REPORT OF SURVEY

Control Over Enriched Uranium
Nuclear Materials & Equipment Corp.
Apollo, Pennsylvania

Division of Nuclear Materials Management
April 6, 1966

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NUCLEAR MATERIALS MANAGEMENT
SURVEY NUMBER DNMM-53
NUCLEAR MATERIALS & EQUIPMENT CORP.

1. General

1.1 A survey of control exercised by the Nuclear Materials and Equipment Corporation (NUMEC), Apollo, Pennsylvania, over enriched uranium held by it was performed during the period November 1-12, 1965 by members of the Headquarters Division of Nuclear Materials Management. Personnel from the New York and Oak Ridge Field Offices and from the Space Nuclear Propulsion Office-Cleveland assisted in selected phases of the survey field work.

1.2 The objectives of the survey were:

(a) to determine the total cumulative U-235 "loss"(1) for the NUMEC Apollo plant operation since start-up in 1957 and to evaluate the extent to which such "losses" could be accounted for in terms of known loss mechanisms (e.g., liquid wastes, stack gases, burial ground disposals), and measurement biases in order to arrive at a material-unaccounted-for quantity(2); and

(b) to attempt to find explanations for the unexpectedly high U-235 loss (about 6% of total U-235 received) attributed by NUMEC to the Westinghouse Astronuclear Laboratory (WANL) Purchase Order 59-NP-12674.

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(1) "Loss" as used here means the difference resulting from the total cumulative U-235 received by NUMEC, less the sum of (a) total cumulative shipments of U-235 by NUMEC to others, and (b) NUMEC's physical inventory of U-235 as of 10/31/65.

(2) Material unaccounted for (MUF) occurs when, after a physical inventory of a plant, there is a difference between the physical inventory and the book inventory after the latter has been adjusted for accidental losses, normal operational losses (discharges to tanks, sewers, stacks, burial grounds, etc.) and other known removals of material. Thus, MUF is usually the result of uncertainties of measurements, unknown losses and undetected errors.

1.3 The survey was performed generally in accord with the standards set forth in AECM 7402 for cost-type contractors.(1) A detailed discussion of the survey steps is provided in sections 4 and 5 of this report.

1.4 The survey covered the plant operating period ending October 31, 1965. Many aspects of the survey were extended back to plant start-up in 1957.

1.5 The survey covered all enriched uranium located at NUMEC's Apollo facility; it is all AEC-owned. Enriched uranium located at NUMEC's Park Township facility (see paragraph 2.2) but carried on the records as part of the Apollo facility was also included; plutonium or U-233 at the Park Township site was not included.

2. Description of Apollo Facility

2.1 NUMEC owns and operates a uranium processing facility at Apollo, Pennsylvania. The major emphasis of the facility is on the conversion of UF_6 into uranium oxide or carbides and the fabrication thereof for use in nuclear reactors, including commercial power, research and governmental applications. The Apollo facility is also equipped to and does recover uranium from various scrap and residue materials. NUMEC is not equipped at its Apollo plant to prepare uranium metal but is equipped for most operations involving uranium compounds. Processing and fabrication lines are operated for uranium enriched above 5% U-235 separate and distinct from that below 5% U-235. Also, NUMEC maintains a scrap reprocessing line for uranium of less than 5% enrichment separate from the line for uranium above 5% U-235.

2.2 NUMEC also owns and operates several facilities located in Park Township, approximately 6 miles from the Apollo facility. Normally only the Apollo facility will process uranium, while the Park Township facility will process other materials of interest to the nuclear industry. In addition, drums containing uranium-bearing residues are stored at the Park Township site. The hillside overlooking this site is the location of NUMEC's burial ground. It is this burial ground which is the point of reference for the 1962 and 1963 burial pits discussed subsequently.

(1) Normally, SNM held by a fixed-price contractor who was financially liable to the AEC for payment for losses would not have been subjected to such an intensive scrutiny; rather the survey would have followed the standards set forth in AEC Immediate Action Directive 7400-8.

3. Summary of Findings

3.1 General

3.11 Based on the survey team's findings, the total cumulative loss[1] (known losses and discards plus material-unaccounted-for) at NUMEC since plant start-up in 1957 has been established as 178 kg U-235. During this period, NUMEC recognized and reported losses year-to-year for a total cumulative quantity of 149 kg U-235. The increase of 29 kg U-235, to 178 kg U-235, was established by the survey team as follows:

	U-235 (Kg)	
Total cumulative U-235 received by NUMEC since plant start-up in 1957.....		14,693
Total cumulative U-235 shipped by NUMEC since plant start-up.....	13,993	
NUMEC U-235 plant inventory as of October 31, 1965.....	522[2]	14,515
Total cumulative quantity of U-235 at October 31, 1965 to be accounted for since plant start-up.....		178[2]

This cumulative loss, while larger (both on an absolute and relative basis) than those reported by other commercial facilities conducting more or less comparable operations, does not appear to be so much larger as to be unexpected, considering the circumstances described

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[1] See footnote (1), paragraph 1.2 for definition of "loss."

[2] There are uncertainties in these quantities due to a large number of heterogeneous uranium-bearing residues on inventory which are not amenable to representative sampling. Therefore, upon recovery by NUMEC, some adjustment, either upward or downward, to the inventory may be necessary. If such an adjustment is made, a compensating adjustment to the cumulative loss of 178 kg U-235 likewise will be necessary. (Also, see para. 3.17.)

subsequently in this report. While it cannot be stated with certainty that diversion did not take place, the survey team found no evidence to support that possibility. Conversely, there were a number of observations by the survey team and others, of NUMEC's practices that would reduce the possibility of diversion. Enriched uranium, except that in process, is stored at the Apollo plant in secured areas under lock and key, and is the responsibility of a vault custodian. Access into and from the plant is through a small waiting room which is monitored by a receptionist or a guard. All visitors are required to sign a register upon entering or leaving the plant. Of particular note is the fact that there have been no instances of reported missing identifiable items such as cylinders of UF_6 or containers of uranium products awaiting shipment or other uranium compounds. Since July 1965, until September 1965, AEC inspectors were in the plant to observe NUMEC's scrap uranium reprocessing operation. From November 20, 1965 until February 23, 1966, Oak Ridge Operations Office has had an inspector observing this operation on a selective work shift basis. Also, during the exhumation of the burial pits, personnel from the Division of Compliance, Division of Industrial Participation, Division of Nuclear Materials Management, and SNPO-C witnessed the recovery. Thus, ample opportunity was afforded AEC personnel for contact and discussion with all levels of NUMEC operating and supervisory employees. None of these varied and lengthy associations revealed any evidence that would lend support to the possibility of diversion of special nuclear material at NUMEC.

3.12 The AEC survey team developed an estimate of 84.2 kg U-235 resulting from known loss mechanisms. When offset against the total cumulative loss of 178 kg U-235 (paragraph 3.11), this results in a cumulative material-unaccounted-for quantity of 93.8 kg U-235 (178 kg - 84.2 kg). Based on total U-235 introduced into NUMEC, the total loss of 178 kg is 1.21% of plant receipts and the unaccounted for of 93.8 kg is 0.64%.

3.13 The estimates of all known loss mechanisms are tabulated as follows and are discussed below:

	U-235 (Kg)
Accidental losses[1]	3.0
Normal operational losses:	
(a) Liquid waste effluent discards[2]	58.0
(b) Burial pit discards (non-recoverable contaminated earth burden)[3]	2.2
(c) Stack gas losses[4]	14.0
(d) Liquid waste in storage drums[5]	2.0
	79.2
(e) Trackout, contaminated laundry and shoe covers[6]	5.0
Total - Known Loss Mechanisms	84.2

3.14 Through an examination of available NUMEC records supporting stack gas losses (14.0 kg), liquid wastes in storage drums (2.0 kg), and liquid waste effluents (58.0 kg), the survey team developed an estimate of about 74 kgs U-235 for the entire operational period of the Apollo facility. Additionally, NUMEC records indicate a loss of about 3 kg U-235 resulting from a vault fire which occurred February 9, 1963. NUMEC's records of the sampling and analysis of the uranium-contaminated earth burden associated with the recovery operation of the 1963 burial pit show in excess of 2.2 kg U-235 which is uneconomical to recover. NUMEC's recovery of 20% of the uranium-bearing recoverable material exhumed from that pit yielded a quantity of

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(1) See para. 3.14

(2) See paras. 5.11-5.13

(3) See para. 5.25

(4) See para. 5.31

(5) See para. 5.32

(6) See para. 5.33

about 1.1 kg U-235. An extrapolation of this recovery experience to the remaining 80% of the pit material on which incineration and recovery is progressing should account for an additional 4.4 kg U-235, resulting in a total of 5.5 kg U-235. However, the 5.5 kg U-235 exhumed from the 1963 pit has now been brought back on to the physical inventory, so it is not to be considered in evaluating known discards or loss mechanisms. Thus, from NUMEC's records, it is possible to support known losses of 79.2 kg U-235.

3.15 NUMEC has developed no historical data which would enable the survey team to place an estimate on the amount of uranium losses from such sources as contaminated laundry, shoe covers, and trackout. However, based on Union Carbide's Y-12 Plant experience factors for such loss, the survey team has estimated NUMEC's losses from this source as 5 kg U-235. Thus, it is possible to place what the survey team believes to be a conservative total estimate of about 84.2 kg U-235 (79.2 kg + 5.0 kg) which NUMEC could have assigned to known discards or loss mechanisms.

3.16 The possibility of the "loss" of uranium resulting from a bias in measurements of shipments of UC_2 from NUMEC to WANL was investigated. No evidence was found to suggest that such a bias existed. The details of that investigation are attached as Appendix A.

3.17 NUMEC has a sizeable backlog of internally generated uranium residues. The U-235 content assigned to these residues by NUMEC was recognized by the survey team as being highly imprecise and is subject to adjustment upon recovery. Nevertheless, such content was, and is, the best data available and was used by the AEC survey team in computing inventory quantities. Many of these residues have lost contract identity. Essentially all of these residues which have lost contract identity have been assigned by NUMEC to the WANL Purchase Order 59-NP-12674.

3.2 Records Audit

The audit of the NUMEC records confirms the findings of prior surveys that the records which purport to control internal movements of material were incomplete and inadequate. Because of this it is impossible to identify with any high degree of accuracy the true physical losses attributable to any given

contract. In addition, the plant-wide material records were based largely on book values of inventory and generally were adjusted for losses only at the time of closing a contract. This adjustment was usually only in the amount of loss which had been estimated on an engineering basis at the time the contract bid was made.

3.3 Nuclear Materials Management

The function of nuclear materials management at NUMEC is in need of direct management attention. Until recently, NUMEC management had not assigned the caliber of full-time professional talent generally found by other compsnies to be necessary in such a complex operation. In addition, direct supervisory attention to this matter in plant operations, coupled with an educational program to stress the importance of proper material control to all plant employees should be a matter of first priority.

4. Discussion

4.1 Records and Reports

4.11 The central (plant-wide) accountability records employed by NUMEC to generate material balance reports for contract material and semi-annual status reports for leased material consist of an external receipts and removals transfer journal and a job order ledger for each report. The job order ledgers contain, by NUMEC internal job number, SS material balance summaries for job orders which are in process. Only external receipts and removals are posted to the job order ledger, and, in the main, losses are shown only when contracts are closed, and then only in the amount of the estimates included in the bid.

4.12 In addition to the records maintained in the central accountability office, a combined contract and lease subsidiary interplant transfer ledger has recently been established and is being maintained by the vault custodian in the uranium processing area. (This ledger was established subsequent to the April 30, 1965 survey.) This book of record reflects, by job order, movement of material through the different processing areas of the facility, However, adjustments had not been made for

significant differences between the book inventories and periodic physical inventories which had been requested by supervision on an individual job order. As with prior job ledgers, job order balances still do not reflect either the quantities physically on hand or losses localized by job order or by process. A quantity measurement is made as material is received and removed from a process, but any material lost due to processing is not recorded.

4.2 Physical Inventory

4.21 The survey team prepared an independent inventory listing of all enriched uranium recognized by NUMEC as being physically present, using NUMEC's data for uranium and U-235 content. Most of the listing was completed on November 2-3, 1965; a few items about to be fed to the processing line were inventoried on November 1 in order to minimize the impact of the inventory listing on production. The inventory list consisted of about 2300 line items. Of these, 77% constituted only 12% of the total U-235 inventory. This relationship demonstrates that many items on the NUMEC inventory consist of low-grade and low-enrichment residues.

4.22 Specially prepared inventory forms were used to facilitate subsequent processing of the inventory by EDP equipment. The approximately 2300 line items of inventory were sorted by NUMEC-assigned job number, and were printed and totaled, using EDP equipment at AEC's data processing center, Oak Ridge Gaseous Diffusion Plant, Oak Ridge, Tennessee.

4.23 In order to test the validity of the inventory data, the survey team check-weighed a statistical sample of 146 items, selected at random. Thirty-four of the items weighed were also sampled for independent chemical and isotopic analysis at AEC's New Brunswick Laboratory, New Brunswick, New Jersey. Of the 146 items that were weighed, six discrepancies which could not be explained by evaporation or other recognized causes were noted. This was considered acceptable on the basis that the statistical sampling plan used (MIL-STD-105D) permitted as many as twelve such errors.

4.24 For those items selected for independent analysis, the criterion of acceptability was considered to be total uranium and U-235 in the batch. Collectively, the total uranium and U-235 values agree favorably, although a large number of individual differences were considered excessive. This was not unexpected, due to the heterogeneous nature of the sampled materials, that is, miscellaneous residues, sludges, ash, and recoverable wastes. In most of these cases, only a small amount of uranium or U-235 was involved and the value placed on the SNM by NUMEC was done by a quick gamma counting technique. However, the survey team selected samples of these materials for independent analysis to avoid the possibility of any significant quantity of U-235 escaping detection.

