumably improved the quality of weight measurements somewhat.

4.6 NUMEC had no formal statistical program (Refs. 15, 44) so could not have calculated limits of error.

4.7 NUMEC's solution tanks were calibrated on the basis of actual or nominal fabrication dimensions and the calibration marks frequently were as much as ten to twelve inches apart (Ref. 21).

5.0 PHYSICAL INVENTORY

5.1 General Description

(1964)

5.1.1 Basic Approach

5.1.1.1 General

The notes of an AEC materials management survey team, prepared for their June 1962, closeout meeting with NUMEC management, address NUMEC's policies and procedures regarding physical inventories:

"Physical Inventories:

The last inventory of Station material by NUMEC was 14 months ago; of leased material it was when (?). Thus personnel are inexperienced in taking a good physical inventory. We recommend a periodic inventory be taken. Suggest every 3 or 6 months be considered.

NUMEC should campaign to clean up the residues, filters, solutions, scrap, etc. - dead inventory, to get it in a measurable form or return it to the AEC for credit. This would result in better utilization of material. (Plant should not be in operation during inventory. About 20% of the inventory is now on estimates.) 3% of the items checked for inventory verification did not stand up to verification. Items (in process) placed in the vault should be weighed more carefully for inventory verification during inventory. Also any material removed from a container in the vault should be noted on the container label and on the vault record" (Ref. 37)

NUMEC was not subject to the requirements of 10 CFR 70.51(e)(3) in 1964 (Ref. 45). The first regulatory requirements regarding physical inventories were published in 10 CFR 70.51 in 1967 (Ref. 32). Among other things, they required licensees to perform annual physical inventories and to submit to the AEC a full description of the licensee's physical inventory procedures (Ref. 32). Apparently in response to the new provisions of §70.51, NUMEC submitted a new accountability manual, Reference 6, to the AEC in May of 1967.

As indicated in 1.1.2.1 (f), inventory planning was the joint responsibility of the Accountability and Production Departments (Refs. 2, 11), and inventory procedures were the province of the Production Manager (Ref. 11). By 1966 the Accountability Representative (then also called the Manager, Nuclear Materials Control Department (Ref. 5)) was the "inventory coordinator," and apparently the individual with overall responsibility for physical inventories (Ref. 47).

5.1.1.2 Procedures

The procedures described in paragraph 5.1.1.2 of Reference 1 generally are in response to specific requirements currently part of 10 CFR 70.51 (Ref. 45). In addition to requiring the licensee to establish detailed physical inventory procedures, the 1973 amendments to 10 CFR 70.51 required him to submit a full description of the program he proposed to use to comply with the physical inventory procedure requirements of 10 CFR 70.51 (Ref 45).

From the documentation reviewed, it appears that the AEC did not, prior to the revision of 10 CFR 70.51 in February 1967, require NUMEC to submit to the AEC a written description of their physical inventory procedures for review (Refs. 22, 32, 48). Nonetheless, NUMEC's 1962 Accountability Department Procedures Manual (Ref. 11) contained a list of inventory procedures. The 1962 manual summarized the physical inventory procedures for their (nominal but not actual-see 5.1.1.1) annual physical inventory this way:

"Inventory planning shall be the joint responsibility of the Accountability and Production Departments. The procedures provided should include area diagrams, sampling plans, cut off procedures, personnel assignments, reporting and recording procedures" (Ref. 11).

NUMEC's 1964 License Renewal Application (Ref. 2) was much less detailed (than Ref. 11) in its description of inventory procedures, and the report of the April - May 1965, AEC materials management survey of NUMEC stated, "The Contractor recognizes that a need exists for a current, revised procedure manual.... The procedures manual should set forth... inventory procedures..." (Ref. 15).

Inventory procedures were addressed also in the report of the next AEC materials management survey of NUMEC which was performed in November 1965 (Ref. 29). The survey report recommended that NUMEC "Establish inventory procedures and perform plantwide inventories periodically, but not less often than annually. After comparison of their inventory quantities with the book quantities, record the resulting gain or loss. In establishing plant inventory procedures, NUMEC should not ignore the need to obtain an adequate inventory of in-process material" (Ref. 29).

The AEC next surveyed NUMEC's material control and accounting system in October - November 1966 (Ref. 22). The report of that survey recommended:

"That NUMEC issue for each material balance area detailed written procedures for the taking of inventory in that area to assure that all items are included, e.g., material 'on deposit' in the vault is verified, material stored as filters and combustibles, but still part of the material balance area account are included" (Ref. 22).

5.1.1.3 Material in Process

The documentation (Refs. 15, 21, 22, 29) indicates that in 1964 (and later) NUMEC did not measure the nuclear material held up in process equipment when they performed a physical inventory. (See in particular, the discussion of unmeasured filters in paragraph 3.1.2.1.1.) Even by 1967, NUMEC's procedures did not require measurement of all in-process material (Ref. 48). NUMEC's Inventory Procedures Manual for their April 29, 1967, inventory stated, "All material in process systems should be included in the inventory. The inventory should include as a separate line item each filter box, and an estimate should be recorded as to the U content in each filter. Estimates should consider, among other factors, the nature of the operation from which air is being filtered and the length of time since the last filter was changed" (Ref. 48).

5.1.2 Schedules

The AEC encouraged regularly scheduled inventories, and preferred them on at least an annual basis (Refs. 15, 37). However, annual inventories were first made a regulatory requirement in the amended version of 10 CFR 70.51 published in 1967 (Ref. 32).

The report of the AEC material control and accounting survey of NUMEC conducted in 1962 stated, "NUMEC had no fixed policy regarding periodic physical inventories. A physical inventory had been taken one week before the arrival of the survey team on May 25 and 26, 1962, and the last previous physical inventory had been March 31, 1961, in connection with the New York office's SS material control survey NY 141" (Ref. 21).

NUMEC's 1964 License Renewal Application (Ref. 2) stated that each active MBA was to take a minimum of four physical inventories every year, and that a plantwide physical inventory was to be taken at least once per year.

From 1964 on, plantwide physical inventories were taken on at least an annual basis, frequently in conjuction with AEC materials management surveys (Refs. 15, 20, 22, 29, 32, 48, 50, 51).

5.1.3 Organization

5.1.3.1 General

In 1964, NUMEC had no position comparable to that of the 1977 Inventories Supervisor (Ref. 2). In 1962, inventory planning was the joint responsibility of the Accountability and Production Departments (Ref. 11). In 1964, the situation was the same, except for name changes: inventory planning was the joint responsibility of the Production Manager and GPA (General Plant - Physical Accountability) (Ref.2).

Presumably these two parties also organized the inventories. In 1964 the taking of an inventory was performed by MBA personnel, and its results were to be reported to the central accounting group which was to compare inventory results to book values (Ref. 2). By 1966, the Accountability Representative was the "inventory coordinator" and apparently the individual having overall responsibility for physical inventories (Ref. 47).

5.1.3.1.1 The documentation reviewed does not directly state who was assigned responsibility for the inventory in a Material Balance Area. However, NUMEC's 1964 License Renewal Application (Ref. 2) stated that the MBA supervisor was to schedule physical inventories for his MBA in conjunction with Accountability, that these inventories were to be taken by MBA personnel, and that any book - physical inventory difference in an MBA was to be resolved by Accountability in consultation with the MBA supervisor. Therefore, it is reasonable to surmise that the MBA supervisor was the staff member ultimately responsible for an inventory in his MBA.

It should be noted that, in 1964, the storage vault operation was not an MBA (Ref. 2). The documentation reviewed does not indicate who was responsible for inventories of the vaults. However, most of the items to be inventoried in the plant were contained in the vaults, and generally, several inventory teams were assigned exclusively to the vaults, with help coming from other teams that also inventoried the MBAs (Refs. 5, 48). Since the material in the vaults was under the control of the Accountability Department, presumably the Accountability Department was responsible for inventorying the vaults, although nonaccountability personnel participated in the vault inventories, and Accountability was not accountable for the material in the vaults (Refs. 2, 5, 11, 48).

5.1.3.2 Inventory Teams

NUMEC inventory procedures included listing and tagging the items inventoried (Refs. 11, 18). Presumably teams consisting of two people were used for the listing and tagging operation in 1964; certainly this was the case by 1967 (Ref. 48).

5.1.4 Procedures

5.1.4.1 Issuance

NUMEC's 1962 Accountability Department Procedures Manual (Ref. 11) and NUMEC's 1964 License Renewal Application (Ref. 2) indicate that the accountability group was to participate with the production group in planning inventories. However, with respect to inventory procedures, or revisions thereto, the 1962 manual states, "Additional (inventory) procedures may be given by the Production Manager" (Ref. 11). The 1964 document is silent on the question of who issued or approved inventory procedures. It was not until 1966 that NUMEC

accountability procedure manuals or applications indicated that inventory procedures were set by the accountability group (Ref. 5). NUMEC's 1966 Procedures Manual (Ref. 5) stated: "Inventories are taken according to procedures prescribed by the Nuclear Materials Control Department." The 1966 Nuclear Materials Control Department was headed by the Accountability Representative (Ref. 5).

5.1.4.2 Preparation

5.1.4.2.1 The responsibility for inventory procedures is discussed in paragraph 5.1.4.1, Issuance. The two following quotations summarize the topics addressed by NUMEC's inventory procedures in the mid-1960s. NUMEC's 1962 Accountability Department Procedures Manual stated: "The procedures provided should include area diagrams, sampling plans, cutoff procedures, personnel assignments, reporting and recording procedures" (Ref. 11).

NUMEC's 1966 Procedures Manual stated:

"Specific instructions for each inventory are issued to process areas in advance of the inventory data. In general, these instructions include:

a) instructions concerning reducing the in-process inventory to the feasible minimum;

b) instructions concerning the listing of each item in an orderly fashion;

c) instructions for establishing an accurate inventory cut-off; and

d) specific instructions for each area, intended to minimize lost production time" (Ref. 5).

The documentation reviewed indicates that, in varying degrees, the procedures describing the conduct of physical inventories at NUMEC issued in the years 1962, 1964, 1966, and 1967 addressed:[1]

a) Makeup of inventory teams and their duties and responsibilities (Refs. 11, 48); see paragraph 5.4.1.1;

b) Instructions for listing and identifying all items containing special nuclear material designed to ensure that each item is

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[1] It should not be inferred that any one of the sets of procedures addressed each of a) through f) or that the procedures provided detailed guidance. See paragraph 5.3.2.1.

inventoried and that there was no duplication (Refs. 5, 11, 48); but see paragraphs 5.4.1.1, 5.4.1.2, and 5.4.5.1;

c) General (nonspecific) guidance on the extent to which process areas were to be cleaned out, and a restriction on the movement of material (Refs. 5, 11, 47); see paragraph 5.3.2, Cleanout;

d) Certain categories of previously made measurements which would be accepted (Refs. 5, 11, 47, 48); see paragraph 5.4.3, Prior Measurements;

e) The measurements to be made for inventory purposes (Refs. 11, 47, 48); see paragraphs 5.3.2.1, 5.4.1.1, and 5.4.3;

f) Use of inventory stickers. Completion and collection of inventory data sheets (Refs. 5, 11, 47, 48); see paragraphs 5.4.1.1, 5.4.1.2, and 5.4.5.1;

The documentation reviewed indicates further that:

g) Instructions for tabulating, auditing and reconciling the results of the inventory were first prepared for the April 1967 inventory (Refs. 47, 48).

h) Separate summaries of material in process were not required to be prepared in accordance with 10 CFR 70 to facilitate calculations of LEMUF. (NUMEC had no statistics program for accountability, so could not have calculated LEMUF (Refs. 15, 44).)

i) NUMEC had no statistics program for accountability measurements (Refs. 15, 44), hence they could not have calculated LEMUF. In addition, NUMEC procedures had no provisions for verification of plant MUF by an individual not involved in the orginal calculation (Refs. 2, 5, 11).

5.1.5 Source Data

In the mid-1960s, NUMEC was not required to base the material quantity assigned to each item on inventory on measured values. Morever, they did not do so (Refs. 15, 23, 29).

The source data used by NUMEC for physical inventories in the mid-1960s included the following:

a) nominal or estimated chemical analyses (Refs. 47, 48); or laboratory analyses, "if the chemical analysis really isn't known" (Ref 47);

b) Data recorded on the container label attached to an item (Refs. 5, 11, 47, 48);

c) Weigh scale readings found on the container label (Refs. 5, 11, 47, 48); weigh scale readings by persons taking the inventory (Refs. 11, 48); new weigh scale readings in the vault office for containers which had been sampled since being placed in storage (Ref. 5).

In the mid-1960s, the following were not used as source data for items on inventory:

d) NDA readings (Refs. 15, 23, 29);

e) Data on tamper-safed items. In the mid-1960's, NUMEC was not required to, and did not, tamper-safe its items (Refs. 3, 5, 10, 11, 22, 37, 46). See Section 7.4 of this appendix for discussion of tamper-safing.

5.1.6 Forms Control

Inventory procedures or instructions used by NUMEC prior to 1966 did not directly address the control of physical inventory data sheets or tags issued to those taking inventory. However, it may be inferred from the documentation reviewed that some form of possibly informal control was maintained. The working papers for the AEC material control and accounting survey of NUMEC in 1962 state that one member of the NUMEC staff "had taken it upon himself to check that the number of inventory stickers which had been issued had been accounted for" (Ref. 37). NUMEC instructions for their June 1966 inventory directly address the control of inventory paperwork: "Inventory sheets and prenumbered inventory stickers will be available from the vault office. . . . All sheets (used, voided, or unused) and all unused stickers are to be returned to the vault office as soon as recording is complete" (Ref. 47).

A listing of material type codes used at the NUMEC could not be found in documentation reviewed dated prior to 1967. NUMEC's Inventory Procedure Manual for the April 1967 inventory provided such a listing, which is included as Table 5.1.1 (1964) (Ref. 48).

5.2 Typical Inventory Composition

5.2.1 Laboratories

5.2.1.1 Typical Inventory Composition

Figure 5.1.4 of Chapter 3.0 contains a listing which includes typical material types used at NUMEC in 1964.

5.2.1.2 Unopened Receipts

Not Applicable

(1964)

TABLE 5.1.1

NUMEC ENRICHED URANIUM

MATERIAL TYPE CODES - 1967*

Code No.	Material Type	Code No.	Material Type
1	Uranium Metal	13	Uranyl Nitrate Solution
2	Uranium Oxides, UO_2, UO_3, U_3O_8	14	Miscellaneous Solutions
3	Binary, uncoated	15	Ammonium Diurante (ADU)
4	Binary, coated	16	Miscellaneous Filter Cake, but not Leached Solids
5	Uranyl Nitrate Crystals	17	Wheelabrator Grit
6	Ternary PWR Powder	18	Scrap from Coating Process
7	Ternary PWR Wafers, Uncoated	19	Incinerator Ashes; Calcined Filters
8	Ternary PWR Wafers, Coated	20	Leached Solids
9	Calcined Binary and Ternary Compounds	21	Miscellaneous Scrap Materials
10	Scrap PWR Powder	22	Combustible Waste; Air Filters
11	Scrap PWR Wafers, Coated or Uncoated	23	Uranium Hexaflouride
12	UO_2F_2 solution	24	Miscellaneous In-Process Materials

Note: Compare to Tables 5.1.1 and 5.1.2 of the 1977 Plan.

*This table is based on information contained in the NUMEC Inventory Procedures Manual dated April 1967 (Reference 48).

5.2.1.3 Ultimate Product

Not Applicable

5.2.1.4 Material under Tamper-Safing

Not Applicable

5.2.1.5 Random and Systematic Errors

Not Applicable

5.2.2 Low Enrichment Uranium

5.2.2.1 Low Enriched Uranium

Figure 5.1.4 of Chapter 3.0 contains a listing which includes typical material types used at NUMEC in 1964.

5.2.2.2 Unopened Receipts

Incoming UF_6 cylinders at NUMEC in 1964 would have met the 10 CFR 70.51 definition of "unopened receipts" until they were introduced into the process. Other incoming material would have met this definition also until it was put into process, or sampled (NUMEC did not tamper-safe items in 1964 (Refs. 2, 3, 5, 11, 22, 37). See Section 7.4 of this Appendix for a discussion of tamper-safing.

5.2.2.3 Ultimate Product

NUMEC's products in 1964 included uranium oxides, uranium carbides, fuel elements, and uranyl nitrate (Ref. 2). Items of each of these material types that received no further processing at NUMEC would have been considered ultimate product under the 10 CFR 70.51 definition.

5.2.2.4 Material Under Tamper-Safing

In 1964, NUMEC did not secure its containers on vaults in a manner that would satisfy the conditions of 10 CFR 70.51(a)(10) (Refs. 2, 3, 5, 11, 22, 37). (See Section 7.4 of this Appendix.)

5.2.2.5 Random and Systematic Errors

NUMEC had no program in 1964 that would meet the requirements of 10 CFR 70.58 or 10 CFR 70.57. (See paragraph 3.7, Measurement Uncertainties). Indeed, NUMEC had no formal statistical program for accountability purposes (Refs. 15, 44).

5.2.3 High Enriched Operations

Figure 5.1.4 (1964) of Chapter 3 contains a listing which includes typical material types used at NUMEC in 1964.

5.2.3.1 Typical Inventory Composition

Figure 5.1.4 (1964) of Chapter 3 contains a listing which includes typical material types used at NUMEC in 1964.

5.2.3.1.1 In 1964 NUMEC did not routinely ship uranium scrap off-site for recovery (Refs. 2, 29).

5.2.3.2 Unopened Receipts

See paragraph 5.2.2.2.

5.2.3.3 Ultimate Product

See paragraph 5.2.3.3.

5.2.3.4 Material under Tamper-Safing

See paragraph 5.2.2.4.

5.2.3.5 Random and Systematic Errors

See Table 3.7.3 and paragraphs 3.7 and 5.2.2.5.

5.3 Inventory Preparation

5.3.1 Special Processing

5.3.1.1 High Enriched Uranium Operations (Plant I)

Neither the requirements in Reference 1 (opposite) nor similar requirements applied to NUMEC in 1964.

5.3.1.1.1 Not applicable.

5.3.1.1.2 Not applicable.

5.3.1.1.3 Not applicable.

5.3.1.1.4 Not applicable.

5.3.1.1.5 Not applicable.

5.3.2 Cleanout

NUMEC's 1962 Accountability Department Procedure Manual (Ref. 11) indicated that not all in-process material would be processed to an item form prior to inventory. This manual instructed the inventory-takers of in-process material to "determine weights to the nearest gram for material > 75% enriched," and to "determine volume and assay, if necessary, for in-process material" (Ref. 11).

However, NUMEC's inventory policy in the mid-1960s did not require NUMEC "to drain down all equipment and work up materials to a measurable form..." (Ref. 1). Indeed, much of the physical inventory was based on estimated values, not measured values. As the quotation from the working papers of the AEC's 1962 material control and accounting survey of NUMEC (Ref. 37) cited in 5.1.1.1 indicates, NUMEC based the material quantities of 20% of the uranium on the May 31, 1962, inventory on estimated values. The AEC also said, "NUMEC should campaign to clean up the residues, filters, solutions, scrap, etc. - dead inventory, to get it in a measurable form..." (Ref. 37).

By 1966, NUMEC's physical inventory policy recognized the importance of reducing unmeasured holdup in process equipment. NUMEC's instructions for their June 1966 physical inventory stated, "Gloveboxes and other equipment will be cleaned to reduce the unmeasurable inventory to the lowest possible level" (Ref. 47). However, the importance of obtaining a good inventory seemed secondary to production considerations. The same set of instructions also stated, "Conduct a general cleanup campaign in your area, designed to reduce your inventory to the minimum level consistent with temporary vault closing. (Remember that the less you have to inventory the faster it will go, and the sooner you can get back in production)" (Ref. 47).

5.3.2.1 Low Enriched Uranium Operation

The AEC survey and inspection reports reviewed indicated that in 1962, the AEC felt it necessary to advise NUMEC to process its "dead inventory" to get it in a measurable form (Ref. 37). In April 1966, the AEC still felt that NUMEC should improve its inventory procedures for process areas. The AEC recommended that NUMEC "establish inventory procedures and perform plantwide inventories periodically," and that in establishing inventory procedures, NUMEC should not ignore the need to obtain an adequate inventory of in-process material" (Ref. 29).

The NUMEC-generated documentation reviewed dated prior to 1967 does not contain any specific guidance on the extent to which either high enriched or low enriched MBAs were to be shut down, cleaned out, and/or remain static at physical inventory time (Refs. 2, 5, 6, 11, 47). As indicated in paragraph 5.3.2, some general (non-specific) guidance was provided on clean out in 1966.

The most extensive guidance on the taking of inventories found in the documentation dated prior to 1966 was contained in NUMEC's 1962 Accountability Department Procedures Manual (Ref. 11). The following excerpt from that manual illustrates the contrast between the level of detail required now (in the 1977 plan) and the level of detail provided by NUMEC to their employees and the AEC in the early 1960s. The excerpt also illustrates the important role played by Production in the taking of physical inventories. Other documentation indicates that NUMEC workers were under pressure to minimize the amount of time they spent on cleanups or inventories so that they could "get back in production" sooner (Refs. 3, 47).

"<u>Inventory Procedures</u>

1. Inventory should be taken on the last <u>two</u> days in the last week of a month. (Emphasis appeared in reference.) The two consecutive inventory days will be designated by Production Control.

2. Transfers should not be made in or out of MBAs during inventory days.

3. Make sure all storage cans are labeled as to Job No., Enrichment, Quantity (Gross, Tare and Net). Attach inventory marker to each container that is recorded on inventory record.

4. Determine weights to the nearest gram for material >75% enriched. Determine weights to the nearest 1/2 pound for all other enrichments, and convert to grams. (Applies to in-process material.)

5. Determine volume and assay, if necessary, for in-process material.

6. Tabulate all in-storage material charged to your MBA according to the gross-tare-net and other data on the container tag. Recheck weights on a statistical sample of in-storage containers that have been in dead storage since the last inventory period (approximately 1%).

7. Submit to Accountability a tabulation to show quantities on hand by enrichment or whether normal, depleted, thorium, plutonium and U-233. Also contract or job number.

8. Additional instructions may be given by the Production Manager" (Ref. 11).

5.3.2.2 <u>High Enriched Uranium Operations</u>

See paragraph 5.3.2.1.

5.4 Conduct of Inventory

5.4.1 Item Inventories

5.4.1.1 General

Inventory teams, consisting of two people each, were to proceed about the area being inventoried, listing each item as they came to it (Refs. 37, 47). One member of the team read information off the container label, and the other team member wrote it on the inventory listing sheets (Refs. 37, 47). The amount of information recorded was not the same from inventory to inventory during the years 1962-66. In 1962, NUMEC's form[1] for listing items on physical inventory had no space for recording an inventory tag (sticker) number (Ref. 11); however, in 1966, inventory sticker numbers were to be recorded on the inventory data sheets (Ref. 47). Inventory stickers (attached to an item as it was inventoried) were used in 1962 and possibly earlier (Ref. 37); however, it is not clear that they were prenumbered at that time (Ref. 37). Certainly they were prenumbered by 1966 (Refs. 27, 47).

Items on inventory were not tamper-safed (Refs. 2, 3, 5, 11, 22, 37). (See Section 7.4 of this appendix.) In general, if the element and isotopic analyses appeared on the label of an item, they were recorded on the listing (Refs. 37, 47). Due to NUMEC's practice of taking samples from items and not always revising the container label to reflect the change in the contents of the container (Refs. 5, 22), the AEC noted in 1966 that this practice could result in an overstatment of the quantity of material on inventory (Ref. 22).

In 1966, NUMEC's inventory instructions said that if the material were not labeled, or if the labeled data were not clear, then the item should be weighed and the observed net weight recorded (Ref. 47).

These instructions went on to say, however, that Accountability would accept "nominal or estimated chemical analyses" in such cases (Ref. 47), but that they would not accept "guesses or grossly rounded nominals." (Ref. 47). If the inventory takers could not come up with nominal or estimated values, they were to submit a sample to the lab, but "obviously, precise chemical analyses should not be requested." (Ref. 47).

Nonetheless, the above method for determining information when container labels were incomplete or missing was an improvement over what an AEC survey team member observed in 1962, during an AEC-requested

[1] See Figure B-III-11 of Appendix B-III-1.

reinventory of certain projects for which the records and previous inventory "in particular do not check out!" (Ref. 37) The inspector's handwritten notes contained in the working papers of the survey give the following description of what he saw:

"...Noted two containers which were not marked. Check vault record- these records should state what material is in each location in vault. Found records had no information on these locations. Call (Account~~abili~~ty Representative)[1] in on the situation. (Accountability Representative)[1] found a guy (don't know his name) who knew. Containers were opened and material identified by (Accountability Representative)[1] and this guy. Containers closed. (Inspector)[1] rechecked containers and found they had not been labeled. So I suppose the next time NUMEC desires to know what's in these cans, this guy will have taken employment at Oak Ridge. - Also noted 11 cans of UF_6 which were not labeled. Called (Accountability Representative)[1] and (Accountant)[1] who identified them to Forms AEC-101 as being for a/c 1008. This time I had (Plant Employee)[1] label as such" (Ref. 37).

