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STUDIES AND RESEARCH CONCERNING BNFP

COMPUTERIZED NUCLEAR MATERIALS CONTROL AND ACCOUNTING SYSTEM DEVELOPMENT EVALUATION REPORT - FY 1978

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October 1978

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ABSTRACT

Development work on a computerized system for nuclear materials control and accounting in a nuclear fuel reprocessing plant is described and evaluated. Hardware and software were installed and tested to demonstrate key measurement, measurement control, and accounting requirements at accountability input/output points using natural uranium. The demonstration included a remote data acquisition system which interfaces process and special instrumentation to a central processing unit.

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1.0 INTRODUCTION

A computerized nuclear materials control and accounting system for a nuclear fuel reprocessing facility is a complex undertaking. Due to the complexity of the system, it must be developed and implemented by subsystem elements in planned stages over an extended period of time.

The Computerized Nuclear Materials Control and Accounting System (CNMCAS) being developed at the Barnwell Nuclear Fuel Plant (BNFP) will represent a modular network of computers, communications equipment, and data collection, storage, and retrieval devices to demonstrate sophisticated, automated nuclear materials management capability. The CNMCAS hardware currently comprises two PDP 11/35 central processing units, one devoted to the Laboratory Data System (LDS) and the other to nuclear materials control and accounting development activities.

The CNMCAS structure* contains a number of interrelated subsystems in addition to the LDS. These subsystems include:

(1) Measurement
(2) Nuclear Materials Accounting
(3) Measurement Control
(4) Item and Seal Control
(5) Physical Inventory
(6) CNMCAS-NMMSS** Interface
(7) Process Monitoring/Process Surveillance
(8) CNMCAS - Safeguards Coordination Center Interface.

An integrated process run using natural uranium was performed at the BNFP during August and September 1978. An objective of this run was the use of the CNMCAS hardware for measurement, accounting, and measurement control functions required for the following process steps of primary concern to nuclear materials control and accounting:

- Input uranium feed to process
- Product uranium produced
- Liquid waste discarded.

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*Refer to AGNS-1040-2.2-18, "Conceptual Design of a Computerized Nuclear Materials Control and Accounting System (Preliminary Report)," May 1978, for additional CNMCAS information.

**NMMSS - Nuclear Materials Management and Safeguards Systems.

This objective was accomplished by the Uranium Input/Output Demonstration Program operating in conjunction with a remote data acquisition system.

The Uranium Input/Output Demonstration Program is extremely important to the evolution of the CNMCAS. The demonstration program carried selected elements of the measurement, accounting, and measurement control subsystems through all stages of CNMCAS development and implementation, i.e.,

- Description
- Software specifications
- Software preparation
- Software/hardware on-line testing.

The experience and knowledge gained from the Uranium Input/Output Demonstration Program will be invaluable in the continuing effort to develop and implement the CNMCAS.

The Uranium Input/Output Demonstration Program is composed of six major, interrelated computer programs as follows:

(1) Input Measurement Program
(2) Product Measurement Program
(3,4) Waste Measurement Programs (GPW and HWW)
(5) Nuclear Materials Accounting Program
(6) Measurement Control Program.

Measurement instrumentation associated with the CNMCAS is interfaced to the central processing unit (CPU) through a remote data acquisition system (referred to herein as the RTP* system). The RTP system is composed of real-time peripheral/preprocessor equipment. The RTP system scans selected process instrumentation; collects, stores, and manipulates instrument signals; and transmits instrument data to the CNMCAS CPU.

In addition to the Uranium Input/Output Demonstration Program and the RTP system, CNMCAS development work during FY 1978 included preparation and demonstration of several auxiliary programs.

This report presents a description and evaluation of the CNMCAS development work conducted in FY 1978. The CNMCAS development work was a segment of the nuclear materials control evaluations objective included in the FY 1978 contract between Allied-General Nuclear Services and the Department of Energy for studies and research concerning the BNFP.

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*RTP - real-time peripheral.

2.0 SUMMARY

Basic descriptions of the software required for the Uranium Input/Output Demonstration Program and the remote data acquisition system* were completed in February 1978. Specifications describing software design were completed by a computer services vendor in April 1978. Software preparation, installation, testing, and demonstration were performed from May 1978 through September 1978.

CNMCAS mainframe hardware was installed and vendor tested during the second quarter of FY 1978. Installation of the RTP system and tie-in of process instrumentation and the Ruska DDR-6000 precision pressure gauges to the RTP system were completed prior to the start of the FY 1978 integrated uranium run.

The Uranium Input/Output Demonstration Program (in conjunction with the RTP system) was conducted during the FY 1978 integrated uranium run. Viewed in total, the demonstration produced excellent results and will serve as a sound basis for future CNMCAS development work. The fact that the demonstration preparation, performance, and evaluation were accomplished on an extremely tight time schedule is worthy of note. The value of pursuing selected CNMCAS elements through all stages of development and implementation was fully demonstrated.

Significant Uranium Input/Output Demonstration Program achievements included:

- Coordination of measurement activities by the measurement programs was demonstrated.
- Measurement data produced by the measurement programs showed excellent agreement with manual data except during problem periods.
- Integration of measurement control comparisons to flag marginal and out-of-control conditions was demonstrated.
- Operator acceptance was excellent. Essentially no time was available prior to the FY 1978 integrated uranium run for detailed training. On-the-job training of operators was accomplished during the run by Nuclear Materials Control and software vendor personnel.
- The value of the data produced by the measurement programs for process control use was demonstrated.
- Transmission of sample requests and analytical results between CNMCAS and the LDS CPU's was demonstrated.

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*Referenced to herein as the RTP system.

- Measurement control program summary reports were generated which reflected the measurement values contained in the data base. The summary reports demonstrated the methods and data needed to determine control limits and to estimate random error variances associated with bulk measurements.

- Accounting program performance was demonstrated by the generation of various accounting reports from measurement data in the data base including:

  - Lot/inventory period accounting reports
  - Material transfer reports
  - Input/output accounting reports.

As anticipated, several problems were encountered during performance of the Uranium Input/Output Demonstration Program, including:

- Typical software "bugs"

- Hardware failures, specifically the lack of spare components for the preprocessor in the RTP system

- Lack of modularity in the design of the accounting program

- Inadequate reliability of the CNMCAS-LDS communications link

- Overloading the capability of the CNMCAS operating system.

The CNMCAS development work planned for FY 1979 will incorporate solutions to these problems, and a refined and enhanced Uranium Input/Output Demonstration Program will be performed during FY 1979. Specific improvements and enhancements include:

- Converting CNMCAS development software from the current time-sharing operating system (RSTS/E) to a real-time operating system (RSX-11M)

- Improving the reliability of the CNMCAS-LDS communications link

- Procuring spare components for RTP system preprocessor

- Controlling Ruska "zero" operation by computer, including accumulation and manipulation of "zero" readings

- Improving measurement program-operator dialogue

- Improving the design of the accounting program to make it easier to modify

- Developing a more comprehensive (but closely controlled) data base edit program

- Developing a limits-of-error program for input and output measurement data

- Continuing operator training to improve competence/performance.

Auxiliary CNMCAS programs were developed and generated results ranging from promising to excellent. These programs included:

- In-Process Inventory Programs

- HA Feed Flow Rate Program

- Calculation programs for manually collected measurement data.