4.25 NUMEC had stored 731 air filters (704 of which were not on inventory), from process hoods and glove boxes; 177 containers of combustible and other wastes accumulated since 1964 (not yet incinerated or leached) and of combustible wastes removed from the 1963 burial pit; and 118 process air filters still in use in the process lines. Each of these inventory categories is discussed below.

4.26 The survey team estimated the U-235 content in the 731 air filters, using a gamma counting technique in which the 184 kev natural decay gamma ray from U-235 is selectively counted under conditions of controlled geometry. A comparison of counting data from the unknown filters with that from two prepared standards, indicated that the 731 air filters contain approximately 6.5 kg U-235. In some instances, however, this estimate is based on assumptions concerning comparability of geometry which are not based on experimental evidence. Recovery of 22 selected filters for checking purposes was performed by the Union Carbide Nuclear Corporation's Y-12 Plant. Comparison of Y-12's recovery data with that obtained by use of a gamma spectrometer was excellent on the basis of total uranium 235 content. While agreement on individual filters was not always within the 10% expected, this was not unexpected because many of the filters contained very small quantities of uranium ($\ll$10 grams uranium 235), and the use of the gamma spectrometer under field conditions will not result in agreement of 5-10% which is possible in laboratory testing when background counts can be minimized, more positions of the filter are counted, and longer counting times can conveniently be used.

4.27 The survey team also estimated the U-235 content of the 177 assorted containers of combustible waste and carbon wool to be 1.5 kg U-235, using the same technique as that used for the air filters. Recovery of three selected boxes for checking purposes was performed by the Y-12 Plant, and showed a wide variation in agreement with the survey team's gamma spectrometer measurements. The survey team believes that this disagreement results from the lack of standards and the variable and uncertain counting geometry of the boxes. However, because these wastes contain such a small amount of U-235, even a large variation in the estimate has little or no effect on the total inventory.

4.28 On the basis of engineering drawings, and a physical examination of the plant, the survey team estimates that 118 air filters currently in use were not included in the physical inventory listing. NUMEC has a scheduled program for removal of in-line air filters based on weight gain and length of time in service. On the assumption that, on the average, each air filter still installed in the plant process lines was 50% loaded, they were estimated to contain 540 grams U-235.

4.29 NUMEC has exhumed both its 1962 and its 1963 burial pits, and has hand-sorted potentially recoverable material. The combustible wastes from the 1962 pit had been ashed and analyzed prior to the survey, and were included in the physical inventory with a U-235 content of 300 grams. Of the material removed from the 1963 pit, the survey team estimated that approximately 5.5 kg U-235 is contained in such wastes.

4.3 Inventory Summation

The NUMEC inventory of 522 kg U-235 (as of 10/31/65) was derived by the AEC survey team on the basis of inventory quantities which almost entirely (99%) had been established by NUMEC. A quantity of 5.2 kg U-235 was independently determined by the AEC survey team by gamma spectrometry of stored filters and combustibles assigned to the Westinghouse Astronuclear Purchase Order 59-NP-12674 (WANL-1231). The following tabulation shows the material assigned to the WANL-1231 contract and to all other contracts. The survey team recognizes the large uncertainty associated with the inventory quantities assigned to the residues, ashes, etc., from the WANL-1231 contract because of their heterogeneity and low U-235 content.

PHYSICAL INVENTORY OCTOBER 31, 1965

	U-235 (Kg)		
	AEC Quantities	NUMEC Quantities	Total
Leased Material - SNM-145	---	97.0	97.0
Non-Leased Material			
Contract WANL P/O 59-NP-12674			
Residue from original job order	---	2.7	2.7
Combustibles	0.3(1)	12.0	12.3
704 Filters	4.9(1)	---	4.9
Filter Ash	---	6.0	6.0
Material from Burial Pit	---	5.8(2)	5.8
Residues from Fire	---	0.7	0.7
Total WANL P/O 59-NP-12674	5.2	27.2	32.4
All Other Contracts	---	391.8(3)	391.8
Total	5.2	516.0	521.2
Rounding Difference			0.8
Total Rounded AEC/NUMEC 10/31/65 Inventory			522.0

(1) Determined by AEC gamma spectrometry.

(2) The AEC reviewed the NUMEC data supporting the quantities of U-235 in combustible waste removed from the 1963 burial pit and accepted NUMEC's estimated quantities.

(3) NUMEC carried on inventory 27 filters with a U-235 content of 3.2 kgs which the AEC accepted notwithstanding that the AEC's gamma spectrometry test indicated that these filters contained 1.7 kg U-235.

4.4 Foreign Transfers

The survey team was aware of the twenty-eight foreign contracts under which NUMEC had performed fabrication services and had transferred enriched uranium. Documents covering these transfers have been reviewed routinely by the Oak Ridge Field Office and by the Division of International Affairs to ascertain that the documents reflect the quantities said to have been shipped and received and that the documents have been appropriately signed. The quantities in specific shipments, domestic as well as foreign, are not confirmed independently by the AEC; such actions have been outside the scope of the present AEC system of control of nuclear material. Instead, reliance has been placed on a technical review of the shipper's internal controls and independently developed receiver's data. The validity of this approach is, of course, largely dependent upon the integrity of the shipper and receiver. A review of NUMEC's shipping practices and procedures, made by representatives of the Division of Nuclear Materials Management, International Affairs, and Office of the Controller is the subject of another report. That report indicated that NUMEC has sufficient internal controls on shipments which, when properly implemented, should, in the absence of a deliberate collusion, ensure that the quantities reported on the transfer documents were indeed those quantities shipped. The Division of Nuclear Materials Management is presently studying the possible feasibility and desirability of independent AEC physical checks of shipments at time of shipment. A summary of the foreign transfers made by NUMEC is attached as Appendix B.

5. Losses, Discards, and Material Unaccounted For

5.1 Liquid Wastes

5.11 During the course of normal processing operations NUMEC discards several thousand gallons of liquid waste per 24 hour period, at a typical uranium concentration of somewhat less than 1 ppm. The survey team reviewed the system used for the collection and measurement of liquid wastes, and examined the log books used for the recording of data. NUMEC was asked to convert the log book data into grams U-235, and to prepare monthly totals. This summation was then subjected to audit testing.

5.12 The survey team adopted a specific activity value of 88 dpm/µg, based on an assumed average enrichment of 5-20% U-235 in calculating the content of the liquid effluent discarded. Thus, it has been estimated that during the period from July 1960 to September 1965, NUMEC

discarded an estimated 54 kg U-235 in liquid wastes. Extrapolation of this data to the start of plant operations results in an additional 4 kg U-235 discarded for a total of 58 kg U-235.

5.13 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.

5.2 Burial of Contaminated Waste

5.21 In each of the years 1961, 1962, and 1963, NUMEC made burials of contaminated wastes which they believed contained insignificant amounts of uranium. In 1964, however, when NUMEC recognized that unacceptably high uranium losses were occurring, NUMEC came to the conclusion that previous estimates of uranium in combustible wastes being buried were low, and no further burials have been made subsequent to that time. The 1962 and 1963 pits were exhumed in the fall of 1965. The exhumation operation was witnessed by AEC personnel representing the Office of Complisnce, the Division of Nuclear Materials Management, the Division of Industrial Participation, and SNPO-C. The results of this reopening are described below.

5.22 The 1962 and 1963 burial pits were reopened by first using a bulldozer to push off the overburden, and then using a "clamshell" type digger to remove all buried wastes. These wastes were then hand sorted to remove all combustible material. Any other material which appeared to be recoverable was also removed for separate processing.

5.23 The survey team was advised that 300 grams U-235, were recovered from the 1962 pit. Incinerated ashes from the 1962 pit, as well as from current operations, were included in the physical inventory.

5.24 Incineration of combustible wastes from the 1963 pit began during October, 1965, and was approximately one-fifth complete as of November 11. The survey team estimates that 5.5 kg U-235 will be recovered.

5.25 Soil samples from the 1963 burial pit indicate a U-235 concentration of about 2 ppm to a depth of about 10" below the pit bottom. The most probable explanation for this contamination is that it represents uranium leached or washed from buried contaminated equipment. The survey team accordingly estimates that the total contaminated volume is 46" thick (36" in the pit, plus 10" below the pit bottom). Since the pit area is approximately 5540 sq. ft. the estimated U-235 content is 2.2 kg.

5.26 Since very little uranium was found in the 1962 pit, the survey team did not extrapolate the contaminated soil data to include soil removed from the 1962 pit.

5.3 Miscellaneous Discards

5.31 The NUMEC Apollo plant currently contains 118 filtered exhaust stacks and three large ventilation fans. Using an average of 110 $d/m/M^3$, the survey team estimates that at least 14 kg U-235 have been lost through this mechanism. The 14 kg estimate is considered to be a minimum because Division of Compliance inspectors have noted that stack gas surveys were not performed on stacks at times when loss rates might be expected to be abnormally high. There does not appear to be any way to estimate the extent (if any) to which the estimated 110 $d/m/M^3$ average loss rate may be lower than actual.

5.32 NUMEC has stored some 1500 drums of waste which, because it contains beryllium, cannot be discarded. Based on samples taken during the survey, these wastes are estimated to contain 2.0 kg U-235.

5.33 The survey team notes that coveralls, lab coats, and rubber shoe covers are cleaned by Nuclear Decontamination Corp., a NUMEC subsidiary, and that no U-235 recovery data is available. The Apollo plant employs about 225 people, of whom perhaps 100 routinely wear coveralls. In addition, shoe covers are used at a rate of 30-50 pair per day. Neglecting the period prior to 1960, when operations were on a smaller scale, these use rates still total about 150,000 coveralls and 80-100,000 pairs of shoe covers. No truly comparable AEC operation exists, but Union Carbide's Y-12 Plant has derived an experience factor of 0.2 g U per working day per employee as loss through trackout, laundry service and sanitary sewers. On this basis, and assuming an average enrichment of 7% U-235, the survey team estimated about 5 kg U-235 lost through this mechanism.

5.4 Material Unaccounted For

Of the total cumulative "loss" of 178 kg U-235, 84.2 kg has been accounted for as discussed above. The remainder, 93.8 kg U-235, is material-unaccounted-for. As defined previously, material-unaccounted-for (MUF) is that quantity remaining when the difference between the physical measurements and book records has been adjusted for all quantities which are capable of measurement, directly or indirectly (accidental losses, normal operational losses -- discharges to tanks, sewers, stacks, burial grounds, etc., and any other known write-offs of material). MUF, then, is the result of measurement uncertainties, unrecognized process losses, bookkeeping errors, diversions or thefts and possibly even other causes. If the uncertainties of input, output and inventory measurements, which result from the use of biased and/or imprecise methods, are large, then it follows that their contribution to the MUF will be large. Likewise, if unrecognized process losses, such as general building contamination, equipment hold-up, clothing absorption, track-out, and air venting, occur individually in very small quantities they may over a long period, accrue into a large contribution to MUF. In the particular case of waste stream effluents at NUMEC, the definite possibility exists that the actual level of discard may be as much as 15 kg U-235 greater than that estimated by the survey team because of the less than optimum sampling conditions under which NUMEC has operated. Thus, what may have been an explainable discard of 15 additional kg U-235 is now included as part of the MUF.

6. Westinghouse Astronuclear Purchase Order 59-NF-12674

6.1 Resolution of Disposition of Material Losses

6.11 This order involved the chemical conversion of 1013 kg U-235 as UF_6 (at 93+% enrichment), furnished by the customer to produce UC_2, of which 713 kg U-235 as UC_2 (at 93+% enrichment) was delivered as acceptable product. A physical inventory performed by OR for the period ended April 30, 1965, disclosed an apparent loss of some 53 kg of U-235 on the WANL contract. While recognizing the stated position of NUMEC that on a production scale this process was of an untried and unique nature, nevertheless the survey team found insufficient technically-based records to account for a loss of the magnitude of 53 kg U-235. As a result

of this survey, the loss ascribed to the WANL contract is now believed to be about 61 kg U-235. This increase is net, after adjusting for additions to inventory from previously unrecognized sources and for reductions to inventory resulting principally from a more accurate estimate of the U-235 content of air filters. It should be noted that NUMEC had recognized and reported losses of 38 kg U-235 chargeable to the WANL contract.

6.12 NUMEC, by letter of December 29, 1965 to the Division of Nuclear Materials Management (Appendix C), set forth its position that "high losses perhaps up to 30 kg of U-235 (or 3%) may have been experienced in this unique and complex operation." NUMEC claims losses of this magnitude have been experienced on jobs involving the same number of processing operations, but on material inherently less dusty in nature. While a loss of this order may be reasonable to assume, the survey team pointed out that some portion of this "loss" should be of a measurable nature, i.e., entrapped in air filters, on glove box walls, in waste solutions, combustible wastes, etc., and as such could subsequently be brought on to the physical inventory, or recorded as a known discard.

6.13 In an attempt to establish yields and loss mechanisms directly applicable to this purchase order, the survey team requested NUMEC production control and process engineering data on this and other contracts. The data made available was of little or no value in this regard. Process lots or batches could not be correlated to points in time nor could a sequence of processing events be established. All efforts in this direction were negated when it was learned that many of the requested records had been inadvertently destroyed by supervisory personnel during a "clean up" campaign at the time of an employee strike, January 1 to February 25, 1964.

6.14 The survey team then reviewed NUMEC's operating practices in regard to segregating or mingling of material assigned to the various contracts held by NUMEC. If it could be established that material assigned to the WANL purchase order had been transferred to other contracts without a record of credit to the WANL account, such transfer would appear as a "loss" on the WANL account. This approach has uncovered the likelihood of such transfers having indeed occurred. The referenced NUMEC correspondence to the Division of Nuclear Materials Management discusses these possibilities in some detail. These, and other

postulated practices whereby WANL material could have become mixed with material from other contracts are discussed below.