5.4.1.2 Storage Vaults

Vault inventories were not taken with the aid of prelistings (Refs. 22, 37, 47). In 1962, the procedure was to use several two man teams to inventory different sections of the vault (Ref. 37). Each team was to list all items in its section: one man read information on container labels, the other recorded the information on inventory forms (Refs. 11, 37). In 1966, several two man teams were still used, but the (post) listing was to be derived from vault cards. The procedure was described in the report of the AEC material control and accounting survey conducted in October and November, 1966, in the following way:

"An inventory cut-off time is set, all SN[2] material movements and routine operations are halted and the original of each vault control card is taken from the vault file and placed with the item in the vault location prior to inventory. The information on the original of the vault control card is compared to the information on the label attached to the item, and to the pink tag which is a carbon copy of the original vault control card. If an item is found to be erroneously tagged, or not tagged at all, a new vault control card is made out and left with the item. After all of the original cards are distributed and all items are checked to assure that each item is associated with an original vault card, the vault cards are collected. As each vault card is retrieved, the item is marked with a self-adhering prenumbered sticker to indicate that it had been

[1]Positions are used in place of the names that appear in Reference 37.
[2]Special Nuclear.

inventoried. After a check has been made to see that all white slips have been picked up, an adding machine tape total is made from the slips to accumulate the vault inventory by job order number. Subsequent to the inventory, the original copies of the vault control cards are returned to the vault file and when an item is requested by an operating area, the original copy is initialed and filed, and the two carbon copies are destroyed. Any material entering the vault is identified by the issuance of a vault control card with a carbon copy being provided to the depositor, and a carbon copy attached to the item. The depositor's copy of the vault control card must be subsequently surrendered in order to withdraw the material from the vault" (Ref. 22).

The AEC noted a slight deviation from this procedure when NUMEC failed to collect some 26 of the white slips from which they were to compile the vault listing (Ref. 22).

5.4.1.3 Process Material

NUMEC's 1962 Accountability Procedures Manual stated that for in-process material, personnel taking the inventory were to determine weights to the nearest gram for uranium enriched to greater than 75% and to the nearest one-half pound for all other enrichments (which was then to be converted to grams) (Ref. 11). They were also to determine volume assay, if necessary, for in-process material (Ref. 11). However, the notes made by an AEC inspector regarding NUMEC's July 28, 1962, reinventory of certain projects indicated that for one process area the "inventory apparently had been taken from ITD's rather than material. There was frequent use of one sticker for 6-8 bottles" (Ref. 37). (ITD's were Internal Transfer Documents). The safeguards problems which can result from basing an inventory on ITD's are evident from the findings related in Chapters 6 and 7 of this Appendix and Chapter 3 of the main report.

NUMEC's instructions for an inventory scheduled for June 25, 1966, indicated that each area should conduct a general cleanup campaign, designed to reduce the area's inventory to the minimum level consistent with temporary vault closing (Ref. 47). The instructions went on to say, "Remember that the less you have to inventory the faster it will go, and the sooner you can get back in production" (Ref. 47).

As indicated before, NUMEC did not tamper-safe containers of special nuclear material (Refs. 2, 3, 5, 11, 22, 37). (See Section 7.4 of this Appendix.)

5.4.2 Current Measurements

Information relative to the measurement methods used at NUMEC, for physical inventories or otherwise, is contained in Chapter 3.0. Little specific information on measurement points used or physical inventories or otherwise, was found in the documentation reviewed that was dated prior to 1968. (See 3.1.1.)

5.4.3 Prior Measurements

The basis for accepting prior measurements essentially was whether the label on the container was legible and complete or not (Refs. 37, 47). If the data were legible and complete, it was accepted (Ref. 47). If it were not complete, nominal or estimated data could be entered by the inventory teams (Ref. 47).

5.4.4 Residual Holdup

5.4.4.1 In 1962, the AEC said that "NUMEC should campaign to clean up the residues, filters, solutions, scrap, etc. - dead inventory, to get it in a measurable form..." (Ref. 37). One of NUMEC's former employees interviewed by the AEC in 1966 as part of the AEC's investigation of the WANL loss indicated "that the biggest source of uranium material losses in the NUMEC plant, in his view, resulted from the incomplete cleaning of process equipment when production lines were shut down, and from loss occasioned by disposing of the resultant liquid waste by dumping it down the drains "(Ref. 3). The interviewee, a former production worker, went on the state that "plant workers were always kept under pressure to keep down the amount of time spent on cleanups so they could get started as soon as possible on new jobs." He added that "NUMEC was always more interested in making a profit than in recovering the maximum amount of uranium" (Ref. 3).

For more information on equipment cleanout, see paragraph 5.3.2.

5.4.4.2 Ducts

There was no indication in the documentation reviewed that NUMEC, in preparation for each physical inventory, performed an NDA survey of process exhaust duct work. Indeed, the fact that they did not measure in-process filters (Ref. 29), which were contained in process exhaust duct work, strongly suggests that they did not routinely measure or survey the rest of the duct work either. Even as late as 1967, NUMEC's instructions to their inventory teams told them to estimate, based on the nature of the operation and the length of time since the filter was last changed, the uranium content in each filter (Ref. 48). Although estimates are not generally as accurate as measurements, the 1967 procedure was an improvement over NUMEC's prior practice of not including filters as part of their inventory of SNM (Ref. 29).

5.4.5 Post-Inventory Inspection

5.4.5.1 List and Tag Accuracy

In October 1966, an AEC materials management survey team witnessed a NUMEC physical inventory in which, at the time of the taking of the inventory, not all vault cards which had been placed with inventory items were collected (Refs. 22, 53). NUMEC's procedure was then to

total the quantities stated on the tickets (Ref. 53). This would result in not all material being listed on the inventory; i.e., in effect not being inventoried.

Partially as a result of the above AEC observation, the AEC recommended in the survey report that "NUMEC issue for each material balance area detailed written procedures for the taking of inventory in that area to assure that all items are included, e.g., material 'on deposit' in the vault is verified, material stored as filters and combustibles, but still part of the material balance area account are included" (Ref. 22).

NUMEC's written inventory procedures for their April 1967 inventory included provisions responsive to the above AEC recommendation and which should have helped to prevent a recurrence of what the AEC saw in 1966 (Refs. 22, 48). NUMEC's written instructions for this inventory stated, "when the inventory of the process area has been completed, the team should call the inventory coordinator who will check the area to determine that all containers have been inventoried and scan the data sheets to determine that all required information has been recorded properly. The inventory coordinator will then take the data sheets from the laboratory team and will indicate what portion of the plant they are to inventory next" (Ref. 48).

It is not clear what measures, if any, NUMEC used prior to this time to ensure that all items had been, or that the listings accurately reflected, the items inventoried. It does not appear that procedures similar to those outlined in the 1967 instruction cited above were used in previous inventories. Indeed, NUMEC's instructions for an inventory in June 1966 did not address checking for completeness or accuracy at all (Ref. 48). Instead, they said that each area could resume production as soon as its own inventory was complete; however, transfers between areas would not yet be permitted (Ref. 47). When all areas had turned in their lists to Accountability and the vault inventory was complete, the Accountability Representative would announce over the P.A. system that the inventory taking was complete, and that normal production activities could resume through the plant, including inter-area transfers (Ref. 47).

With respect to accounting for inventory tags, the AEC observed that during one inventory in 1962, a NUMEC employee took it upon himself to check that the number of inventory stickers which had been issued had been accounted for (Ref. 37).

5.4.5.2 Cut-off Verification

Although NUMEC-generated documentation dating as early as 1962 said that NUMEC would provide for cut-off procedures in their inventory planning (Ref. 11), the documentation reviewed does not address what NUMEC's procedures were for ensuring the proper recording of MBA transfers or receipts or shipments. Certainly in 1962, cutoff

procedures for shipments and receipts were only of academic interest, since NUMEC's transfer journals were not maintained on a current basis and were not complete (Ref. 21). A similar statement applied at that time with respect to MBA transfers since NUMEC maintained no central internal transfer ledgers which could be checked against MBA records (Ref. 21). The working papers of the AEC's materials management survey of NUMEC in November 1965 indicate that the lack of records on internal transfers may well have persisted until as late as April 1965 (Ref. 19).

Discards were not measured for accountability purposes, and accountability records did not reflect liquid, gaseous, or solid discards (Refs. 15, 21, 22, 27, 29, 31, 34) at least prior to 1966.

5.4.5.3 MUF and LEMUF Adustments

NUMEC received scrap from other plants for recovery (Refs. 29, 49). The documentation reviewed does not suggest that NUMEC routinely shipped scrap generated onsite to other facilities for recovery.

NUMEC was not subject to a requirement similar to that reflected in Reference 1 (opposite). Indeed, scrap generated onsite might not be recovered for years (Refs. 21, 29), and scrap generated offsite and reprocessed at NUMEC might not be entirely recovered for years (Ref. 37).

Since NUMEC had no statistics program for accountability purposes (Refs. 15, 44), they could not have calculated LEMUF.

5.4.5.4 Bias Corrections

NUMEC did not use statistics for accountability purposes (Refs. 15, 44). Therefore, they could not have calculated measurement biases, much less have made any corrections to records, etc. for the effects of measurement biases.

6.0 MATERIAL ACCOUNTING SYSTEM

6.1 System Description

(1964)

6.1.1 Accounting Structure

NUMEC's 1964 License Renewal Application (Ref. 2) provided few details concerning NUMEC's nuclear material accounting structure. However, NUMEC's 1962 Accountability Procedures Manual (Ref. 11) contained a detailed discussion of the accounting system NUMEC purported to have in place at that time. The description that follows is based primarily on the system NUMEC described in the 1962 manual, modified to reflect information in the 1964 application when possible.

NUMEC maintained a record system which, if operated as described in the 1962 manual, should have provided information sufficient to maintain a material balance around each material balance area (but not ICA-NUMEC did not have ICAs (Ref. 2)) and the total Apollo plant. The records contained information pertaining to receipts, shipments, and internal transfers (Ref. 11). In addition, the 1964 License Renewal Application indicated the records should also have contained information on discards. The documentation reviewed does not indicate that the accounting system maintained records of additions to or removals from process, unopened receipts, or ultimate product awaiting shipment (tampersafing was not practiced at NUMEC in 1964 (Refs. 2, 3, 5, 11, 22, 37). See Appendix A of this report.) The MBA records were to have been reconciled with central records on a monthly basis (Ref. 2), and the central control records summarizing the MBA records were to be reconciled to the monthly Material Balance Report submitted to the AEC (Ref. 1). Entries to the accounting records could be based on estimates: they did not have to be based on measurements (Refs. 21, 29, 48).

The AEC found that NUMEC's accounting system did not in fact operate as described by NUMEC in References 2 and 11. Various AEC materials management surveys found numerous deficiencies in NUMEC's material accounting system in the mid-1960's. Representative of the deficiencies found were the following:

- The central accountability records did not contain balances by material balance area (1962 survey: Ref. 21).
- The records contained incomplete information pertaining to receipts, shipments, and internal transfers (1962 survey: Ref. 21).
- The accounting records did not record material discards (November 1965 survey: Ref. 29).

The central accounting records reflecting MBA balances did not exist, and therefore, they could not have been reconciled to monthly Material Balance Reports to the AEC 1962 survey: Ref. 21).

Perhaps the most serious indictment of the extent and quality of NUMEC's records is found in the working papers of the AEC survey team which went to NUMEC in November 1965 to try to establish the extent of NUMEC's loss on the Westinghouse Astro-Nuclear Laboratory (WANL) contract. Concerning the WANL contract and NUMEC internal records, one inspector wrote:

> "The first evidence of trouble apparently was the July 1963 survey performed by OR, which showed NUMEC 48 kg short of about 850 kg received (∿5%). From the sketchy record I have available, I surmise that (Accountability Representative)[1] reinventoried and confirmed the OR data, but I find no evidence of management action of concern . . . There was a February 1, 1964, inventory by NUMEC, and it is clear that at this point NUMEC knew they were in trouble. Apparently the shortage was 60 kg; there is some reason to guess that PC-3 may have been the trouble spot, but the records really do not permit a localization of losses...
>
> A December 5, 1964 inventory exists, in which NUMEC had already begun to shift material into 1231[2] from other jobs. This is evidenced by the presence of batches labelled UO_2-ZrO_2 or UO_2-Tho_2, neither of which were associated with the WANL contract" (Ref. 91).

In addition to having records that could not provide for localization of losses to the MBAs responsible (Refs. 15, 91), NUMEC's records were incomplete. Again, excerpts from the November 1965 AEC work papers:

> "On Tuesday November 9, and Wednesday, November 10, (Inspector)[3] attempted to review production control data on job 1231.[2] This effort was aborted about 9:30 am November 10, when it became apparent that the major portions of the record did not exist. For example, while 1231 must have involved about 70 cylinders

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[1] The person's position replaces his name which was used in this reference. The person referred to here was apparently Accountability Representative from early 1963 (Ref. 2) until April 27, 1964 (Ref. 89), the day the AEC started their first materials management survey of NUMEC's plutonium plant (Ref. 28). He also submitted periodic (weekly) status reports on the WANL contract to a small group of NUMEC managers from December 1962 through May 1963 (Refs. 2, 90). Internal evidence indicates that he may also have been a production engineer in addition to being Accountability Representative (Refs. 2, 90).

[2] 1231 was NUMEC's job number for the WANL contract.

[3] Positions are used in place of the names that appear in the reference.

of UF_6, data sheets showing the conversion of UF_6 to UO_2F_2 could be located for only 26 cylinders. Even these were incomplete, only 9 showed a gU/liter analysis of the resulting solutions and only 16 showed that, after washing, the resultant heel was negligible. No records were found for UO_2F_2 to ADU, to UO_2, and to UC_2...The offered data included several NUMEC physical inventory listings, nearly all of them undated. It also included numerous (illegible) but discussion with (Accountability Clerk)[1] indicated that these were complete only back to about September - October, 1963. Thus the major early processing is not included" (Ref. 90).

"Somewhat dismayed at the limited extent of the 1231[2] data provided by (Accountability Clerk)[1], I asked (Accountability Representative)[1] to meet with us in the conference room to let us know whether more information was available or not... (Accountability Representative)[1] perused the data and assured us that this, indeed, was the production data normally generated. He quickly recognized that much of it was missing and that it was impossible to establish any kind of a material balance on 1231. He indicated that any other data must have been destroyed during the strike and that (Accountability Clerk)[1] had given us everything that was now in existence, I asked that (Accountability Clerk)[1] get us the data (production data) on the other jobs requested... (Accountability Clerk)[1] later brought us the production data (on the other jobs). This data is no better than that available on 1231..." (Ref. 19).

"(Accountability Representative)[1] inquired of our progress on determining loss across 1231. I told him of our problem of incomplete data; he replied that he often met with the same problem when he tried to arrive at a balance" (Ref. 19).

"Complete production records apparently do not exist across any prior NUMEC job" (Ref. 19).

"In short these records don't tie into anything and are a disgrace to the company" (Ref. 19).

A description of the general and subsidiary ledgers and journals together with a chart of accounts is given in the following paragraphs.

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[1] Positions are used in place of the names that appear in the reference.

[2] 1231 was NUMEC's job number for the WANL contract.

6.1.1.1 Accounting Forms

Source Documents. The following documents were used for data entry in the journals and ledgers:

a.1) Nuclear Material Transfer Document, Form AEC-101 (Figure B-III-1, Appendix B-III)

This form was one of two required by the AEC for the documentation of external receipts and shipments. It was used to document transactions between NUMEC as an AEC prime or sub-contractor and other AEC offices or contractors. It was not used when the material being transferred was, or became, leased from the AEC (Refs. 5, 11).

a.2) SS-Material Transfer Form - Leased Material, Form AEC-388 (Figure B-III-2, Appendix B-III)

This form, required by the AEC, was used to document external transactions involving leased special nuclear material, including SNM which became leased as a result of the transaction or which was being returned to the AEC for credit (Refs. 5, 11).

b) Nuclear Material Discard Report (Figure B-III-3, Appendix B-III)

This documentation reviewed does not indicate this form was in use prior to 1966 (Ref. 5); however the 1964 License Renewal Application did call for MBAs to separately break out discards in their monthly reports to the central accountability group (Ref. 2).

This form was to be used "to document known (or at least estimated) losses of enriched uranium. Discard reports must be prepared at least monthly; they may be prepared at any time, and should be prepared at the time of each accidental loss" (Ref. 5).

c) Inter-Job Transfer Authorization (Figure B-III-4, Appendix B-III)

The documentation reviewed does not indicate that this form was in use prior to 1966 (Ref. 5). This form was to be used to document transfers between NUMEC contracts (Ref. 5). It was to be initiated by the Nuclear Materials Control Department upon suitable evidence that such a transfer was authorized by the relative contracts (Ref. 5). It was to be completed by the material balance area custodian to show the actual quantity transferred (Ref. 5).

d) Internal Transfer Receipt (Figure B-III-5, Appendix B-III)

NUMEC's 1962 Accountability Department Procedures Manual (Ref. 11) described the use of this document in the following way: "Upon

receipt of SS materials from an offsite station it will be charged directly to the applicable MBA on an internal transfer receipt form... Subsequent transfers of materials also will be made on the basis of NUMEC Internal Transfer Receipts prepared by the MBA originating the transfer. The receiving MBA will verify the quantity received and acknowledge receipt by requiring the transfer form. Restrictions of the internal transfer form shall be as follows:

Copy #1 to Accountability
Copy #2 to Receiving MBA
Copy #3 retained by Orginating MBA"
(Ref. 11).

By 1964, the internal transfer forms were to be prenumbered, and they were to be signed by authorized representatives of the originating and receiving MBAs and by Accountability (Ref. 2).

It should be noted that prior to 1967, NUMEC's storage vaults were not MBAs, so internal transfer forms were not used to document transfers to or from them (Ref. 20). Instead, a vault control card was used (see Paragraph 7.3.4.2) (Refs. 2, 11). However, the central accountability group did not receive copies of these forms so they could not determine how much or which material was supposed to be in any vault (Refs. 2, 11). Moreover, before 1967 the laboratories were not MBAs (Ref. 20). Transfer forms were not necessary when process or analytical samples were transferred to or from the laboratories (Ref. 2).

6.1.1.2 Flow Charts

See Figures B-II-7 and B-II-8 (1964), Appendix B-II.

6.1.1.3 Basic Records

The AEC requirements governing NUMEC's records through 1967 were contained in 10 CFR 70.51 and AEC Manual Chapter 7401-075 (Refs. 10, 32, 54, 55). The requirements were simple:

10 CFR 70.51: Records.

"Each licensee shall keep records showing the receipt, inventory and transfer of special nuclear material" (Ref. 55).

AEC Manual Chapter 7401-075: Records.

"Records, as approved by the Manager of Operations, of SS material transactions shall be maintained by each SS station in such detail as will disclose fully all such transactions. In approving such records, Managers of Operations should be guided by the many uses of SS material quantity data and ensure that a

single system for collection of such data is devised which also will meet such needs as those for production control, cost accounting, contractual payments, etc." (Ref. 10).

NUMEC's records were arranged by material category and/or contract (Ref. 11). Their basic records were as follows:

6.1.1.3.1 Ledgers

a) Material Balance Area Ledgers

Each MBA was to maintain a ledger to record the receipt and transfer of SS materials (Ref. 11). These ledgers were to be divided into appropriate sections, i.e., >75% U-235, <75% U-235, normal, depleted, thorium, plutonium, and U-233 (Ref. 11). Material was to be transferred to and from MBAs on Internal Transfer Receipts (ITRs), and the receiving MBA was to verify the quantity received (Ref. 11). One copy of the ITR was to go to each of the two MBAs involved in the transfer, and one copy to the central accountability group (Ref. 11). The MBA ledgers were to reflect information taken from the Internal Transfer Receipt (Ref. 11). Control sheets summarizing the postings to all MBAs were to be maintained and the inventory balances reconciled to the monthly Material Balance Report submitted to the AEC (Ref. 11). Separate control sheets were to be maintained for station (AEC contract) and licensee (leased) material (Ref. 11).

Transfers in and out of an MBA were to be summarized on a "Check and Balance Sheet for MBAs;" a separate sheet was to be maintained for each contract and for each enrichment per contract (Ref. 2). MBAs were to use the Check and Balance Sheet to establish their monthly book balance, and these balances were to be in agreement with the central accounting group's balance for the MBA (Ref. 2).

In their May-August 1962 materials management survey of NUMEC, the AEC found that the procedures in place at NUMEC differed from those described above by Reference 11 (Refs. 21, 26). They found that the MBA ledgers for MBA's CRP-2 and CRP-3 (scrap recovery) were "basically for the purpose of determining production" (Ref. 26). The ledgers "are not totalled and do not tie-out to the central accountability group's ledger (job book). They do not tie-out since the receipt of scrap posted in the central accountability group's records is based on shipper's quantities until NUMEC is notified by New York Operations Office of the official number NUMEC is responsible for... (The MBA Custodian's)[1] records on the other hand, reflect NUMEC's

[1] The person's position has been substituted for his name which appeared in the reference.

measurements. It was also learned that the Area Material Balance records are not reconciled to the central accountability record..." (Ref. 26).

b) General Active Contracts Ledgers (Job Ledger) Station Material:

Receipts and shipments of SS materials were to be posted to this ledger, which was arranged by NUMEC internal job number (Ref. 11). A control sheet (Figure B-III-6, Appendix B-III) summarizing the postings to the individual job sheets was to be "agreed to" the monthly Material Balance Report (AEC-577) submitted to the AEC (Ref. 11). Postings to the job ledgers were to be from AEC Form-101 (Ref. 11).

Licensee Material

A second contracts ledger recording receipts and shipments of leased SS material held as a licensee was also be be maintained (Ref. 11). Postings to it were to be made from AEC Form-388 and other appropriate sources, and the cumulative balances were to "be agreed or reconciled to the Semi-annual Material Status Report (AEC-578) submitted to the AEC" (Ref. 11).

Contract ledgers in essentially the form described above were in use at NUMEC in 1966 (Ref. 5).

Regarding NUMEC's contract ledgers, the report of the 1962 AEC materials management survey of NUMEC noted the following:

"The subsidiary ledger ("General Active Contract Ledger" or "job book") also was incomplete, and had not been maintained on a current basis. In total, this record did not agree with reported quantities. It could not be in agreement with the journal since the journal itself was incomplete. Dissolution samples of 6,002 gm uranium (93% U-235), which had been reported monthly as project NY-44004-01-3, had not been given a NUMEC job number and had not been entered in the subsidiary ledger. Recordkeeping inconsistencies noted were: ledger sheet columns were not headed; accounts were not balanced and ruled off at month end; when balances were posted no dates were stated; transfers were posted but the dates of the transactions were omitted; some receipts and removals were not recorded; postings were made with the wrong transfer series listed; and month-ending balances were footed to wrong totals. NUMEC compared its physical inventory data . . . to this subsidiary record, but this comparison was of no value since the record quantities were incorrect" (Ref. 21).

6.1.1.3.2 Journals

a) Receiving Journal (Station Material)

This receiving record was to be divided into seven sections, and it was to be used to record the receipt of SS materials transferred from other (offsite) SS stations (Ref. 11). The seven sections were: >75% U-235, <75% U-235 normal, depleted, thorium, plutonium, and U-233 (Ref. 11). Postings to this receiving record were to be made from Form AEC-101 and were to "include the date of receipt, shipper, description or form of material received, quantity, and other pertinent information" (Ref. 11).

b) Shipping Journal (Station Material)

This shipping record was to be used to record all shipments of station materials made to offsite stations (Ref. 11). The ledger was to be maintained in the same general manner as the Receiving Journal (Ref. 11).

c) Licensee Materials Journal (Leased Material)

A record of the receipt and shipment of all SS materials as a licensee was to be maintained in this journal (Ref. 11). The journal was to be divided into two sections: (1) Enriched and (2) Normal and Depleted (Ref. 11). Postings to this journal were to be made from form AEC-388 for enriched materials and from appropriate forms applicable to Normal and Depleted materials (Ref. 11).

By 1966, NUMEC had replaced the separate journals for receipts and shipments with a single transfer journal (Ref. 5). This journal was a chronological record of all external transactions, subdivided according to the nuclear material involved and according to the other party to the transaction (Ref. 5).

With respect to the 1962 NUMEC journals described above, the report of 1962 AEC materials management survey at NUMEC stated:

"The transfer journals were not maintained on a current basis, and were not complete at the time of the audit. In many instances where NUMEC was the receiver of material, the receiver's quantities were not posted. This condition was also noted in the report of survey NY 141. Correct balances as of May 31, 1962 were inserted by the survey team. Other deficiencies noted in the transfer journals were: dates not properly posted; transactions posted in months other than when the transactions took place; totals for months of receipts and removals were not shown in proper columns; and transfer documents were grouped and the total posted" (Ref. 21).

6.1.1.4 Chart of Accounts

The report of 1962 AEC materials management survey of NUMEC observed that "NUMEC does not maintain a general ledger or book of final entry. The purpose of this record would be to summarize the accounts listed in the transfer journal and shown on monthly material balance reports (Form AEC-577)" (Ref. 21).

The report of the April 1965 AEC materials management survey of NUMEC (Ref. 15) again took NUMEC to task for not having a general ledger to record monthly summaries of transactions.

The report stated:

"The records consist, for the most part, of job order ledgers supported by external transfer documents, e.g., AEC-101 and AEC-388. We suggest that a material balance summary be initiated for the purpose of recording control accounts which are reported to the AEC, i.e., inventories, receipts, shipments, material cross-over, discards, losses, etc., on a month and year-to-date basis. In addition, a transfer journal in which to record transfers by facility and license series would be in order" (Ref. 15).