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3.0 CNMCAS HARDWARE

The Computerized Nuclear Materials Control and Accounting System (CNMCAS) will represent a modular network of computers, communications equipment, and data collection, storage, and retrieval devices to demonstrate sophisticated, automated nuclear materials management capability. The Laboratory Data System (LDS), an integral part of the CNMCAS, has been in place and functioning. FY 1978 objectives included the installation and on-line testing of additional CNMCAS hardware required for development work.

3.1 Installation of CNMCAS Hardware

3.1.1 Mainframe Hardware

Installation and vendor testing of a second central processing unit (PDP-11/35), data storage disks, and auxiliary equipment were completed during the second quarter of FY 1978. A simplified hardware schematic is included as Figure 3-1.

3.1.2 Remote Data Acquisition Equipment

Installation of remote data acquisition equipment for process instrumentation was satisfactorily completed. Major equipment components are an RTP* Wide-Range Analog Controller equipped with 416 input channels for receipt of process instrument signals and a PDP 11/04 minicomputer to preprocess the instrument signals for transmission to the central processing unit (CPU).

The design engineering work required for tie-in of the process instrument signals to the RTP unit was completed. Cable access holes were drilled in the Control Room floor, the RTP unit positioned, and multi-paired, shielded cable installed in the cable spreading room beneath the Control Room. Cable connections were made to process instrument terminals and the RTP unit. An RTP Uniform Temperature Reference Assembly was installed to provide essentially instantaneous temperature compensation for the majority of the thermocouple signals to be scanned.

3.1.3 Ruska-RTP Tie-In

Tie-in of the Ruska DDR-6000 precision pressure gauge signals to the RTP unit represented a special case. These instruments are equipped to output either analog or binary coded digital (BCD) signals, but normally over short distances. The planned transmission of analog signals over 200 feet and the low input impedance of the RTP unit were considered potential problems.

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*RTP - real-time peripheral.

Tests were completed simulating Ruska DDR-6000 precision pressure gauge analog signal input to an RTP Wide-Range Analog Controller. Significant signal degradation was confirmed, and the use of Ruska analog signals for accountability measurements was judged unacceptable. A method to use binary coded digital (BCD) signals from the Ruska digital voltmeters was devised and required instrumentation ordered and installed. The BCD signals are routed to an RTP Universal Controller, then to the PDP 11/04 preprocessor via serial interface units.

3.1.4 Miscellaneous Hardware

Two visual terminals were installed in the Control Room for use by CNMCAS operators and programming personnel.

- DEC VT-50 - used by CNMCAS operators to follow software internal operations, and by the programmers for software troubleshooting, corrections, modifications, etc.

- Intecolor 8001 - used to display measurement program status and process feed rate data.

3.2 CNMCAS Hardware Performance

On-line testing of CNMCAS hardware was conducted via the Uranium Input/Output Demonstration Program during the FY 1978 integrated uranium run.

CNMCAS mainframe hardware performance was essentially trouble-free until September 15, 1978, when a hardware failure in the disk drive occurred, shutting down CNMCAS. The problem was diagnosed as a faulty data path card which was replaced. Recovery time required approximately four hours.

A second hardware failure occurred on September 21, 1978. The failure was traced to a faulty system control and receiving scan card, which was replaced from spare inventory. CNMCAS downtime amounted to approximately three hours.

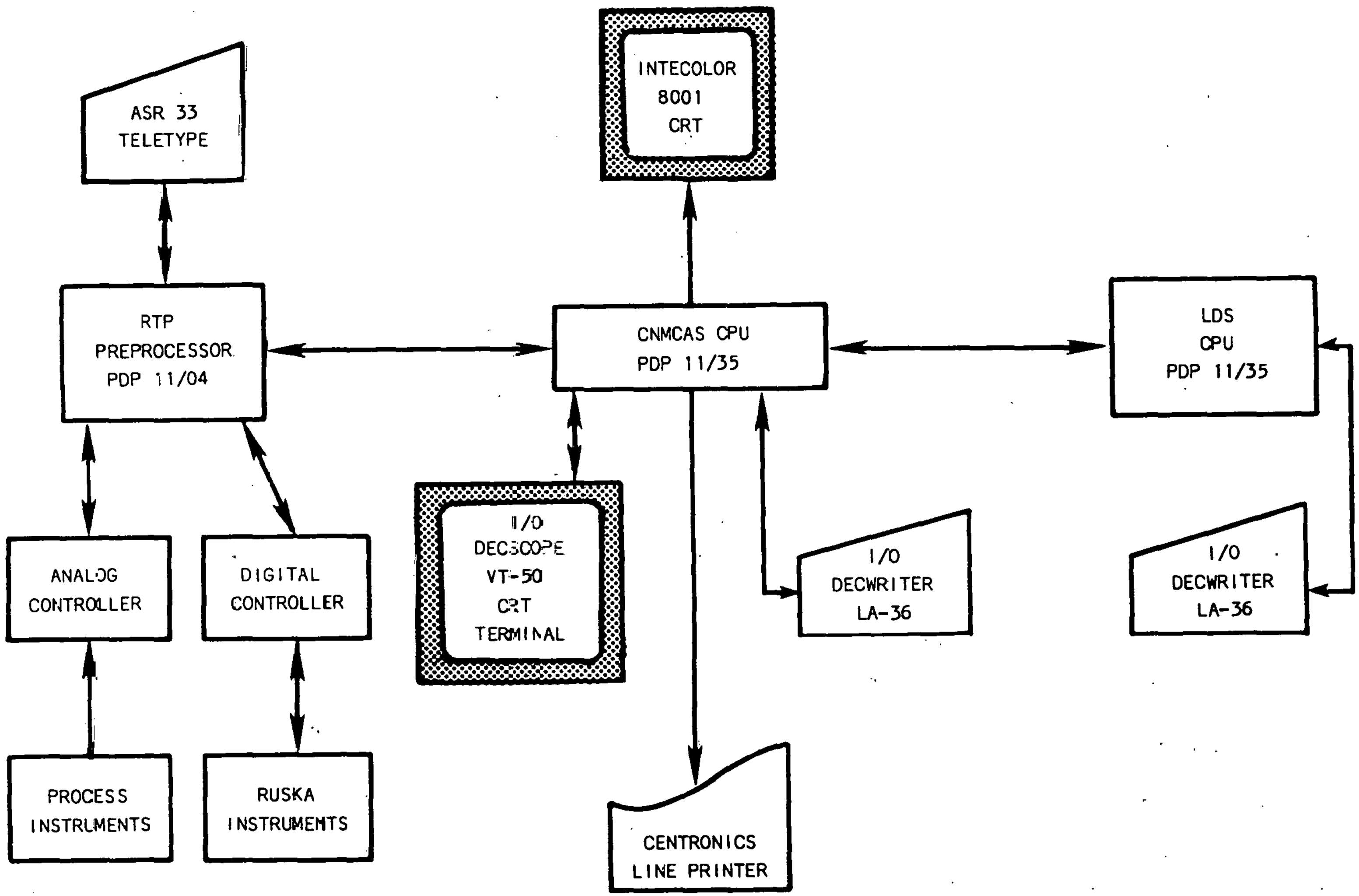
The Centronics line printer has not performed to expectations. The need for numerous "resets" was required prior to printout of batch summaries. During off-shifts, this problem required the CNMCAS Control Room operator to go to the HCLA computer room to restart the printer. In addition, the ribbon track and spooling device gave periodic problems.