(a) In a letter of July 8, 1963 from NUMEC to WANL, NUMEC substantiates the possibility that material from the WANL contract may have been mixed with other material. Of 24.5 kg U-235 as UO_2 which because of slight isotopic degradation was unacceptable to WANL, only 19.8 kg U-235 is shown as having been returned to AEC for credit to the WANL contract. NUMEC suggests the possibility that, in the course of scrap recovery, 4.7 kg U-235 from the WANL contract may have been returned to the AEC under other contracts.

(b) By memo of October 5, 1963 from C. Beltram, NUMEC, to F. Forscher, NUMEC, an incident involving the degradation of 2.5 kg U-235 of WANL material is described. No evidence is available that this material was returned as a credit to the WANL job. NUMEC suggests that it can be reasonably inferred that this material was recovered with other scrap material and not credited as WANL material.

(c) The manner in which NUMEC has conducted its scrap recovery operation has an important bearing in evaluating the possibility of NUMEC's allocating material from Westinghouse Astronuclear Purchase Order 59-NP-12674 (referred to as Contract 1231) to other scrap recovery contracts. This is best explained in NUMEC's referenced letter to the Division of Nuclear Materials Management (Appendix C), and the pertinent section is quoted as follows:

"The Nature of NUMEC's Scrap Recovery Operations

"The possibility for the allocation of materials generated in the recovery of scrap to contracts other than 1231 is quite great in view of the manner in which NUMEC's scrap recovery operation was conducted.

"A scrap recovery facility, in a company handling a large number of special nuclear materials contracts each year, cannot be reserved for an extended period of time to

"recover all of the scrap that may be generated under a contract which may require a year or more to complete and which, from time to time, may generate quantities of scrap material. Of necessity, the scrap from a long-term contract must be scheduled for recovery intermittently with scrap material from other contracts. Such was the case with respect to the 1231 scrap material.

"A major clean-up between jobs would be required in order to insure against the downgrading of material in an intermittent operation of this type. Such a clean-up itself, however, will generate additional losses since material is bound to be lost in the huge amounts of solution required to adequately clean the complex equipment in the plant.

"Moreover, since the scrap recovery operation involves a solvent extraction process, one must reach near saturation equilibrium in the plant before extracted material is chemically clean. Thus, the first material removed from the process must always be recycled to achieve clean material. Correspondingly, the material last removed from the process is, as a general matter, never pure enough to be used in end product and, therefore, again becomes scrap.

"The foregoing suggests the economic infeasibility, if not the practical impossibility of totally segregating each job in a plant with a view toward 'finishing' each job before moving to the next. To offset these consequences, it was NUMEC's practice to segregate material by contract only through the point of dissolution, at which point the accountability under a given contract was established. Thereafter, our scrap recovery equipment was operated on a 'heel to toe' basis without segregation of material between jobs. Thus, if scrap from ten jobs, for example, was processed in one recovery campaign, certain assumptions had to be made in assigning the recovered material between the originating contracts. This assignment was made on a basis proportionate to each contract's feed contribution.

"Losses were calculated in the manner described below. We believe that this method of scrap recovery operation is generally consistent with industry practice.

"Disposition of 1231 Material (1962-63)

"With this information as background, it becomes pertinent to examine the scrap recovery contracts most likely processed at NUMEC during the same time the 1231 contract was active. Table I, attached, lists these contracts. We believe these jobs were run on a 'heel to toe' basis in conjunction with the recycle and/or scrap material from Contract 1231. Excluded, however, are those contracts involving the processing of uranium of less than 5% enrichment. Since NUMEC maintained a separate reprocessing facility for material less than 5% enriched, it is unlikely that such material would have been run on a 'heel to toe' basis with highly enriched material.

"The total quantity of uranium represented by the contracts in Table I is approximately 470 kilograms of U-235. These jobs were closed out with an average overall U-235 loss of approximately 1.5 per cent, or 7 kilograms. The average 1.5 per cent loss figure was selected on the basis of our best estimate, at the time, of the losses experienced in our recovery operation. A definite figure could not be established since, in the 'heel to toe' process, described above, there was no complete clean-up between reprocessing campaigns. It is important to note, at this point, that due to the complexity and quantity of the scrap on hand during 1962-1963, there was a large uncertainty with respect to total plant accountability during this period. As a result there was no clear evidence, at the time, to indicate that the 1.5 per cent figure was inaccurate.

"It was only within the last year, during which NUMEC performed two large scrap contracts of 108 kilograms [AT(40-1)3302] and 137 kilograms [AT(40-1)3375] that it became evident that the

"losses were greater than those initially anticipated. In both cases, a closed accountability was maintained; that is, there was no 'cross-over' between jobs. In the first case, losses were 4.1 per cent; in the second, 3.0 per cent. (The second contract is approximate because final accountability has not been established.) In both cases the scrap involved was similar in nature to that processed during 1962-1963 and, accordingly, utilized nearly the same process chemistry and equipment. On the basis of our current experience, it would appear that a loss factor of 3.5 per cent may have been more appropriate than one per cent. On this basis, the losses experienced under the scrap recovery contracts itemized in Table I could have been 16.5 kilograms instead of the 7 kilograms declared. This would suggest that approximately 9 kilograms of 1231 contract U-235 could have been inadvertently mixed and returned with material under these scrap recovery contracts."

6.15 NUMEC has further indicated that as a result of underestimating its reprocessing losses on other purchase orders closed out before and during the WANL contract, as much as 12 kg U-235 more of WANL material may have been returned to the AEC on other purchase orders. Thus, after a close-out of all inactive NUMEC contracts, only the WANL contract remained as the identifiable point for all other prior misassigned losses and therefore became the final repository for those losses.

6.16 In the survey team's judgment, there is a high degree of probability that WANL contract material was transferred to other contracts in the manner described above. The survey team's review and observation of NUMEC's operations and the findings of other surveys of the NUMEC operation since plant start-up in 1957 contribute in a large part to this judgment.

7. Recommendations

7.1 To prevent a recurrence of the circumstances which resulted in this survey; to put NUMEC in a position to recognize and to minimize its losses; and, to record and report to the AEC in a timely manner losses and material-unaccounted-for actually being experienced, it is recommended that NUMEC:

1. 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.

2. Take immediate action to:

a. Install a general ledger to summarize accounts periodically and 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 area 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.)

d. 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.

e. 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 forms and recorded in the subsidiary ledger.

f. Issue periodically, by material balance areas, a report to NUMEC management of ending inventory and losses which shows and explains losses by job order and the quantity and forms of material physically on hand by job number.

3. Identify and establish the magnitude of all significant loss mechanisms and technical bases thereof. Translate such data to U and U-235 content and record and report on a current basis.

4. Establish inventory procedures and perform plant-wide inventories periodically, but not less often than annually. After comparison of these 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.

5. Establish all control procedures in a procedure manual and submit same to the Oak Ridge field office for review and approval.

6. Process the large quantity of accumulated residues, combustibles, filters, ash, etc., and return the SNM recovered to the AEC. In so doing, care must be exercised to identify and to process residues in such a manner as to permit comparison of recovered values with book values. After such comparison, the resulting gain or loss should be recorded.

7. Adjust the NUMEC October 31, 1965 book inventory to agree with the AEC's October 31, 1965 physical inventory which establishes a U-235 content of 521,179 grams. In making this recommendation, the survey team recognizes that there are uncertainties in this quantity due to the large number of heterogeneous uranium-bearing residues on inventory which were not amenable to representative sampling. Therefore, upon recovery, some adjustment, either upward or downward, to the inventory may be necessary from time to time. (A detailed tabulation of the physical inventory has been provided to NUMEC.)

8. Initiate a company-wide educational program stressing the high intrinsic and strategic value of special nuclear material and re-emphasize the health and safety implications of careful handling practices.

8. Meeting with NUMEC

8.1 On February 3, 1966, the AEC senior survey team personnel met with NUMEC management to discuss the findings of the survey and the recommendations that were being made. That meeting is summarized in a memorandum to the files attached as Appendix D. A NUMEC letter dated February 5, 1966 setting forth their comments and actions is attached as Appendix E.

April 6, 1966
Date

S. C. T. McDowell
Assistant Director for Control
Division of Nuclear Materials Management

APPENDIX A - Attachment 1

DETAILS OF THE INVESTIGATION

DRAFT

NUMEC PROCEDURES

NUMEC weighed their product on a Sauter direct reading scale with a sensitivity of one gram. The balance is checked with standard weights by the NUMEC quality control staff about every two weeks. This balance has been reviewed by a member of my staff, and is considered fully adequate.

NUMEC took grab samples from 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 WAML 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%.

NUMEC used analytical method 1.101 published in TID-7029, "Selected Measurement Methods for Plutonium and Uranium in the Nuclear Fuel Cycle," with the modifications discussed below. The method is believed to be capable of a precision of 0.4% relative, under conditions of routine use. (Procedure 1.101 is reprinted as Attachment 3.)

Some laboratories have experienced difficulty in avoiding loss of sample due to "popping" during the ignition step (during which the carbon oxidizes in CO_2 and the uranium converts to U_3O_8). To preclude this, NUMEC placed their samples on a bed of Al_2O_3 which had previously been ignited to constant weight. This should be an effective means of avoiding loss of sample.

Procedure 1.101 suggests that the addition of filtered oxygen to the ignition furnace will speed the analysis. NUMEC adds about 200 ml of filtered oxygen per minute.

*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.

DRAFT

b. uranium content agreed to within 50 grams on all but fourteen shipments and to within 100 grams on all but nine shipments. The largest single difference was 258 grams U. These were more or less randomly dispersed in time, however, and were equally divided between WANL high and WANL low. The net total difference in uranium content between the two laboratories is 15 grams (WANL high), or only 0.002%. A graph of these differences is attached.

c. For all practical purposes, U-235 content agreed unless there was a difference in uranium content. The net total difference between the two laboratories is 37 grams (WANL low) or 0.005%.

Attachments:
Details of Investigation
A Graph of S-R Differences
Method 1.101, "Gravimetric-Volumetric Determination of Uranium in Oxide-Organic Dispersions"

APPENDIX A - Attachment 1

DETAILS OF THE INVESTIGATION

DRAFT

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Procedure 1.101 suggests that the addition of filtered oxygen to the ignition furnace will speed the analysis. NUMEC adds about 200 ml of filtered oxygen per minute.

*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.

NUMEC used method 2.401 (also in TID-7029) to verify that isotopic degradation had not occurred. Since this method is less accurate than the mass spectrometric technique used by Goodyear Atomic Corporation (AEC's Gaseous Diffusion Plant near Portsmouth, Ohio) to analyze UF_6 delivered to NUMEC, the Goodyear data was used as a basis for product shipments.

WANL PROCEDURES

Scales and balances used by WANL have been reviewed by NMM survey teams, as part of required annual surveys. Since there was no basis for suspecting a bias in net weights, no additional review was made for this investigation.

WANL used a riffle sampling technique in which the batch is progressively split into two approximately equal portions until the desired sample size is reached. This is a standard sampling technique for materials of this type; there is no basis for suspecting that the samples thus obtained are not representative of the parent batch.

WANL also used method 1.101 from TID-7029. In fact the WAPD laboratory at Waltz Mill, Pennsylvania, which performed the analyses for WANL, was responsible for developing method 1.101 and for estimating its precision at 0.4% relative. WANL does not use the aluminum oxide bed, but does follow the recommendations in method 1.101 that ignition begin at 250° C, and that final ignition at 900° C be carried out overnight. Under these conditions of slow heating there should be no sample "popping."

WANL used methods 2.401 and 2.406 to determine U-235 content. In combination these two methods are more accurate than the single method used by NUMEC, but still not as accurate as the mass spectrometric analyses. This undoubtedly accounts for the small differences noted.

ADDITIONAL COMMENTS

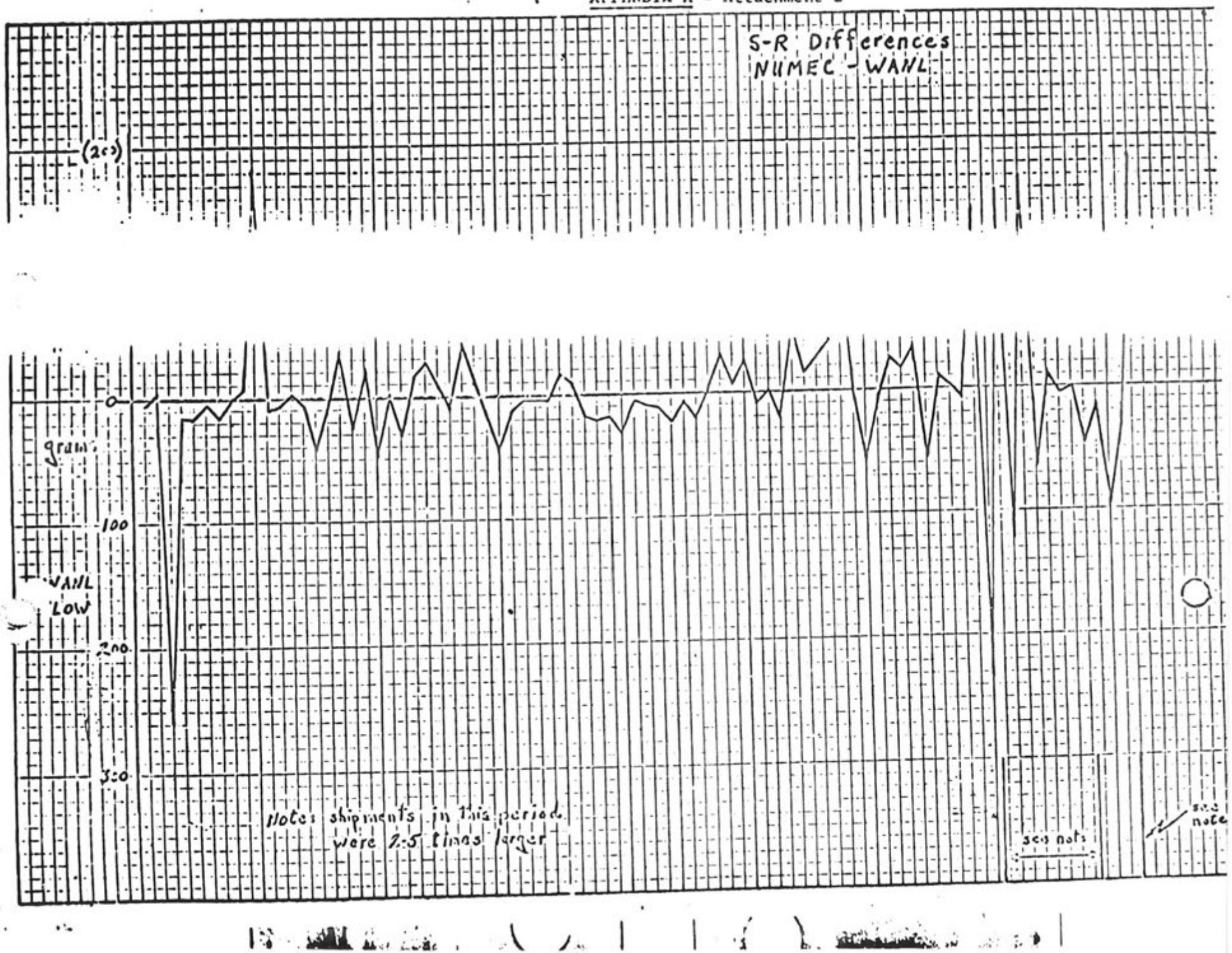
Both laboratories have confirmed their procedures using NBS certified chemical and isotopic standards. The NBS chemical standard is certified to ± 0.02%, including a conservative allowance for uncertainties in the stoichiometry of U_3O_8. The isotopic standards in the range of 93% U-235 are certified to ± 0.05%.