The report of the AEC material control and accounting survey of NUMEC in November 1965 (Ref. 29), recommended that NUMEC "take immediate action to:

a. Install a general ledger to summarize accounts periodically to support data reported in material balance reports to the AEC.

b. Develop a subsidiary ledger to account physically for SS material by material balance areas and by NUMEC job order number.

c. Create a chart of accounts (job order numbers) referenced to the project, contract, and purchase order numbers. (The account number itself should identify that the SS material associated with the account is either AEC contract material or leased material." (Ref. 29).)

The AEC reports cited make it clear that NUMEC had neither a general ledger nor a chart of accounts in 1964. In 1966, in response to the AEC recommendations a. and c. above, NUMEC included in their revised procedures manual provisions for a general ledger, to be used as a monthly summary of all transactions, and which was subdivided according to the following chart of accounts:

CHART OF ACCOUNTS[1]

Series 100 - Material Held Subject to Customer Contracts,
Report Symbol FAP
Sub-series 100 - Enriched Uranium
100 - Normal Uranium
120 - Depleted Uranium

Series 200 - Material Held Subject to Customer Contracts,
Report Symbol MAN
Sub-series 200 - Enriched Uranium
210 - Normal Uranium
220 - Depleted Uranium
230 - Plutonium (239 + 241)
250 - U-233

Series 300 - Material Held Subject to Oak Ridge Supply Agreement,
Report Symbol TBL
Sub-series 300 - Enriched Uranium

Series 400 - Material Leased on Lease 149 and License SNM-145,
Report Symbol ZQN
Sub-series 500 - Enriched Uranium
530 - Plutonium (239 + 241)
540 - Pu-238
550 - U-233

Series 600 - Material Leased by Others and Held by NUMEC on License SNM-145
Sub-series 600 - Enriched Uranium

Series 700 - Material Leased by Others and Held by NUMEC on License SNM-145
Sub-series 700 - Enriched Uranium
730 - Plutonium (239 + 241)

Series 800 - Material Owned by NUMEC
Sub-series 810 - Normal Uranium
820 - Depleted Uranium
860 - Np-237
870 - Am-241
880 - Po-210
890 - Thorium

Series 900 - Material Leased on Lease 149, In the Possession of Others

[1] This chart was taken from NUMEC's 1966 Procedure Manual (Ref. 5).

It should be noted, in particular, that in 1964 or even 1966, NUMEC did not have an account for material discards and MUF (inventory difference or material unaccounted for) (Refs. 2, 5, 18).

6.1.2 Accounting Procedures

6.1.2.1 Procedures Manual

NUMEC apparently had no policy regarding a periodic review and/or update of their accounting procedures manual. Indeed, NUMEC generally issued, modified or updated their procedures manual only after receiving (in some cases, considerable) pressure from the AEC. The earliest accounting procedures manual found in the documentation reviewed was Reference 11 (1962). Its issuance was promised by NUMEC to the AEC during the AEC's March 1961 materials management survey of NUMEC (Ref. 44); yet it was dated May 14, 1962, barely two weeks before the next AEC survey which began May 31, 1962, and which had been announced to NUMEC at least six weeks earlier (Refs. 11, 56).

The next AEC materials management survey of NUMEC in July-August 1963 found the procedures manual acceptable (Ref. 18).

A 1964 survey of NUMEC's Plutonium Facility by New York's Operations Office resulted in the recommendation that NUMEC issue a procedure manual for the Pu site which was to stress "An accounting record and reporting system, which will provide adequate control over nuclear materials..." (Ref. 28).

The AEC materials management survey conducted in April-May 1965 found that "The facility's SS procedures manual is incomplete and does not accurately portray current procedures" (Ref. 15). The report of this survey indicated that NUMEC had previously been requested by the AEC to issue a current Procedures Manual, but that this had not been accomplished (Ref. 15). The revised manual was then in the process of preparation (Ref. 15). Several deadlines for the revised manual were promised and missed (Ref. 57). An accountability procedures manual, Reference 5, dated March 30, 1966, was finally sent to the AEC for approval on April 15, 1966 (Ref. 79). The next NUMEC procedures manual Reference 6, was dated May 1, 1967, and was sent by NUMEC to the AEC as a result of the AEC's strengthening the provisions of 10 CFR 70.51 in February 1967, requiring licensees to fully describe to the Commission procedures for control of and accounting for special nuclear material (Refs. 6, 32).

6.1.2.2 Approval

NUMEC's 1962 Accountability Department Procedures Manual contained the name of NUMEC's Accountability Representative on its cover (Ref. 11), suggesting that the Accountability Representative not only approved the manual and any revision to it, but also prepared

the manual. NUMEC's 1966 accountability procedures manual bore the signature of the Accountability Representative on the bottom left-hand side of the cover and the signature block of the NUMEC President and General Manager on the bottom right-hand side of the cover (Ref. 5). This suggests that this manual was prepared by the Accountability Representative but was subject to approval by the company president. The only copy of this manual found in the documentation reviewed was not, in fact, signed by the president. The 1967 manual contained only one signature block and was signed only by the Accountability Representative who also held the title of Manager, Nuclear Materials Control (Ref. 6).

6.1.3 Source Data

NUMEC measurement values were generally used for shipments of product (Refs. 3, 15, 21). However, receipts of material were generally carried on shipper's values with NUMEC performing only a checkweight (Ref. 3). Intermediate products were not handled as carefully as final product: in some cases nominal or target weights were recorded instead of actual weights (Refs. 21, 26). Many items, such as filters and other combustible waste, were not measured (Refs. 15, 21, 22, 29). Filters generally were not carried on inventory (Refs. 15, 21, 22, 29). In some instances, as much as 20% of the material carried on inventory might have had its uranium content based on estimates (Refs. 21, 37).

See paragraph 3.1.2.1 for a more complete discussion of NUMEC's measurements.

6.1.3.1 NUMEC used shipper's values for elemental and isotopic analyses for UF_6 received from the AEC (Ref. 3). This practice continued through at least 1968 (Ref. 25). NUMEC generally inspected and checkweighed the incoming UF_6, and the production group used NUMEC determined weights (Refs. 3, 5, 33).

NUMEC accepted the incoming UF_6 values without

a) using a NUMEC surveillance agent (Refs. 2, 3, 5, 11).

b) using tamper-safing (Refs. 2, 3, 5, 11, 22, 37). (See Section 7.4 of this Appendix.)

d) always performing independent gross weight measurements of incoming cylinders (Ref. 22).

e) independent measurement of element and isotope (Ref. 3).

f) certification of acceptance based on independent measurement (Ref. 3).

6.1.4 Adjustments to Records

6.1.4.1 Bias Adjustment

NUMEC did not use statistics for accountability purposes (Refs. 15, 44), and they had no formal measurement control program for accountability measurements (Refs. 2, 3, 5, 11, 15, 21). (The nearest program NUMEC had to a measurement control program was a scale and balance program covering the weighing devices used for shipments and receipts (Refs. 2, 11, 15, 21).) Since NUMEC did not have these programs, they could not have meaningfully determined biases, and consequently they would have had no basis upon which to make bias adjustments.

6.1.4.2 Prior Values

The documentation reviewed is not specific regarding what criteria, if any, NUMEC required to be met in order to change prior recorded values in their books. It is known that some original entries were not supported by documentation, and this seems to have also been the case with changes (Refs. 15, 18). The report of the AEC materials management survey in 1963 stated: "All records in the ledgers have not been referenced and/or supported by bona fide documents, particularly in the case of internal transfers" (Ref. 18). The report of the AEC materials management survey in April 1965 stated that NUMEC had previously been requested (1) to use journal entries to authorize and record all adjustments and (2) to establish official documentary support for all ledger entries (Ref. 15). The report goes on to say that NUMEC had not accomplished these actions (Ref. 15).

The following documents were used at NUMEC, and presumably they were used to document at least some of the changes to the records:

a.1) Nuclear Material Transfer Document, Form AEC-101 (Figure B-III-1, Appendix B-III)

This form was discussed in paragraph 6.1.1.1 a.1). It generally was signed by the Accountability Representative (Ref. 2) but presumably it could have been signed by someone authorized to sign for him (Ref. 58). Before 1966, NUMEC used the title Accountability Representative but not the title Manager, Nuclear Materials Control (Refs. 2, 3, 5). In early 1966, a former AEC employee started work for NUMEC and assumed both titles (Refs. 5, 16).

a.2) SS Material Transfer Form - Leased Material Form AEC-388 (Figure B-III-2, Appendix B-III)

This form was discussed in paragraph 6.1.1.1 a.2). It was signed by the Accountability Representative (Ref. 2), but in some cases it was signed by someone authorized to sign for him (Ref. 58).

b) Nuclear Material Discard Report (Figure B-III-3, Appendix B-III)

This form was not in use prior to 1966 (Refs. 2, 5, 11, 29). It appears that this document was completed and signed by a representative of the area reporting the discard and that it was then approved for posting by someone in the Nuclear Materials Control Department (Refs. 5, 6, 25). See paragraph 6.1.1.1 b).

c) Internal Transfer Receipt (Figure B-III-5, Appendix B-III)

Although this form existed at least as early as 1961 (Ref. 44), NUMEC's use of it was sporadic at best (Refs. 20, 21, 59, 60, 61, 65). See paragraph 7.2.2.1.

6.1.5 Inventory Reconciliation

Upon completion of the physical inventory:

a) Presumably the physical inventory listings were reviewed for completeness (all columns filled in) and accuracy (Refs. 5, 6). NUMEC's 1966 procedure manual indicates that physical inventory lists were to be totalled, audited, and tested by repeat measurements (Ref. 5).

b) Inventory listings were not key punched. NUMEC first used automated data processing to help with inventory tabulation in 1967 (Ref. 20).

c) NUMEC obviously did not have computer printouts to reconcile with anything else prior to 1967 (Ref. 20). Moreover, central accountability records were not generally reconciled with records kept at the MBA level (Refs. 15, 19, 21, 26, 29).

d) The MUF (inventory difference), if significant, was, in 1962, to be referred to the Manager of Production for disposition (Ref. 11). In 1964, such a difference was to be resolved jointly by Accountability and the supervisor in whose area the difference occurred (Ref. 2).

e) Nuclear material discards were neither measured for accountability purposes nor recorded in the accountability records prior to 1966. (Refs. 22, 29, 34). In 1966 only some of the loss mechanisms were being evaluated and recorded (Refs. 20, 22).

6.1.6 Account Reconciliation

6.1.6.1 Reconciliation

Reconciliation of subsidiary records with central or control records is an accounting practice that was not rigorously practiced by NUMEC (Refs. 15, 19, 21, 26, 29).

a) Transfer Journals

Monthly reconciliation of transactions on a plant-wide basis with records summarized from MBA records was not performed (Refs. 15, 21, 26). In 1962, the AEC found that NUMEC's transfer journals were not maintained on a current basis and were not complete (Ref. 21). Moreover, the MBA records that did exist were not reconciled with the central accountability records (Refs. 21, 26). In 1965, the AEC found that none of the following actions previously requested by the AEC of NUMEC had been accomplished: establishment of a facility control ledger and a transfer journal; setting up of internal material control areas and subsidiary ledgers for them (Ref. 15). Clearly, if these records, in effect, did not exist (which the AEC's 1965 (and earlier) findings seem to imply), they could not have been reconciled.

b) MBA Journal

NUMEC's 1962 Accountability Department Procedure Manual and NUMEC's 1964 License Renewal Application both indicate that accountability records were to be kept at the MBA level, and that monthly inventory reports (which most often would be based on book inventories, not physical inventories) were to be sent to Accountability, which was responsible for central records and presumably was to reconcile central and MBA level records (Refs. 2, 11). However, as indicated in 6.1.6.1 a), the AEC found that such reconciliations either were not performed or could not have been performed because of the need to "establish" or "set up" certain ledgers (Ref. 15). Indeed, in 1962, the AEC found that the central (contract) ledger which presumably would have been the most appropriate central accounting record to reconcile with MBA records on an area by area basis was neither complete nor current (Ref. 21). Moreover, this record reflected movements of material only when material was transferred from one project (NUMEC contract) to another, not from one area to another (Ref. 21).

c) Material Status Report

NUMEC was required by 10 CFR 70.53 to submit Material Status Reports, Forms AEC-578, to the AEC twice yearly to report their holdings of material leased from the AEC (Refs. 32, 46). The AEC found in 1962 that NUMEC's records supported neither the leased material reports on file at NUMEC nor the leased material reports sent by NUMEC to the AEC (Ref. 59). In 1964 and 1965, the AEC found that NUMEC apparently had permitted cross-over of nuclear materials between fixed-price contracts and leased material agreements (Refs. 50, 60). Hence the leased (and station) material reports sent by NUMEC to the AEC would not have been accurate.

6.1.6.2 Adjustments

See paragraph 6.1.4.

6.1.7 Location and Identity Records

The following records were used to provide information relative to the identity and location of special nuclear material:

a) Source Documents, Inventory Records and Reports

These documents were to be used by the Accountability Representative to account for special nuclear material held under contract or license from the Atomic Energy Commission (Refs. 2, 5, 11).

b) MBA Ledgers and Monthly Inventory Reports

These documents were to be used by the MBA custodians, clerks, and supervisors to account for the special nuclear material charged to their operations by the Accountability Representative (Refs. 2, 5, 11).

c) Vault Control Records

These documents, which included vault tags, vault logs, and inventory reports, were to be used by the vault custodians to account for the items in the vaults (Refs. 2, 5, 11). NUMEC did not have daily or weekly reports of items in "static control areas" within a vault or storage area (Refs. 2, 5, 11). Prior to 1967, vaults were not MBAs (Ref. 20), and it is not clear that they had to submit monthly inventory reports as MBAs were supposed to (Refs. 2, 11).

6.1.8 Electronic Data Processing

NUMEC did not use electronic data processing (EDP) to assist in accounting for special nuclear material prior to 1967 (Ref. 20). EDP was used by NUMEC for the first time for their Sept. 20, 1967, inventory (Ref. 20). The AEC remarked that the EDP listing "of all items in the vaults as well as process areas is regarded as a significant improvement in NUMEC's inventory procedures" (Ref. 20).

6.1.8.1 Reports/Accounts

Not applicable. See 6.1.8.

6.1.8.2 Capabilities

Not applicable. See 6.1.8.

6.1.8.3 Preoperational Testing

Not applicable. See 6.1.8.

6.2 Records and Reports

6.2.1 Accounting Reports

6.2.1.1 SNM Inventory Reports

NUMEC would not have met any of the 1977 requirements (Refs. 15, 20, 21, 22). Annual inventories were first published as a regulatory requirement in 1967 (Ref. 32).

6.2.1.2 a) Material Status Reports, Form AEC-578 (Leased Material)

NUMEC was required by 10 CFR 70.53 to submit Material Status Reports covering their leased material holdings to the AEC on a semiannual basis (Refs. 32, 46). These reports were to have been based on information taken from NUMEC's transfer journal and subsidiary ledgers (see paragraphs 6.1.1.3.1 and 6.1.1.3.2 (Refs. 11, 59).

However, in 1962 the AEC found these records neither complete nor current and that NUMEC's records supported neither the leased material reports on file at NUMEC nor the leased material reports sent by NUMEC to the AEC (Refs. 21, 26, 37, 59). Apparent crossover of leased and contract material was found by the AEC in 1964 and 1965 (Refs. 50, 60). See paragraph 6.1.6.1.c)

6.2.1.2 b) Material Balance Reports, Form AEC-577 (Station Material)

AEC Manual Chapter 7401 required NUMEC to submit to the AEC Material Balance Reports covering material held under AEC contract or subcontract on a monthly basis (Refs. 10, 54). The AEC materials management survey of NUMEC in 1962 found the following: "The records employed by NUMEC to generate monthly material balance reports (Forms AEC-577) consist of a shipment transfer journal, a receipt transfer journal (both journals use transfer journal sheets, Form AEC-104), and a columnar subsidiary ledger defined by NUMEC as a 'General Active Contract Ledger,' or 'job book'" (Ref. 21). The report of this survey went on to say, "The transfer journals were not maintained on a current basis, and were not complete at the time of the audit" (Ref. 21).

In 1965 the AEC found that NUMEC was not, in general, reporting physical inventories (rather than book inventories) on their ledgers and Material Balance Reports (Ref. 15). This finding was made despite the fact that the AEC had earlier requested NUMEC to base their reports on physical inventory values (Ref. 15).

6.2.2 Accounting Records

The following accounting documents were to have been retained as part of the accounting record:

a) (Station Material) - Separate files for materials received from and transferred to offsite stations were to be maintained by station symbol (Ref. 11).

b) (Leased Material) - Transfer forms AEC-388 were to be filed by license number (Ref. 11).

c) (Station or Leased Material) - Internal transfer forms were to be filed by originating MBA (Ref. 11).

Presumably NUMEC also retained, for a period of time, AEC Forms 577 and 578. It should be noted, however, that as late as 1965, the AEC found that no information regarding physical inventory listings was kept on file and that physical inventory results were transmitted to the central accounting group by telephone (Ref. 19).

6.2.3 Short-Term Storage

The documentation reviewed did not address how long NUMEC stored their accountability records. However, the following excerpt from the report of the AEC's 1961 materials management survey of NUMEC gives some indication of the extent of the files:

"The files consist of two steel cabinets providing space for the following folders, captions of which are easily legible:

1. Outgoing AEC-101 shipping forms, filed alphabetically.
2. Incoming AEC-101 shipping forms, filed alphabetically.
3. Loose post binder for Material Balance Reports, by month.
4. Approved inventory write-offs.
5. Forecasts.
6. Unclassified contracts by stations and licensees.
7. Forms AEC-388 for transfer to licensees, kept on the same basis as the shipping forms, AEC-101.
8. Folder for biannual reports to the Division of Licensing and Regulations.

A separate steel file cabinet with a safe locker provides space for:

1. Classified AEC-101 shipping forms.

2. Classified contracts.

3. Classified transfers from and to licensees" (Ref. 44).

The separate file cabinet for classified matter was an approved four-drawer metal file cabinet with two changeable combination locks, located in the office of the Accountability Representative (Refs. 8, 9, 62, 63).

At least two of the four drawers were used by Accountability, with the other two being used by or shared with the Manager of Engineering (Refs. 8, 9, 37). Knowledge of combination to two of the drawers was limited to accountability personnel (Refs. 8, 9, 37).

6.2.4 Long-Term Storage

See paragraph 6.2.3.

6.3 Audits

6.3.1 Audits

Before 1967, NUMEC did not provide for internal or external audits of its material control and accounting system (Refs. 20, 22).

The report of the AEC materials management survey conducted in October and November of 1967 contained the recommendation that NUMEC should "verify by internal audit procedures that their SN material accountability system is in fact operating in accordance with the plan that they have established" (Ref. 22).

The report of the next AEC materials management survey of NUMEC conducted in October 1967 stated that "NUMEC has performed internal audits of the SNM management functions and written reports have been submitted to management. The auditing group was organizationally independent of the SNM management group" (Ref. 20).

6.4 License Conditions

6.1 NUMEC did not make accountability measurements of discards, much less report them to the AEC, prior to 1966 (Refs. 20, 22, 29). Under the provisions of AEC Manual Chapter 7401, NUMEC was to submit a Material Balance Report (AEC Form 577) to the AEC on a monthly basis (Refs. 10, 54). MUF and NOL (normal operating losses) for AEC contract material were to be reported separately to the AEC as part of these monthly submittals (Ref. 85), and the reports were to be submitted by the fifteenth working day of the month being reported

(Refs. 10, 54). However, the AEC found that NUMEC often reported book, rather than physical, inventories to the AEC (Refs. 18, 21, 22, 29), even when physical inventory results were available. The report of the AEC materials management survey of NUMEC in 1967 contained the following finding:

> "It is the practice at NUMEC, as at other installations, to use the MUF as an "account" for removing quantities from or adding quantities to the material balance by way of corrections to receipts, etc., and accumulating "interim MUF" quantities which are normally transferred to the "loss" account at the time a given job is closed out. This practice is dictated by the circumstance that most contracts do not provide for interim payment of losses, but rather they provide for the settlement of losses at the completion of a contract only...The circumstances noted above make it very difficult to evaluate the MUF reported by a licensee for a survey period since it becomes an almost meaningless and confused quantity" (Ref. 85).

6.2 In 1970, 10 CFR 70.54 was amended to require that each licensee who received SNM in a quantity of one gram or more was to submit to the AEC and the shipper a copy of Form AEC-741 within ten days after receipt of the material (Ref. 86). Prior to 1970, the requirement was that the receiver submit to the AEC a copy of Form AEC-388 (which along with Form AEC-101 was the predecessor of Form AEC-741) "promptly" after transfer took place (Refs. 32, 46, 87, 88). The regulation did not define "promptly." Given that "in most instances," NUMEC did not receive Forms AEC-101 or 388 from the shipper until ten to fourteen days after physical receipt of SNM (Ref. 5), it does not appear that NUMEC could have completed and sent these same forms on to the Commission within ten days of receipt.

Form AEC-284 apparently was in use at NUMEC at least as early as 1962 (Ref. 11). At that time, NUMEC's written procedures stated, "If the accuracy of the SS content cannot be determined within 10 days, receipt should be made on a tentative basis using SS Material Receipt Form AEC-284 pending completion of Form AEC-101. If the SS material content is not determined within 60 days, the shipper's SS material content must be unqualifiedly accepted unless the SS material received is scrap" (Ref. 11).

6.3 Since NUMEC had no formal statistical program for accountability purposes (Refs. 15, 44), they would have had no basis upon which either to determine the effect measurement bias may have upon MUF or to make bias adjustments to their material balance.

6.4 NUMEC's scrap was basically recovered onsite, but the period of time until recovery might be indefinite (Refs. 15, 18, 21, 22, 29, 37). It should be noted, in addition, that NUMEC did not routinely adjust their books to reflect the results of physical inventories (Refs. 18, 21, 22, 29). Even after the AEC put pressure on NUMEC to record the

results of physical inventories and adjust their accounting books appropriately (Refs. 22, 29), NUMEC did not record final results in a timely fashion (Refs. 20, 85). Indeed, an AEC survey team noted that "NUMEC was making adjustments to the September 30, 1967, inventory during the month of December 1967" (Ref. 85).

7.0 INTERNAL CONTROL

7.1 Material Receipt

(1964)

7.1.1 Receiving Procedures

7.1.1.1 Receipts and Storage

The following is a description of procedures followed covering external receipt of special nuclear material at NUMEC in the mid 1960s. The references cited span the years 1961 to 1966, so not all of the below procedures were necessarily in effect at any one date.

a) All shipments were dispatched or received during the day shift (Ref. 9).

b) Whether material was classified or not was a consideration in arranging transportation. Certain classified shipments required the exclusive use of a vehicle and armed guard escort (Ref. 64).

c) The shipper, in accordance with the provisions of AEC Manual Chapter 7401 or 10 CFR 70.54, would prepare and issue to NUMEC a material transfer form (AEC-101 or AEC-388, respectively) (Refs. 10, 32, 54). However, these forms usually were not received until 10-14 days after physical receipt of the material (Ref. 5).

d) The documentation reviewed does not indicate the internal NUMEC distribution for AEC-101 or AEC-388. Presumably Accountability received one copy of it.

e) Shipments were usually received at the Apollo site for high and low enriched UF_6 and at the Parks Township site for plutonium and drums of uranium-bearing scrap (Refs. 9, 11, 30).

f) Shipping and Receiving Personnel (Plant Services Department) were to:

1. Visually inspect inner and outer container/ cylinders for:

   (i) Condition of packaging (Ref. 5),

   (ii) Identification, description, and other markings on labels and/or tags attached to the packaging (Ref. 5).

2. Notify the Accountability Representative "if inspection discloses improper packaging, container damage, material leaks, improper labeling, identification or description, or other irregular or nonstandard conditions" (Ref. 5). If one of these conditions was noted, Shipping and Receiving was not to permit further handling except in accordance with instructions from the Nuclear Materials Control Department (Ref. 5).

3. A Receiving Control Form (Form NUMEC 34-8) was to be prepared for each shipment, with copies to the Project Engineer and Nuclear Materials Control Department (Refs. 5, 64). The incoming UF_6 or other forms of material was weighed, labeled with a NUMEC job number and accepted for the storage area or process area by a representative of accountability (Ref. 44). SS material received at NUMEC was to be stored by Accountability in designated storage area(s) to await transfer to the department (MBA) which was to process the material (Refs. 2, 11).

g) Upon receipt of SS materials from an offsite station, the material was to be charged directly to the applicable MBA on an internal transfer receipt form (Ref. 11).

h) GPA (General Plant - Physical Accountability) was to maintain records for all receiving storage areas (Ref. 2). The receiving storage areas were not MBAs; rather, they provided repositories for SNM charged to the MBAs (Ref. 2).

i) After receipt and storage, GPA was to transfer material to the operating MBA (Ref. 2).

j) All transfers from GPA to any MBA were to be documented by internal transfer receipts (Ref. 2).

7.1.1.2 <u>Measurement</u>

NUMEC's 1964 License Renewal Application stated: "In the case of UF_6 material, no analysis can be made until the hexafluoride is withdrawn and converted to an assayable form. In these and similar instances, the material shall be checkweighed upon receipt and tare weight determined after the material is withdrawn from the cylinder" (Ref. 2).

Receiving weights were to be recorded by vault custodians or by operating personnel (Ref. 5).

NUMEC did not routinely perform NDA checks on incoming shipments of SNM (Refs. 2, 5, 11).

Material assigned to production areas was not weighed by the foreman, but was admitted to process areas on the basis of the weights stated on the label attached to the container by Accountability (Ref. 44).

The Nuclear Materials Control (Accountability) Department was responsible for assuring that all material received was properly measured, and that all measurement results were properly documented. The containers were to be opened by accountability personnel, checkweighed and stored in one of the vaults pending issuance to the department which was going to use the material (Ref. 5).