During functional testing of the RTP system, a fault was identified in the serial formatter card in the RTP Universal Controller which handles digital signals to and from the Ruska instruments. The card was successfully repaired.

Late in Campaign 3 the PDP 11/04 preprocessor malfunctioned. The problem appeared to be in a memory card. Since no spare cards were available for the PDP 11/04, operation of the RTP system was terminated.

Also, the lack of a control panel on the PDP 11/04 hampered trouble-shooting efforts.

In summary, hardware performance was satisfactory to accomplish FY 1978 CNMCAS development objectives. However, the reliability of the Centronics line printer was inadequate and must be improved in FY 1979, or a suitable line printer procured. In addition, the need to spare critical components of the PDP 11/04 preprocessor to ensure RTP system operating continuity was brought home emphatically. This must be a prime FY 1979 CNMCAS hardware objective.



BASIC CNMCAS HARDWARE FOR THE URANIUM INPUT/OUTPUT DEMONSTRATION PROGRAM - FY 1978

FIGURE 3-1

4.0 URANIUM INPUT DEMONSTRATION PROGRAM PERFORMANCE

4.1 Introduction

The FY 1978 integrated uranium run was performed at the BNFP during August and September 1978. An objective of this run was the use of the Computerized Nuclear Materials Control and Accounting System (CNMCAS) hardware for measurement, accounting, and measurement control functions required for the following process steps* of primary concern to nuclear materials control and accounting:

- Input uranium feed to process
- Product uranium produced
- Liquid waste discarded.

This objective was accomplished by the Uranium Input/Output Demonstration Program operating in conjunction with a remote data acquisition system.

The Uranium Input/Output Demonstration Program is extremely important to the evolution of the CNMCAS. The demonstration program carried selected elements of the measurement, accounting, and measurement control subsystems through all stages of CNMCAS development and implementation, i.e.,

- Description
- Software specifications
- Software preparation
- Software/hardware on-line testing.

The experience and knowledge gained from the Uranium Input/Output Demonstration Program will be invaluable in the continuing effort to develop and implement the CNMCAS.

The Uranium Input/Output Demonstration Program is composed of six major, interrelated computer programs as follows:

(1) Input Measurement Program
(2) Product Measurement Program
(3,4) Waste Measurement Programs (GPW and HWW)
(5) Nuclear Materials Accounting Program
(6) Measurement Control Program.

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*Figure 4-1 presents a simplified process flowsheet for uranium accountability. Note that uranium product was recycled from the uranium product sample tank to the accountability tank to provide input feed solution.

4.2 Software Development

A description of the basic software required for the Uranium Input/Output Demonstration Program was completed in February 1978 with the assistance of a computer software vendor.* The description is included as Appendix A. Using the description as a guide, the vendor prepared a software (control) specification (refer to Appendix C). The software specification outlined the program design in sufficient detail to enable programming to proceed in an orderly fashion without additional overall design effort. The software specification was completed in April 1978.

Software preparation incorporating a RSTS/E operating system and BASIC PLUS 2 language started in May 1978. Major software elements** included:

- Data Base System
- General State Table
- Data Base Maintenance Program
- Data Base Edit Program
- Input Measurement Program
- Product Measurement Program
- GPW Measurement Program
- HWW Measurement Program
- RTP Driver System
- LDS Driver System
- Accounting Program
- Measurement Control Program.

Installation, testing, editing, etc., of major software with exceptions were completed on August 19, 1978. On-line shakedown of the software was conducted during Campaign 1 of the FY 1978 integrated uranium run. Various problems were resolved during on-line shakedown and several corrections/modifications were identified for later action.

Significant problems encountered during software installation and testing included:

- CNMCAS - LDS Communications Link

  The software development required to transmit sample requests and analytical data between CNMCAS and the LDS required considerable time and effort, as expected when a programming interface is crossed. The demonstration of the communications link was not accomplished until Campaign 3 of the FY 1978 integrated uranium run which limited the

*Scientific Systems Services, Melbourne, Florida.

**A detailed list of programs and modules appears in Appendix E. A description of the LDS-CNMCAS interface program generated by AGNS is presented in Appendix F.

time available to troubleshoot corrections. Software problems (and possibly hardware problems) remain which affect the reliability of the link. These problems will be resolved during FY 1979 to achieve satisfactory reliability.

- Measurement Programs

  During the on-line shakedown period, Nuclear Materials Control (NMC) personnel identified several enhancements for the measurement programs. Implementing these modifications in the limited time available created a number of secondary problems in the programs. Time spent on resolving these problems detracted from effort required in other software areas.

- Accounting Program Reports

  Accounting program reports required more time to correct and modify than anticipated. A contributor to this problem was the lack of modularity in the accounting program. Design of the program will be improved in FY 1979.

  Measurement Control Program Reports

  Concentrated effort on finalizing the software required to produce the measurement control program reports was delayed until the last half of the Uranium Input/Output Demonstration Program, due to the time required for on-line shakedown and corrections/modifications of the measurement programs and the RTP system, plus work on the CNMCAS-LDS communications link. As a result, a few software problems remain for resolution in FY 1979.

4.3 Measurement Programs Performance

4.3.1 Introduction

The measurement programs coordinate input, product, and waste measurement activities. The programs acquire measurement data from the RTP and LDS systems, examine data for gross errors and potential measurement problems, calculate solution and uranium quantities for process control use, and move data to storage at the completion of measurement and transfer activities for each batch of input, product, and waste solution. Activities coordinated by the measurement programs include:

- Batch initiation
- Before-receipt measurements (input only)
- Before-sampling measurements
- Sampling
- After-sampling measurements
- Analytical data handling
- Transfer
- After-transfer measurement
- Batch summary information.

A detailed description of the input, product, and waste measurement programs is included in Appendix A, Sections 2.0, 3.0, and 4.0, respectively. Software specifications for the measurement programs are contained in Appendix C.

4.3.2 Performance Summary

The measurement programs performed very well considering the initial stage of CNMCAS development. Performance highlights included:

- Coordination of measurement activities by the programs was demonstrated.

- Measurement data produced by the programs showed excellent agreement with manual data except during problem periods.

- Integration of measurement control comparisons to flag marginal and out-of-control conditions was demonstrated.

- Operator acceptance was excellent. Essentially no time was available prior to the FY 1978 integrated uranium run for detailed training. On-the-job training of operators was accomplished during the run by NMC and software vendor personnel.

- The value of the data produced by the programs for process control use was demonstrated.

Several problems affected the performance of the measurement programs. A number of the problems proved valuable in that they identified worthwhile modifications to be incorporated in FY 1979 CNMCAS development work. Significant problem areas included:

- Typical software "bugs" inherent in any computer system being brought on-line for the first time.

- Instances of missed or erroneous (without corrective action) data caused by operator oversight, software/hardware problems, or time constraints. These problems resulted in voids or erroneous data in the data base and pointed out the need for a more comprehensive (but closely controlled) data base edit program. Improved training and coordination and an ensured supply of critical hardware component spares will help minimize these problems.

- CNMCAS-LDS communications link proved erratic. Software modifications are required to improve reliability.

- RSTS/E operating system provided slower response time than desired and periodically showed overload symptons. RSTS/E is a time-sharing system and its ability to handle additional CNMCAS development work is inadequate. Conversion to a real-time operating system, e.g., RSX-11M, offers real advantages for future development work.