WANL and NUMEC have not engaged in any formal sample exchanges. However, WANL has exchanged samples of similar material with AEC's New Brunswick Laboratory (NBL), Union Carbide Corp. (Y-12), the Los Alamos Scientific Laboratory (LASL), and Nuclear Fuel Services, Erwin, Tennessee (NFS).

Average values obtained are as follows:

WANL	0.6985 g U/g sample
NBL	0.6979 " " "
Y-12	0.6961 " " "
LASL	0.6943 " " "
NFS	0.6937 " " "

Since NBL, Y-12, and LASL used high precision titrimetric procedures, while WANL and NFS used the routine gravimetric procedure discussed above, the best estimate of the true value probably is about 0.696. It is not unlikely that NFS and possibly LASL experienced some loss of sample due to "popping" during ignition.


S-R Differences
NUMEC - WANL
(2σ)
0
grams
100
WANL
LOW
200
300
Note: shipments in this period were 2.5 times larger
see note
see note

METHOD 1.101

GRAVIMETRIC–VOLUMETRIC DETERMINATION OF URANIUM IN OXIDE–ORGANIC DISPERSIONS*

DRAFT

A. Scope

This method is applicable to the determination of uranium in uranium oxide dispersions in graphite and in polystyrene or other plastic-dispersion media.

B. Summary of Method

The material to be analyzed is thermally decomposed, and the residue is ignited to 900°C. Uranium is determined either gravimetrically with correction for impurities or volumetrically.

C. Procedure

1. Gravimetric. a. Ignite a platinum crucible or dish to constant weight at 900°C.

b. Accurately weigh a sample estimated to contain from 1 to 5 g of uranium into the platinum crucible, and ignite it in a muffle furnace. For polystyrene or other plastic samples, begin the ignition at about 250°C. After all material volatile at 250°C has been removed, gradually increase the temperature to 900°C.

c. Continue the ignition until all material volatile at 900°C has been removed. Ignition for 30 min at 900°C may be sufficient for plastics, but an ignition time of several hours to overnight may be required for graphite mixtures. Passing filtered oxygen over the sample will accelerate the ignition.

d. After all material volatile at 900°C has been removed, ignite the sample to constant weight at 900°C in air.

e. With an emission spectrograph determine the metallic impurities in the ignited sample. See Methods A, B, and D in the Appendix.

f. Calculate the uranium content as described in Method 1.100.

2. Volumetric. a. Accurately weigh a sample estimated to contain about 200 mg of uranium into a platinum dish or crucible.

b. Ignite the sample to constant weight as described in Sec. C1 of this method.

c. Dissolve the residue from the ignition in 3 ml of concentrated nitric acid.

d. If an insoluble residue remains, filter the solution through a Whatman

*Submitted by R. W. Bane, Argonne National Laboratory, Argonne, Ill.

No. 41 filter paper (hardened), and wash the paper and residue free of acid with hot water. Retain the filtrate and washings.

e. Ash the paper and residue in a platinum crucible.

f. Treat the residue in the platinum crucible with a few drops of sulfuric acid (1 + 1) and 10 ml of concentrated hydrofluoric acid.

g. Evaporate the contents of the crucible to dryness and ignite for 10 min at 900°C.

h. Dissolve the ignited residue in 5 ml of concentrated nitric acid, and quantitatively transfer the solution to the retained filtrate and washings from the initial filtration.

i. Add 5 ml of concentrated sulfuric acid to the combined solution, and evaporate to SO_3 fumes.

j. Cool the solution, rinse the sides of the beaker with water, and, without adding additional acid, repeat the fuming twice to ensure removal of all nitrate ion.

k. Determine the uranium content as directed in Method 1.200, beginning with Sec. F6, step a.

APPENDIX B

TRANSFERS TO FOREIGN ENTITIES
License No. SNM-145 - Uranium Enriched in the Isotope 235
Nuclear Materials and Equipment Corporation, Apollo, Pennsylvania
for the Period December 1, 1957 to October 31, 1965

Date Shipped	Destination	Material Description	Unit Gram Uranium	Percent Isotope	U-235
8/7/58	U.S. Exhibit, Switzerland	UO_2	7,521	19.94	1,500
10/30/58	France	UO_2	4,407	1.50	66
12/30/58	"	UO_2	487,969	1.50	7,359
12/26/58	"	UO_2	489,886	1.50	7,387
12/12/58	"	UO_2	487,422	1.51	7,350
12/17/58	"	UO_2	488,567	1.51	7,368
12/19/58	"	UO_2	486,600	1.51	7,338
1/30/59	"	UO_2	321,461	1.50	4,848
1/9/59	"	UO_2	485,360	1.50	7,319
1/14/59	"	UO_2	324,227	1.50	4,889
2/25/59	"	UO_2	74,330	1.50	1,121
2/25/59	"	UO_2	43,923	3.49	1,533
4/22/59	"	UO_2	170,119	3.49	5,935
5/14/59	Canada	UO_2 Powder	39,989*	6.99	2,794*
5/29/59	France	UO_2	70,241	3.49	2,451
6/4/59	"	UO_2	200,451	3.49	6,994
7/3/59	Italy	Uranyl Sulfate	7,523	19.94	1,500
9/4/59	France	UO_2	70,006	3.49	2,443
9/18/59	"	UO_2	72,059	3.49	2,515
10/16/59	"	UO_2	16,966	3.49	592
11/10/59	Australia	Metal Powder	500*	93.40	467*
4/20/60	France	U Dioxide Powder	127*	19.83	25*
4/20/60	"	Metal Blend	(21*	93.00	20*
			(80	Normal	0
11/9/60	Japan	Uranium Dioxide	54,067	20.00	10,732
11/10/60	"	Uranium Dioxide	22,231	20.00	4,413
7/11/61	France	UO_3 Powder	107,384	2.984	3,204
7/11/61	"	UO_3 Powder	1,475	90.00	1,328
8/24/61	"	U Dioxide Powder	15,000	20.0568	3,009
4/19/62	"	U Dioxide Pellets	9,130	4.025	367
4/19/62	"	U Dioxide Pellets	9,110	4.52	412
4/19/62	"	U Dioxide Powder	5,265	4.50	238
6/15/62	Italy	U Dioxide Pellets	47,976	19.96	9,576
7/31/62	Japan	$UO_2(NO_3)_2$ and U_3O_8 Powder	21*	93.16	20*
8/24/62	Netherlands	U Dioxide Pellets	390,187	3.136	12,236
9/7/62	"	U Dioxide "	370,669	3.136	11,624
10/11/62	"	UO_2 Pellets	316,139	3.813	12,054

Unit Gram

Date Shipped	Destination	Material Description	Uranium	Percent Isotope	U-235
10/12/62	Netherlands	UO_2 Pellets	313,986	3.813	11,972
11/2/62	"	UO_2 Pellets	58,385	3.813	2,227
11/2/62	"	UO_2 Pellets	32,553	3.136	1,021
11/2/62	"	UO_2 Pellets	104,754	3.813	3,994
11/23/62	France	UO_3 Powder	4,000	89.82	3,593
11/23/62	"	ADU Powder	10,027*	19.86	1,991*
11/30/62	Netherlands	UO_2 Pellets	19,423	3.136	609
11/30/62	"	UO_2 Pellets	1,664	3.813	63
1/27/63	Italy	Al clad U_3O_8 Fuel Plates	12,360	19.83	2,451
5/9/63	France	UO_2 Powder	300,227	4.027	12,090
4/25/63	"	ADU Powder	20,998	60.03	12,605
4/26/63	"	ADU Powder	20,998	60.03	12,605
9/26/63	United Kingdom	Fused UO_2	88,125*	2.90	2,555*
3/27/64	Canada	UO_2 Pellets	131,008	6.00	7,860
3/30/64	Germany	UO_2 Pellets	286	1.00	3
3/30/64	"	UO_2 Pellets	282	1.50	4
3/30/64	"	UO_2 Pellets	283	2.00	6
3/30/64	"	UO_2 Pellets	286	2.50	7
3/30/64	"	UO_2 Pellets	285	3.00	8
3/30/64	"	UO_2 Pellets	286	3.50	10
3/30/64	"	UO_2 Pellets	281	4.00	11
3/30/64	"	UO_2 Pellets	282	4.50	13
3/30/64	"	UO_2 Pellets	446,266	5.02	22,403
4/20/64	France	ADU Powder	84,809	6.00	5,089
4/24/64	Japan	UF_6	49,230	5.704	2,808
4/24/64	"	UF_6	5,297	4.981	264
5/18/64	France	UO_2 Powder	300,000	4.00	11,970
7/13/64	"	ADU Powder	100,000	59.98	59,980
9/2/64	"	UO_2 Pellets	130,513	3.99	5,207
9/15/64	Japan	UF_6	164,721	2.598	4,280
10/13/64	Sweden	UO_2 Powder	52,578*	5.00	2,629*
12/14/64	France	UO_2 Powder	48,916	3.99	1,952
1/13/65	Italy	Al clad U_3O_8 Fuel Plates	5,034	19.83	998
3/13/65	France	UO_2 Powder	481,690	3.977	19,157
4/5/65	"	ADU Powder	100,000	59.93	59,930
10/4/65	Japan	Foils and UO_2 Powder	4	93.00	4
Total NUMEC Foreign Transfers 12/1/57 to 10/31/65			8,788,246		425,396

*Indicate sales transactions which equal or total 191 kgs uranium and 11 kgs U-235. All other transactions represent material which is leased.

APPENDIX C

Nuclear Materials and Equipment Corporation Apollo, Pennsylvania 15613 Telephone GRover 2-8[illegible] Cable NUMEC

December 29, 1965

Mr. Douglas George
Director, Division of Nuclear Materials Management
United States Atomic Energy Commission
Washington, D. C. 20545

Dear Mr. George:

In the course of the past two months, representatives of The Division of Nuclear Materials Management have conducted an extensive physical inventory at NUMEC and have examined the Company's records in an effort to determine the disposition of approximately 55 kilograms of uranium-235, presently unaccounted for under Westinghouse Astronuclear Purchase Order No. 59-NP-12674. Although the precise dimensions of the materials loss have not as yet been established, we fully appreciate the overriding importance of investigating and resolving any question of safeguards connected therewith at the earliest possible date.

Necessarily, in any task as complex as the Commission's current investigation, your staff will have derived a vast amount of information from the records of the Company and through conversations with NUMEC personnel. Because much of this data has been derived from old and, in some instances, incomplete records or from the recollections of individuals of the events of several years ago, the information you have received may be somewhat fragmentary. Accordingly, I believe it would be helpful if we were to set forth, as completely as possible, our best analysis of the disposition of the material presently unaccounted for under Purchase Order 59-NP-12674 (NUMEC Contract 1231).

Unusual Nature of The 1231 Contract

In order to place this matter in perspective, it is important to understand the nature of the product and the process required under the 1231 Contract. The manufacture of pyrolytic graphite coated uranium dicarbide fuel particles on a production scale had never been done before. In general, the process involved the following steps: (1) conversion of UF_6 to UO_2; (2) blending of UO_2 with graphite and a binder material; (3) pressing of the

blended material into sinter stock; (4) sintering of the pressed material; (5) crushing of the sintered stock to form melt stock; (6) melting of the material by direct arc to form carbide ingots; (7) crushing, grinding and sizing of the ingots to form fine on-size particles; (8) spheroidizing of the particles in a plasma torch; (9) carbon coating of the spherical particles in an induction heated fluid bed reactor in an atmosphere of methane and an inert carrier gas.

Although the foregoing is only a brief description of the process, it may serve to illustrate the complexity of the manufacturing operation which may be characterized fairly as an extremely dirty and dusty process. As described below, more fully, NUMEC's product yield in this process was quite low, necessitating an extensive recycling of material in order to deliver sufficient product to the customer. Extensive recycling of material, as you know, inevitably involves a repetition of losses.

As noted earlier, the manufacture of this material was, for NUMEC, a "first of a kind contract"; it has never been performed again by the Company. Consequently, our direct experience factors are limited in terms of comparing the losses on this job with other contracts. Nevertheless, we believe it is not inconceivable that high losses* -- perhaps up to 30 kilograms of material (or 3%) -- may have been experienced in this unique and complex operation. For instance, on jobs involving the same number of unit operations, but on material inherently less dusty in nature, we have experienced losses of the same magnitude.