Despite the emphasis stated by NUMEC on check-weighing incoming UF_6 receipts, sometimes this procedure broke down. The report of the AEC materials management survey conducted in October 1966, stated:

"All nineteen (19) cylinders of UF_6 were checkweighed by the survey group. Our weights were compared to Goodyear's weights because NUMEC had not checkweighed these upon receipt. NUMEC advised that their policy is to weigh each cylinder upon receipt, normally within 24 hours, a policy with which we completely agree. In the case in point, the cylinders were received when the scale was out of service and after it was repaired the fact that these cylinders had not been weighed was overlooked" (Ref. 22).

7.1.1.3 Sampling Plans

Sampling of receipts was done as follows:

a) Uranium Hexaflouride (High and Low Enriched) - Not sampled. Incoming UF_6 was not analysed (Refs. 3, 25).

b) Uranium Scrap - Continuous Sample (Sample after first dissolution step, mix solution using air sparge) (Refs. 25, 30).

7.1.2 Shipper/Receiver Comparison

Accountability measurements, records of NUMEC's receipts and shipments and shipper-receiver comparisons were the responsibility of the Accountability Representative (Refs. 11, 44). He was responsible for determining, or causing to be determined, the accuracy of the shipper's measurements (Refs. 2, 11). Any shipper-receiver difference was to be noted in the receiving block of the AEC-101 returned to the shipper (Ref. 2). If a difference were found, the shipper was to be notified promptly (Ref. 2). For receipts other than UF_6 and scrap, NUMEC was to unqualifiedly accept shipper's values if NUMEC

had not determined the material content within 60 days of receipt (Refs. 2, 11).

NUMEC performed gross/tare shipper-receiver comparisons on an item basis and on a shipment basis (Refs. 5, 25). However, there is no indication in the documentation reviewed that they evaluated receipts on a cumulative basis.

Shipper-receiver differences were examined by the AEC materials management survey teams that visited NUMEC in the 1960's. The 1961 survey team felt that the differences for the period July 1959 to March 1961 were not unusual (Ref. 44). They noted an apparent minor bias in which NUMEC, as receiver, was measuring slightly more material than the shipper (Ref. 44). The 19 differences noted totalled only 246 g U-235 (> 75% enriched), and NUMEC did not wish to issue corrected shipping forms even though the differences were favorable to them (Ref. 44). This was because if a future shipper-receiver difference occurred which was not in their favor, NUMEC would "be in a position where they have not compromised the accuracy of their own laboratory" (Ref. 44).

The 1962 survey noted that minor shipper-receiver differences had occurred in the shipment of U_3O_8 to Oak Ridge and in the receipt of UF_6 from Oak Ridge (Ref. 21). The report went on to state: "NUMEC has adjusted its records to agree with Oak Ridge measurements. Large shipper-receiver differences have occurred in the receipt of scrap materials, but these are eliminated by ~~the~~ shipper's acceptance of NUMEC's data from the dissolver solution measurement"[1] (Ref. 21). The report continued: "Based on a review of forms AEC-101, NUMEC's customers have not usually verified the SS content of product received from NUMEC. Where this certification has been performed, the S/R differences have been negligible" (Ref. 21).

The report of the April-May 1965, survey treated NUMEC's shipper-receiver differences in the following manner:

> "Inasmuch as a considerable portion of NUMEC receipts and shipments are (1) carefully measured product materials, and (2) involve transactions on which no shipper-receiver differences are permitted, shipper-receiver differences have not been a major factor at NUMEC.
>
> . . .

[1] Acceptance by the shipper of the scrap reprocessors' measurements was, and is, common practice in the nuclear industry. However, see the discussion in subsequent paragraphs.

A comparison of shipper's estimates of uranium contained in scrap and NUMEC dissolver solution values on scrap recovered during the survey period is presented below:

	Shipper	NUMEC	Percent
Kg. Uranium	2,364,055	2,359,441	0.2
Kg. U-235	365,957	359,382	1.8

This is considered to be good experience" (Ref. 15).

The survey period for the April-May 1965, survey, was July 1, 1963, through April 30, 1965 (Ref. 15), and the above table apparently reflects large amounts of low enriched uranium. Reference 68, a letter from NUMEC to the AEC dated December 29, 1965, contained scrap recovery data on about 100 lots of scrap enriched to 5% or greater received at NUMEC for recovery between October 1959 and July 1964, and recovered by January 1965 (Ref. 68). The tables in this reference listed data for the scrap recovery contracts "most likely processed at NUMEC during the time the 1231 (WANL) contract was active" (Ref. 68). The following tables summarize the shipper vs. receiver data contained in the two tables in Reference 68.

TABLE 7.1.2a

NUMEC LOSS EXPERIENCE ON SCRAP RECOVERY CONTRACTS, 1959-1964, >5% ENRICHMENT
(Table based on data contained in Reference 68)

	NUMEC	Shipments Out	Loss	Percent
g Uranium	1,274,749	1,263,103	11,646	0.91%
g U-235	1,012,604	1,002,960	9,644	0.95%

TABLE 7.1.2b

SHIPPER-RECEIVER DIFFERENCES ON NUMEC SCRAP RECOVERY CONTRACTS, 1959-1964, >5% ENRICHMENT
(Table based on data contained in Reference 68)

	Shipper	NUMEC	Difference	Percent
g Uranium	1,368,415	1,274,749	93,666	6.84%
g U-235	1,091,657	1,012,604	79,053	7.24%

Table 7.1.2a indicates that NUMEC was returning to the AEC all but about 1% of the material NUMEC had measured at the first dissolution step of their scrap recovery process. Returns of this magnitude (i.e., 99%) were considered by the AEC at the time to be unusually large (Ref. 92).

Table 7.1.2.b indicates that of approximately 1090 kg of U-235 estimated by the shippers to be in the scrap sent to NUMEC, NUMEC measured approximately 1010 kg of U-235, or 7.24% less. The material involved had an average enrichment of approximately 80%. Due to the common practice then, and now, of a shipper's accepting the values obtained by the scrap reprocessor, these shipper-receiver differences disappeared, from an accounting viewpoint so far as NUMEC was concerned, when the shipper changed his values to agree with NUMEC. Any resulting change in MUF (Inventory Difference) was reflected in the shipper's records rather than NUMEC's records. Shippers traditionally accept the values of the scrap reprocessor because the shipper cannot measure scrap material as accurately as the reprocessor, who, after the first dissolution step can perform a precise chemical assay for uranium content of a homogeneous material. Unless the shipper sends personnel to observe the reprocessing, he generally has no viable recourse if he thinks the reprocessor's values are too low. He has to accept the reprocessor's values, making the shipper-receiver difference, and whatever value it may have as a safeguards indicator, disappear from the books. It is common, although not always the case, for receiver's values (including scrap reprocessors) to be less than shipper's values for the same material. Such a practice makes economic sense for both parties. However, it is not common, at least for current licensees, to have shipper-receiver differences for scrap contracts consistently at the 7% difference level.

There was some indication in the documentation reviewed that, at least in some cases, the shipper disagreed with, and made an issue of, NUMEC's low recovery values (Ref. 93). In 1962, General Electric/ San Jose sent NUMEC what they estimated to be 6.5 kg of U-235 in 93% enriched uranium for recovery (Ref. 93). NUMEC's recovery values reported to the AEC on their 12/31/63 Material Status Report showed they recovered only 4.1 kg of U-235 in 35% enriched uranium (Ref. 93). The difference in dollar value was $30,747 (Ref. 93). The General Electric spokesman's "position was that he could see no relation between the material that had been sent for recovery and the material which had been returned to Oak Ridge alleged to have come from the General Electric job. While recognizing the uncertainties in the SS content of scrap shipments, he was likewise of the opinion that the differences found (particularly in U-235 content) were too great for the quantities of material originally involved. From a material control standpoint he felt that if the NUMEC returns represented an accurate situation an increase of approximately 2 kgs. of U-235 should show up some place in the General Electric materials inventory - and this had not occurred. His point was that one does not misplace or lose 2 kgs. of U-235 that easily. He was strongly of the opinion that his values on the transfer document were reasonably correct. Although reimbursement for losses and degradation has been paid to NUMEC by General Electric, (the spokesman)[1] stated this was because

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[1]The spokesman's name appears in the reference.

of the nature of the purchase order which had been placed with NUMEC which apparently gave no option other than paying for degradation or losses deemed to have occurred. It was readily apparent that considerable ill-will has been generated by this transaction between the two companies" (Ref. 93).

If, in fact, NUMEC's scrap dissolution measurements were biased low or otherwise incorrect on the low side, the actual loss figures for NUMEC would be higher than the 178 kg U-235 figure established for the period covering plant startup in 1957 through October 30, 1965 (Ref. 29).

7.1.3 Acceptance Criteria

The documentation reviewed did not specify the acceptance criteria used by NUMEC in the mid-1960s. This may be because NUMEC did not have formalized accept/reject criteria. NUMEC's standard operating procedure for incoming shipments seemed to be:

a) Any differences should be noted on the AEC-101 returned to the shipper,

b) The shipper should be notified promptly if a major shipper/receiver difference existed, and

c) Large differences, especially for UF_6, should be brought to the attention of the Production Manager for disposition (Refs. 2, 11).

7.1.4 Conditions for Transfer

The Plant Services Department was not authorized to release incoming material to processing areas (Ref. 25). All nuclear material was to be under the direct control of Accountability until appropriate weight and other checks could be performed, and until appropriate transfer documents had been received (Ref. 25). In some cases, the Quality Control Department would place a hold on incoming material, pending receipt of analytical data essential to quality certification (Ref. 25).

7.1.5 Records

NUMEC did not have a statistician, nor does it appear that they evaluated shipper/receiver differences for cumulative trends (Ref. 2). Indeed, it appears that even as late as 1968, NUMEC was not using calculated limits of error (LE) based on measurement uncertainty to evaluate shipper/receiver differences (Ref. 25).

7.2 Internal Transfers

7.2.1 Timeliness

According to NUMEC documents describing their accountability procedures in the mid 1960s, transfers between MBAs and from receiving storage (which was under Accountability) to an MBA were supposed to be documented by Internal Transfer Receipts (ITRs) (Refs. 2, 5, 11). These transfer forms usually were to be executed at the time of the transfer (Ref. 5). One copy of the three part form was to go to the central accounting group for posting and cross-checking (Ref. 2). The central records were not computerized (Ref. 20), and they were to be reconciled to MBA records on a monthly basis (Refs. 5, 11).

Materials management surveys by the AEC, however, found that NUMEC in-place procedures for documenting internal transfers were deficient. The report of an AEC survey conducted in mid-1962 states: "except for transfers from one project to another, the internal transfer documents which did exist are not posted to the central accountability records" (Ref. 21).

The report of an AEC survey conducted in November of 1965 recommended that NUMEC "Establish an internal transfer system so that internal transfers to and from material balance areas and from one account (job order) to another within the same material balance area are documented with transfer and recorded in the forms subsidiary ledger" (Ref. 29).

7.2.2 Documentation of Internal Transfers

7.2.2.1 Internal Transfers

According to NUMEC documents describing their accountability procedures in the mid-1960s, transfers between Material Balance Areas and from receiving storage to MBAs were to be documented on a general purpose internal transfer form (Internal Transfer Receipt) (Ref. 2). These forms were not used to document transfers between MBAs and storage vaults or between MBAs and the laboratories (Ref. 2). Starting in 1966 or 1967, transfers to the Analytical Laboratories were to be documented on a Analytical Request and Sample Transfer Form (Refs. 5, 6). The transfer documents had spaces for the identity, quantity, and isotopic analysis of the material transferred (Ref. 11).

NUMEC's actual use of Internal Transfer Receipts was not entirely consistent with the above descriptions. Numerous transfers were made for which NUMEC had no transfer document to show the AEC (Refs. 59, 60). Working papers from the AEC's 1962 survey contained the following information:

"The internal transfer form was revised in Dec. 1961. Prior to that time use of the form was limited primarily to transfers involving

(illegible) or S&R. After about March 1962, use of the form because more prevalent.... A number of material flows still are not being documented." (Ref. 65)

An internal NUMEC memo dated November 1963 indicated that at least some transfers were made without Internal Transfer Receipts being issued (Ref. 61). Although NUMEC certainly documented some of their internal transactions, the conscientiousness with which they did this was such that in 1967 the AEC referred to NUMEC's use of internal transfer documents as a "relatively new" procedure (Ref. 20).

7.2.2.2 Prenumbered Internal Transfer Receipts

An AEC materials mangement survey conducted in March of 1961 resulted in the suggestion that NUMEC's Internal Transfer Receipts (ITRs) be prenumbered (Ref. 44).

An AEC materials management survey in 1962 resulted in another suggestion, which was transmitted to NUMEC by letter dated October 26, 1963, that NUMEC revise its internal transfer document system "so that internal forms are pre-numbered" (Ref. 17).

NUMEC's 1964 License Renewal Application indicated that the ITRs were prenumbered. However, the report of the AEC materials management survey of NUMEC in early 1965 suggested that NUMEC do the following: "Any authorized internal transfers between jobs are to be recorded on and posted from numbered journal vouchers (journal entry documents) and the results thereof recorded in the ledger and the material balance report" (Ref. 15).

The report of the AEC materials management survey of NUMEC conducted in October 1967 lists as an item representing satisfactory performance and/or improvement since the preceding survey (which was in Oct-Nov. 1966) the following: "Internal transfers between balance areas are documented on serially numbered forms. No exceptions to this procedure were noted" (Ref. 20).

The NUMEC-generated documentation reviewed does not indicate how the ITRs were issued or controlled. The emphasis of the AEC in the mid-1960s seemed to focus more on getting NUMEC to use ITRs to document transfers than on controlling the documents (Refs. 15, 21). However, the report of an AEC materials management survey of NUMEC in late 1966 contained the following finding:

"Although the internal transfer documents are prenumbered, there has been no means established to account for all the numbered documents issued for all or to record the areas or personnel where these numbered documents were assigned "(Ref. 22).

7.2.2.3 Reconcilation

Reconciliation of MBA records with central records was not being performed in 1961 or 1962 (Ref. 21). The report of the 1962 AEC materials management survey of NUMEC stated, "certain internal transfer records are maintained by material custodians but these records are not reconciled with the central accountability records. This same situation existed and was pointed out in the report of survey NY 141" (Ref. 21).

NUMEC's 1964 License Renewal Application indicated that prenumbered Internal Transfer Receipts were to be used and that MBAs should establish their monthly book balances using summary sheets based on the ITRs (Ref. 2). Moreover, the application stated that these MBA-generated book balances were to be in agreement with the central accounting group's balance for the respective MBAs (Ref. 2).

What NUMEC described in their 1964 application was not what the AEC found when it performed subsequent materials management surveys. The report of the AEC survey of leased material, which was done in conjunction with a survey of contract material during April and May 1965, stated: "Inasmuch as the Contractor has not presented for audit any internal transfer documents authorizing the movement of SN material within the plant areas, we were unable to document the internal job numbers cited above..." (Ref. 60).

The report of the AEC materials management survey of NUMEC in November 1965 recommended that NUMEC take immediate action to "Establish an internal transfer system so that internal transfer to and from material balance areas and from one account (job order) to another within the same material balance area are documented with transfer forms and recorded in the subsidiary ledger" (Ref. 29).

The AEC reports and working papers (Refs. 15, 21, 22, 29, 60, 65) indicate internal transfers were frequently made without documentation being generated and/or recorded in both sets of records (MBA-level and central). Given this, reconciliation of the two sets of records would have been a useless exercise. This suggests that NUMEC could not have routinely reconciled MBA-level records with central records until after the establishment of the internal transfer system called for by the AEC in the 1965 survey. The AEC reported that this system had been "essentially" established by October 1966 (Ref. 22).

7.2.3 Signature Requirement

In 1964, internal transfer documents were to be signed by authorized representatives of the originating and receiving MBAs and Accountability (Ref. 2). The report of an AEC materials management survey conducted in 1965 suggested that at least the Accountabilty signature may have, in some cases, been missing. The report of the April 1965 survey indicated that NUMEC should record internal transfers between

jobs on numbered journal vouchers for posting to the records (see paragraph 7.2.2.2) and, in addition, NUMEC should ensure that this journal entry document was signed by an authorized company official and that evidence of posting should be shown in the document (Ref. 15).

In 1964, NUMEC did not have nuclear material discard and loss reports; in fact, loss data was not reported to the Accountability Representative and it was not reflected in the accountability records (Refs. 19, 21, 29, 34).

The earliest documentation found which described a loss or discard report was NUMEC's March 1966 Procedure Manual (Ref. 5). The manual stated that a special form, called a Uranium Removal Request (see Figure B-III-7 of Appendix B-III) was to be used for disposing of any waste material besides filters, combustible waste, or liquid waste to be discarded to the river. This form was to be subject to the specific approval of Accountability (Ref. 5). The manual also introduced the Nuclear Material Discard Report (see Figure B-III-3 of Appendix B-III), a form that was to be used to document known (or at least estimated) losses of enriched uranium. It was to be used for discards and accidental losses, and it was to be used as the basis for journal entries (Refs. 5, 6). It apparently was to be signed by a representative of the MBA reporting the loss and approved for posting by someone in the Accountability Organization (Refs. 5, 6).

As with the Nuclear Material Discard Report, the NUMEC Inter-Job Transfer Authorization (see Figure B-III-4 of Appendix B-III) appears to have been first introduced in 1966 (Refs. 2, 5, 11). This form was to be used to document transfers between NUMEC contracts (Ref. 5). It was to be initiated by the Nuclear Materials Control Department (Accountability) upon suitable evidence that such a transfer was authorized by the relevant contracts, and it was to be completed by the MBA custodian to show the actual quantity transferred (Ref. 5). The form contained a space for the signature of a representative of Accountability (Ref. 5).

Finally, nuclear material transfer documents, i.e., Forms AEC-101, AEC-338, and AEC-284, were to be signed by the Accountability Representative (Ref. 5).

7.2.3.1 The NUMEC Internal Transfer Receipt (see Figure B-III-5 of Appendix B-III) had spaces for the signatures of representatives of the shipping and receiving MBAs and Accountability (Refs. 5, 11). There appears to have been nothing in NUMEC's procedures that would prevent the same individual's signing a transfer form as both shipper and receiver. Indeed, it was possible for different MBAs at NUMEC to have the same Material Balance Area Accountability Clerk (Ref. 26), and presumably he was authorized to sign an Internal Transfer Receipt on behalf of either of his MBAs. Certainly there was nothing in the written NUMEC procedures (Refs. 2, 5, 6, 11) to prevent him from signing for either or both MBAs.

7.3 Storage and Item Control

7.3.1 Basic Features

In 1964, NUMEC did not have Item Control Areas (ICAs) (Ref. 2). Moreover, NUMEC did not have "items" in the sense of 10 CFR 70.51(e)(1), which requires containers of special nuclear material not in process to be tamper-safed, thus becoming "items" (Ref. 45). NUMEC did have vault[1] storage areas which handled discrete (nontamper-safed) containers and which in general were the predecessors of ICAs (Refs. 2, 5, 11).

The basic features of the vault control system are outlined below. For a detailed discussion of access controls at the MBA and plant level, refer to Section 4 of Appendix A of this report.

a) Only persons authorized by a Vault Custodian were to be permitted inside a vault (Ref. 2).

   Material transactions were to be conducted only with persons authorized by their supervisors (Ref. 2). Their names were to appear on a list posted in the vault office (Ref. 2).

   The combinations and/or keys to the doors of the SNM vaults were held only by the Foreman, SS Material Accountability, and by the four Vault Custodians who worked for him (Ref. 3). Members of the guard force also had the key to the outer door of the main vault which they used when making their hourly security checks at night (Ref. 3).

b) A Vault Custodian was to be present in the general area when someone else was in the vault (Ref. 3). For example, someone from Quality Control might be in the vault to take a small sample of material from a container in the vault (Ref. 3).

c) NUMEC did not have a container tagging system providing for unique identification of containers by alpha/numeric symbol or otherwise (Refs. 17, 19, 29, 39, 49). Containers in a vault were identified by a label attached to the container and by a three-part vault tag (also called inventory card, shelf tag, vault control card, or deposit slip) (see Figure B-III-10 of Appendix B-III) one copy of which was affixed to the containers or placed on its storage shelf (Refs. 2, 5, 11, 22). The shelf number or location was to be marked on all copies of the tag (Ref. 2). The label and the tag had spaces for information on total weight (gross, tare, net), weight of contained uranium, chemical form, enrichment, and job number (Refs. 2, 11). A copy of the tag was to be filed by contract and enrichment in the vault record file, and the other copy was to be given as a receipt to the MBA depositing the material (Refs. 2, 11). When

[1]The vault storage areas at NUMEC would not meet the current definitions of "vault" or "vault type room" found in 10 CFR 73.2 (Refs. 8, 9, 66).

a container was requested by an operating area, the original copy (file copy) was initialed and filed, and the other two copies were destroyed (Ref. 22).

The report of the AEC survey in November 1965 recommended that NUMEC "Establish a system of inventory identification such as by pre-numbering process containers or other comparable technique. These numbers could then be entered on internal transfer forms and posted to records maintained for the different material balance areas" (Ref. 29).

d) In 1964, the vault tag was to be used to document transactions of material to or from the vaults (Refs. 2, 11). The deposit or withdrawal of material from a vault was to be posted on a daily basis to a Vault Log by the custodian (Refs. 5, 11).

It should be noted that the report of the AEC materials management survey of NUMEC conducted in October and November, 1966, stated that although NUMEC's 1966 Procedures Manual, Reference 5, stipulated that a vault log was to be maintained, the log was not in existence at the time of the survey (Ref. 22).

e) NUMEC did not have ICAs in 1964 (Ref. 2). Transfers to and from the vaults were documented only by the vault tag and perhaps the Vault Log (see Figure B-III-8 of Appendix B-III) (Refs. 2, 22). In particular, Internal Transfer Receipts were not prepared and no documentation of the deposit or withdrawal of material was sent to the central accountability group (Ref. 2). Hence the only individual(s) having a single set of records showing how much material was supposed to be in the vault was (were) the vault custodian(s).

The vault tags retained by the MBAs provided the only potential overcheck of the vault records, and for any given MBA the overcheck would be only partial. There is no indication in the documentation reviewed that NUMEC overchecked the vault records by comparing them to the MBA records.

f) NUMEC did not use an SNM movement form for vault transactions in 1964, nor did they use automated data processing for accountability at that time (Refs. 2, 5, 20).

g) The only reports that NUMEC generated in the mid-1960s to provide knowledge of the holdings in the plant were listings made during the occasional inventories (Refs. 21, 29).

In particular, there were no daily or biweekly reports (Ref. 2). The monthly reports sent by MBAs to the central accountability group were usually book balances, not the results of inventories (Ref. 2). Moreover, a vault, since it was not an MBA, was not subject to the monthly reporting requirement (Refs. 2, 11).

h) A deposit of material in a vault (the 1964 version of incorporation of a container into the item control system) was to be permitted only if the container bore a label or tag providing the following information: job number; enrichment; chemical form and/or description; date; gross, tare, and net weight; and weight of contained uranium in grams (Ref. 2).

i) In 1964, NUMEC accountability records, including vault records, were manual (Ref. 20).

7.3.2 Identification

Containers of special nuclear material were to be labeled (see 7.3.1 h), and if they were stored in the vault, they were to be identified by vault tags also (Ref. 2). Tamper-safing seals and alpha/numeric symbols were not required and were not used (Refs. 2, 3, 5, 11, 17, 19, 29, 37, 39, 49). (See Section 7.4 of this Appendix for a discussion of tamper-safing.)

7.3.3 Quantity Determination

Each container transferred to the vault for storage was to bear a label containing gross and net weight, element content, and enrichment (Ref. 2). Vault custodians weighed (or checkweighed) material when it was brought to the vault for deposit (Ref. 3). It should be noted that this was, in general, a gross weight only. Unless the container had been brought to the vault office previously for tare weighing, the vault custodian's weighing could not verify the net weight. (Presumably a fairly good tare approximation could have been available by tare weighing a similar container.)

With respect to uranium content, NUMEC's 1964 License Renewal Application stated, "Each container (small or large) with SS-material shall be marked as to job number, quantity and enrichment. It shall also show the total U-content and the 'source' of this value (estimate, assay, AEC weight)" (Ref. 2). This implies that the uranium content assigned to the container may have been an estimated value, not a measured value. The 1964 application also said that, "Based on a check analysis at NUMEC" the enrichment assigned by the AEC to incoming UF_6 was to "be carried through our processing and passed on to our customers upon delivery of finished product" (Ref. 2). Due to comingling of materials of different enrichments at NUMEC (Refs. 29, 50, 60, 68), NUMEC's practice of carrying through isotopic values without remeasurement did not ensure that correct isotopic values were assigned to the container.

7.3.4 Records

7.3.4.1 Source Documents

Since NUMEC did not have an item control system as is currently required by 10 CFR 70.51 (Ref. 45) or some other system to uniquely identify containers of SNM (Refs. 19, 29, 39, 49), NUMEC had no need or capability to record the source or disposition of such containers.

7.3.4.2 Transaction and Inventory Records

NUMEC used the following records for recording vault transactions:

a) Vault Tag (Also called inventory card, shelf tag, vault control card, or deposit slip) (See Figure B-III-10 of Appendix B-III) (Refs. 2, 5, 11, 22).