4.3.3 Measurement Program Dialogue

Typical measurement program-operator dialogue produced at the CNMCAS input/output (I/O) terminal in the Control Room of the Separations Facility is presented in the following exhibits:

- Exhibit 4-1 - Input Measurement Program Dialogue (Accountability Tank-Measurement Point 02003)
- Exhibit 4-2 - Product Measurement Program Dialogue (Uranium Product Sample Tank-Measurement Point 02009)
- Exhibit 4-3 - Waste Measurement Program Dialogue (HWW Sample Tank-Measurement Point 02023)
- Exhibit 4-4 - Waste Measurement Program Dialogue (GPW Check Tank-Measurement Point 02028)

Explanatory notes have been added to the exhibits to provide a better understanding of the measurement dialogue presented. Note that the program messages for the specific batches exhibited have been consolidated. In actual practice, program-operator dialogue develops chronologically for all programs. A status program was available to the operator to print the measurement program status of batches in progress. The operator could activate this program at any time. A typical status report is presented in Exhibit 4-5, which also contains explanatory notes.

4.3.4 Future Improvements

Based on experience gained during the Uranium Input/Output Demonstration Program, the following improvements will be made in the measurement program:

- Printout of all instrument readings acquired by the measurement programs at time of receipt. Currently, the programs print out these data only in the batch summary.
- Printout of the comparison data at the time comparisons are made. Currently, the programs provide a printout of "marginal" and "out-of-control" comparison data on a near real-time basis with "satisfactory" comparison data included only in the batch summary.

4.4 Nuclear Materials Accounting Program Performance

4.4.1 Introduction

The nuclear materials accounting program is used to define accounting control units and to produce accounting, summary, and material balance reports. The accounting control units consist of individual measurement batches, lots consisting of several batches, and an inventory period consisting of several lots. Each batch measured is automatically incremented by the measurement programs to provide sequentially numbered batches. A measurement point file in the data base is utilized by the accounting program. This data base file services all the programs, i.e., accounting, measurement, and measurement control programs. The accounting program is subdivided as follows:

(1) Lot/Inventory Period Programs
(2) Material Balance Area (MBA) Transfers
(3) Input/Output Accounting:
- Accounting Report
- Summary Report
- Material Balance Reports.

The accounting program and its objectives are outlined in Appendix A, Section 5.0. The following performance discussions and exhibits are directed at the objectives and reports outlined therein.

4.4.2 Lot/Inventory Period Program

Table 4-1 shows the three inventory periods for the FY 1978 integrated uranium run, the four lots within these inventory periods, and the batches within the lots.

Inventory Period No. 1, corresponding to Campaign 1, was used for on-line shakedown of CNMCAS development hardware/software. In addition, the CNMCAS was shut down prior to the end of the period for installation of additional software. Therefore, Inventory Period No. 1 is not included in the evaluation of the accounting program.

A typical accounting report is shown in Exhibit 4-6 which represents Lot No. 2 data for measurement point 2-003 (accountability tank). This report, with the exception of the uranium concentration entries, was generated from the data base automatically by the accounting program. The final results for uranium concentration were entered manually since, at this point, the CNMCAS-LDS communications link was not in operation. This report represents a completed lot with all final values. All input batches were received from the uranium product sample tank (measurement point 2-009) and input-product batches can be correlated by comparing the two batch number columns.

The grouping of input batches 83 through 103 into Lot No. 2 represents the activity for the accountability tank for the second inventory period, which corresponds to Campaign 2. Exhibit 4-7 represents applicable product data for Inventory Period No. 2.

By referring to Exhibit 4-14, Material Balance Report for Periods 2-2, the reason for designating inventory periods can be seen. The Material Balance Report is the final consolidated report for a Material Control Area (MCA) and is used to provide the book balance to which the physical inventory is compared. The quantities on this report for the input point 2-003, Lot No. 2, batches 83 through 103 represent the "received" quantities on the accounting report (Exhibit 4-6). In order to obtain the MBR reports, only the entry of the desired inventory period by the requestor at a CNMCAS I/O terminal is required. To generate the accounting report, the measurement point and lot number must be entered. These reports could be generated at any time they were requested. The applicable codes shown (i.e., "P" or "F") indicate if the values are preliminary or final.

Once a lot was assigned beginning and ending batch numbers, these batch numbers could not be readily changed. This represents a design shortcoming since the ability to group combinations of batches into different lots is required for accounting system flexibility. With this exception, the lot/inventory period program functioned satisfactorily and demonstrated the planned objectives.

4.4.3 Material Balance Area (MBA) Transfers

This objective was only partially accomplished. Comparisons of before-sampling and after-sampling solution and uranium quantity data were made within a measurement point but not between measurement points. When out-of-control limits were exceeded, the message printed out on the NMC line printer (see Exhibit 4-8). It was originally planned that transferred-received quantity comparison would be accomplished by the accounting program for transfers between the product and accountability tank and printed out in the same manner. This represents a potential FY 1979 enhancement for the accounting program.

However, transferred-received quantity comparisons can be made by comparing applicable Batch Summary Reports, which are printed immediately upon completion of the measurement programs (see Exhibit 4-9). The Batch Summary Reports provide preliminary uranium values based on calculated uranium concentrations. Exhibit 4-9 shows the quantity of uranium transferred from the uranium product sample tank in batch 02009-94 was 1647.612 kilograms versus 1659.883 kilograms of uranium received in the accountability tank and measured as batch 02003-101.*

The hard copy Batch Summary Reports (Exhibit 4-9) would be provided automatically to each custodian when generated and to the NMC line printer at the same time. These reports would, in effect, act as the source data transfer documents between MBA's.

Comparisons of quantities transferred from the product tank and received in the accountability tank can also be demonstrated by comparing the input/output accounting reports for each point (see Exhibits 4-6 and 4-7). Lot No. 2 for both points are comparable on a batch-by-batch

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*On the input/output accounting reports for these two batches, note that the final results were 1676.632 kilograms uranium transferred (Batch 94, Exhibit 4-7) and 1679.228 kilograms uranium received (Batch 101, Exhibit 4-6).

basis or in total, since the first product batch, 02009-76, was transferred to the first accountability batch, 02003-83, and so on for the next 20 batches and the lot totals. The total quantity transferred from the product tank (Exhibit 4-7), Lot No. 2, was 34830.918 kilograms uranium. This is shown in the subtotal section along with the destination point, 2003. On the accountability tank report (Exhibit 4-6), the quantity received from 2009 was 34781.977 kilograms uranium as shown in the subtotal section.

4.4.4 Input/Output Accounting

4.4.4.1 Accounting Report

A typical accounting report for one lot is shown in Exhibit 4-6. A similar accounting report for three lots is shown in Exhibit 4-10. Exhibit 4-10 shows the quantity totals for each lot, for all three lots, and a breakdown of the measurement points from which the material was received for the accountability tank. All of the results shown are final as indicated by the codes. Most of these final uranium concentration results were entered manually into the data base, since the CNMCAS-LDS communications link was not in operation. Some of the final uranium values, however, were transmitted directly from the LDS to the CNMCAS data base. When requesting a report for a measurement point, the beginning inventory must be entered at a CNMCAS I/O terminal by the requestor, since this feature was not included in the software design. All of the planned design features were demonstrated. One of the problems not anticipated was handling the receipt of a partial batch from one point and the receipt of an additional quantity from another point into the same batch. This situation occurred occasionally when there was insufficient time to sample, due to the need to relieve two points almost simultaneously. This situation must be factored into future design modifications.