Even assuming, however, that such losses were experienced, this will not fully explain the disposition of the total amount of U-235 presently unaccounted for, approximately 6 percent of the total U-235 received by NUMEC for processing under the contract. Such an explanation must be derived from an examination of NUMEC's scrap recovery operations.

Scrap Generated Under 1231 Contract

The basic reference point in an inquiry into the disposition of 1231 material must be the amount of scrap generated under the contract.

*As used in this context, losses are defined as both the accounted for and the unaccounted for losses, i.e., all material not shipped to the customer as product or returned to the Commission or recovered from scrap.

The records of NUMEC's CP-2 facility, in which the initial conversion of UF_6 to UO_2 was performed, show that 1240 kilograms of material entered the facility for conversion under the 1231 contract. It should be noted, however, that only 1087 kilograms of UF_6 containing 93+ percent U-235 were furnished by the customer for conversion under the contract. The difference (153 kilograms) represents the quantity of recycled material required to make the final product accepted by the customer. It is, therefore, apparent that 153 kilograms of recycle material were, at some point, reprocessed in NUMEC's facilities. Illustrative of the process by which such recycle material is generated is the initial conversion (UF_6 to UO_2) in the CP-2 facility. NUMEC's records show that this conversion was performed in six discrete batches of approximately 163, 272, 252, 150 and 250 kilograms each, spaced three months apart between October 1962 and October, 1963. One would expect to leave behind, in the first pass through the facility, approximately ten kilograms of material from each batch. This non-yield uranium settles in clean-up materials and in the form of other wastes which are subsequently recovered and recycled. Thus, in the initial step of the process, at least 50 of the 153 kilograms of scrap described above, were generated.

It is also clear, in view of the fact that 1087 kilograms were processed to produce 763 kilograms of end product [illegible] that NUMEC had as inventory, after final product shipment, some 324 kilograms of material (process losses aside) which it was required to reprocess.

Finally, it should be noted that 65 kilograms of uranium, in the form of UO_2 prepared by NUMEC from the aforementioned scrap, were rejected by the customer. This material, too, required reprocessing.

In summary, a total of 542 kilograms (153 + 324 + 65) of scrap uranium, generated under the 1231 contract, were at various times injected into NUMEC's scrap recovery stream. It is in the reprocessing of this 542 kilograms of material that there exists the greatest possibility of mixing and consequent allocation of special nuclear material to other contracts.

The Nature of NUMEC's Scrap Recovery Operations

The possibility for the allocation of materials generated in the recovery of scrap to contracts other than 1231 is quite great in view of the manner in which NUMEC's scrap recovery operation was conducted.

A scrap recovery facility, in a company handling a large number of special nuclear materials contracts each year, cannot be reserved for an extended period of time to recover all of the scrap that may be generated

under a contract which may require a year or more to complete and which, from time to time, may generate quantities of scrap material. Of necessity, the scrap from a long-term contract must be scheduled for recovery intermittently with scrap material from other contracts. Such was the case with respect to the 1231 scrap material.

A major clean-up between jobs would be required in order to insure against the downgrading of material in an intermittent operation of this type. Such a clean-up itself, however, will generate additional losses since material is bound to be lost in the huge amounts of solution required to adequately clean the complex equipment in the plant.

Moreover, since the scrap recovery operation involves a solvent extraction process, one must reach near saturation equilibrium in the plant before extracted material is chemically clean. Thus, the first material removed from the process must always be recycled to achieve clean material. Correspondingly, the material last removed from the process is, as a general matter, never pure enough to be used in end product and, therefore, again becomes scrap.

The foregoing suggests the economic infeasibility, if not the practical impossibility of totally segregating each job in a plant with a view toward "finishing" each job before moving to the next. To offset these consequences, it was NUMEC's practice to segregate material by contract only through the point of dissolution, at which point the accountability under a given contract was established. Thereafter, our scrap recovery equipment was operated on a "heel to toe" basis without segregation of material between jobs. Thus, if scrap from ten jobs, for example, was processed in one recovery campaign, certain assumptions had to be made in assigning the recovered material between the originating contracts. This assignment was made on a basis proportionate to each contract's feed contribution. Losses were calculated in the manner described below. We believe that this method of scrap recovery operation is generally consistent with industry practice.

Disposition of 1231 Material (1962-63)

With this information as background, it becomes pertinent to examine the scrap recovery contracts most likely processed at NUMEC during the same time the 1231 contract was active. Table I, attached, lists these contracts. We believe these jobs were run on a "heel to toe" basis in conjunction with the recycle and/or scrap material from Contract 1231. Excluded, however, are those contracts involving the processing of uranium of less than 5% enrichment. Since NUMEC maintained a separate reprocessing facility for material less than 5% enriched, it is unlikely that such material would have been run in a campaign to process highly enriched material.

The total quantity of uranium represented by the contracts in Table I is approximately 470 kilograms of U-235. These jobs were closed out with an average overall U-235 loss of approximately 1.5 per cent, or 7 kilograms. The average 1.5 per cent loss figure was selected on the basis of our best estimate, at the time, of the losses experienced in our recovery operation. A definite figure could not be established since, in the "heel to toe" process, described above, there was no complete clean-up between reprocessing campaigns. It is important to note, at this point, that due to the complexity and quantity of the scrap on hand during 1962-1963, there was a large uncertainty with respect to total plant accountability during this period. As a result there was no clear evidence, at the time, to indicate that the 1.5 per cent figure was inaccurate.

It was only within the last year, during which NUMEC performed two large scrap contracts of 108 kilograms [AT(40-1)3305] and 137 kilograms [AT(40-1)3376] that it became evident that the losses were greater than those initially anticipated. In both cases, a closed accountability was maintained; that is, there was no "cross-over" between jobs. In the first case, losses were 4.1 per cent; in the second, 3.0 per cent. (The second contract is approximate because final accountability has not been established.) In both cases the scrap involved was similar in nature to that processed during 1962-1963 and, accordingly, utilized nearly the same process chemistry and equipment. On the basis of our current experience, it would appear that a loss factor of 3.5 per cent may have been more appropriate than one per cent. On this basis, the losses experienced under the scrap recovery contracts itemized in Table I could have been 16.5 kilograms instead of the 7 kilograms declared. This would suggest that approximately 9 kilograms of 1231 contract U-235 could have been inadvertently mixed and returned with material under these scrap recovery contracts.

To further substantiate the possibility of mixing of material from the 1231 contract, we refer you to a letter of July 8, 1963, from A. H. Kasberg, NUMEC, to T. C. Johnson, Westinghouse Astronuclear, a copy of which is attached. This letter indicates that 30 kilograms of out-of-specification UO_2 (26.3 kgs of U) was scheduled for scrap return to Oak Ridge. The only supporting evidence to show that this material was returned is an entry on NUMEC-CCC-95, a copy of which is attached, indicating that only 21.4 kilograms of uranium, slightly downgraded, was returned. This suggests the possibility that 4.6 kilograms of 1231 contract material may have in the course of scrap recovery, been returned under other contracts.

A further example is illustrated in the attached memo of October 5, 1965, from C. Bellman, NUMEC, to F. Forscher, NUMEC, describing a degradation incident involving 2.7 kilograms of 1231 contract material. We find no evidence that this material was returned to AEC. It can be reasonably inferred that this material may have been recovered along with other scrap material and subsequently returned, although possibly misidentified.

These are but examples of specific instances in which 1231 contract material might have been mixed with other scrap. The fact of overriding importance, however, is that because of the nature of NUMEC's scrap recovery operations, it is highly probable that scrap from the 1231 contract may have been returned under other purchase orders.

Disposition of 1231 Material as a Function of Overall Company Operations (1960-1963)

The foregoing analysis covers only the period during which 1231 contract material was being processed at NUMEC. It is important to note, however, that the same type of scrap recovery operation was conducted at NUMEC prior to the arrival of the 1231 material creating the same possibility of unavoidable mixing of material. In the period, prior to and during which, 1231 material was being processed at NUMEC, a large number of scrap recovery contracts involving 1020 kilograms U-235 in scrap were processed and closed including contracts shown in Table I, plus additional contracts shown in Table II. Using an estimated average 1.5 per cent loss figure, NUMEC declared losses of approximately 15 kilograms U-235 on these contracts. Had the more recently derived loss figure of 3.5 per cent been used, losses could have amounted to 36 kilograms U-235.

It is possible that the difference, amounting to 21 kilograms U-235 was compensated for through the return of scrap material from other purchase orders closed out before, and during, the 1231 contract. Scrap from the 1231 contract, it can be reasonably surmised, may in turn, have been returned under these purchase orders. Although it is not possible to state that a given amount of 1231 material was returned under another given purchase order, it is nevertheless probable that the net difference - 21 kilograms - (which includes the 9 kilograms discussed above) has, in fact, come to reside in the 1231 contract.

The 1231 contract has become the final depository of these estimated losses through a chain of relatively recent events. It is only within the past year, that through a concerted measurement effort and a reduction in the NUMEC inventory, it became possible to measure with a reasonable certainty, the materials loss experienced at NUMEC. After a close-out of all inactive NUMEC contracts, only the 1231 contract remained as the identifiable point for all other prior misassigned losses.

With respect to NUMEC's over-all facility operation, I believe your analysis will indicate that NUMEC's loss experience is well within the range one might reasonably expect in a facility such as ours. Moreover, our loss experience is probably not significantly higher than that of other facilities of a like nature. Accordingly, the possibility of any diversion of special nuclear material can be discounted with reasonable certainty.

I hope that this information will assist you in your investigation of this matter. Should you desire any further information, please do not hesitate to call on us.

Very truly yours,

S. A. Weber
Accountability Representative

SAW/geo

COPY

cc: RE CO-1231
ANK
FF
Chron

July 8, 1963

Ref: CO-1231

Mr. T. Johnson
Purchasing Department
Westinghouse Electric Corporation
Astronuclear Laboratory
P.O. Box 10864
Pittsburgh 36, Pennsylvania

Subject: Status of P.O. #57-NP-12674

Dear Mr. Johnson:

On 7-3-73 lot numbers 68, 77 and 78 were shipped on the above purchase order. The total of shipments to date, minus reject material, is approximately 440 kg as uranium. Lot numbers 74, 75, 76, 79, 80 and 81 were completed but rejected at NUMEC on the basis of substrate carbon analysis below specification. Material that would have made lot numbers 82 and 83 was rejected at NUMEC before coating on the basis of low carbon. Recycling of the above material has been started. The last 30 kg of recycled UO_2 that was to have entered the system was found to be slightly degraded in isotope, consequently, this material was scrapped.

Approximately 150 kg of UF_6 has been converted to UO_2 and is ready for carbide production. We are currently shut down for AEC inventory and plant reroofing. We will start carbide production as soon as possible after the roof is complete. We have scheduled 3 and 4 shift operation for completion of this order. Completion will require 6 weeks of production operations with delivery of the first lots 3 weeks after startup.

We trust that the above information meets with your approval. If you have any questions, don't hesitate to contact me.

Very truly yours,

A. H. Kasberg

AHK/mhb

COPY

COPY

NUMEC

WANL Purchase Order 59-NP-12674

Status Report - As of December 28, 1963

All Values - Kg. of Uranium

OPERATION	CUMULATIVE
Uranium Received	1240
Converted to Oxide	1140
Arc Melted (Virgin)	1114
Released to Spheradize	1095
Classified	1059
Final Processing	869
Released for Inspection	794
Rejects	72
To be Certified	42
*Certified	90
Shipped	590

*78 Kgs of this quantity has been transferred to WANL account at NUMEC.

(s) L. A. Hughes

COPY

1 & Equip... Corp.

n Avenue

...nia

6. LOU. 3
N...C ...ack

...iched (UO_2) from internal scrap recovery

P.O. ... 74 (NUMEC 1231)

...on Carbide Nuclear Company

D. McClean

(SS Representative)

... Y-12 Plant

Oak Ridge, Tennessee

7. CAR NO. & INITIALS

8. SEALS NOS.

11. DOCUMENTATION

a. Page 1 of 1 Pages

b. Copy 1 of 5 Copies

c. ...

A. ...	...	...
...	CCC	95

9. ...	...
1	CCC ... ...
2	CCC
3	CCC ... CPA
4	CPA
5	...
6	
7	
8	
9	

SHIPPER'S DATA

... No.	C. Date Material Shipped	D. Date ...
CH-42003-01-1	8/22/63	8/23/63

[illegible]

... by NUMEC Assay

13. RECEIVER'S DATA

A. ... No.	B. Date Material Received	C. Date Document Dispatched
	8-22-63	SEP 19 1963

D. Signature of Receiver (SS Representative) [illegible]

E. Measurement Method

SHIPPER'S DATA ACCEPTED

E. Chem.-L.E.	I. Isotopic L.E.	J. Total-L.E.	F. Net Wt.-L.E.	G. Chem.-L.E.	H. Isotopic-L.E.	I. Total-L.E.

N. Tare	O. Net	P. Element	Q. Isotope	J. Gross	K. Tare	L. Net	M. Element	N. Isotope
	24,470	21,377	...,806	SEP	MBS			

97.57

TO: F. Forscher DATE: October 5, 1963

FROM: C. Beltram

SUBJECT: Mix-up of Boats Between Job 1231 (93%) and N-0723 (Depleted)

What happened:

At about 10:00 A.M. on October 3, Jim Hart agreed to process a rush job for Roy Cline involving the reduction of 1831 grams of depleted binary powder through the CP-2 Lindberg mesh belt furnace. Verbal instructions were given by Jim Hart to the furnace operator, Spang, for the immediate reduction of the depleted binary. Spang's primary function at this time was feed preparation operator for t e 4" column, but he was feeding trays of 93% U_3O_8 into the reduction furnace as time permitted. Spang placed two empty boats before and after the two boats containing the depleted binary.