A vault tag was to be prepared for each item received into vault storage (Refs. 2, 11). Theoretically, these cards could have been used to identify and locate each container in the vault(s). The file copies of these cards could have collectively served as a perpetual inventory of the containers in storage. However, they could not have been relied upon to provide an accurate perpetual inventory of all SNM in storage because (1) the uranium content stated on them may have been estimated, not measured (Ref. 2), and (2) the AEC observed discrepancies between container weights and container labels (Ref. 18) (sometimes samples were withdrawn from the containers without corrections being made to the weight data on the container label and/or vault tags (Refs. 3, 5, 22)).

The return by the MBA of its deposit slip (i.e., the MBA's copy of the vault tag) was required for the removal of containers from storage (Refs. 2, 22). The original vault tag was then initialed and filed and the two carbon copies destroyed (Ref. 22). Release notification from Accountability was not required (Refs. 2, 5).

b) Other Vault Records

There were two other vault records used at least temporarily during the mid-1960s. One was the vault log which is mentioned in the following passage from NUMEC 1966 Procedure Manual: "Because many instances arise in which the product of one MBA is stored for issue as feed to a second MBA, vault personnel record each transaction in a vault log..." (Ref. 5).

However, the next AEC materials management and survey of NUMEC after the 1966 manual was issued found that this log was not then in existence (Ref. 22).

NUMEC's 1966 Procedure Manual also stated that material was not to be issued to an MBA other than the one placing it in storage unless an Internal Transfer Receipt was completed. While other documentation reviewed neither specifically confirmed nor refuted whether this stated procedure was indeed in place in 1966, it certainly was not the procedure in place in 1964 (Ref. 2). See 7.3.1 e).

A daily vault log was in existence as early as 1961 (Ref. 44). This log was used to record the movement of material into and out of the vault and its location by shelf. Its column headings were "Job," "Enrichment," "Chem - Form," "Net Wt. In," "To Shelf," "Net Wt. Out," "From Shelf," and "Remarks" (Ref. 11). See Figure B-III-8 of Appendix B-III.

Another record that was used for the vault operation, as early as 1962, was a kind of perpetual inventory booklet broken out by NUMEC job number (Ref. 11). A description of this record is provided by the working papers of the AEC materials management survey conducted in May - August 1962:

"The F and G vaults, which physically are two units but have one record and one custodian, are not material balance areas. Physically they are in-process storage for all NUMEC material balance areas... The book of record is a loose leaf notebook containing a page for each job regardless of what material balance area the material came from. Each page is, for the lack of a better term, a perpetual inventory sheet. Each item is posted by the location it is placed in the vault as it is received. This occurs on the right hand side of the sheet or page, which is columnar paper. Across on the left hand side, on the same identification line, a posting is made when the material leaves the vault. -These pages are not totalled nor recopied to a summary sheet. Thus, this record does not reveal a balance of any past date... Thus, it was determined that the book of record maintained for the F and G vaults was a subsidiary to all other material balance area records" (Ref. 26).

c) Material Balance Area/Item Control Area Journal

In 1964, the vault(s) did not comprise a Material Balance Area or an Item Control Area (Refs. 2, 26). Moreover, in the mid-1960s, NUMEC's accountability records were not computerized (Ref. 20), and Accountability did not issue periodic activity reports to MBA or vault custodians (Refs. 2, 11, 21, 29).

7.4 Tamper-Safing Program

7.4 Tamper-Safing Program

NUMEC did not secure its containers or vaults in a manner that would satisfy the conditions of 10 CFR 70.51(a)(10), (Refs. 2, 3, 5, 11, 22, 37). (See Appendix A of this report for another discussion of tamper-safing).

NUMEC did not require that containers placed in a vault be sealed, only that they be closed (Ref. 2). This provision seemed more motivated by health physics considerations than by safeguards (Ref. 2). The following paragraph from NUMEC's 1964 License Renewal Application sets forth NUMEC's requirement that containers placed in vault storage be closed:

"All containers must be closed. The outside of each container must meet the cleanliness rules set forth under the section covering Health and Safety. No gross contamination is permitted on the outside of any container that is to be stored in the vault areas" (Ref. 2).

7.4.1 Types of Devices

As indicated in 7.4, NUMEC was not required to use, and did not use, tamper-safing seals or other devices (Refs. 2, 3, 5, 11, 22, 37).

7.4.2 Indicating Features

If material were removed from a container (e.g., a container in vault storage), and the lid put back on, there would be no external indication on the container that material had been removed unless a notation was made on the container label (Refs. 3, 5, 22). Removal of quality control samples from containers in storage was not uncommon at NUMEC, and NUMEC's procedures called for either a relabeling of the container to show the new weight or the attachment of an obvious new label (e.g., one saying "SAMPLED") to the container so that the container would be reweighed if it were still in the vault at inventory time (Refs. 3, 5, 22).

However, the AEC noted in 1963 that, in some cases, the actual weight of NUMEC's SNM containers did not agree with the weight data stated on the labels affixed to the containers (Ref. 18). Such disagreement might have arisen (as it did later in 1966) as a result of samples having "been removed from containers without revision of the label and/or tag for the change in gross and net weights" (Ref. 22).

The report of the 1966 survey went on to say, "The gross weight of a number of items was misstated, and some containers were not identified as having been sampled so that the label data would not be used until the item was reweighed... Obviously, a physical inventory

listing at a later date, using the data on the uncorrected tag or label, would be erroneous" (Ref. 22).

7.4.3 Application

Not applicable. See 7.4.

7.4.3.1 NUMEC was not required to, and did not, provide for a second party to attest to the contents of a container when it was weighed and closed (Refs. 2, 3, 5, 11, 22, 37). Attesting to material contents would have been of little value in the absence of tamper-safing because without tamper-safing, material still could have been removed from the (attested to) container without leaving any external trace. The only way such a removal would show up would be if the container were reweighed later, e.g., at inventory time. NUMEC's operating procedures did not ensure that this would happen (Refs. 2, 3, 5, 11, 22, 37). Indeed, NUMEC's inventory procedure called for their physical inventory values to be based on data from the container labels if they were legible and complete (Refs. 11, 37, 47, 48). (See paragraph 5.4.3, Prior Measurements.) Since NUMEC's procedures called for only a small percentage (one percent) of containers in "dead storage" since the last inventory to be reweighed (Ref. 11) on a random basis for inventory verification purposes, there was little likelihood that such a removal would be detected later. Even if the container were reweighed and a different weight (from that on the container label) noted, the removal quite likely would have been assumed to have been caused by a legitimate removal for quality control sampling purposes (Refs. 3, 5, 22).

7.4.4 Identification

Since there were no tamper-safing devices, there was no identification system for their control. For the identification system used for containers, see the discussions in paragraphs 5.4.1.1 and 7.3.1.

7.4.5 Access

Not applicable. See 7.4.

7.4.6 Control

7.4.6.1 General

Not applicable. See 7.4.

7.4.6.2 Control of Scrap

Not applicable. See 7.4.

7.4.6.3 Retained Samples

Not applicable. See 7.4.

7.4.6.4 Procedures

Not applicable. See 7.4.

7.4.7 Records

Not applicable. See 7.4.

7.4.8 Monitoring Program

Not applicable. See 7.4.

7.4.9 Response

For discussions of the response to a discovery that the container weight differed from the stated data on the container label, see paragraphs 7.4.2 and 7.4.3.1.

7.5 Scrap and Waste Control

7.5.1 Location

Figure 5.1.4 and the figures in Appendix B-I reflect the types of material and some of the processes in use at NUMEC in 1964. The types of scrap generated by NUMEC can be inferred from Figure 5.1.4 of Chapter 3, because each process inherently generates some scrap. The quantities of scrap generated by NUMEC varied according to the nature of the processing steps involved. As an example, the scrap generation rate for WANL contract (1962-64) is given by the following NUMEC-supplied figures: 1087 kg of HEU as UF_6 was provided by WANL to NUMEC to produce 763 kg of product; NUMEC introduced 1240 kg of HEU in various forms into their process to make the 763 kg of product, and WANL rejected 65 kg which did not meet specification (Ref. 68). So NUMEC claimed that a total of 1240-(763-65) = 542 kg of scrap uranium generated under the WANL contract, was at various times injected into NUMEC's scrap recovery stream (Ref. 68). NUMEC indicated that the product yield for this process was quite low (Ref. 68), so these figures should not necessarily be regarded as typical.

The principal storage areas for NUMEC generated scrap was G-Vault (Ref. 2). Vaults E, F, and I might also have been used for scrap storage (Ref. 2). M-Vault was an isolated space for the storage and inspection of incoming contract scrap (Ref. 2). (See Drawings L-1042 and L-1043. M-Vault appears as N-Vault, area #37, on Drawing L-1042. This inconsistency appeared in Ref. 2.) Before being sent to Apollo for recovery, incoming contract scrap was stored at the NUMEC facility at Parks Township (Refs. 8, 9, 30). At Parks Township, the incoming

scrap (most of which was in 50-gallon drums) was stored in an open area measuring 75' x 30' which was surrounded by a 6' chain link fence topped with three strands of outward-angled barbed wire (Ref. 8). The vehicle gate at the south end was secured by an S&G approved combination padlock, and knowledge of the combination was limited to Accountability personnel, the company truck driver, and members of the guard force (Refs. 8, 9).

In 1964, NUMEC's high enriched fuel fabrication operation was conducted exclusively at Apollo; the Parks Township high enriched operation began later.

7.5.2 Processing

7.5.2.1 10 CFR 70.58(i)(2) requires regular processing and recovery of scrap so that no item of low enriched scrap generated in a licensee's plant and having an uncertainty of greater than ±10% remains on inventory longer than twelve months (Ref. 4). Because this regulation was published later, NUMEC was not subject to it in 1964 (Ref. 4). At that time, there were requirements in some contracts stipulating that scrap generated under a certain contract either be returned (to the AEC or prime contractor) by a specified date or be paid for (Ref. 69). Not all contracts contained such requirements and the WANL contract was more stringent than most in this regard (Ref. 69). NUMEC elected the second option on occasion (Ref. 69), and NUMEC stored some scrap items having an uncertainty greater that ±10% for more than twelve months (e.g., filters) (Refs. 15, 19, 21, 22, 37, 70).

The documentation reviewed does not indicate the capacity of the low enriched uranium scrap recovery facility, but it does indicate that NUMEC received for recovery in its own facility some low enriched scrap from other plants (Ref. 68).

7.5.2.2 NUMEC was permitted to, and did, let quantities of high enriched scrap accumulate for years (e.g., filters) (Refs. 29, 37). The documentation reviewed did not indicate the capacity of NUMEC's high enriched scrap recovery facilities.

NUMEC did not routinely send scrap to other plants for recovery; indeed, they contracted out their own scrap recovery services to the AEC and other facilities (Refs. 49, 68, 93).

7.5.3 Measurement

Scrap and waste materials unsuitable for chemistry assay were, in general, not measured in 1964 (Refs. 15, 21, 29). Indeed, filters, waste, and scrap were carried on the records on an estimated basis, if at all, at least into 1966 (Refs. 3, 22).

NUMEC had an NDA capability (gamma spectrometry) as early as 1962 (Refs. 30, 37), but they did not routinely use this capability for accountability purposes (Refs. 15, 21, 22, 29).

The documentation reviewed did not address how NUMEC's NDA calibration standards were prepared. Apparently some NDA standards were used in analysis of trace quantities of uranium in-plant effluents (Ref. 30).

7.5.4 Inventory Control

NUMEC routinely maintained material on inventory having a measurement uncertainty of greater than ±10% (Refs. 15, 19, 21, 22, 37, 70).

There were no regulatory requirements for timely recovery of such scrap, and NUMEC kept certain forms of it, e.g., dissolver solutions, on inventory indefinitely (Refs. 19, 29, 37).

7.5.5 Waste Disposal

Prior to 1966 and perhaps later, waste from the Apollo plant was not routinely measured by NDA or any other method; its material content was estimated (Refs. 3, 29).

In addition to not making accountability measurements of their burials, NUMEC kept incomplete records of their disposition. NUMEC was cited on October 7, 1965, by the AEC for several violations of 10 CFR 20, one of which was failure to maintain records of source and special nuclear material disposed of by burial after March 8, 1962 (Ref. 71). NUMEC's reply to this citation said "Burials of source and special nuclear material since March 8, 1962 are documented by records which, unfortunately, could not be located during the time of your inspection. Even these newly located records, however, are not complete. At least one period of burials during October 1963 is not well documented as to items buried. There have been no burials since that time" (Ref. 72).

(Note: The date NUMEC stopped making burials of uranium at their Parks Township site is not clear. On August 10, 1965, the President of NUMEC, in an appearance before the AEC Commissioners, stated that he had ordered all burials of this waste halted, the waste combusted, and all material collected and that this procedure had been followed since April 1964 (Ref. 73).)

NUMEC's Special Plant Services Group was responsible for making the burials, maintaining records of them, and sending copies of the records to NUMEC's Manager of Health and Safety (Ref. 2). No provision was made for transmitting whatever burial data existed to the Accountability Representative (Ref. 2), and burials were not reflected in the Accountability records (Refs. 19, 29, 74).

NUMEC did not have a Segmented Gamma Scanner (SGS) in the mid-1960s, and NUMEC did not use tamper-safing at that time, either (Refs. 2, 3, 5, 11, 22, 37). (See Section 7.4 of this Appendix for a discussion of tamper-safing.)

7.6 Shipping

7.6.1 Internal Transfer

7.6.1.1 Measurement Data

The type of measurement data is given in Chapter 3.0.

7.6.1.2 Tamper-Safing Information

Tamper-safing was not required in 1964 and NUMEC did not practice it (Refs. 2, 3, 5, 11, 22, 37). See Section 7.4 and Appendix A of this report for discussions of tamper-safing.

7.6.2 Overchecks

In March of 1964 NUMEC made an error on a shipment to Interatom, Germany (Ref. 33). Some of the shipment documentation indicated erroneously that more material had been shipped than actually was sent (Ref. 33).

An examination of the documented procedures in place in 1964 suggests that such an error might have been prevented if NUMEC's procedures had provided for overchecks on the quantity shipped. The following excerpts from NUMEC's 1964 License Renewal Application describe the procedures NUMEC said were in place in 1964:

"All SS material leaving the plant shall be either weighed or observed during weighing by Q. C. representatives" (Ref. 2).

"Shipping and receiving (S&R) of all SS material shall be done under the cognizance of GPA[1].... All transfer documents (i.e., forms AEC-101, AEC-388, AEC-284, etc.) shall be prepared by S&R and signed by the Accountability Representative. A copy shall be filed in MFA[2].... Loading of the (inner) containers shall be the responsibility of the originating production department. Q. C. shall assist in determining the weight and isotopic content of the product (Part of Q. C. certification).... No shipment shall leave the plant before

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[1] GPA was General Plant-Physical Accountability. See Appendix B-IV.

[2] MFA was Main Office-Financial Accountability. It is not clear that this group ever actually kept the central material accounting records. See 1.1.2.2(c).

completion of the Shipper's Check List.... S&R shall provide production departments with the required birdcages for normal shipments.... After birdcages have been cleared by the Health and Safety Department, S&R shall arrange to load the cages on the carrier's vehicle.... S&R shall keep a record of all SS material shipments in and out of our accountability station. A monthly summary shall be submitted to MFA and to Contract Administration" (Ref. 2).

The noteworthy feature of these procedures is that they did not call for the Accountability Representative, his representatives, GPA, or anyone else to confirm or overcheck the weight of the shipment. The weighing was to be done by production and/or quality control. Preparation of the AEC transfer forms was to be done by S&R and signed by the Accountability Representative. Nowhere in these procedures was a requirement for the Accountability Representative, who was to sign the transfer forms, to verify the material quantities. Figure B-III-9(a) of Appendix B-III is a copy of the Shipper's Check List in use in 1962 and presumably also in use in 1964. This list contains spaces for Accountability to enter SS (uranium) and isotope (uranium-235) values. Based on the cited 1964 procedures, it appears that these blanks on the Shipper's Check List may have been filled in without independent confirmation or overcheck by Accountability.

Support for this conclusion is given by a 1966 AEC report which examined NUMEC's shipping procedures (Ref. 33). Describing how the error on the Interatom shipment occurred, the report said:

"The Material to be shipped was transferred from the Production Department to the Quality Control Department where certain items were rejected because they did not meet specifications. The rejected items were returned to Production and the acceptable items were transferred to the Shipping and Receiving Department. In the Quality Control Department the items rejected were lined out on the list that indicated which items were to be shipped; however, the total quantity was not changed. This uncorrected total quantity was issued to accountability, entered on the material transfer document and was ultimately received by Germany "(Ref. 33).

AEC working papers developed during the above AEC investigation of this incident state, "... this error occurred in March of 1964. In about May of 1965, NUMEC established a check on the quality control department. Since that time, material flows from the production department to accountability (the vault) and then to quality control and back to the vault. The vault custodian, when issuing material to Q. C., retains a copy of the backup list and rechecks material against this list when it is returned from Q. C. prior to transfer to shipping and receiving. Shipping and receiving determines item count of material being shipped prior to shipment" (Ref. 75).

By 1966, NUMEC's procedures called for the production and accountability groups to independently weigh (overcheck) material being shipped offsite (Refs. 3, 33, 64, 76).

However, it appears that NUMEC's procedures in 1964 did not provide assurance that the quantities reported on a transfer document were in fact the quantities shipped. (The absence of tamper-safing practices would, in any case, have diluted the effectiveness of any overchecks that NUMEC might have subsequently instituted (see Section 7.4).) A draft AEC memo, dated 3/9/66, from the 1966 AEC Interview Team to the AEC's Assistant General Manager for Administration stated:

"The review of NUMEC's receiving and shipping procedures is the subject of a separate report. However, the interview team discussed and reviewed these procedures at some length with several of those interviewed. On this basis we believe that NUMEC has instituted sufficient internal controls (checkweights, shipment check-offs, quality control measurements, independent verification substantiated by signatures of responsible supervisors) which if properly implemented would ensure that the quantities reported on the transfer documents were indeed those quantities shipped. There is a common belief expressed by the NUMEC interviewees that the AEC through DIA[1] has in the past and does now make independent verification of quantities shipped to foreign entities" (Ref. 77).

The key is that by March 1966, NUMEC had instituted overcheck procedures. Reference 77 does not say either that the overchecks were in place before March 1966, or that the procedures were being properly implemented then.

7.6.2.1 Packaging

Loading of the inner containers was the responsibility of the originating production department (Ref. 2). Since Shipping and Receiving was to provide the production departments with birdcages (Ref. 2), apparently they packaged the shipments also. By 1966, packaging of inner containers was still the responsibility of the MBA involved but outer packaging was the responsibility of Accountability (then also called Nuclear Materials Control Department) (Ref. 5).

7.6.3 Records

In 1964, AEC transfer forms were to be prepared by Shipping and Receiving and signed by the Accountability Representative with a copy being filed with the central accountability group (Ref. 2). Shipping and Receiving was to keep a record of all SS material shipments in and out of the facility (Ref. 2). Presumably the central accountability group discharged the Accountability Representative's responsibility to have shipping documents posted to the transfer ledgers.

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[1]Division of International Affairs.

The first draft of the AEC's April 1966 report on NUMEC procedures for overseas shipments, Reference 33, characterized NUMEC's shipping records for foreign transfers in the following way:

"Material quantity records for individual foreign transfers were incomplete and inadequate" (Ref. 94).

In explanation of this statement, the draft report said: "The material quantity records for individual foreign transfers on a contract job order basis were reexamined for the purpose of identifying losses attributable to a given contract. As previously determined through survey audits the quantities received, shipped and reported as losses could be established but there were many instances where the individual job order ledger did not balance and the records which purport to control internal movements of material were incomplete and inadequate" (Ref. 94).

7.6.4 Shipping Strategic Materials

See Appendix A of this report for a description of how material was transferred to the shipping area. Tamper-safing devices and seals were not required or used in 1964 (Refs. 2, 3, 5, 11, 22, 37, 46, 78).

7.6.4.1 Shipment Escorts

Material falling into AEC's Security Group I (e.g., over 5 kg of U-235 contained in uranium metal enriched to over 80%) in accessible form required an armed L-cleared escort (Refs. 2, 78).

Tamper-indicating seals were not required in 1964 (Ref. 78). For a more complete discussion of the physical security afforded SNM in transit by NUMEC, see Appendix A of this report.

7.7 In-Process Storage Areas and Item Staging Areas within the High Enriched Uranium Vault

7.7.1 In-Process Storage Areas

The storage vaults at NUMEC in 1964 were considered in-process storage areas (Ref. 2). Under current definitions, they would be still considered in-process storage areas, but not vaults or vault-type rooms (Ref. 66). Material in them was not maintained under tamper-safing and material quantities transferred to them were not necessarily based on measured elemental and isotopic values (Refs. 2, 3, 5, 11) as is now required by 10 CFR 70.51(a)(7) and 10 CFR 70.58(d)(1), (Refs. 4, 14).

7.7.2 Item Staging Areas

It does not appear that in 1964 NUMEC had any areas directly comparable to an Item Staging Area. Area #38 on Drawing L-1042 was at one time used for the storage of outgoing shipments of product (Ref. 2). Material in this area awaiting shipment was to be stored in birdcages approved for shipment (Ref. 2).

8.0 MANAGEMENT

8.1 Procedures

(1964)

Selection of appropriate measurement methods, changes to inventory procedures, and disposition of inventory differences were responsibilities of the Production Manager (Ref. 11), at least in 1962. From this it may be surmised that the Accountability Representative did not have to approve MBA material control or accounting procedures. It was not until 1968 that a NUMEC procedure manual stated that the Accountability Representative (then called Manager, Nuclear Materials Control Department) had approval responsibilities for nuclear material control procedures (Refs. 2, 5, 6, 11, 25). Accountability procedure manuals in 1962, 1966, 1967, and 1968 appear to have been prepared and/or approved by the Accountability Representative (Refs. 2, 5, 6, 25).

8.2 Compliance

8.2.1 Management Review

Reference is made to Paragraph 1.2.9, Audits and Reviews, and Section 6.3, Audits.

Prior to 1967, NUMEC did not have a program providing for reviews and/or audits of their material control and accounting program. As a result of an AEC materials management survey of NUMEC conducted in late 1966, the AEC recommended that NUMEC verify, through internal audits, that their accountability system was operating in accordance with written plans (Ref. 22). By the time of the next AEC materials management survey in October 1967, NUMEC had initiated an internal audit program of the accountability function (Ref. 20).

8.2.1.1 Report

Not applicable to NUMEC prior to 1967 (Ref. 20). (See 8.2.1.)

8.2.1.2 Action

Not applicable to NUMEC prior to 1967 (Ref. 20). See paragraphs 8.2.1 and 8.2.1.1.

8.2.2 Measurement Controls

As indicated in Chapter 4.0, the nearest program NUMEC had to a measurement control program for accountability measurements was a scale and balance program, administered by Quality Control and involving periodic checks of scales and balances (Refs. 2, 3). Since NUMEC did not use statistics for accountability purposes (Refs. 15, 44), whatever control limits they may have had for their weighing devices were apparently not based on statistically derived control charts. Presumably, some predetermined criteria were applied to determine whether a scale or balance was "out of control," but the documentation reviewed does not address this issue.

8.2.3 Shipper/Receiver Differences

Since NUMEC had no statistics program for accountability measurements (Refs. 15, 44), they could not have determined whether a shipper/receiver difference was statistically significant at the 95% confidence level.

Neither NUMEC's procedure manuals nor AEC survey reports dated prior to 1967 describe NUMEC's procedures for resolving shipper/receiver differences. However, the AEC sent a letter to NUMEC dated May 31, 1966, responding to NUMEC's submittal dated April 15, 1966, of their 1966 Nuclear Materials Control Procedure Manual, Reference 5, (Ref. 79). The letter suggested several subjects as additions to NUMEC's manual upon revision, one of which was procedures for resolution of shipper/receiver differences (Ref. 79). Apparently in response to this suggestion, NUMEC's 1967 Procedure Manual, Reference 6, addressed shipper/receiver differences. The following excerpts were taken from that manual:

"As a lessee and fixed-price contractor, NUMEC normally does not encounter shipper/receiver differences...true shipper/receiver differences are unusual...Shipments of UNH crystals to the AEC are measured prior to shipment, and are remeasured by the AEC on receipt. If the receipt measurement is significantly different, it is reported to NUMEC for acceptance. The decision to accept or go to referee is made by the Manager, Nuclear Materials Control Department, in consultation with the process engineer and the analytical laboratory. Among other factors, the decision will consider:

a. the magnitude of the difference.

b. whether the laboratory experienced unusual difficulties or conditions.

c. available GAE* or other comparative data which describe the relative accuracy/precision of the two laboratories.

. . .

Irrespective of the comments above, all forms AEC-101 for NUMEC shipments are reviewed when signed and returned, to determine if a shipper/receiver difference was reported by the receiver. What action to take, if any, is determined on a case-by-case basis" (Ref. 6).

For a further discussion of shipper/receiver differences, see paragraphs 7.1.2 and 7.1.3.

*General Analytical Evaluation.

8.2.4 Material Balance Discrepancies

NUMEC did not have a statistics program for accountability measurements (Refs. 15, 44), so they could not have determined LEMUF (LEID) which is an estimate of the uncertainty in the material balance or MUF (ID) arising from the measurements performed to determine the ID.

It is not clear what criteria, if any, NUMEC used to determine if an ID were significant and/or whether it warranted investigation or not. The earliest mention of any such criteria in a NUMEC procedure manual was in 1968, and it applied on a contract basis, not a plantwide basis (Ref. 25). Even then, the manual said that the decision of whether an ID was "reasonable" or "not" was up to the Manager, Nuclear Materials Control (NMC) Department, as was the decision to "re-evaluate" the ID and the methods to do it (Ref. 25).