The report format was planned to provide a ready means of determining if gross errors or omissions appear on the report. One check is to see if all batches are recorded. Since all batches are sequentially numbered, the user would scan the batch column to assure they are all there. The lot total section shows the inclusive batches for the lot. In Exhibit 4-10, note that all batches for each lot are recorded, i.e., Lot No. 2 should have batches 83 through 103; Lot No. 3, batches 104 through 113; and Lot No. 4, batches 114 through 127. On Exhibit 4-11, Lot No. 4 shows it should have batches 105 through 120, but only batches 105 through 115 are listed, representing a minor programming problem.

The status code shows if uranium concentrations are preliminary (P) or final (F). Only final values are used for accounting purposes. Preliminary values are used for estimating and timely analysis of potential problems.

In Exhibit 4-12, the status code represents a mixture of the various conditions that can be present on a report during accumulation of final uranium values. In this example for the HWW sample tank, note that a number of recycled (R) batches were generated. The summaries in the subtotal section provide the quantities that are final and preliminary for all three lots.

Each measurement point has only a few points from which it can receive material and to which it can transfer material. These can be quickly scanned to establish the validity of the entries. In addition, comparison between reports can be made of destination points and received-from points to assure that these have been correctly reported. For example, in Exhibit 4-11, note that the destination point for batches 2009-3-100 and 102 was 2001. In Exhibit 4-10, these two batches are shown as being transferred to batches 2003-3-111 and 112. This could only occur by a manual change in the data base file. Comparison of the totals would be the first indication that a problem existed.

Since the accounting program uses the raw data stored in the data base files generated by the measurement programs, it was subject to the problems that were encountered in the measurement programs. In addition, numerous programming problems existed in the generation of accounting reports and extensive revisions were required.

4.4.5 Summary Report

A Summary Report for measurement point 02003 is shown in Exhibit 4-13. The Summary Report represents the accounting report in Exhibit 4-10 without the individual batch listings. It provides the batches that are included in each lot, status condition, and received-from points along with the corresponding quantities.

4.4.6 Material Balance Report (MBR)

Material Balance Reports for the input/output points covering the second and third inventory periods are shown in Exhibits 4-14 and 4-15, respectively. The beginning inventory has to be entered manually at a CNMCAS I/O terminal by the requestor. The batches included in the report are shown, plus the from- and to-points, and the code status. The detail section includes those quantities recycled but they are excluded from the MBR totals. This is shown for measurement points 02023 and 02028.

The ending inventory is the sum of the beginning inventory and the input total less the three output totals. This ending balance is the quantity which should be on hand. The difference between this balance and the physical inventory is the book-physical inventory difference (BPID). The quantities on the MBR should be the same as those on the accounting reports for the same lots. This was the case for measurement points 02003 and 02023 on both MBR's but not for point 02009, which was not a completed lot. The MBR should, however, show whatever the accounting report shows.

4.5 Measurement Control Program Performance

4.5.1 Introduction

The Measurement Control Program provides for various checks and comparisons of measurement data to control measurement anomalies, prior to acceptance into the data base, for trend and error analysis of stored measurement data and for propagation of errors into limits of error for material balance calculation.

Software development for propagation of errors into limits of error was not included in the FY 1978 Uranium Input/Output Demonstration Program.

A detailed description of the Measurement Control Program is included in Appendix A, Section 5.0. The software specification for the Measurement Control Program is contained in Appendix C.

4.5.2 Performance Summary

In general, the measurement control program performed satisfactorily in that output summary reports were obtained which reflected the measurement values contained in the data base. The summary reports provide a demonstration of the methods and data needed to determine control limits and to estimate random error variances associated with bulk measurements.

The demonstration of an effective method to detect measurement anomalies incorporated the use of a control limits table. Measurement data comparison outside the 0.05 and 0.01 levels of significance generated message flags at the CNMCAS Control Room input/output terminal and at the NMC line printer. Due to the pressure of other test activities, process problems, measurement program problems, etc., supervisory approvals and documentation of corrective actions were handled informally.

Summary reports were obtained for level comparisons, density comparisons, and replicate measurements for all input/output tanks, product to input comparisons, and input uranium concentration comparisons for the accountability tank. Each of these types of reports are discussed in the following sections.

Extreme values were excluded from the summaries to provide for more meaningful summary data. Extreme value identifiers were input at the time the summary was requested.

4.5.3 Level Comparisons

Redundant instrumentation was provided for the four uranium input/output measurement points. Examples of summaries of the liquid level instrumentation comparisons are provided in Exhibits 4-16 and 4-17 for the accountability tank and GPW check tank, respectively. These data are used to establish control limits for instrument performance and to detect instrument trends and/or calibration requirements. On

Exhibit 4-16, note the extreme differences in readings between the two temperature instruments indicating a failure in the TI-109 instrument loop.

4.5.4 Density Comparisons

Process densities were obtained from at least two different instruments for each of the four uranium input/output measurement points. In the case of the input and product measurements, the pressure differential was determined directly by the Taylor instrumentation and indirectly as the difference between two Ruska instruments (refer to Appendix A, Sections 6.3.1.3 and 6.3.2.2 for calculation methods). For the two waste measurement points, both the Westinghouse and Taylor instruments provide a direct measure of the differential pressure across the high and medium pressure probes.

The density comparison reports provide instrument-to-instrument comparisons, process density-to-lab density comparisons for each instrument, and a listing of laboratory density results at 25°C. In addition, for the input and product tanks, the laboratory density is calculated at tank temperature and compared to process densities. Examples of density comparison reports are provided in Exhibits 4-18 and 4-19 for the accountability tank and GPW check tank, respectively. The density comparisons provide excellent indicators of measurement anomalies. Excessive differences between laboratory and process densities were a reliable indication that either probes were beginning to plug or the sample was not representative of tank contents.

4.5.5 Replicate Measurements

Replicate measurement data summary reports for solution quantities provide reliable estimates of the repeatability of the bulk measurement systems. These reports indicate any systematic effects between before-sampling and after-sampling measurements as well as providing a realistic estimate of the random error variances. In addition, for the accountability tank, the comparison between after-transfer and before-receipt solution quantities provides additional assurance that the tank has been properly isolated. Examples of these reports are provided in Exhibits 4-20 and 4-21 for the accountability tank and the HWW sample tank, respectively. The very large quantity differences shown as "extreme values excluded" in Exhibit 4-20 represent missed measurement actions caused by operator oversight or program/hardware problems.

4.5.6 Product/Input Comparisons

Comparisons of product versus input quantities shown in Exhibit 4-22 provide a measure of the effectiveness of the other control methods and error estimates. This type of report could be expanded to include additional points where quantities are transferred and measured in two different tanks. This report provides the basis for the control limits to indicate that a measurement problem exists for one or both of the measurements.

The transferred-received values shown in Exhibit 4-22 represent process control-type data, e.g., laboratory densities at 25°C were used. Therefore, the range of the transferred-received differences is considerably broader than the range of the differences developed from accounting-type data where, for example, laboratory densities corrected-to-tank temperatures are used.

4.5.7 Uranium Concentrations

Since the largest error sources for material balance determinations are analytical, it is important to be able to assess analytical performance and trends. For the FY 1978 integrated uranium run, uranium concentrations for input measurements were determined by two different methods. The uranium concentration report provides a comparison of the two methods, isotopic dilution/mass spectrometric (U-ID) versus potentiometric (U-VP), on a batch-by-batch basis as well as summary statistics. An example of the comparison report is provided in Exhibit 4-23.