In the meantime, Lloyd Hughes had arranged for Ed Wright to temporarily transfer Hepler from PC-3 to the CP-2 furnace operation in order to reduce 1231 material on a full time basis. Hepler was not apprised of the two boats of depleted and treated all boats existing in the furnace as 93%. Hughes did not know there was depleted in the furnace and Hart did not know Spang had been replaced.

Consequences: [illegible] 4122 grams U containing 2680 grams. 93% WAL material

A total of 4857 grams of "mixed" enrichment resulted, containing 60.7% U-235. C. Ellison has effectively upgraded a sample of the mixed material to 87.7%. The upgrading is possible due to the distinct chemical and physical differences between the depleted binary and the enriched UO_2. The value difference between the 87.7% material and the 93% material is $84. The incident cost us this $84, plus the labor involved to "upgrade" the mixture, and the labor expended in making the depleted binary and the enriched U_3O_8. It is estimated that the total dollar cost of the incident is less than $300. There is an equal or greater value which can be assessed to the lesson that was learned and discussed in detail with all Production Supervisors and Foremen.

What was done wrong:

1. Material transfer form was not used.

2. Written instructions were not given to the operator.

3. Foreman in the prod [illegible] was not informed of the different work being processed in the furnace.

What was done right:

1. Ed Wright brought the relief man, Hepler, up to the CP-2 Foreman, Condo
2. The calcining boats were cleaned out prior to and after the depleted binary was run.
3. CP-2 cooperated with CH-3 by accommodating their immediate need for the reduction of the depleted binary.

CF /mel

TABLE I

CF	COF	MATS. NO.	SHIPPERS VALUES U	SHIPPERS VALUES U-235	SHIPPERS VALUES % Enr.	FIN. RESP. U	FIN. RESP. U-235	FIN. RESP. %Enr.	DATE MAT. REC'D.	SHIPMENTS U	SHIPMENTS U-235	SHIPMENTS %Enr.	LOSSES U	LOSSES U%	LOSSES U-235	LOSSES U-235%	INCLUSIVE DATES SHIPMENT
AT(30-1)29[illegible]	30A	[illegible]	6338	5909	93.23	3878	3605	92.95	July-62	3800	3530	92.89	78	2.01	75	2.08	12/63
AT(30-1)29[illegible]	30I	[illegible]	[redacted]		93.13	[redacted]		92.3	Mar.-63	[redacted]		92.3*	23	[redacted]	21	[redacted]	5/63
AT([illegible]-1)[illegible]	31A	[illegible]	[redacted]		93.10	[redacted]		86.123	July-62	[redacted]		84.24	2	[redacted]	6	[redacted]	6/63
AT(30-1)30[illegible]	30G	[illegible]	34494	32098	93.05	33696	31388	93.15	July-62	33443	31132	93.09	253	.75	256	.82	9/62-3/63
AT(30-1)30[illegible]	30H	[illegible]	48054	44830	93.29	45074	41955	93.17	July-62	44735	41621	93.04	339	.75	374	.89	8/62-12/62
NY 62-[illegible]	35A	[illegible]	[redacted]		92.97	[redacted]		90.72	July-62	[redacted]		90.72*	2	[redacted]	2	[redacted]	8/63
NY 62-[illegible]	35B	[illegible]	[redacted]		93.04	[redacted]		90.97	Sept.62	[redacted]		90.70	31	[redacted]	39	[redacted]	7/63-10/63
NY 62-[illegible]	35C	[illegible]	[redacted]		93.15	[redacted]		92.70	July-62	[redacted]		92.47	45	[redacted]	50	[redacted]	11/62
NY 62-[illegible]	35D	[illegible]	550	550	93.27	589	545	89.83	Aug.-62	573	515	89.83*	11	1.88	10	1.88	1/63
NY-62-[illegible]	35E	[illegible]	724	674	93.04	619	545	88.14	Aug.-62	616	532	86.41	3	.48	14	2.56	8/63
NY-62-[illegible]	35F	[illegible]	391	364	93.17	237	198	83.54	Aug.-62	235	196	83.5[illegible]	2	.84	2	.84	6/63
NY-62-[illegible]	35G	[illegible]	731	681	93.12	634	591	93.15	Aug.-62	629	574	91.31	5	.78	17	2.88	8/63
NY 63-72	[illegible]	Multiple Contract				311	272	87.60		311	262	84.25	—	--	10	3.68	11/63
AT(40-1)3038	37I	[illegible]	39553	2175	5.5	37366	2081	5.57	Dec.-62	36986	2060	5.57*	380	1.02	21	1.02	7/63-8/63
AT(40-1)3042	37J	[illegible]	2142	35	16.34	2138	517	24.17	Jan.-63	2103	503	24.17	35	1.63	9	1.64	8/63-9/63
AT(40-1)3042	37K	[illegible]	[redacted]		91.85	[redacted]		91.20	Jan.-63	[redacted]		91.14	124	[redacted]	120	[redacted]	
										[redacted]			1333		1025		

b-3 per DOE letter dated 4/6/85

b-3 per DOE letter dated 6/6/85

TABLE I
Page 2

CT AEC	LOT	TRANS. NO.	SHIPPERS VALUES U	U-235	%Enr.	FIN. REP. U	U-235	%Enr.	DATE MAT. RPC'D	SHIPMENTS U	U-235	%Enr.	LOSSES U	U%	U-235	U-235%	INCLUSIVE DATES SHIPMENT
AT(40-1)3047	40A	MAC-[illegible]-3	[redacted]		93.14	[redacted]		91.14	Mar.-63	[redacted]		91.83	171	[redacted]	(14)	[redacted]	9/63-11/63
AT(40-1)3047	40B	CFC-[illegible]-2	41620	38765	93.14	36919	34271	92.85	May-63	36053	33017	91.58	866	2.35	1262	3.68	8/63-12/63
AT(40-1)3047	40C	WFD-[illegible]-5	6644	6189	93.15	6450	6005	93.12	Apr.-63	6428	5953	92.61	22	.3%	53	.88	11/63
AT(40-1)3047	40E	WED [illegible]-16	1709	430	25.16	1673	393	23.81	Apr.-63	1649	436	26.43	24	1.43	(38)	(9.55)	6/63-10/63
AT(40-1)3048	39E	ANL-[illegible]-5	47906	23057	48.13	41681	20040	48.10	May-63	40611	19843	48.85	1070	2.57	206	1.03	9/63-3/64
AT(40-1)3048	39F	ANL-[illegible]-6	3893	3628	93.19	3405	3165	92.95	May-63	3388	3132	92.43	17	.50	33	1.04	9/63-12/63
AT(40-1)3048	39F	ANL-[illegible]-6	[redacted]		93.15	[redacted]		93.10	Apr.-63	[redacted]		92.65	258	[redacted]	465	[redacted]	10/63-12/63
AT(40-1)3048	39H	SGE-[illegible]-8,9,10	[redacted]		92.92	[redacted]		92.77	Apr.-63	[redacted]		92.77	222	[redacted]	206	[redacted]	6/63-8/63
AT(40-1)3048	39J	WE[illegible]-17	22660	21144	93.31	20573	18631	90.57	Apr.-63	20053	18421	91.86	520	2.53	212	1.14	9/63-12/63
AT(40-1)3048	39K	AIC-[illegible]-5	914	437	47.81	906	429	47.40	Apr.-63	881	425	48.25	25	2.76	4	.93	7/63-10/63
AT(40-1)3048	39L	AIC-[illegible]-6															
AT(40-1)3173	46C	CI[illegible]-2,3	745	693	93.00	643	584	90.78	Dec.-63	625	575	91.92	18	2.80	9	1.54	1/64
AT(40-1)3215	45D	E[illegible]-3,4,5, 6,7,	15312	14268	93.18	13777	12791	92.86	Apr.-64 May-64	13950	12749	91.39	(173)	(1.26)	44	.34	7/64-12/64
AT(40-1)3251	46D	CA[illegible]	1839	1716	93.31	1459	1359	93.56	July-64	1431	1322	92.33	28	1.92	28	2.07	8/64-10/64
AT(40-1)3251	46C	CA[illegible]	47239	3056	6.47	43812	2905	6.63	July-64	42692	2843	6.66	1120	2.56	62	2.13	10/64-12/64
			[redacted]			[redacted]				[redacted]			[redacted]				

b3 per DOE letter dated 6/6/85

TABLE I
Page 3

PROJECT AEC	LOT	TRANS. NO.	SHIPPERS VALUES U	U-235	%Enr.	FIN. RESP. U	U-235	%Enr.	DATE MAT. REC'D	SHIPMENTS U	U-235	%Enr.	LOSSES U	U%	U-235	U-235%	INCLUSIVE DATES SHIPMENT
AT(40-1)3251	49II	MAD-FAP-1	157544	146784	93.17	157356	146603	93.17	July-64	157274	146532	93.17	82	.05	76	.05	12/64
AT(40-1)3251	49I	MIO-FAP-1	30799	28643	93.00	28743	26622	92.62	June-64	28299	26160	92.44	444	1.54	462	1.74	9/64-1/65
AT(40-1)3163		Sample Contract				8474	3085	36.05		9019	399	4.42	(545)	(6.43)	2606	87.06	
TOTAL						[redacted]		76.92		[redacted]		76.50	5502		[redacted]		

Per DOE letter dated 6/6/85

[illegible] is taken from A C Form CR 653 and in those cases where applicable, does not show upgrading when it was disallowed.

Table II p. 1

CY AEC	LOT	TRANS. DO.	SHIPPERS VALUES U	SHIPPERS VALUES U-235	SHIPPERS VALUES %Enr.	FIN. RESP. U	FIN. RESP. U-235	FIN. RESP. %Enr.	DATE MAT. REC'D	SHIPMENTS U	SHIPMENTS U-235	SHIPMENTS %Enr.	LOSSES U	LOSSES U%	LOSSES U-235	LOSSES U-235%	INCLUSIVE DATES SHIPMENTS
AT(30-1)2432	3-A	MSH 4 SC-1,3,4, 6,7	29395	27371	93.11	26304	24463	93.00	Oct.-59	26149	24319	93.00	155	.59	144	.59	8/60-7/62
AT(30-1)2432	3-B	MSH 4 SC-1	23963	22325	93.16	23076	21495	93.15	Nov.-59	22821	21235	93.05	255	1.11	260	1.21	3/62-5/62
NY-60-1237-2	5-D	WEP 4 SC-5R-6R	[redacted]		93.15	[redacted]		93.00	Mar.-60	[redacted]		93.00	57	[redacted]	53	[redacted]	4/61-7/62
NY-60-1381	8-A	MAC 4 SC-1	[redacted]		93.14	[redacted]		93.00	Apr.-60	[redacted]		93.00	95	[redacted]	88	[redacted]	4/61-7/62
AT(30-1)2603	10A	MAC 4 SC-2	[redacted]		93.16	[redacted]		93.00	July-60	[redacted]		93.00	129	[redacted]	120	[redacted]	4/61-9/62
AT(30-1)2603	10B	MAC 4 SC-3	[redacted]		93.21	[redacted]		93.00	July-61	[redacted]		93.00	5	[redacted]	5	[redacted]	8/61
AT(30-1)2603	10E	WEP 4 SC-12,13	[redacted]		92.87	[redacted]		83.53	July 60	[redacted]		88.36	0	[redacted]	3	[redacted]	10/61-5/62
AT(30-1)2603	10F	MAC 4 SC-14 14,15	[redacted]		88.98	[redacted]		87.53	July-60	[redacted]		83.92	8	[redacted]	15	[redacted]	6/62
AT(30-1)2603	10G	WEP 4 SC-10,-15	[redacted]		92.72	[redacted]		82.23	June 60	[redacted]		82.23	29	[redacted]	24	[redacted]	5/62
AT(30-1)2603	10I	WSH 4 SC-10,11	12364	1826	14.77	10516	1577	15.00	July-60	10445	1534	14.69	71	.68	43	2.73	4/62-5/62
AT(30-1)2642	12A	SCH 4 SC-1,2	[redacted]		93.20	[redacted]		93.00	Jun.-60	[redacted]		93.00	84	[redacted]	73	[redacted]	8/61-4/62
AT(30-1)2642	12B	HIC 4 SC-1	15086	14884	93.69	15090	13734	91.346	Sept.-60	14820	13537	91.346	270	1.79	247	1.79	9/61-2/62
AT(30-1)2642	12C	SCH 4 SC-3	[redacted]		93.14	[redacted]		93.00	Sept.-60	[redacted]		93.00	9	[redacted]	8	[redacted]	8/61
AT(30-1)2677	13B	CVTR 4 SC-21 SC-6-12	25331	23603	93.18	24145	22444	92.95	Dec.-60 Jan.-61	23923	22236	92.95	223	.92	208	.92	1/62-7/62
AT(30-1)2677	13C	CVTR 4 SC-6	20723	26764	93.13	29567	27512	93.05	Dec.-60	29272	27226	93.01	295	1.00	286	1.03	4/62-7/62
AT(30-1)2707	15A	WSH 4 SC-27	[redacted]		93.12	[redacted]		91.55	Dec.-60	[redacted]		91.55	47	[redacted]	43	[redacted]	11/61-3/62
													1713		1615		

43 per DOE letter dated 6/6/85

TABLE II
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b3 per DOE
letter dated
6/4/85