8.2.5 Item Discrepancies

From the date of NUMEC's first being licensed for possession of SNM in 1957 (Ref. 81), NUMEC was subject to the provisions of 10 CFR 70.52, which required licensees to "promptly report to the Commission any case of accidental criticality and any loss, other than normal operating loss of special nuclear material" (Ref. 82).

AEC materials management surveys found that NUMEC carried projects on their accounting books for which no physical inventory could be identified, or vice versa (Refs. 18, 21, 37, 49). However, apparently neither the AEC nor NUMEC concluded that the reason for such situations was an actual loss of material reportable under 10 CFR 70.52 (Refs. 18, 21, 49). The AEC apparently attributed these apparent losses of material to deficiencies in NUMEC's records system.

It is important to understand, in regard to this conclusion, that NUMEC did not have a records system which tracked uniquely identified items (Refs. 19, 29, 39, 49). Hence, while a quantity of material might appear to have been lost from a project, there were no uniquely identified items that one could point to as having disappeared. Therefore, it appears that the AEC concluded that the "loss" of material was not real, but that it was caused by a failure by NUMEC to declare losses on the projects involved to the AEC (Ref. 49) or by the shifting of material from one contract or project to another by NUMEC (Refs. 18, 21, 29, 50, 60, 68, 83, 84).

The point is that NUMEC's accounting system was not able to detect item discrepancies (because they did not have uniquely identified items and records to track them), only bulk discrepancies. Because of this, and the fact that neither the AEC nor NUMEC really believed NUMEC's records (Refs. 3, 15, 18, 19, 21, 37, 49), the loss of a discrete item would very likely not have been detected, even if the record system indicated it was missing.

8.2.5.1 Not Applicable. See 8.2.5.

8.2.6 System Failure

The documentation reviewed does not suggest either that NUMEC had criteria for what constituted an accountability system failure or that NUMEC had any procedures for reporting such a failure to the AEC. Indeed, NUMEC had no individual in 1964 whose specific responsibility it was to determine or monitor the effectiveness of the accountability system (Refs. 20, 22).

APPENDIX B-I

Site Description

APPENDIX B-I

Site Description

B-I.1 General Description
(1964)

B-I.1.1 Drawings Number L-1042 and L-1043 provide a plan view of the Apollo Plant. No uranium processing related to the Apollo operation took place at the Parks Township site; however, the outdoor Scrap Storage Area, and the uranium burial pits were located at Parks Township (Refs. 2, 27).

B-I.2 Laboratories

Analytical Laboratories

In 1964 the analytical laboratories did not constitute an MBA or separate MBAs and internal transfer forms were not required for transfers of samples from process areas to the analytical labs (Ref. 2). It was not until 1967 that NUMEC initiated the use of an Analytical Request and Sample Transfer form to document transfers of samples (Refs. 5, 6). The result of not using internal transfer forms for samples attested to by the MBA and the Laboratory was that there was no way for the central accounting records to overcheck the amount of material the laboratory should have. Indeed, NUMEC's procedures in 1964 not only precluded independent overcheck of the material holdings of the lab; they apparently also did not require the laboratories to maintain accurate book balances of their holdings (Ref. 2). This follows from the observation that NUMEC apparently did not weigh samples (into and out of the laboratory) for accountability purposes.

NUMEC's 1964 License Renewal Application lists six accountability weigh stations. The only scale listed suitable for weighing samples was the scale used for vault transfers (Ref. 2). Unless this scale were used to weigh samples (none of the documentation reviewed indicates it was), it appears that the samples were transferred to the labs on, at best, estimated values.

NUMEC's 1964 License Renewal Application stated that "process control samples shall be returned to the originating MBA within a short time, usually within hours, rarely more than a day. The analysis losses shall appear as normal operating losses (samples) on the MBA reports" (Ref. 2). The document goes on to indicate that transfer forms were to be used only in the case of retainer or referee samples (Ref. 2).

The analytical or service laboratories did have some accountability responsibility. Quoting again from the same reference: "When residues or solutions containers are filled, the service labs determine

U-content and label each container (quantity, enrichment, job number). Containers shall be transferred to Production Service Department who shall store them in appropriate in-process storage areas for scheduled recovery...A record of this transfer shall be maintained by all service labs even if they are not an active MBA...Accountability records shall be maintained of MBA's sample transfer to service labs and service labs records of returned solution and residues. This will not balance nor is a book balance required. Over a reasonably long period a service lab's loss can be estimated. Those numbers will be compiled by MFA"[1] (Ref. 2).

Since NUMEC apparently did not make accountability weighings of transferred samples (Ref. 2), the long term estimates of a service lab's loss determined by comparing lab inputs to lab outputs (as described above) would not be very meaningful. Moreover, since the lab's losses were apparently not measured (Refs. 19, 29, 34), there would not be, in any case, a way to draw a complete material balance around the lab operations.

B-I.2.1 Wet Analysis Laboratory - CH-2

The analyses performed in this lab included, but were not limited to, gravimetric, volumetric, titrimetric, and spectrophotometric analysis of uranium bearing compounds (Ref. 2).

B-I.2.2 Instrumental Analysis Laboratory - CH-1

The analyses performed in this lab included, but were not limited to, spectrographic, x-ray diffraction/ fluorescence, and gamma-ray spectrometric analyses (Ref. 2).

B-I.2.3 Mass Spectrograph

In 1964, NUMEC did not have a mass spectrometer (Ref. 24).

B-I.2.4 Quality Control Laboratory - MBA Q.C.

Analyses performed in this lab included, but were not limited to, physical measurements such as tensile, bend, shear, crushing and impact strengths, surface area, particle size distribution, dimension and density (Ref. 2). Hence the statement in the 1977 plan that no

[1]MFA stands for Main Office-Financial Accountability. Reference 2 implied that MFA kept the central material accountability records in 1964, but this was not corroborated by any AEC sources. See 1.1.2.2.(c).

material control measurements, only physical characteristics, were determined in the Quality Control Laboratory applied in 1964 also.

Note: In 1964, numerous research and development activities were being conducted at NUMEC. The lab facilities associated with these activities are not included here since they did not perform analyses for accountability purposes (Ref. 2).

B-I.3 Low Enrichment Uranium Operations - Production of UO_2

The following process description was taken from NUMEC's 1968 Fundamental Material Control Plan, Reference 25. Most paragraphs are direct quotations from that source. Note the similarities between the process descriptions from the 1977 and 1968 references.

B-I.3.1 As shown on the process flow chart, Figure B-I-1, NUMEC produces reactor grade UO_2 at enrichments up to 5% U-235 in a continuous process system. Intermediate products (ADU, U_3O_8, unmilled UO_2) can be drawn off if desired.

B-I.3.2 UF_6, in approved cylinders, is received...and is stored in storage racks until used. The UF_6 is hydrolyzed to produce a solution in the range of 180 grams of uranium per liter. This solution is reacted with ammonium hydroxide. The resulting ammonium diuranate is vacuum filtered and washed on a continuous belt filter.

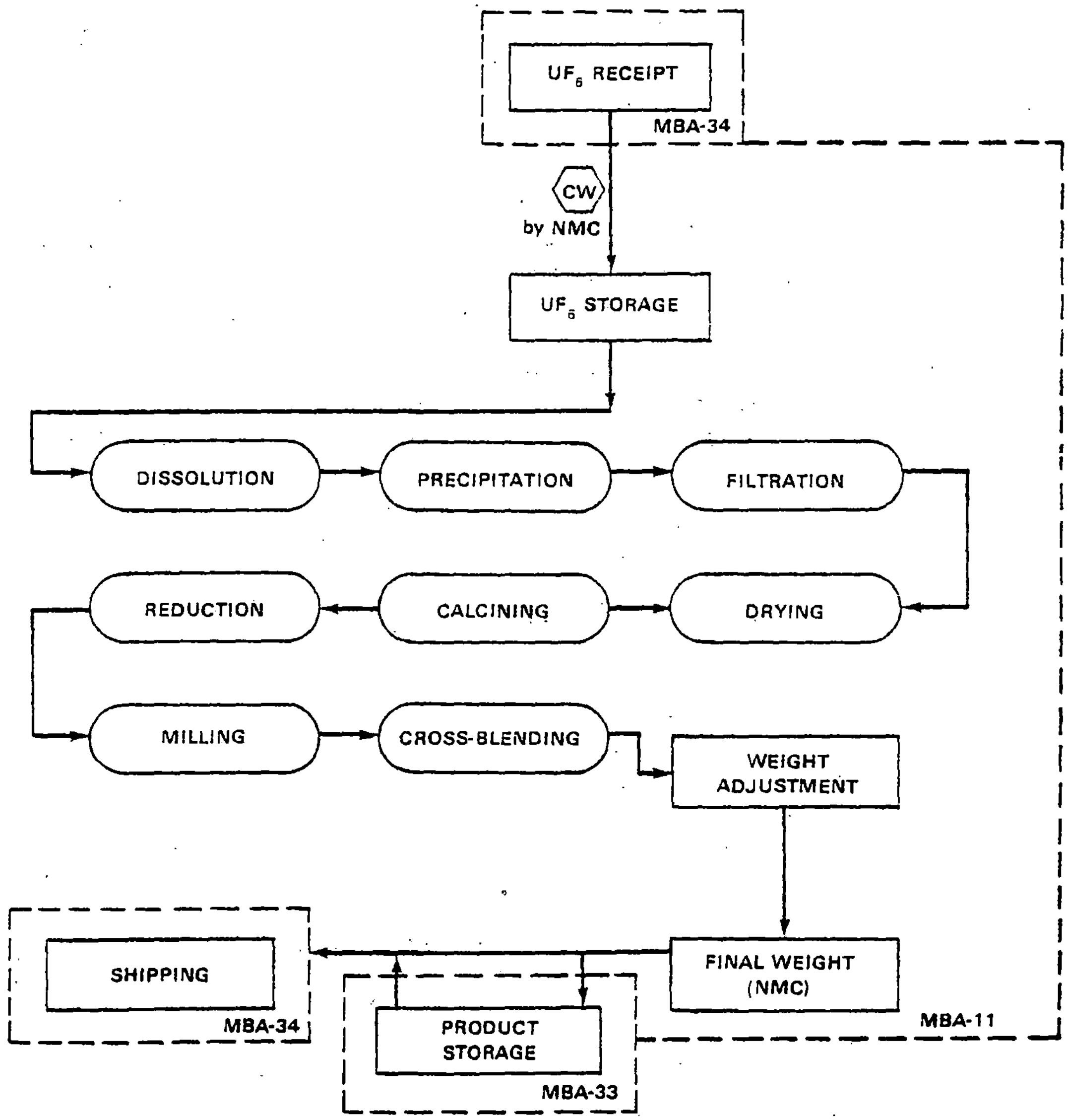
B-I.3.3 The wet ADU cake is dried on a continuous stainless steel belt. The ADU is granulated after drying, and then conveyed to a calciner, where it is converted to U_3O_8. The calcined U_3O_8 is then conveyed to a rotary tube kiln, where it is reduced in a hydrogen atmosphere to UO_2.

The UO_2 is then hammermilled, and distributed, in 500 gram increments, among 118 containers on a conveyor system. Approximately 2000 kgs UO_2 are collected in 118 bottles (max. 18 kgs/bottle). This constitutes a blend for analytical and shipping purposes.

B-I.3.4 After filling, the 118 bottles constituting a blend are transferred to a second conveyor. Two randomly selected bottles of UO_2 are shell blended and sampled for uranium and specification analyses. The weight of each bottle is adjusted to a net between 17 and 18 kgs, and the bottles are sealed by production personnel. Sealed bottles are color coded, labelled, and weighed by NMC personnel, and are transferred either directly to shipping or to the H vault for storage pending shipment.

The weight of the UF_6 cylinder will have been determined prior to storage. The first 50-60 liters of water for each cylinder hydrolysis are used to wash the last prior cylinder. After washing, the cylinder is dried and the tare or empty weight is determined.

(1964)
Figure B-I-1
Typical Flow Diagram Low Enriched Uranium Conversion



SOURCE: REFERENCE 25 (1968)

B-I.3.5 The filtrate from the ammoniation step is treated and refiltered to reduce its uranium content below 50 ppm. It is then sampled and discarded, with the residual uranium being recorded as a measured discard. There are no other significant process losses other than general system cleanup. At all stages of the process both liquid and solid cleanup material is collected in 3 gallon bottles for scrap recovery and recycle.

(Source: Ref. 25.)

B-I.4 <u>Incinerator</u> (Not an MBA in 1964 (Ref. 2))

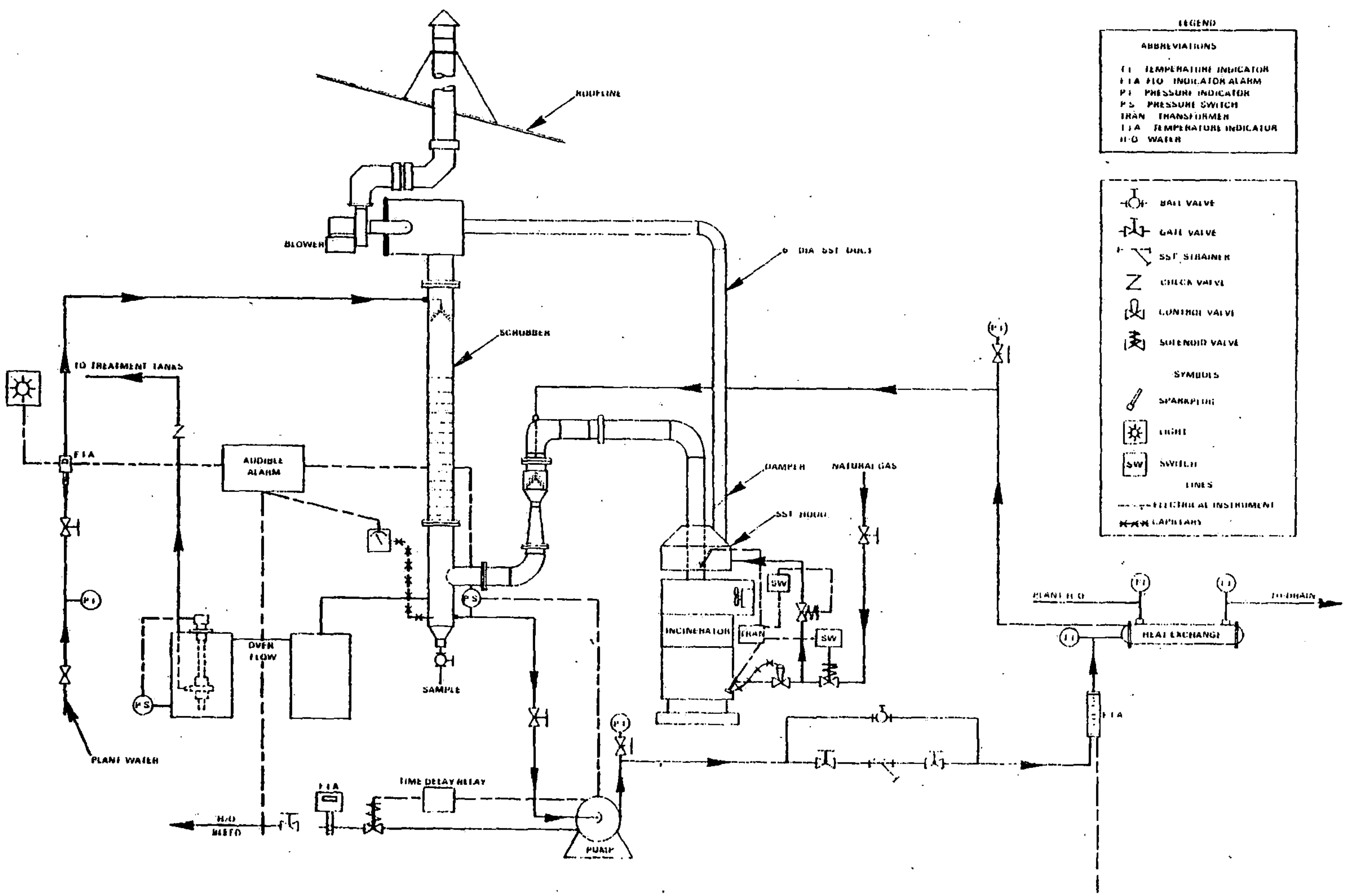
The following process description was taken from NUMEC's 1964 License Renewal Application, Reference 2. Most paragraphs are direct quotations from that source.

B-I.4.1 The incineration of combustible contaminated solid wastes will be accomplished in Area 62, Apollo plant. A schematic diagram of the incinerator and its support equipment is shown on attached drawing B-I-2, Incinerator and Scrubber Flow Sheet. Briefly, the system consists of a Hoskinson H-100 incinerator equipped with a main burner in the firebox and an after burner in the stack just above the firebox. Both burners use natural gas for fuel. Combustion gases pass through the afterburner to a water operated venturi-type fume scrubber (Schuttle-Koerting Model 4010), wherein large dust particles (flyash, etc.) are wetted and separated from the gas. Downstream of the venturi, the gases are passed through a packed tower, [10 inch diameter x 8 feet long packed with 1 inch x 1 inch pall rings] where the very fine particles which escape the venturi are scrubbed from the gas by counter current flow of fresh water. Downstream of the tower, the gases pass through a blower and are then exhausted from the building, approximately 15 feet above the roof line. In parallel with the combustion gases, the blower also provides ventilation over the charging door of the incinerator to catch and exhaust fumes encountered when the charging door is opened. While it is recognized that this air leaves the building unfiltered, air activity samples taken to monitor the operation are taken in the stack downstream of the blower, and therefore, are representative of the total activity leaving the building from this operation.

B-I.4.2 Ashes from the incinerator shall be assayed for the principal radioisotope and the enrichment, if uranium.

B-I.4.3 Out-plant control on the activity released via the stack shall be the responsibility of the Manager, Health and Safety. In accord with this, the incinerator may be operated only as authorized by the Manager, Health and Safety. In this connection Health and Safety shall continuously monitor the stack activity at the point of discharge to the atmosphere for a period of time equivalent to or greater than 25 percent of the time the incinerator operates. Sampling times shall be selected so that the sample is truly representative of the

(1964)
Figure B-I-2
Incinerator and Scruber Flow Sheet



total activity released during any burning period (i.e., burning, charging etc). On a basis of these numbers averaged over a period of not greater than one year, the Manager, Health and Safety, shall schedule incineration so that the specific isotopic activity released is not greater than that listed in Appendix B, Table II, 10 CFR Part 20. The Manager, Health, and Safety, shall maintain records necessary for compliance with this regulation.

B-I.4.4 Nuclear safety for this operation is based on administrative controls over the incoming material, the accumulation and storage of ash, and the uranium concentration in the scrub water.

B-I.4.5 All incoming material shall be packaged in standard boxes, which are identified as to job number and enrichment of their contents. Ashes shall be removed from the furnace after a maximum of three boxes have been burned. [A one pound inventory of ashes in the furnace will thereby not be exceeded.] Ashes shall be placed into one gallon containers, and stored in the vault.

B-I.4.6 Scrub water shall be sampled every hour during operation for uranium concentration. Assays shall be done by gamma spectrometry assuming all uranium is enriched to 5% U-235. [For full enriched uranium, a safety factor of 20 on the uranium concentration is thereby incorporated.] When concentrations in excess of 1 gm/ liter are determined, the Nuclear Safety Engineer shall be informed. Simultaneously, the sample shall be reanalyzed for U-235 assay, and for total uranium concentration. Based on the new assay, the Nuclear Safety Engineer shall take appropriate action, as necessary, to assure proper disposition of the scrub water.

(Source: Reference 2.)

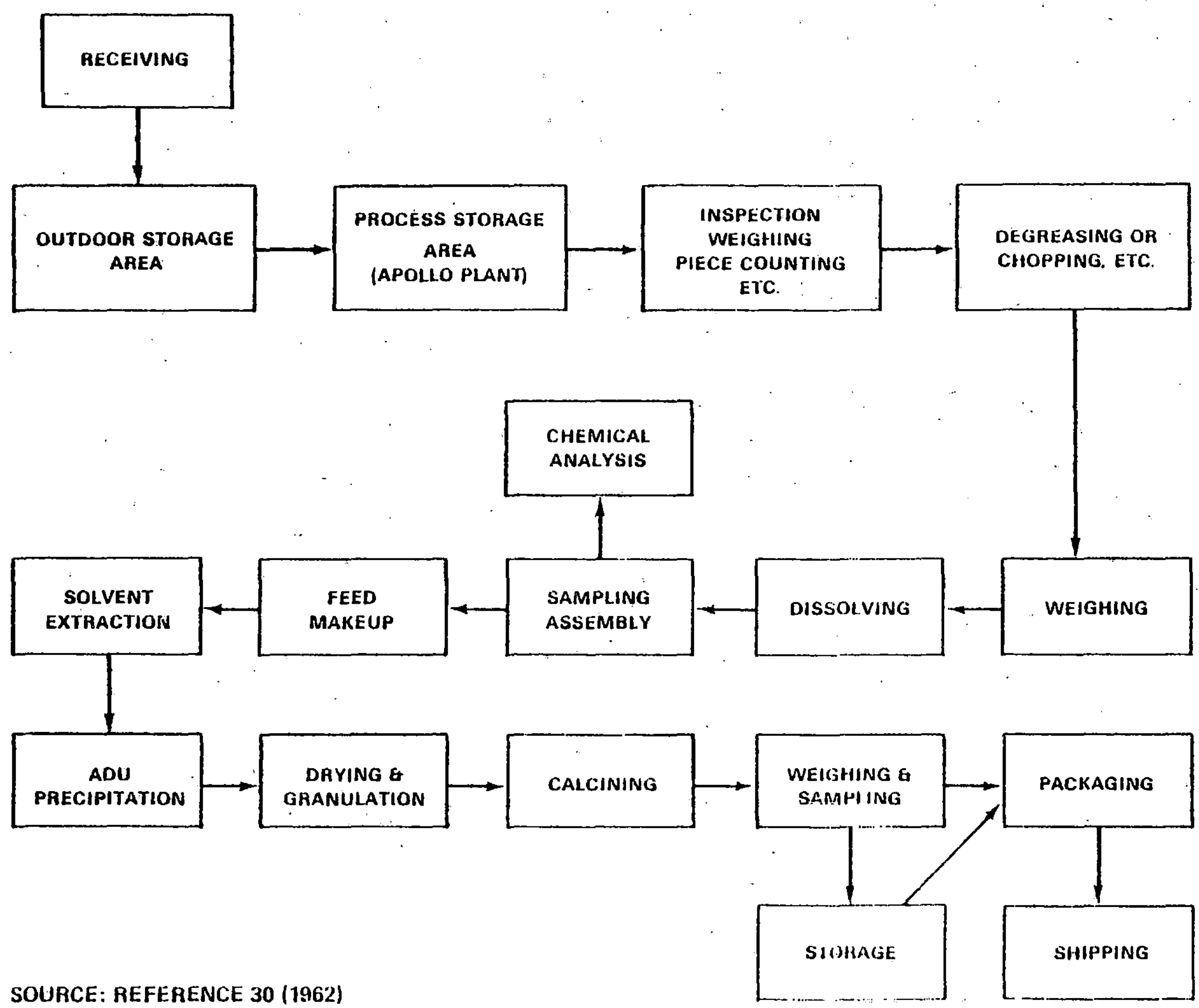
B.I.5 Scrap Recovery - MBA CRP-2

The operations in this area are shown on the process flow diagram Figure B-I-3. The input to this operation consisted mostly of materials from outside contractors and licensees, which were recovered under AEC or other contracts.

The description of the process that follows[1] was taken from the 1962 NUMEC Scrap Reprocessing Manual, Reference 30. Most paragraphs are direct quotations from that reference. Note that some of the accountability measures that NUMEC said in Reference 30 that they used were not found to be in place in subsequent AEC surveys (e. g., use of internal transfer receipts) (Refs. 15, 17, 18, 21, 29).

[1]See the note beginning on page B.I.9 which describes some of NUMEC's scrap reprocessing procedures in 1966.

(1964)
Figure B-I-3
Typical Flow Chart Scrap Reprocessing



SOURCE: REFERENCE 30 (1962)

B-I.5.1 Since it is required that the scrap be sent by the shipper in critically safe "birdcages," the containers and birdcages are stored "as received" in the outdoor storage area.

As required, the containers (usually 55 gal. drums or birdcages) are moved to the Apollo Plant in groups of one day's production and stored in a special receiving area on the second floor level, separated from the rest of the second floor plant. One drum at a time is then carried through the checking process and wheeled to the head end of the processing area.

Upon receipt at the Apollo Plant, the Receiving Department transfers accountability to the Chemistry Processing Department using a NUMEC Internal Transfer Receipt... At the same time, a copy of the Shipper's 101 Form backup sheet is also supplied. This has the drum numbers, type of scrap, alloy weight, SS weight, U-235 weight and any other pertinent information supplied by the shipper. A gross piece count has been made previously against the 101 backup sheet on receipt of scrap by the NUMEC Receiving Department and is rechecked by the Production Department when the accountability is transferred. If any discrepancy is noted at this point, the Shipper and NYOO[1] (AEC's New York Operations Office) is immediately notified and the lot is set aside until a resolution and/or permission is received to proceed.