4.6 Uranium Input/Output Demonstration Program Evaluation Summary

Viewed in total, the Uranium Input/Output Demonstration Program (in conjunction with the RTP system) produced excellent results and will serve as a sound basis for future CNMCAS development work. The program was described, software specifications written, and software developed and tested on an extremely tight time schedule. The value of pursuing selected CNMCAS elements through all stages of development and implementation was fully demonstrated.

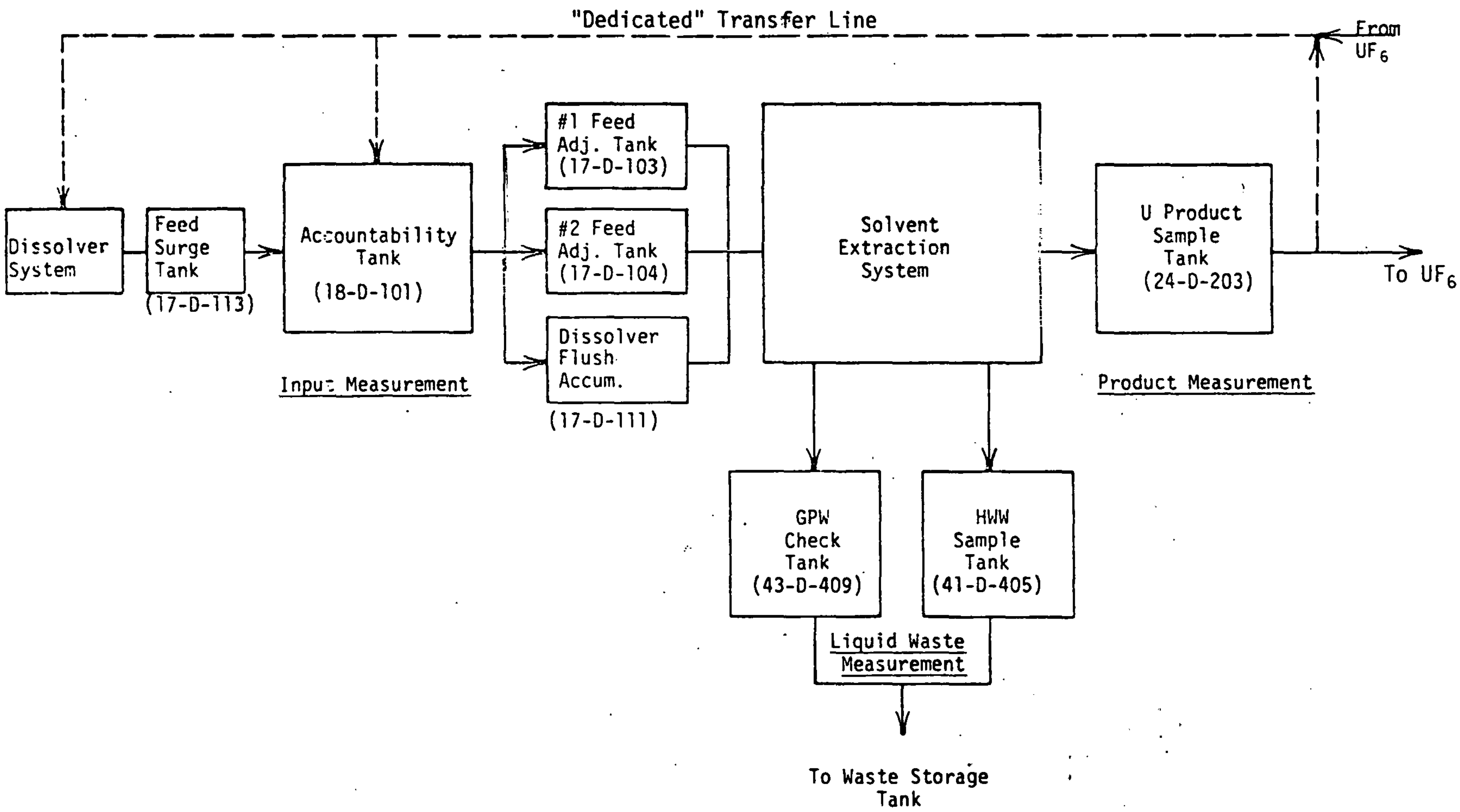
Although several problems remain to be corrected, the overall performance of the measurement, accounting, and measurement control programs was satisfactory. A number of these problems have clarified planning for a refined and enhanced uranium input/output demonstration to be conducted in FY 1979 as part of the CNMCAS development work. FY 1979 work will include:

- Conversion of CNMCAS software to a real-time operating system
- Improving the reliability of the CNMCAS-LDS communications link
- Increasing the modularity of the accounting program
- Improving measurement program-operator dialogue
- Developing a more comprehensive (but closely controlled) data base edit program
- Developing a limits-of-error program for input and output measurement data
- Continuing operator training to improve competence/performance.

TABLE 4-1

INVENTORY PERIOD-LOT-BATCH CORRELATION
FY 1978 INTEGRATED URANIUM RUN

Inventory Periods	1	2	3	
Lots	1	2	3	4
Measurement Points	Batches			
Accountability Tank 2003	61-82	83-103	104-113	114-127
Product Tank 2009	60-75	76-96	97-104	105-120
HWW Waste 2023	50-62	63-80	81-92	93-104
GPW Waste 2028	262-306	306-333	334-354	355-398