CONTRACT AEC	LOT	TRANS. NO.	SHIPPERS VALUES U	SHIPPERS VALUES U-235	SHIPPERS VALUES %Enr.	FIN. REP. U	FIN. REP. U-235	FIN. REP. %Enr.	DATE MAT. REC'D	SHIPMENTS U	SHIPMENTS U-235	SHIPMENTS %Enr.	LOSSES U	LOSSES U%	LOSSES U-235	LOSSES U-235%	INCLUSIVE Dates Shipment
AT(30-1)2707	15B	WE-[illegible]-25	[redacted]	[redacted]	93.15	[redacted]	[redacted]	92.96	Dec.-60	[redacted]	[redacted]	92.48	23	[redacted]	36	[redacted]	1 /61-9/6[illegible]
AT(30-1)2707	15C	WPP-[illegible]-4,5, 6,7,	5176	4821	93.14	4491	415[illegible]	92.52	Feb.-61	4458	4105	92.09	33	.73	50	1.20	9/61-9/62
AT(30-1)2707	15D	SCL-[illegible]-4,5,6, 7,8,	[redacted]	[redacted]	93.14	[redacted]	[redacted]	93.065	Mar.-61	[redacted]	[redacted]	93.00	150	[redacted]	152	[redacted]	8/61-9/62
AT(30-1)2707	15E	SCL-[illegible]-9	[redacted]	[redacted]	93.15	[redacted]	[redacted]	92.95	Dec.-60	[redacted]	[redacted]	91.36	56	[redacted]	171	[redacted]	10/61-9/62
AT(30-1)27[illegible]7	15F	MAC-[illegible]-5	[redacted]	[redacted]	93.15	[redacted]	[redacted]	89.53	Dec.-60	[redacted]	[redacted]	89.55	51	[redacted]	46	[redacted]	10/61-9/62
NY-61-1472	14D	[illegible]-2600	[redacted]	[redacted]	74.69	[redacted]	[redacted]	74.67	Mar.-61	[redacted]	[redacted]	74.67	3	[redacted]	3	[redacted]	[illegible]/62
NY-61-1472	14E	[illegible]-1	400	375	93.75	348	324	92.96	Mar.-61	348	322	92.65	—	—	2	.62	11/61
NY-61-1006	17A	SCL-[illegible]-8	[redacted]	[redacted]	93.26	[redacted]	[redacted]	93.03	Mar.-61	[redacted]	[redacted]	93.03	—	[redacted]	—	[redacted]	11/61
AT(30-1)2762	16A	WE-[illegible]-52	[redacted]	[redacted]	86.75	[redacted]	[redacted]	86.06	Apr.-61	[redacted]	[redacted]	86.85	3	[redacted]	3	[redacted]	3/62-9/62
AT(30-1)2762	16B	WE-[illegible]-30,37,41, 46,47	[redacted]	[redacted]	92.45	[redacted]	[redacted]	92.98	Apr.-61 Feb.-62	[redacted]	[redacted]	92.162	0	[redacted]	134	[redacted]	10/61-[illegible]
AT(30-1)2762	16C	SCL-[illegible]-1000, 1100,1200	[redacted]	[redacted]	91.76	[redacted]	[redacted]	93.05	Apr.-61	[redacted]	[redacted]	92.93	154	[redacted]	159	[redacted]	11/61-7/62
		Sample Recovery Contract				2218	205[illegible]	92.6	—	—	—	—	2218	100.	2053	100.	— —
		Sample Recovery Contract				778	8[illegible]	10.5	—	—	—	—	778	100.	82	100.	— —
NY-61-1033-2	1[illegible]	WP-[illegible]-8	8704	8109	93.16	8503	791[illegible]	93.06	Apr.-61	8440	7819	92.64	63	.74	94	1.19	9/61-9/62
NY-61-1834	1[illegible]	[illegible]-9	1529	1425	93.20	1415	1,[illegible]	93.128	May-61	1404	1281	91.28	11	.78	37	2.01	[illegible]/62-[illegible]
NY-61-1834-2	19C	SCL-[illegible]-13,14	[redacted]	[redacted]	93.15	[redacted]	[redacted]	93.10	[illegible] 61	[redacted]	[redacted]	93.03	90	[redacted]	51	[redacted]	1[illegible]/61-[illegible]
NY-61-1834	1[illegible]	WE-[illegible]-32	[redacted]	[redacted]	93.04	[redacted]	[redacted]	92.86	May-61	[redacted]	[redacted]	91.22	90	[redacted]	230	[redacted]	[illegible]
						[redacted]	[redacted]			[redacted]	[redacted]		5415		490[illegible]		

TABLE II
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h.3 per DOE letter dated 6/6/63

...RACT A.C	LOT	TRANS. NO.	SHIPPERS VALUES U	U-235	%Enr.	FIN. RESP. U	U-235	%Enr.	DATE MAT. REC'D	SHIPMENTS U	U-235	%Enr.	LOSSES U	U%	U-235	U-235%	INCLUSIVE DATES SHIPMENTS
NY-61-1834	19E	WS[illegible]EC-33	32772	514	15.68	29672	[illegible]	15.1	May-61	29713	438	14.73	(41)	(.14)	10	2.23	4/62-9/62
AY(30-1)2833	20H	AIC[illegible]EC-16	994	925	93.05	964	778	80.67	Sept.-61	952	768	80.67	12	1.24	10	1.24	6/62
AY(30-1)2833	20J	LA[illegible]EC-3-5	33787	31479	93.17	26190	24299	92.78	Aug.-61	26190	24299	92.78	—	—	—		6/62-11/63
AY(30-1)2833	20K	LA[illegible]EC-1,2,4,5,6,	55788	51978	93.17	56398	52461	93.02	Aug.-61	56015	52127	93.01	353	.63	334	.64	1/63-11/[illegible]
AY(30-1)2843	22A	SC[illegible]EC-15-16	[illegible]		93.16	[illegible]		93.126	July-61	[illegible]		92.71	60	[illegible]	88	[illegible]	11/61-12/6[illegible]
AY(30-1)2843	22D	[illegible]SC-5	826	770	93.22	715	651	91.1	July-61	710	647	91.1	5	.70	4	.70	5/[illegible]
AY(30-1)2843	22F	[illegible]EC-39cc	32686	3530	10.8	32180	3475	10.8	July-61	31907	3446	10.8*	273	.85	29	.85	4/62-9/62
AY(30-1)2843	22G	[illegible]C-10	[illegible]		93.14	[illegible]		90.784	July-61	[illegible]		90.784	4	[illegible]	3	[illegible]	1[illegible]/61-[illegible]/63
AY(30-1)2843	22H	[illegible]EC-14,15,16,17,18,	40394	37638	93.18	33882	31588	92.64	July-61	33074	30587	92.48	808	2.38	801	2.55	[illegible]/63-3/64
AY(30-1)2874	24D	[illegible]C-1	927	863	93.09	877	793	90.452	Sept.-61	832	752	90.452	45	5.13	41	5.13	5/62
AY(30-1)2874	24F	SC[illegible]EC-20-23	[illegible]		93.15	[illegible]		92.966	Oct.61	[illegible]		91.74	79	[illegible]	156	[illegible]	1[illegible]/61-[illegible]/62
AY(30-1)2693	25[illegible]	SC[illegible]EC-10	[illegible]		93.35	[illegible]		91.808	Nov.-61	[illegible]		91.000*	26	[illegible]	23	[illegible]	5[illegible]/62
AY(30-1)2893	25B	SC[illegible]EC-24	[illegible]		93.14	[illegible]		92.997	Nov.-61	[illegible]		92.997	27	[illegible]	25	[illegible]	1/62-12/62
AY(30-1)2893	25[illegible]	[illegible]C-44	[illegible]		93.09	[illegible]		92.62	Oct.-61	[illegible]		92.15	13	[illegible]	50	[illegible]	[illegible]
AY(30-1)2893	25[illegible]	[illegible]C-44	[illegible]		93.16	[illegible]		92.93	Oct.-61	[illegible]		92.76	22	[illegible]	25	[illegible]	1/62-[illegible]/62
AY(30-1)2893	[illegible]	SC[illegible]EC-9,11	[illegible]		93.15	[illegible]		92.26	Dec.-61	[illegible]		82.26	8	[illegible]	7	[illegible]	[illegible]
[illegible]	[illegible]	SC[illegible]EC-8,9	5084	4736	93.15	[illegible]	[illegible]	92.09	Dec.-61	4573	4246	92.86	57	1.23	55	[illegible]	[illegible]
			[illegible]			[illegible]				[illegible]			1166		1032		

1 - Page 1, 2 and 3

b3 per DOE letter dated 6/6/85

TABLE II
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CONTRACT APC	LOT	TRANS. NO.	SHIPPERS VALUES U	U-235	%Enr.	FIN. RESP. U	U-235	%Enr.	DATE MAT. REC'D	SHIPMENTS U	U-235	%Enr.	LOSSES U	U%	U-235	U-235 %	INCLUSIVE DATES SHIPMENTS
								92.885	Oct.-61			92.885	139		139		
7 AT(30-1)2893	25L	WEB-MSC-44			93.13			41.19	Oct.-61			-0-	129		53		2/62-6/62
1 HY-62-75-4	24D	SCM-MSC-18,19, & G 21,22,			93.07			93.07	Oct.-61			93.07	188		175		2/62-7/62
1 HY-62-220-8	26F	WCE-MSC-16	78	73	93.00	123	99	80.56	May-62	105	85	80.56*	18	14.63	14	14.63	3/63
AT(30-1)2547	27J	WFD-MSC-45			93.36			93.13	Dec.-61			93.02	302		304		3/62-12/6
1 AT(30-1)2569	30C	MSC-MSC-7			93.16			87.1	May-62			87.1*	18		16		7/62
1 AT(30-1)2969	30F	MSC-MSC-9			92.80			87.1	May-62			87.1*	43		37		7/62
AT(30-1)2569	30G	MSC-MSC-8			93.06			90.1	May-62			90.1*	13		11		7/62
AT(30-1)3007	31B	MCE-MSC-11	673	627	93.1	689	623	90.47	May-62	684	619	90.47*	5	.73	4	.73	5/
AT(30-1)3007	31D	CE-MSC-1	14012	2976	21.24	13872	2974	21.44	May-62	13065	2953	21.30	7	.05	21	.21	10/62
AT(30-1)3007	31D	CE-MSC-3A	30878	28535	92.41	25152	23173	92.15	May-62	25127	23155	92.15	25	.10	23	.10	10/62
AT(30-1)3007	31E	LAC-MSC-9-19	36440	33951	93.17	33164	30825	92.95	June-62	33005	30665	92.91	159	.48	161	.52	10/62-6/
HY-62-68	32A	AGE-MSC-3	4094	3815	93.19	4001	3705	92.63	May-62	3978	3683	92.58	23	.57	23	.62	9/62-3/6
HY-62-63	32J	AGE-MSC-6	8114	2751	33.9	8786	2911	33.12	May-62	8439	2783	32.98	347	3.95	127	4.35	9/62
HY-62-96	36A	Pilot Contract				2046	1895	92.67	--	2022	1869	86.52	24	1.17	197	[illegible]	[illegible]
AT(30-1)3058	37L	STC-MSC-1 D.	802	821	93.07	827	751	90.78	June-62	824	748	90.78*	3	.36	3	.36	5/62
								81.38				81.05	861		79.80		

upgrading when it was discontinued.

process losses.

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APPENDIX D

Memorandum

TO : Files

DATE: February 7, 1966

FROM : Douglas E. George, Director
Division of Nuclear Materials Management

SUBJECT: MEETING WITH NUMEC - FEBRUARY 3, 1966

On February 3, 1966, D. E. George, S. C. T. McDowell, L. C. Solem, (DNMM), and E. D. Marshall (OR), met with Messrs. Shapiro, Newman, Weber, and Lovett, of NUMEC for the purpose of discussing the findings and recommendations resulting from the DNMM survey made at NUMEC in November 1965.

We explained the purpose of the meeting was to review with NUMEC management the survey findings and recommendations to assure that we had not misrepresented any facts or had not overemphasized unimportant points.

We also called attention to the fact that we were aware that some of the recommendations had already been acted upon by NUMEC, including some aspects that had been underway at the time of the November survey. We asked to be brought up to date on the current status of such actions and requested that NUMEC confirm these actions and provide a schedule indicating when the recommendations would be accomplished. It was recognized that some were obviously recommendations of a continuing nature and thus, in effect, would never be finished.

NUMEC was given a copy of the IBM run of the October 31, 1965 inventory, including a run of the dollar value thereon. They were also provided a copy of the tabulation of the gamma spectrometer data on the filters. We agreed to send a reconciliation of the October 31, 1965 inventory.

NUMEC was then handed copies of three sections of the draft survey report (Sec. 3 - Summary of Findings, Sec. 6 - Discussion of WANL Losses, and Sec. 7 - Recommendations). After they had read these sections, Dr. Shapiro asked that NUMEC personnel be excused from the meeting to discuss the sections among themselves. After slightly more than 2 hours, the meeting reconvened. Dr. Shapiro had a number of editorial suggestions which we accepted, the more important of which included a definition of the word "loss" as a direct part of, or as a footnote to, the summary. We pointed out that "loss" was already defined on the first page of the report, but we would make a special point of referring to that definition in the summary. Dr. Shapiro also requested that the NUMEC letter of December 29, 1965, which discussed in some detail the NUMEC processes and practices and which we used extensively in preparing this report, be attached to the report as an appendix. We agreed to attach the letter. At their request we

also agreed to quote from the letter in our discussion of the WANL losses, rather than to paraphrase and summarize it as we had done.

Dr. Shapiro then went over the attached recommendations as presented. He said he felt they were good recommendations and that a number had been completed, with practically all others being significantly on the road toward completion. Specifically, Dr. Shapiro commented, referring to the recommendations by the same numbers as used in the report:

1. This recommendation is accomplished as is evidenced by the fact that he hired one of the DTAM staff, J. E. Lovett. We agreed that a long step towards accomplishment had been taken, but called his attention to the fact he had made personnel changes in the past and that such change, of itself, without continued personal interest on his part would not assure long-term continued satisfactory performance.