The procedures used for net weight check methods are quite varied depending on the nature of the scrap. In many cases as in heterogeneous mixtures of filters, mixed smaller containers in the shipping container, vapor blast sand, etc., the gross weight must suffice. However, whenever possible as in the case of chips, fuel elements, fuel assemblies, sculls, etc., the individual cans are opened one at a time, inspected visually and the contents transferred into a tared container for determining net weights. The values are recorded on NUMEC Form Number CRP-2-A. These weights are determined on an Ohaus triple beam balance.

In the case of pickle liquors and other solutions containing less than five grams of uranium per liter, the solutions are transferred by pumping from the receiving drum to another tare weighed drum on a 1000 lb platform scale. The emptied drum is again checked for residues and treated as above. A portable Lightnin mixer is used to mix the solution. The assay samples are withdrawn and the solution weighed. It is then pumped by gravity to the feed storage columns for subsequent extraction. Weighing accuracy in this case is ± 0.5 lbs.

[1]In 1964, Oak Ridge Operations Office (OROO), not NYOO, administered NUMEC's scrap recovery contracts (Ref. 49). The reference from which this process description was drawn was written in 1962.

In all cases, the Production Clerk checks the operation on a daily basis against the 101 Form and records the number of drums, drum numbers, net weights, etc. The Clerk then enters the data in the NUMEC Master Log (CRP-2-I).

A second mass check is afforded as the scrap is weighed into the dissolving buckets. These data at this step are recorded on NUMEC Form Number CRP-2-B. The purpose of this step is to control the uranium concentration and quantity of acid required for dissolution so that the feed will be compatible with the succeeding processes.

Thus at least two independent weighings are implemented and separate checks, by the operator and clerk, are made against the 101 Form. In addition the balance readings and the log entries by the Production Department are checked by a second operator.

B-I.5.2 NUMEC performs the required dissolutions in two areas designated CRP-2 and CRP-3 which are shown on Drawing L-1043.

Dissolution of the scrap is carried out in the dissolving hoods by a variety of methods depending on the material to be dissolved. In all cases the total quantity of U-235 in each hood section (I and II) is limited to 350 grams as controlled by the quantity of scrap weighed into the individual containers.

The actual solution methods vary, of course, for different types of scrap:

1) U-Zr chips and solid pieces:

   Dissolution is accomplished by hydrofluoric acid added dripwise after the chips are covered with water. Following the dissolution, the uranium is oxidized to the hexivalent state with H_2O_2. To assure that this reaction ($U^{+4} \rightarrow U^{+6}$) is complete, the solution is checked by the addition of $KMnO_4$. The persistence of the red-purple color indicates the completeness of the oxidation reaction and also destroys the residual peroxide.

2) U-Al alloy:

   The alloy is dissolved by the standard nitric acid-mercury catalyst procedure. An alternative method use for low concentration of uranium in the alloy is to dissolve in caustic, filter off the precipitated uranium, wash and redissolve the precipitate in nitric acid. For this operation the solutions are transferred by suction to a 5" diameter plastic filter. By this means 350 grams or less of U-235 is collected, washed and redissolved. The filtrate is checked for uranium content for discharge.

3) UO_2, U_3O_8, Uranium Metal:

These materials are dissolved in the same equipment, using all the above precautions, directly in nitric acid. Checks for completeness of the oxidation to U^{+6} are also performed as described above.

4) BeO-UO_2 Scrap

The dissolution of the powdered scrap is accomplished in a HF-HNO_3 solution essentially as described above except that the plastic dissolving buckets are heated in a "double boiler" arrangement utilizing an outer stainless steel boiler pot containing a small volume of water. Each boiler pot is heated with an electric hot plate and a vent is supplied by having the supporting ring holding the plastic bucket notched. This opening serves as a vent for steam as well as a fill port for replenishing the water.

B-I.5.3 All solutions are filtered and the residue, if any, is returned to the next dissolving batch as are any heels left in the dissolving buckets. By this repetitive treatment, total solution is effected.

In the few cases referred to above where total solution is not feasible, the material is leached with HNO_3 or HF-HNU_3 until chemical analyses of the insoluble residue shows an economically small level of residual uranium, i.e., 10-100 ppm.

B-I.5.4 After a given batch of scrap is dissolved, it is transferred through a polishing filter to a vertical 12 foot long by 5 inch I.D. mixing tank. Solid residues from this polishing filter are checked for uranium and returned to the dissolving step, if required. The average fill in the tank is approximately 8-10 feet (8-10 gals). Mixing is accomplished by means of an air sparge for about 45 minutes. After mixing the solution is drained into tared 3 gallon, 5 inch diameter, polyethylene bottles. This procedure allows for 500 ml samples to be taken from solution at the bottom, middle and top of the column. Each bottle is then weighed independently by two operators, removing the bottle from the balance and replacing it each time by the individual making the weighing. The balance used is an Ohaus Triple beam 20 kg solution balance on which the solutions can be weighed to 0.01 percent. The 500 ml sample is similarly weighed.

These batch samples are transferred, together with NUMEC Form CPR-2-J, to the Analytical Laboratory for the preparation of the assay composites. Based on the weights reported on CRP-2-J, the batch samples are composited on a weight basis to prepare an assay composite.

B-I.5.5 All raffinates, waste streams, condensates and filtrates are sampled and stored in ever-safe tanks before discharge to guarantee no inadvertent loss of uranium. In addition, all effluents from all

NUMEC plants are held in a hold tank for a second check before discharge to the sewer. If the waste storage columns indicate a uranium level higher than 5 ppm, the waste stream is recycled until the level is brought to the 5 ppm value and then sent to the hold tank before sewer discharge.

(Source: Reference 30)

Note: This report in draft form was reviewed by representatives of the Department of Energy (DOE). The entire set of DOE comments is included as part of the main report. One of their comments regarded scrap recovery procedures and it read as follows:

> "I might also note that the procedures for processing scrap at NUMEC - as indicated on Page 14, Appendix B-I, were modified somewhat regarding weighing and sampling after ORO took over the management of the scrap recovery program in 1962. We made a number of contractual requirements with respect to how weighing and sampling would be performed. Beginning in 1966 we placed AEC representatives in the plant to witness on an around-the-clock basis all weighing and processing steps to the point where an accurate sample could be taken to determine the amount of uranium contained in the scrap. This was coupled with an effort to improve scrap identification and segregation by installations generating the scrap that was subsequently offered for commercial recovery." [Comment of C. A. Keller, Oak Ridge Operations Office, DOE]

Reference 111 is a March 14, 1966, memorandum to files by one of the AEC (Oak Ridge Operations Office) representatives sent to the NUMEC plant to witness NUMEC's reprocessing of NUMEC scrap in 1966. Some excerpts from that memorandum pertinent to NUMEC's 1966 weighing and sampling procedures follow:

> "The procedure for handling this material was basically the same for all three lots. Upon receipt, an item count was made to assure that all containers were received. All inner containers were gross-weighed, after which the contents were removed, crushed, and dissolved. The inner containers (plastic sacks) were then tare-weighed to determine net weight on a by-difference basis. Following dissolution, the solution was mixed, sampled and weighed. The contractor was then responsible for extracting the uranium from the solution and returning it to the AEC as UNH crystals. The dissolution samples were composited and submitted to NBL for analysis.
>
> . . .
>
> The material was shipped in 55-gallon drums with pipe-casing center inserts. The material was contained in several plastic bags in each drum. The net weight included only the tubes; the

plastic bags were included in the tare. Check-weighing procedures were as follows: Gross weight of each individual plastic bag in the drum. The plastic bags from a drum were accumulated as emptied and weighed. The total of the gross weight for a drum, less the weight of the empty bags, gave the net weight for each drum.

. . .

After dissolution, the liquor was pumped through a dynel cartridge-type filter into a vertical tank where it was mixed by air sparging for a minimum of 45 minutes.

The solution was then drained into safe-geometry polybottles. During the filling of each bottle in the batch (usually 3 per batch), a sub-sample was withdrawn. These were combined to make a batch sample. The bottles, which had been tare-weighed were then gross-weighed. The sum of the net weights for the dissolver solution and the sample gave the batch weight.

. . .

Dissolution samples taken as described above were weighed and taken to the laboratory for compositing. A composite represented several batches containing a maximum of 5 kilograms of U-235. As a general rule, a composite did not represent more than 750,000 grams of solution weight. The composites were prepared by NUMEC laboratory personnel, as a general rule. The calculations were checked by this AEC representative, and actual physical preparations of composites for shipment were observed.

. . .

Due to a misunderstanding, the NUMEC processing people were not aware of the new contractual requirement that they submit to NBL samples for all residues (previous contracts excluded residues of less than 2 kilograms net). However, AEC special samples were taken for the two batches of residues totaling less than 2 kilograms (64A and 64B).[1] NUMEC took a regular sample for 64C[1] (2-100 gram samples)." [Ref. 111]

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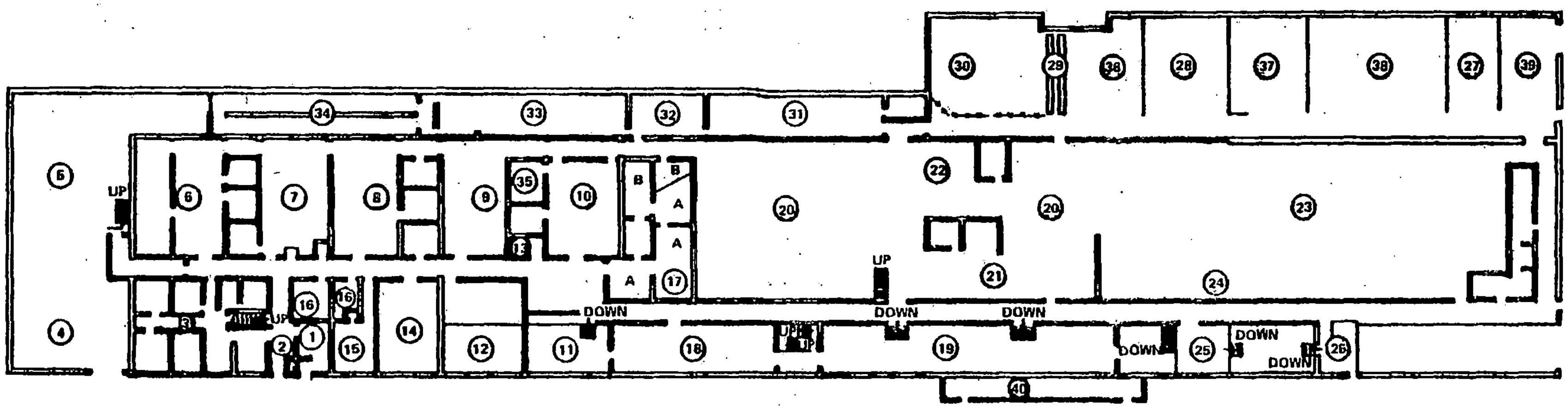
[1]64A, 64B, and 64C refer to the three scrap lots being processed by NUMEC at the time.

(1964)
Figure L-1042

NUCLEAR MATERIALS AND EQUIPMENT CORPORATION
APOLLO, PENNSYLVANIA
FIRST FLOOR

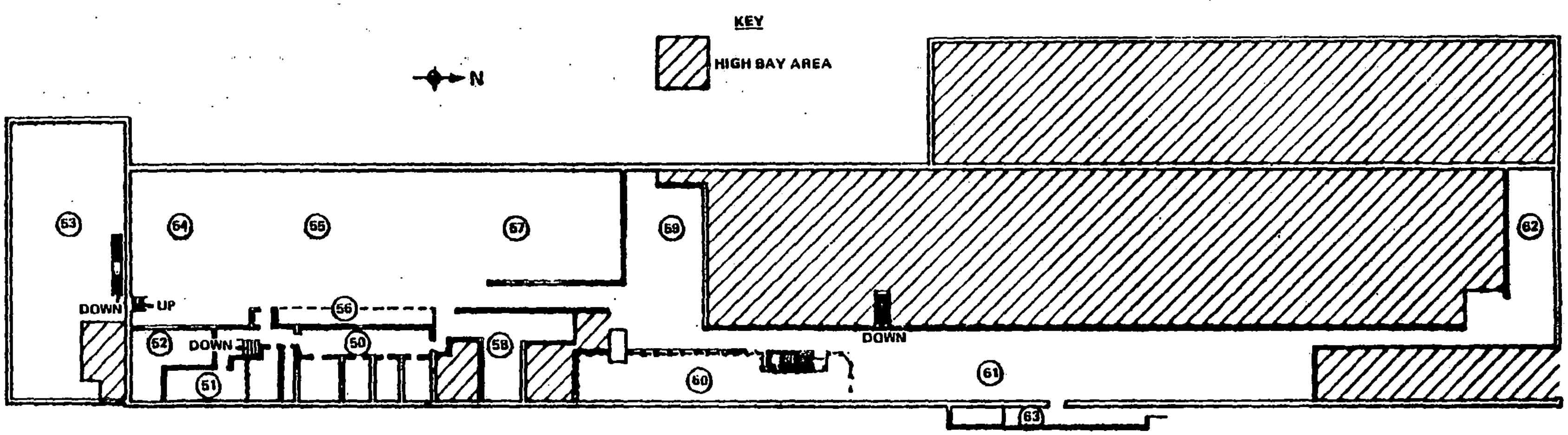


1 RECEPTION
2 SECURITY & TIME CLOCK STATION
3 METALLOGRAPHY LABS (ML)
4 MAINTENANCE & WELDING SHOP (GPM)
5 MACHINE SHOP (MS)
6 INSTRUMENTAL CHEMICAL ANALYSIS LAB. (CH-1)
7 ANALYTICAL CHEMISTRY LAB. (CH-2)
8 INORGANIC CHEMISTRY R & D LAB (CH-30)
9 PROCESS DEVELOPMENT LAB (PC-1)
10 CERAMICS LAB (CF-2)
11 CORROSION TESTING LAB (CH-23)
12 PLANT WASTE TREATMENT AREA
13 HEALTH PHYSICS LAB (GPH-2)
14 INORGANIC CHEMISTRY LAB. (CH-32)
15 DISPENSARY (GPH-1)
16 REST ROOMS
17 CHANGE ROOMS
18 PROCESS COATING OXIDES (PC-2)
19 PROCESS COATING CARBIDES (PC-3)
20 CERAMICS FABRICATION (CF-1)
21 ARC MELTING AREA
22 TRANSFORMER STATION
23 LOW ENRICHMENT UF_6 CONVERSION PLANT (CP-1)
24 LOW ENRICHMENT SCRAP RECOVERY PLANT (CRP-1)
25 STORES
26 SHIPPING & RECEIVING
27 LOW ENRICHMENT RECEIVING STORAGE (M-VAULT)
28 LOW ENRICHMENT PRODUCT STORAGE (H-VAULT)
29 SAMPLE STORAGE
30 LOW ASSAY LIQUID STORAGE (G-VAULT)
31 QUALITY CONTROL & PHYSICAL TESTING LAB (QC)
32 HIGH ENRICHMENT ACCOUNTIBILITY CONT. STA. (P.S.)
33 HIGH ASSAY LIQUID STORAGE (E-VAULT)
34 HIGH ENRICHMENT PRODUCT STORAGE (F-VAULT)
35 HIGH ENRICHMENT IN-PROCESS STORAGE (A-VAULT)
36 NORMAL & DEPLETED STORAGE (L-VAULT)
37 PRODUCT SHIPPING AREA LOAD & HOLD (N-VAULT)
38 HEX STORAGE (J-VAULT)
39 EMPTY BIRD CAGE HOLD & CLEAN AREA (P-VAULT)
40 COMPRESSOR HOUSING & PAD

SOURCE: REFERENCE 2

(1964)
Figure L-1043

NUCLEAR MATERIALS AND EQUIPMENT CORPORATION
APOLLO, PENNSYLVANIA
SECOND FLOOR



50 PRODUCTION CONTROL OFFICES
51 LUNCH ROOM
52 INORGANIC CHEMISTRY (GH-31)
53 GENERAL FABRICATION AREA (GF-1)
54 HIGH ENRICHMENT SCRAP RECOVERY (CRP-2)
55 HIGH ENRICHMENT UF_6 CONVERSION (CP-2)
56 PRODUCTION SERVICES (PS)
57 HIGH ENRICHMENT SCRAP RECOVERY (CRP-3)
58 IN-PROCESS STORAGE
59 SCRAP HEAD ENDING AREA
60 HIGH ENRICHMENT RECEIVING STORAGE (I-VAULT)
61 LOW ENRICHMENT PRODUCT BLENDING (CP-1)
62 RECONDITIONING AREA
63 OUTSIDE LOADING DOCK

SOURCE: REFERENCE 2

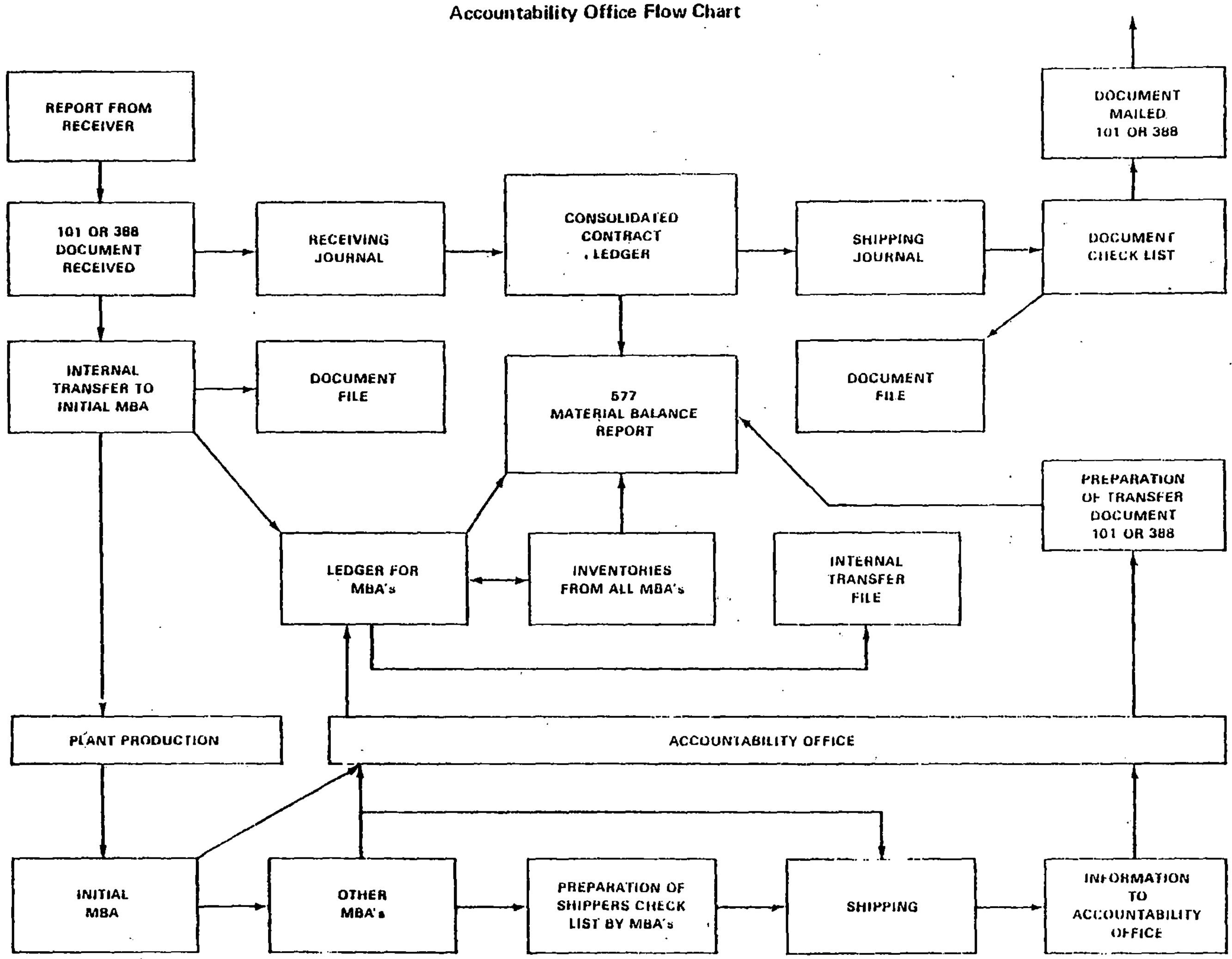
APPENDIX B-II

Accounting System

(1964)

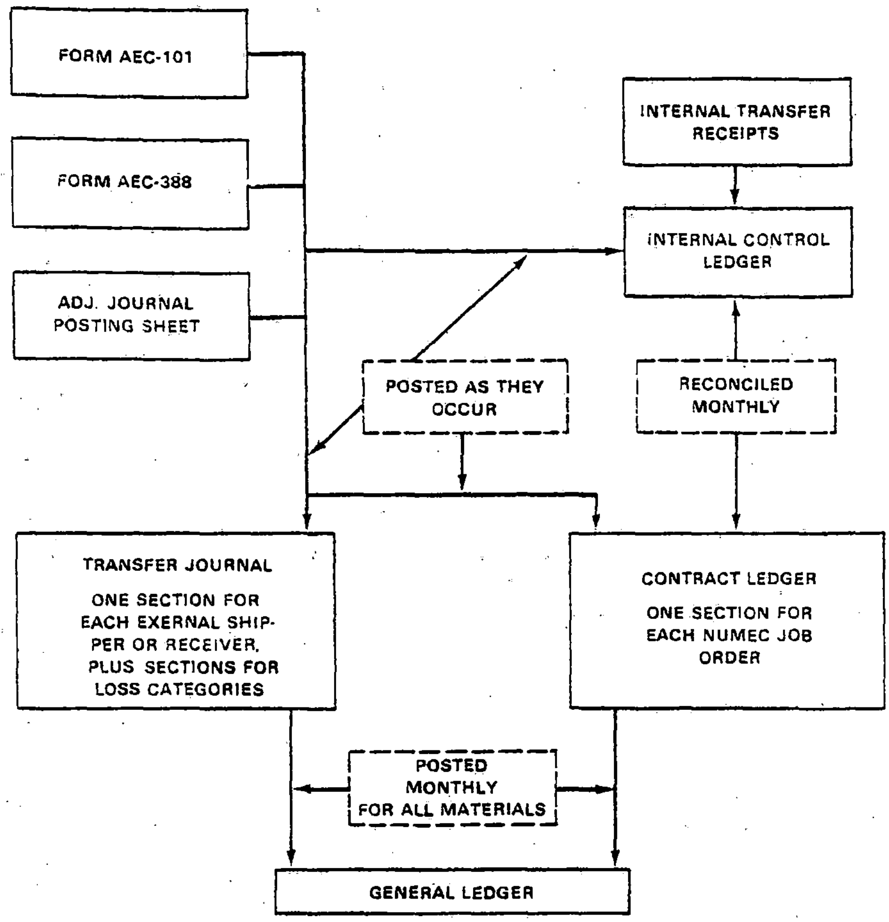
Figure B-II-7

Accountability Office Flow Chart



SOURCE: REFERENCE 65 (19

(1964)
Figure B-II-8
Interrelations of Journals and Ledgers



SOURCE: REFERENCE 5 (1966)

APPENDIX B-III

Accountability System Forms

(1964)

Figure B III-1

Form AEC-101 (Rev. 8-64)
U.S. Atomic Energy Commission
AECM-7401

NUCLEAR MATERIAL TRANSFER DOCUMENT

1. TRANSFER NO.

4. No.	DISTRIBUTION of COPIES
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	

2. SHIPPER'S FACILITY CODE ______

Name

Address

3. RECEIVER'S FACILITY CODE ______

Name

Address

Attention:

5. SHIPPED FOR ACCOUNT OF (Facility Code) ______

Name

Address

6. SHIPPED TO ACCOUNT OF (Facility Code) ______

Name

Address

7. MATERIAL TRANSFERRED IS: (Check if applicable)

	Shipper	Receiver
a. Under Supply Agreement with AEC	( )	( )

8. THIS TRANSFER:

a. Initiates or Alters Financial Liability to the AEC ( )

b. Does Not Initiate or Alter Financial Liability to the AEC ( )

9. DOCUMENTATION (If document is classified)

a. Page ____ of ____ Pages

b. Copy ____ of ____ Copies

c. Series ______

10. TRANSFER AUTHORITY:

11. MATERIAL TYPE AND DESCRIPTION

12. TRANSFER DATA

a. The Quantities Listed Below Were Shipped On ______ 19____

______
(Signature of Shipper's Authorized Representative)

b. Units

c. From-AEC Project No.

13. a.*

______
(Signature of Receiver's Authorized Representative)

*FOR OTHER THAN AEC COST-TYPE CONTRACTORS, COMPLETION OF BLOCK 13. a. CONSTITUTES ACCEPTANCE OF THE DATA IN BLOCK 12; IF THE RECEIVER INTENDS TO CONTEST THE DATA, BLOCK 13. a. SHOULD NOT BE COMPLETED AND THE SHIPPER SO NOTIFIED

AEC COST TYPE CONTRACTORS MUST SHOW THEIR RECEIVER'S DATA IN BLOCK 13.

b. To-AEC Project No.

c. Date Material Received

d. Lot & container no.	e. Gross weight	f. Net weight	g. Element weight	h. Weight % Isotope	i. Isotope weight	d. Gross weight	e. Net weight	f. Element weight	g. Weight % Isotope	h. Isotope weight

B.III.1

(1964)
Figure B-III-2

Form AEC-386
(Rev. 11-63)
Supersedes Form AEC-388 (1-60)

UNITED STATES ATOMIC ENERGY COMMISSION

SS MATERIAL TRANSFER FORM—LEASED MATERIAL

1. Transfer Series: A. .... (From) B. .... (To) C. .... (Number)

2. Shipped by (*Shipper*):
Name ....
Address ....

3. Shipped to (*Receiver*):
Name ....
Address ....

4. Shipped for Account of: Lic. No. ....
Name ....
Address ....
Lease No. ....

5. Shipped to Account of: Lic. No. ....
Name ....
Address ....
Lease No. .... Order No. ....

6. (For AEC Use Only):
Nuclear Material Draft (Form AEC-437)
Number ....