SIMPLIFIED PROCESS FLOWSHEET
FOR URANIUM ACCOUNTABILITY -
FY 1978 INTEGRATED URANIUM RUN

FIGURE 4-1

EXHIBIT 4-1

INPUT MEASUREMENT PROGRAM DIALOGUE
ACCOUNTABILITY TANK - MEASUREMENT POINT 02003

Dialogue	EXPLANATORY NOTES
******* MESSAGE FOR TANK 2003 BATCH 107 ******* 23-Sep-78 01:27 PM MEASUREMENT FOR THIS BATCH IS COMPLETE. CALL ME WHEN READY FOR NEXT BATCH. BEGIN ENTER MEASUREMENT POINT? 02003 PROGRAM STARTED Bye	Program prints batch complete Statement for previous input batch Operator enters BEGIN to access Measurement Programs Operator enters 02003 which initializes next accountability tank batch
******* MESSAGE FOR TANK 2003 BATCH 108 ******* 23-Sep-78 01:29 PM ENTER OPERATOR INITIALS WFH	Program assigns sequential batch no. Program compares initials to authorized list
******* MESSAGE FOR TANK 2003 BATCH 108 ******* 23-Sep-78 01:29 PM ENTER SOURCE VESSEL MEASUREMENT POINT ID 02009	Operator enters measurement point no. of input source (U prod. Sample Tk.)
******* MESSAGE FOR TANK 2003 BATCH 108 ******* 23-Sep-78 01:29 PM ENTER OPERATOR INITIALS WFH	
******* MESSAGE FOR TANK 2003 BATCH 108 ******* 23-Sep-78 01:29 PM I'M READY TO MEASURE BEFORE-RECEIPT DATA. RUSKA ZEROES SHOULD BE READ. SPARGER SHOULD BE OFF. INSTRUMENT PURGES SHOULD BE SET AT 0.5 SCFH. SHALL I PROCEED ? (YES OR NO) YES	Before receipt (B-R) measurements: Program states prerequisites Operator enters YES to activate B-R measurement data collection
******* MESSAGE FOR TANK 2003 BATCH 108 ******* 23-Sep-78 01:29 PM ENTER RUSKA (LEVEL) ZERO VALUE -.42	Operator enters Ruska (level) zero value
******* MESSAGE FOR TANK 2003 BATCH 108 ******* 23-Sep-78 01:30 PM ENTER RUSKA (DENSITY) ZERO VALUE -.11	Operator enters Ruska (density) zero value
******* MESSAGE FOR TANK 2003 BATCH 108 ******* 23-Sep-78 01:33 PM PROCESS TEMPERATURE COMPARISION IS OUT-OF-LIMITS TJR-108-10 = 43.8361 AND TI-109 = 20.0523	Program has collected B-R data Temperature comparison out-of-limits T1-109 malfunctioning; TJR-OK
******* MESSAGE FOR TANK 2003 BATCH 108 ******* 23-Sep-78 01:33 PM SUPERVISOR IS REQUIRED TO PROCEED. ENTER PASSWORD	Supervisor Password entered (non-printing)
******* MESSAGE FOR TANK 2003 BATCH 108 ******* 23-Sep-78 01:33 PM POSSIBLE OPTIONS ARE: 1 = PROCEED WITH MEASUREMENT 2 = REMEASURE 3 = USE AFTER-TRANSFER DATA ENTER OPTION (1, 2, OR 3) 1	Program provides operator with options Operator selects proceed with measurement option
******* MESSAGE FOR TANK 2003 BATCH 108 ******* 23-Sep-78 01:33 PM CALL BACK WHEN TRANSFER IS COMPLETE AND SPARGER IS OFF. I'LL WAIT TO HEAR FROM YOU.	Program signs off to wait on completion of transfer

Bye

EXHIBIT 4-1

(Continued)

	EXPLANATORY NOTES
******* MESSAGE FOR TANK 2003 BATCH 108 ******* 23-Sep-78 03:54 PM ENTER OPERATOR INITIALS DER	Transfer completed; program called up by Operator Operator authorization check by program
******* MESSAGE FOR TANK 2003 BATCH 108 ******* 23-Sep-78 03:54 PM I'M READY TO MEASURE BEFORE-SAMPLE DATA. RUSKA ZEROES SHOULD BE READ. SPARGER SHOULD BE OFF. INSTRUMENT PURGES SHOULD BE SET AT 0.5 SCFH. SHALL I PROCEED ? (YES OR NO) YES	Before sampling (B-S) measurements: Program states prerequisites Operator enters YES to activate B-S measurement data collection
******* MESSAGE FOR TANK 2003 BATCH 108 ******* 23-Sep-78 03:54 PM ENTER RUSKA (LEVEL) ZERO VALUE -.42	Operator enters Ruska (level) zero value
******* MESSAGE FOR TANK 2003 BATCH 108 ******* 23-Sep-78 03:55 PM ENTER RUSKA (DENSITY) ZERO VALUE -.09	Operator enters Ruska (density) zero value
******* MESSAGE FOR TANK 2003 BATCH 108 ******* 23-Sep-78 04:04 PM PROCESS LEVEL COMPARISION IS MARGINAL LR-125 = 309.464 AND LR-125-R = 304.91	B-S data collection completed Program states liquid level reading Comparison is marginal - prompts check of instruments by operator
******* MESSAGE FOR TANK 2003 BATCH 108 ******* 23-Sep-78 04:04 PM PROCESS TEMPERATURE COMPARISION IS OUT-OF-LIMITS TJR-108-10 = 39.1088 AND TI-109 = 24.5293	TI-109 bad; TJR-OK
******* MESSAGE FOR TANK 2003 BATCH 108 ******* 23-Sep-78 04:04 PM SUPERVISOR IS REQUIRED TO PROCEED. ENTER PASSWORD	Supervisor password entered (non-printing)
******* MESSAGE FOR TANK 2003 BATCH 108 ******* 23-Sep-78 04:05 PM POSSIBLE OPTIONS ARE: 1 = PROCEED WITH MEASUREMENT 2 = REMEASURE ENTER OPTION (1 OR 2) 1	Program provides operator with options Operator selects proceed with measurement option
******* MESSAGE FOR TANK 2003 BATCH 108 ******* 23-Sep-78 04:05 PM PROCESS DENSITY COMPARISION IS MARGINAL DR-166 = 1.54438 AND DR-166-R = 1.53287	Program states density reading comparison is marginal - prompts check of instruments by operator
******* MESSAGE FOR TANK 2003 BATCH 108 ******* 23-Sep-78 04:05 PM ENTER OPERATOR INITIALS DER	Operator authorization check by Program
******* MESSAGE FOR TANK 2003 BATCH 108 ******* 23-Sep-78 04:06 PM TANK CONTAINS 7229.84 KG SOLUTION TANK CONTAINS 4681.38 LITERS SOLUTION I'M GOING TO REQUEST LDS TO SAMPLE. SPARGER SHOULD BE OFF. SHALL I PROCEED ? (YES OR NO) NO	Program calculates/prints B-S quantities Program asks operator if he wants a sample requested. Operator not ready for sample - enters NO
******* MESSAGE FOR TANK 2003 BATCH 108 ******* 23-Sep-78 04:06 PM SPARGER AT W840 EL296 PURGES IN RUSKA ROOM I'LL WAIT TO HEAR FROM YOU.	Program sign off to wait on recall when operator is ready to request sample

	EXPLANATORY NOTES
BEGIN ENTER MEASUREMENT POINT? 02003 PROGRAM STARTED Bye	Operator recalls program: ready to request sample
******* MESSAGE FOR TANK 2003 BATCH 108 ******* 23-Sep-78 04:07 PM ENTER OPERATOR INITIALS DER	Operator authorization check by program
******* MESSAGE FOR TANK 2003 BATCH 108 ******* 23-Sep-78 04:07 PM TANK CONTAINS 7229.84 KG SOLUTION TANK CONTAINS 4681.38 LITERS SOLUTION	Program restates B-S quantities and sample request question
I'M GOING TO REQUEST LDS TO SAMPLE. SPARGER SHOULD BE OFF. SHALL I PROCEED ? (YES OR NO) YES	Operator enters YES - Program sends sample request to LDS, then signs OFF (non-printing) to wait on sample results from the LDS.
ENTER MEASUREMENT POINT? 02003 PROGRAM STARTED Bye	
******* MESSAGE FOR TANK 2003 BATCH 108 ******* 23-Sep-78 07:08 PM SAMPLING IS COMPLETE. SAMPLE LOG NUMBER IS 19722 RESULTS SHOW DENSITY IS 1.5456 G/ML CONCENTRATION IS 388.869 G URANIUM/LITER SOLUTION AND H+ IS .79 MOLAR.	Sampling, analyses completed. LDS sends results to CNMCAS Program prints results
******* MESSAGE FOR TANK 2003 BATCH 108 ******* 23-Sep-78 07:08 PM ENTER OPERATOR INITIALS DER	Operator authorization check by program.
******* MESSAGE FOR TANK 2003 BATCH 108 ******* 23-Sep-78 07:08 PM I'M READY TO MEASURE AFTER-SAMPLE DATA. RUSKA ZEROES SHOULD BE READ. SPARGER SHOULD BE OFF. INSTRUMENT PURGES SHOULD BE SET AT 0.5 SCFH.	After sampling (A-S) measurements: Program states prerequisites
SHALL I PROCEED ? (YES OR NO) YES	Operator enters YES to activate A-S measurement data collection
******* MESSAGE FOR TANK 2003 BATCH 108 ******* 23-Sep-78 07:08 PM ENTER RUSKA (LEVEL) ZERO VALUE -.40	Operator enters Ruska (level) zero value
******* MESSAGE FOR TANK 2003 BATCH 108 ******* 23-Sep-78 07:08 PM ENTER RUSKA (DENSITY) ZERO VALUE -.07	Operator enters Ruska (density) zero value
******* MESSAGE FOR TANK 2003 BATCH 108 ******* 23-Sep-78 07:11 PM TRANSFER QUANTITY COMPARISION IS OUT-OF-LIMITS 8080.87 KGS SOLN WERE TRANSFERRED FROM TANK 2009 AND YOU RECEIVED 7213.12 KGS SOLN	Program error--Comparison actually OK Program is comparing kilograms solution received in Acct. Tk. to the total kilograms solution that were in the U prod. Sample Tk. rather than the quantity transferred.