2. Dr. Shapiro agreed with the general objective of the six detailed portions of this recommendation and commented as follows:

   a. The general ledger is now in process of being prepared. It will be completed in a few days and will support their January 31, 1966 Material Balance Report to the Oak Ridge Field Office.

   b. The recommended subsidiary ledger is now in use for almost all plant areas and will be completed in the immediate future.

   c. A chart of accounts has been drafted and is expected to be completed and fully in use by the end of February.

   d. Dr. Shapiro agreed with the need of a system of inventory identification, but asked that there be some latitude to achieve the objective in another fashion than as specifically recommended. We agreed and the recommendation has been revised accordingly.

   e. The internal transfer system is now in practice throughout almost all plant areas and will be instituted in those remaining areas in the immediate future.

   f. Internal management reports are now being issued as recommended.

3. Work has begun to accomplish this recommendation. In discussing it Dr. Shapiro noted that this really was a never-ending recommendation.

4. This recommendation resulted in an extensive discussion as NUMEC interpreted it to mean that adjustments would be made to the records regardless of the precision with which an inventory had been taken. I recognized that operating needs of a company for a "ball-park inventory" might result in routine inventories which would produce the operating results required, but which would not have the accuracy needed to adjust the records. On the other hand, I pointed out to Dr. Shapiro that the recommendation was to establish that not less often than annually, a precise inventory would be made. Even here we recognized that a book value for certain portions of an inventory might be a superior number to one obtainable by other methods. After this discussion Dr. Shapiro seemed to understand the thrust of the recommendation and agreed that it would be accomplished; no changes in the recommendation were proposed.

5. NUMEC expects to have a draft procedure manual available for review by Oak Ridge in March 1966.

6. Dr. Shapiro noted that NUMEC was now cleaning up its residues on current jobs with approximately four months lag. Regarding the residues on the WANL job, it was noted that NUMEC had agreed with the Commission that the residues would be processed by November 1966.

7. This recommendation apparently was the cause of the two-hour private meeting. NUMEC expressed a reluctance to adjust their October 31st book inventory to a fixed quantity as was recommended. They requested that the recommendation be revised to adjust the inventory based on recovery data as it became available, noting that recovery would not be complete until November 1966. They also suggested that the recommendation was a departure from the agreement signed in November. I disagreed, stating that the agreement signed in November recognized that NUMEC would be billed for the total amount of U-235 not returned to the AEC and would be given a year in which to (a) recover and return material as an offset to the total bill, and (b) make full payment of any outstanding amount. I stated that I knew of no agreement with NUMEC which would permit the maintenance of an inventory record different from that obtained during the survey.

NUMEC raised a series of questions dealing with the uncertainty of the data, particularly those in the residues. They pointed out that there were quite large individual differences between New Brunswick data and the value carried on the NUMEC books. I pointed out to Dr. Shapiro that I had recognized this and explained that

after applying the analytical results to the parent batch, there was good agreement with the data carried by NUMEC. I recognized that during recovery of the residues the inventory might very well be adjusted upward or downward with a compensating adjustment in the reported loss. I also acknowledged that there might be as much as 5 to 10 kg uncertainty in the residue inventory. However, I pointed out there was no better data available and that the sampling plan used by the AEC had, in my judgment, confirmed the NUMEC inventory quantities for the residues as being reasonable. Therefore, I saw no way to alter the recommendation.

I agreed that if he had additional data that he would like to present, we would be glad to review it and we would make ourselves available at any time. I invited Dr. Shapiro to re-examine his data, re-evaluate his inventory if he felt justified in so-doing, and submit such data to me for review. I also told him that, if necessary, to get to the full and complete truth I would have the residue recovered at Oak Ridge. (I later told Dr. Shapiro that I would have to back up on that offer as I had no authority to commit the AEC to an expenditure of some $50 to $75,000 for this purpose). I asked Dr. Shapiro if he would adjust his inventory records should the residues be recovered or a more extensive sampling plan be used to determine their U-235 content. His answer was that such an adjustment would not necessarily be made because there was still material from the pit which had not been incinerated and evaluated.

I told Dr. Shapiro that I thought there was no further usefulness in discussing this point further; that he should set his views in writing and I would see that they were made a part of the record. I told Dr. Shapiro that I would assure that the survey report clearly reflected that there was an uncertainty in the inventory of these residues and that upon recovery a quantity different from that reported might be found.

8. Dr. Shapiro showed me a draft educational program which I believe is a step in the right direction. He assured us that within a very short period of time all plant personnel would be given training along the lines suggested.

Dr. Shapiro and Jack Newman called me on February 5 to read the letter being sent in response to my request of February 3. This letter states that NUMEC will now (as of February 28, 1966) adjust their inventory to reflect the quantity reported by the AEC survey team. It also reiterates that further adjustments, upward or downward, may be necessary as recovery progresses and that a final adjustment will not be made until recovery is complete on November 23, 1966.

Enclosure
Recommendations of Survey Team

RECOMMENDATIONS EXTRACTED FROM DRAFT SURVEY REPORT (1)

7.0 Recommendations

7.1 To prevent a recurrence of the circumstances which resulted in this survey; to put NUMEC in a position to recognize and to minimize its losses; and, to record and report to the AEC in a timely manner losses and material-unaccounted-for actually being experienced, it is recommended that NUMEC:

1. 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.

2. Take immediate action to:

   a. Install a general ledger to summarize accounts periodically and 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 area 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.)

   d. Establish a system of inventory identification by pre-numbering process containers. These numbers could then be entered on internal transfer forms and posted to records maintained for the different material balance areas.

   e. 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 forms and recorded in the subsidiary ledger.

   f. Issue periodically, by material balance areas, a report to NUMEC management of ending inventory and losses which shows and explains losses by job order and the quantity and forms of material physically on hand by job number.

3. Identify and establish the magnitude of all significant loss mechanisms and technical bases thereof. Translate such data to U and U-235 content and record and report on a current basis.

4. Establish inventory procedures and perform plant-wide inventories periodically, but not less often than annually. After comparison of these 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.

5. Establish all control procedures in a procedure manual and submit same to the Oak Ridge field office for review and approval.

6. Process the excessively large quantity of accumulated residues, combustibles, filters, ash, etc., and return the SNM recovered to the AEC. In so doing, care must be exercised to identify and to process residues in such a manner as to permit comparison of recovered values with book values. After such comparison, the resulting gain or loss should be recorded.

7. Adjust the NUMEC October 31, 1965 book inventory to agree with the AEC's October 31, 1965 physical inventory which establishes a U-235 content of 521,197 grams. (A detailed tabulation of the physical inventory has been provided to NUMEC.)

8. Initiate a company-wide educational program stressing the high intrinsic and strategic value of special nuclear material and re-emphasize the health and safety implications of careful handling practices.

(1) These recommendations are as shown to NUMEC on February 3, 1966. Recommendations 2d., 6, and 7 were revised somewhat as a result of that meeting.

APPENDIX E

Nuclear Materials and Equipment Corporation Apollo, Pennsylvania 15613 Telephone GRover 2-8411 Cable NUMEC

February 5, 1966

Mr. Douglas E. George
Director, Division of Nuclear Materials Management
United States Atomic Energy Commission
Washington, D.C. 20545

Dear Mr. George:

I would like to express our gratitude for your courtesy in coming to Apollo to review with us the summary of your findings and other pertinent data derived from your survey of the special nuclear materials inventory and accountability procedures at NUMEC.

The recommendations contained in your report concerning accountability procedures are clearly sound. They have already been implemented, for the most part, and firm completion dates have been established for all required action. Indeed, in some areas, the remedial action taken or contemplated is over and above the recommendations contained in the report. A brief survey of our activities in this regard follows:

Staff

In recognition of the need for a thoroughly professional and high-level staff to deal with nuclear material management activities, NUMEC has employed Mr. James Lovett, formerly with the Division of Nuclear Materials Management. Mr. Lovett is serving as Manager of the Nuclear Materials Control Department. In this capacity, he is receiving full management support and will be assisted by an adequate staff, in terms of both number and quality. Although we have had several discussions concerning the size and nature of the required staff, Mr. Lovett has not yet decided as to his exact needs. His recommendations, which should be forthcoming shortly, will be promptly implemented.

Records

In regard to the Nuclear Materials Control record system, NUMEC has in process changes which will provide the following basic records:

a. A primary transfer journal with a separate page for each reporting facility with which NUMEC has had material transactions.

b. [illegible] the primary transfer

C. A contract ledger summarizing all the nuclear materials activities under a given job number.

D. An internal control ledger detailing the physical movement of nuclear materials between material balance areas and between jobs.

E. A general ledger which summarizes data in the other ledgers and journals and which will support data reported to the AEC and to NUMEC customers.

Significant progress has been made in developing all of the foregoing records and in assuring their accuracy. In many instances, this has necessitated the reconstruction of records back to July 1, 1965, the beginning date of the AEC fiscal year. Although this is a lengthy process, important strides have already been made.

The primary transfer journal and contract ledger are complete and in balance. The summary transfer journal is now being reconstructed and will be complete before our next material balance report is issued.

The internal control ledger has been set up. It is complete and in balance for all transactions since January 1, 1966, and for earlier transactions on some contracts as to which reconstruction was either unnecessary or relatively simple. For lack of adequate physical data, the internal control ledger has not yet been brought into balance with NUMEC's other records. As a result of a sustained effort now under way, we expect that the internal control ledger will be 100% complete shortly after NUMEC's next precise physical inventory which is scheduled for June 30, 1966.

The general ledger is now being reconstructed and we expect that it will be a complete and auditable record by March 31, 1966.

In addition to the foregoing records, a draft chart of accounts referenced to project, contract or purchase order numbers, as appropriate, has been completed. A copy of this draft was furnished to you during our February 3 meeting. The final version of this chart will be included in the draft procedures manual, discussed below.

Inventory Identification

NUMEC is investigating alternative systems of container identification which would assure better control of stored materials. It is our [illegible] that permanent [illegible] would storage tags would [illegible] Action in this regard will [illegible] (30) days.

Reports to Management

The Nuclear Materials Control Department will issue, not less than once each month, summary reports to NUMEC management on the status of nuclear materials control. These reports will reflect inventories and losses by materials balance area and explain, insofar as possible, losses experienced in individual job orders. The first such report will be issued as soon as the January 31 inventory data has been completed and reconciled, probably within the next 7-14 days. We have already initiated the practice of regular meetings with management to review and plan nuclear materials control activities.

Identification of Loss Mechanisms

In addition to reporting accurately on the status of inventories and losses, it is vital that loss mechanisms be carefully identified in order to prevent or reduce, insofar as possible, further losses. A major portion of Mr. Lovett's time during January was devoted to the identification and investigation of loss mechanisms with special empahsis on preventative efforts. This will be a major continuing activity of the Nuclear Materials Control Department. As each loss mechanism is identified and a method is developed for determining the quantity of uranium being lost, such data will be recorded and reported on a current basis. The major loss thus far investigated is that of liquid waste discards, and the January material balance report will reflect known liquid waste discards during the month.

Inventories

NUMEC will take "routine" physical inventories at the end of each month and "precise" physical inventories every six months. Apparent losses as reflected by the "routine" inventories will be posted to the NUMEC internal records, and the apparent losses reflected by the "precise" inventories will be used in the preparation of reports to the AEC and to NUMEC customers.

Procedures Manual

NUMEC had previously made a commitment to the Oak Ridge Office that a draft Nuclear Materials Control Procedure Manual would be submitted for review no later than March 1, 1966. While we still consider that the March 1 date is a realistic deadline which can be met, the Nuclear Materials Control Department is at the present time attempting to make a wide variety of changes in NUMEC's nuclear materials control procedures.

We believe that a deadline of March 31, if acceptable to you and to Oak Ridge, would give us the time necessary to make needed changes and to incorporate these changes in the draft procedure manual, thereby reducing the probability that the manual would be significantly out of date before it had been finally approved.

Training

In the belief that effective special nuclear materials control can be achieved only with the cooperation and understanding of all employees, NUMEC has initiated a company-wide educational program in which special emphasis will be placed on the high intrinsic and strategic value of special nuclear materials. You were furnished with a draft outline of one training lecture during our February 3 meeting. The first session in this program will be held on February 7, 1966.

Although we believe that the foregoing improvements will strengthen NUMEC's accountability system, we shall be alert to the need for any additional changes. In this regard, we would, of course, appreciate any further recommendations you may wish to make.

Inventory Adjustment and Materials Recovery

As noted in paragraph 3.17 of your report, NUMEC has a sizeable backlog of internally-generated uranium residues with an unmeasured U-235 content. In addition, as we discussed during our meeting and as recognized in your report, there are uncertainties with respect to the U-235 content of the substantial residues which have been assayed. These uncertainties will, of course, be resolved as NUMEC begins to reprocess these residues for return in accordance with the terms of our provisional financial settlement of November 23, 1965, under WANL Purchase Order 59-NP-12674.

These uncertainties, as we discussed during our meeting, arise out of the heterogeneous nature of the above-described residues and can only be resolved, as we agreed, by a sampling plan which is tantamount to full recovery of the materials in question. Accordingly, as we had indicated in our discussion, we believe it would be preferable to stay a final adjustment of our book inventory until full recovery is accomplished, thereby allowing our book inventory to reflect the best and most accurate physical data obtainable. In these circumstances, adjustments to our book inventory would be made as recoveries are completed. A final adjustment would be made by November 23, 1966, the then date on which material may be returned for credit under the terms of the above-mentioned provisional financial settlement with WANL.

Nevertheless, we would be willing, as an interim measure, and in accordance with your recommendation, to adjust our book inventory to accord with the results of the AEC's October 31, 1965 inventory check taken in the course of your safeguards investigation at NUMEC. As the above-mentioned uncertainties are resolved, we would adjust our book inventory to accord with the data so obtained. In these circumstances, an interim book inventory adjustment to accord with the results of your inventory check would be reflected on NUMEC's February 28, 1966 materials balance report.

We believe that, in any event, the ultimate result is identical and, accordingly, we shall abide by your advice and recommendation in this regard.

Again, I would like to express our sincere appreciation for your courtesy in reviewing these matters with us.

Very truly yours,

Zalman M. Shapiro
President

ZMS/mm