7. SS Material (*Check One*):
(A) Enriched Uranium ( )
(B) Uranium-233 ( )
(C) Plutonium ( )
(D) Other .... ( )

8. Material Description:

9. This Transfer Involves:
(A) Initiating lease responsibility ( )
(B) Transfer of lease responsibility ( )
(C) Return to AEC for credit ( )
(D) No change in lease responsibility ( )
(Transfer of material only)

10. Material Quantities: A. Weight Units ....

B. Container No.	C. Piece Count	D. Gross Weight	E. Tare Weight	F. Net Weight	G. Element Weight	H. Weight % Isotope	I. Isotope Weight
Totals							

11. The Items and Quantities Listed Above Were Shipped
On .... 19......
....
[illegible]

12. The Items and Quantities Listed Above Were Received
On .... 19. ...
....
[illegible]

(1964)
Figure B-III-3

No.________

NUCLEAR MATERIAL DISCARD REPORT

The Nuclear Material listed below has been discarded or otherwise irretrievably lost, as noted, during the period	Date________
From________	MBA________
To________	JOB________

( ) Discard (By definition, a discard must be intentional and supported by measurement data. Examples include filtrates, leached solids, evaporated condensates, etc.)

( ) Accidental Loss (Must not have been intentional, may or may not be supportable with measurement data. Examples include UF_6 vented to atmosphere, the non-recovered portion of spills, etc.)

QUANTITY DATA

Description	Wt. or Vol.	Analysis	U	U-235
		Total	____	____

Signed________________

Approved for Posting________

N. M. Control
Job________
MBA________
Control________

Distribution: 1 - N.M. Control
2 - Accounting
3 - Contract
4 - MBA

SOURCE: REFERENCE 5 (1966)
NOTE: It does not appear that NUMEC used this form prior to 1966 (Ref. 5,29)

B.III.4

(1964)
Figure B-III-4

No.___

NUMEC INTER-JOB TRANSFER AUTHORIZATION

Date__________

Area __________ is authorized to transfer nuclear material between Numec Job Orders as indicated below.

From: Job __________ To: Job __________

RIS __________ RIS __________

Maximum quantity __________ U___

Nominal enrichment __________ Pu___

REMARKS

Cust. Auth. Reference

N. M. Control

ACTUAL TRANSFER DATA

Date of Transfer__________

By__________

Net Weight - grams__________

%U or Pu__________ Total U or Pu__________

%U-235__________ Total U-235__________

Description, container identification, etc.

Distribution:
Copy 1-N.M. Control Copy 2-Area Custodian Copy 3-Contract Files

SOURCE: REFERENCE 5
NOTE: It does not appear that NUMEC used this form prior to 1966 (Ref. 5,29)

(1964)
Figure B-III-5

NUMEC INTERNAL TRANSFER RECEIPT

☐ LICENSEE ☐ STATION DATE ____________

TRANSFER FROM ____________ SIGNATURE ____________

TRANSFER TO ____________ SIGNATURE ____________

NUMEC CONTRACT NO. ____________ NET WEIGHT-GRAMS ____________

PHYSICAL FORM ____________ % URANIUM ____________

CHEMICAL FORM ____________ URANIUM IN GRAMS ____________

ENRICHMENT % ____________ % U235 ____________

ACCOUNTABILITY APPROVAL ____________ U235 IN GRAMS ____________

ACC. POSTING DATE ____________ POSTED BY ____________

REMARKS ____________

SOURCE: REFERENCE 11 (1962)

(1964)
Figure B-III-6

GPA
NUMEC
1-62

NUMEC CONSOLIDATED ACTIVE CONTRACTS

Station ______________

License ______________

Date	Beginning Inventory		Receipts				Removlas				Losses		Ending Inventory	
	Uranium	U-235	Date	Reference	Uranium	U-235	Date	Reference	Uranium	U-235	Uranium	U-235	Uranium	U-235

SOURCE: REFERENCE 11 (1962)

(1964)
Figure B-III-7

NUCLEAR MATERIALS AND EQUIPMENT CORP.
Uranium Removal Request

Burial .... ☐ **Outside Storage** .... ☐ **Dump** .... ☐

Date .... **Department** .... **Enrichment** .... **Originator** ....

Description ....

Smear Report or Lab Analysis ....

H & S Approval ....**Accountability** ....

Maintenance Approval ....

Nuclear Materials Control

Maintenance Approval ....

Health and Safety

Maintenance Approval ....

Maintenance

Maintenance Approval ....

Production

SOURCE: REFERENCE 5
NOTE: It does not appear that NUMEC used this form prior to 1966 (Refs. 5, 29)

(1964)
Figure B-III-8

F and A VAULT

DAILY LOG

Job	Enrichment	Chem-Form	Net Wt. In	To Shelf	Net Wt. Out	From Shelf	Remarks	

SOURCE: REFERENCE 11 (1962)

(1964)
Figure B-III-9(a)

FORM NO. NU-100A

NUMEC

APOLLO, PA.

SHIPPERS CHECK LIST

JOB NO.________ ENRICHMENT________ DATE________

CUSTOMER P. O.________ DESIRED SHIPPING DATE________

PARTIAL ☐ DESCRIPTION (INCLUDE LOT, BOTTLE OR PIECE NUMBERS):________

COMPLETE ☐ ________

____

NET WEIGHT________ ________

PRODUCTION: U ASSAY________

OK TO SHIP ________ PRODUCTION FOREMAN OR PROJECT ENGR. ________ DATE

QUALITY CONTROL: SPECIFICATION NO.________

CERTIFICATIONS: ENCLOSED ☐ TO FOLLOW ☐ DATE________

OK TO SHIP ________ Q. C. SUPERVISOR ________ DATE

ACCOUNTABILITY: LICENSEE ☐ STATION ☐ OTHER ☐

SS________ ISOTOPE________

OK TO SHIP ________ ACCOUNTABILITY OFFICER ________ DATE

HEALTH AND SAFETY

MONITORING RESULTS ENCLOSED ☐ NOT REQUIRED ☐

OK TO SHIP ________ HEALTH & SAFETY ________ DATE

SHIPPING: METHOD OF SHIPMENT________

ROUTING ________

NOTIFICATION OF RECEIVER________ DATE________

SHIPPED ________ SHIPPING FOREMAN ________ DATE

SOURCE: REFERENCE 11 (1962)

(1964)
Figure B-III-9 (b)

SHIPPER'S CHECK LIST

DATE

···EC CONTRACT NO.	CUSTOMER P.O. NO.	PROJECT NO.

DESIRED SHIPPING DATE	PARTIAL SHIPMENT		FINAL SHIPMENT	

PRECISE MATERIAL DESCRIPTION

ELEMENT ANAL.	TYPE	L.E. (% REL.)	ISOTOPIC ANAL.	TYPE	L.E. (% REL.)
GROSS WT.	SCALE TYPE	L.E. (±UNITS)	TARE WT.	SCALE TYPE	L.E. (±UNITS)

NET WT.	L.E. (%)	ELEMENT WT.	ISOTOPE WT.	TRANSFER DOC'T. DESIGNATION

LICENSE NUMEC F.R.		LICENSE NOT NUMEC F.R.		SUPPLY CONTRACT		FACILITY CONTRACT		SOURCE OR BY-PRODUCT		OTHER	

CERTIFICATION ENCLOSED		CERTIFICATION SENT/TO FOLLOW		DATE	CERTIFICATION NOT REQUIRED	

DESCRIPTION OF PACKAGING

NUCLEAR SAFETY ACCORDING TO:	B OF E PERMIT NO.

METHOD OF SHIPPING AND ROUTING

RECEIVER NOTIFIED	DATE	BY WHOM	MEANS	NOTIFICATION NOT REQUIRED	

MONITORING RESULTS ENCLOSED		MONITORING NOT REQUIRED	

DATE OF SHIPMENT		

APPROVED FOR SHIPMENT	SIGNATURE	DATE
PRODUCTION		
NUCLEAR MATL'S. MGT.		
QUALITY CONTROL		
SHIPPING		
NUCLEAR SAFETY		
HEALTH SAFETY		

SOURCE: REFERENCE 5 (1966)

(1964)
Figure B-III-10

SHELF NO.

	INVENTORY CARD	NUMEC CONTRACT NO.
GROSS WT.	CHEM. FORM	
TARE WT.	ENRICHMENT	
NET WT.	NET URANIUM	
ASSAY & SOURCE		
DESCRIPTION:		
DEPT.	DEPT.	
DATE IN	DATE OUT	
INITIALS	INITIALS	
CUSTODIAN	CUSTODIAN	
REMARKS:		

SOURCE: REFERENCE 11 (1962)

(1964)
Figure B-III-11

NUMEC

PHYSICAL INVENTORY

Job Number ______ | Enrichment ______ | Inventory Date ______

Department ______ | Initials or Recorder ______

Location	Chem. Form - Description	Net Weight	Net U Grams	Remarks

SOURCE: REFERENCE 11 (1962)

(1964)
Figure B-III-12

PHYSICAL INVENTORY

Date ______________ ☐ Enr. U Job ______________

MBA ______________ ☐ Plutonium Page ____ of ____

☐ ________

Inv. No.	Location	Cont. Ident.	Description	Net Weight	Anal.	Element	% Iso.	Isotope

SOURCE: REFERENCE 5 (1966)

Appendix B-IV

Job Descriptions

The responsibilities of the members of NUMEC's Accountability organization and the structure of the organization itself changed frequently in the mid-1960s (Refs. 2, 3, 5, 11, 17, 28, 89, 95). The position descriptions that follow for 1964 are approximations based on the documentation reviewed. Those descriptions may not be 100% accurate for 1964, a year of frequent change in the Accountability organization (Refs. 2, 3, 28, 89, 95). However, they generally capture the generic responsibilities of these positions during the period 1962-1966.

1964 Position

Accountability Representative

Foreman, SS Material Accountability

GPA Technician
(GPA = General Plant-Physical Accountability)

MBA Custodians
Vault Custodians

FIGURE B-IV-1
1964 ACCOUNTABILITY POSITIONS

NOTES: In 1966 and later the Accountability Representative (who also held the title of Manager, Nuclear Materials Control Department starting in 1966) was in charge of inventories and officially had many of the duties discharged by the 1977 Inventory Specialist (Refs. 5, 6, 25, 47, 48 and 96).

The nearest position in 1964 to Radiochemist (NDA Supervisor) was that of Manager, Instrumental Analysis (Ref. 2). However this position was not part of the Accountability organization (Ref. 2) and NDA measurements were not used routinely for accountability purposes (Refs. 15, 21, 22, 29).

Vaults were not MBAs (or ICAs) in 1964 (Ref. 2). However, the 1964 position of Vault Custodian is roughly comparable to the 1977 position of SNM Custodian (for an ICA).

TITLE: ACCOUNTABILITY REPRESENTATIVE[1]

DEPARTMENT: ACCOUNTABILITY DEPARTMENT (Ref. 2)

REPORTS TO[2]: VICE PRESIDENT, PRODUCTION AND CONTRACT ADMINISTRATION (Refs. 2, 12)

MAJOR RESPONSIBILITIES:

Responsible for implementing SS material inventory, measurement, record, and reporting procedures in conformance with AEC requirements (Ref. 10). Principal contact for AEC regarding these procedures (Ref. 10). Signed SS transfer forms and SS reports and represented the company in all matters of accountability assigned to him (Ref. 2). Position "shall be analogous to a treasurer of a company authorized to sign checks up to a specified amount" (Ref. 2).

REPRESENTATIVE RESPONSIBILITIES:

(Some of these are responsibilities of the Accountability Department, which was headed by the Accountability Representative.)

Maintenance of accountability records in conformance with AEC requirements (Ref. 11).

Administration of all (accountability) functions as a station and as a licensee (Ref. 11).

Review and/or approval of all communications pertaining to SS material: ordering, shipping, transferring, reporting (of shipments) to and from AEC installations and other contractors (or licensees) (Ref. 11).

Responsible for accountability measurements of material in transfer, storage or process (Refs. 7, 11). Responsible for securing analytical assistance of the service labs (Ref. 7).

Maintenance of records of company's shipment and receipts (Ref. 11).

---

(1) The Accountability Representative was also referred to at various times in the 1950's and 60's as the Accountability Officer, Chief Accountability Officer, the SS (source and special nuclear material) Representative, and the Manager, Nuclear Materials Control Department (Refs. 2, 5, 6, 11, 97, 100, 101, 102, 103, 104).

(2) It should be noted that although the Accountability Representative technically reported to a Vice-President, he in practice reported to the Manager of Plant Services, at least prior to 1964 (Refs. 2, 3, 12). In 1964, the Manager of Engineering and Production also assumed responsibility for Accountability (Ref. 3)

Responsible for transfer of SS materials from receiving department to the operating MBAs (Refs. 2, 11).

Approval of transfers between internal MBAs (Refs. 2, 11).

Provision to the MBAs of forms used in tabulating, recording and reporting of SS materials by the MBA's (Ref. 11).

Responsibility for the Storage Vault Operation (Refs. 3, 5, 11).

Comparison of physical inventory quantities with book records. Reporting of significant Book-Physical Inventory Differences to Production for disposition (Refs. 2, 11).

Planning and scheduling of physical inventories in conjunction with Production (Refs. 2, 11).

Issuance of periodic reports on material balances and material status to the AEC. Issuance of reports of shipments and receipts to the AEC (Ref. 10). Signing these reports (Ref. 2).

EDUCATION:

The documentation suggests that a college degree may not have been required (Ref. 3).

EXPERIENCE:

One year's experience as an accountability clerk (Ref. 97) or several years of experience in the nuclear processing industry (Refs. 2, 3, 7).

Accountability Representative was the 1964 position most nearly comparable to that of the 1977 Manager of Nuclear Materials Control.

In 1966 NUMEC hired as their new Accountability Representative a former AEC employee with extensive experience in nuclear materials management (Refs. 3, 16, 19, 98, 99). He was given the new title of Manager, Nuclear Materials Control Department (Refs. 3, 5, 16). This action reflected a general upgrading of the importance of nuclear materials management at NUMEC in response to an AEC recommendation resulting from their November 1965 survey (Refs. 19, 29). The AEC had recommended that NUMEC "give added recognition to its nuclear materials management responsibility by establishing at an appropriate high-level adequate staff to deal with materials management with full support from company management" (Refs. 22, 29). The report of an AEC survey in October 1966 indicated that the new nuclear materials manager had been allocated a staff of nine people and that eight had already been hired (Ref. 22).

The 1964 Accountability Representative discharged, or was responsible for discharging, a number of duties held by the 1977 Accountability Representative. However, the 1964 position encompassed a broader spectrum of duties and presumably was at a higher level in the corporate organization than the 1977 Accountability Representative position.

TITLE: FOREMAN, SS MATERIAL ACCOUNTABILITY[1]
DEPARTMENT: ACCOUNTABILITY DEPARTMENT (Ref. 3)
REPORTS TO: ACCOUNTABILITY REPRESENTATIVE (Ref. 3)

MAJOR RESPONSIBILITY:

Maintenance of central SS records for both the uranium and plutonium facilities (Refs. 3, 19). Supervisor of vault custodians (Ref. 3). Preparation of reports to AEC (Refs. 3, 58).

REPRESENTATIVE RESPONSIBILITIES:

Maintenance of complete central accountability records for all enriched uranium at Apollo plant (Refs. 3, 19).

Maintenance of central accountability records for plutonium at Leechburg plant (Refs. 3, 19).

Supervisor of the four vault custodians who operated the storage vault operation (Refs. 3, 5).

Comparison of central records to records of receipts and shipments maintained by the vault custodians (Ref. 3).

Receipt of inventory reports on a periodic basis from vault custodians (Ref. 19).

Preparation of reports to the AEC for approval by the Accountability Representative (Ref. 58).

EDUCATION:

The documentation reviewed does not suggest what level of education was required. Presumably, it was at least a high school education since some, if not all, vault custodians were high school graduates (Ref. 3).

EXPERIENCE:

Some prior experience in a fuel processing plant was desirable, and possibly a requirement (Ref. 3).

---

[1] It is not clear that this position had this title before 1965 or early 1966 (Refs. 3, 19). The incumbent holding this position was also referred to as the Accountability Clerk (Ref. 5).

TITLE: GPA[1] TECHNICIAN

DEPARTMENT: ACCOUNTABILITY DEPARTMENT (Refs. 2, 11)

REPORTS TO: ACCOUNTABILITY REPRESENTATIVE (Ref. 2)

MAJOR RESPONSIBILITIES:

The objectives for GPA were to minimize SNM losses and to "maximize knowledge of what and where SNM is located" (Ref. 2). GPA was concerned with the physical accountability of SS material, its measurements and its physical control (Ref. 2). GPA was "a production support operation in the sense that Quality Control or Health and Safety is a production support operation" (Ref. 2). GPA was to serve the same function in plant accountability as Quality Control and Health and Safety served in their respective areas, "with corresponding responsibility and similar authority" (Ref. 2). GPA was to maintain cognizance of shipments and receipts and to make surveillance checks of SNM in process and in storage (Ref. 2).

REPRESENTATIVE RESPONSIBILITIES:

For receipts, GPA was to determine, or arrange with the analytical laboratories or appropriate departments to determine, the accuracy of the supplier's weights and analysis (Ref. 2).

GPA was to review with Health and Safety the nuclear safety of any incoming SNM (Ref. 2). For unusual shipments or packaging, GPA was to postpone any unloading or storing until a safety determination could be made by Health and Safety and/or the Nuclear Safety Engineer (Ref. 2).

GPA was to assure the safe storage of all incoming SNM in conformance with standard or special procedures prepared by the project engineer (or Hazards Committee) (Ref. 2).

GPA was to maintain records for all receiving storage areas (Ref. 2).

GPA was to make surveillance checks on in-process storage operations, vault records, and checkweighings of stored SNM deposited in the vaults (Ref. 2)

Upon receipt and storage, GPA was to transfer material to the operating MBAs (Ref. 2).

Internal Transfer Receipts were to be signed by authorized representatives of the originating and receiving MBAs and by GPA (Ref. 2).

GPA was charged with accountability surveillance of all operations involving SNM (Ref. 2).

[1] General Plant - Physical Accountability (Ref. 2).

Inventory planning was to be the joint responsibility of the Production Manager and GPA (Ref. 2).

GPA, in conjunction with production supervisors, was to work toward the standardization of containers (Ref. 2).

Book-Physical Inventory Differences were to be resolved in consultation with GPA and the supervisor in whose MBA the difference appeared (Ref. 2).

Shipping and receiving of all SS material was to be done under the cognizance of GPA (Ref. 2). (However, Shipping and Receiving, not GPA, was to make shipping arrangements (Ref. 2).)

EDUCATION:

The documentation reviewed does not indicate what educational level was required for a position in the GPA group.

EXPERIENCE:

The documentation reviewed does not indicate what level of experience was required for a position in the GPA group.

TITLE: MBA CUSTODIAN
DEPARTMENT: PRODUCTION (Refs. 2, 11)

REPORTS TO: MBA SUPERVISOR (Refs. 2, 11)

MAJOR RESPONSIBILITIES:

Responsible for custody and control of all SS material within the department (MBA) in which he has been assigned to be material custodian (Ref. 2).

REPRESENTATIVE RESPONSIBILITIES:

MBA supervisors were to select and train SS material custodians for their MBA so that they could accomplish the following efficiently and accurately:

Maintain accurate MBA accountability records (Ref.11).

Prepare monthly MBA inventory reports to Accountability (Ref. 11).

Properly execute material transfer forms (Ref. 11).

Check on and improve measurement methods (Ref 11).

Ensure security of SS materials (Ref. 11).

Prevent the "mixing of station and license SS materials of different enrichments (unless specifically authorized by accountability)" (Ref 11).

EDUCATION:

The documentation reviewed does not indicate what educational level was required in order to become an MBA custodian.

EXPERIENCE:

The documentation reviewed does not indicate what level of experience was required in order to become an MBA custodian.

TITLE: VAULT CUSTODIAN

DEPARTMENT: ACCOUNTABILITY (Refs. 2, 11)
REPORTS TO: FOREMAN, SS MATERIAL ACCOUNTABILITY[1] (Refs. 2, 3, 11)

MAJOR RESPONSIBILITIES:

Responsible for custody and control of special nuclear material deposited by various MBAs in the storage vaults (Refs. 2, 3, 11).

REPRESENTATIVE RESPONSIBILITIES:

Controlled access to the vaults (Refs. 2, 3). Ensured that only authorized persons were allowed inside the vaults (Refs. 2, 3).

Weighed or checkweighed material upon deposit in the vault by an MBA (Ref. 3).

Prepared three part shelf tags for items on deposit in the vault (Refs. 2, 11). Affixed one copy to the container or its storage shelf, filed another copy in vault record file, and gave third copy as a receipt to the responsible (depositing) MBA (Refs. 2, 11). See Section 7.3.

Maintained vault records, including daily log[2] sheets (Refs. 5, 11) and contractor job balance sheets (Ref. 11).

Responsible for opening secondary storage vaults for deposits or withdrawals by MBA. Held keys and/or combinations to the storage vaults (Ref. 3).

EDUCATION:

The documentation reviewed does not indicate what educational level was required in order to be a vault custodian. However, some, if not all, vault custodians were high school graduates (Ref. 3).

EXPERIENCE:

Apparently no previous experience was required (Ref. 3).

---

(1) It is not clear that the position of Foreman, SS Material Accountability existed before 1965 or early 1966 (Refs. 3, 19). Before the establishment of this position, the vault custodians reported to the Accountability Representative (Ref. 11).

(2) Reference 22 indicates that such a log was not in existence in Oct. 1966.

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21. D. E. George, DNMM Survey #50 - Nuclear Materials & Equipment Corporation memorandum to S. R. Sapirie, dated September 26, 1962, with enclosed survey report (part of YC-1).

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41. J. A. Powers, letter to R. A. Williams, dated January 19, 1978, approving B&W Apollo's October 1977, Fundamental Nuclear Material Control Plan as amended, and transmitting revised license conditions.

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NRC FORM 335 (7-77) U.S. NUCLEAR REGULATORY COMMISSION **BIBLIOGRAPHIC DATA SHEET**	1. REPORT NUMBER (Assigned by DDC) NUREG-0627 Appendix B - Unclassified
4. TITLE AND SUBTITLE (Add Volume No., if appropriate) A Safeguards Case Study of the Nuclear Materials and Equipment Company/Uranium Processing Plant/Apollo, Pennsylvania	2. (Leave blank)
	3. RECIPIENT'S ACCESSION NO.
7. AUTHOR(S) Willard Altman, John Hockert, Elizabeth Quinn	5. DATE REPORT COMPLETED MONTH December YEAR 1979
9. PERFORMING ORGANIZATION NAME AND MAILING ADDRESS (Include Zip Code) Division of Safeguards U.S. Nuclear Regulatory Commission Washington, D.C. 20555	DATE REPORT ISSUED MONTH April YEAR 1980
	6. (Leave blank)
	8. (Leave blank)
12. SPONSORING ORGANIZATION NAME AND MAILING ADDRESS (Include Zip Code) Division of Safeguards U.S. Nuclear Regulatory Commission Washington, DC 20555	10. PROJECT/TASK/WORK UNIT NO.
	11. CONTRACT NO N/A
13. TYPE OF REPORT Formal NRC Staff Technical Report	PERIOD COVERED (Inclusive dates) N/A
15. SUPPLEMENTARY NOTES	14. (Leave blank)

16. ABSTRACT (200 words or less)

The report characterizes the Atomic Energy Commission safeguards requirements and the safeguards systems and procedures in place at the Nuclear Materials and Equipment (NUMEC) uranium processing plant in Apollo, Pennsylvania during the spring of 1964. Based upon this characterization, a list of safeguards weaknesses which would be considered deficiencies under 1979 requirements is developed. Appendixes A and B to the report provide a detailed characterization of AEC safeguards requirements as well as a side by side comparison of NUMEC's safeguards program in 1964 with the safeguards program currently required of a comparable licensed facility. The main report discusses AEC regulatory requirements and philosophy during the mid-1960s, lists the specific areas in which the NUMEC safeguards program would be considered deficient under 1979 NRC requirements, and discusses the conclusions to be drawn from the comparison of the 1964 NUMEC safeguards program with AEC requirements during the mid-1960s and with 1979 NRC requirements. Based upon the deficiencies identified, the report concludes that it is possible that during the mid-1960s significant quantities of high enriched uranium could have been removed from the NUMEC Apollo facility, by a knowledgeable insider or by an outside group with the assistance of an insider, without detection.

17. KEY WORDS AND DOCUMENT ANALYSIS — 17a. DESCRIPTORS

NUMEC
Safeguards
Physical Security
Nuclear Material Control
Nuclear Material Accounting
Inventory Difference
Material Unaccounted For

17b. IDENTIFIERS/OPEN-ENDED TERMS

18. AVAILABILITY STATEMENT	19. SECURITY CLASS (This report)	21. NO. OF PAGES
Unlimited	Unclassified	
	20. SECURITY CLASS (This page)	22. PRICE S

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