EXHIBIT 4-1
(Continued)

EXPLANATORY NOTES

```
*******  MESSAGE FOR TANK 2003 BATCH 108  *******   23-Sep-78  07:11 PM
SUPERVISOR IS REQUIRED TO PROCEED.
ENTER PASSWORD
```

Supervisor password entered (non-printing)

```
*******  MESSAGE FOR TANK 2003 BATCH 108  *******   23-Sep-78  07:13 PM
POSSIBLE OPTIONS ARE:  1 = PROCEED WITH MEASUREMENT
                       2 = REMEASURE
ENTER OPTION ( 1 OR 2 )
 1
```

Program provides operator with options since transfer quantity comparison out-of-limits was due to program error, operator selects proceed with measurement option

```
*******  MESSAGE FOR TANK 2003 BATCH 108  *******   23-Sep-78  07:17 PM
PROCESS TEMPERATURE COMPARISION IS OUT-OF-LIMITS
TJR-108-10 =  38.9917   AND   TI-109    =  24.6712
```

T1-109 bad; TJR-OK

```
*******  MESSAGE FOR TANK 2003 BATCH 108  *******   23-Sep-78  07:17 PM
SUPERVISOR IS REQUIRED TO PROCEED.
ENTER PASSWORD
```

Supervisor password entered (non-printing)

```
*******  MESSAGE FOR TANK 2003 BATCH 108  *******   23-Sep-78  07:17 PM
POSSIBLE OPTIONS ARE:  1 = PROCEED WITH MEASUREMENT
                       2 = REMEASURE
                       3 = GO BACK TO B.S. MEASUREMENTS
ENTER OPTION ( 1, 2, OR 3 )
1
```

Program provides operator with options

Operator selects proceed with measurement option

```
*******  MESSAGE FOR TANK 2003 BATCH 108  *******   23-Sep-78  07:17 PM
TANK CONTAINS   7229.05   KG SOLUTION
TANK CONTAINS   4677.18   LITERS SOLUTION
TANK CONTAINS   1818.81   KG URANIUM
YOUR NEXT STEP IS TO MAKE THE TRANSFER.
```

Program calculates/prints A-S quantities

```
*******  MESSAGE FOR TANK 2003 BATCH 108  *******   23-Sep-78  07:17 PM
POSSIBLE OPTIONS ARE:  1 = HOLD
                       2 = TRANSFER
                       3 = GO BACK TO B.S. MEASUREMENTS
ENTER OPTION ( 1, 2, OR 3 )
1
```

Program provides operator with options

Operator not ready to make transfer so elects to put program in HOLD

```
*******  MESSAGE FOR TANK 2003 BATCH 108  *******   23-Sep-78  07:18 PM
TANK IS NOW ON HOLD.  CALL BACK WHEN DECISION HAS BEEN MADE.
```

Program signs off to wait on transfer decision

```
BEGIN
ENTER MEASUREMENT POINT? 02003
PROGRAM STARTED

Bye
```

Operator enters BEGIN and 02003 to recall program

```
*******  MESSAGE FOR TANK 2003 BATCH 108  *******   23-Sep-78  11:05 PM
ENTER OPERATOR INITIALS
BED
```

Operator authorization check by program

```
*******  MESSAGE FOR TANK 2003 BATCH 108  *******   23-Sep-78  11:05 PM
TANK CONTAINS   7229.05   KG SOLUTION
TANK CONTAINS   4677.18   LITERS SOLUTION
TANK CONTAINS   1818.81   KG URANIUM
YOUR NEXT STEP IS TO MAKE THE TRANSFER.
```

Program restates A-S quantities

EXHIBIT 4-1

(Continued)

EXPLANATORY NOTES

```
*******  MESSAGE FOR TANK 2003 BATCH 108  *******   23-Sep-78  11:05 PM
POSSIBLE OPTIONS ARE:  1 = HOLD
                       2 = TRANSFER
                       3 = GO BACK TO B.S. MEASUREMENTS
ENTER OPTION ( 1, 2, OR 3 )
2
```

Program restates options available to operator

Operator ready to make transfer so he selects Option 2

```
*******  MESSAGE FOR TANK 2003 BATCH 108  *******   23-Sep-78  11:06 PM
SUPERVISOR IS REQUIRED TO PROCEED.
ENTER PASSWORD
```

Supervisor password entered (nonprinting) to approve transfer action.

```
*******  MESSAGE FOR TANK 2003 BATCH 108  *******   23-Sep-78  11:06 PM
ENTER DESTINATION VESSEL MEASUREMENT POINT ID
02006
```

Operator enters destination ID; 02006 (No. 2 Feed Adjustment Tank)

```
*******  MESSAGE FOR TANK 2003 BATCH 108  *******   23-Sep-78  11:07 PM
CALL BACK WHEN TRANSFER IS COMPLETE AND SPARGER IS OFF.
BEGIN
ENTER MEASUREMENT POINT? 02003
PROGRAM STARTED

Bye
```

Program signs off to await recall when transfer is completed

Operator enters BEGIN and 02003 to recall program

```
*******  MESSAGE FOR TANK 2003 BATCH 108  *******   23-Sep-78  11:07 PM
ENTER OPERATOR INITIALS
BED
```

Operator authorization check by Program

```
*******  MESSAGE FOR TANK 2003 BATCH 108  *******   23-Sep-78  11:09 PM
I'M READY TO MEASURE AFTER-TRANSFER DATA.
RUSKA ZEROES SHOULD BE READ.  SPARGER SHOULD BE OFF.
INSTRUMENT PURGES SHOULD BE SET AT 0.5 SCFH.
SHALL I PROCEED ?  (YES OR NO)
YES
```

After-Transfer (A-T) measurements:
Program states prerequisites
Operator enters YES to activate
A-T measurement data collection

```
*******  MESSAGE FOR TANK 2003 BATCH 108  *******   23-Sep-78  11:08 PM
ENTER RUSKA (LEVEL) ZERO VALUE
-.43
```

Operator enters Ruska (Level) zero value

```
*******  MESSAGE FOR TANK 2003 BATCH 108  *******   23-Sep-78  11:08 PM
ENTER RUSKA (DENSITY) ZERO VALUE
-.11
```

Operator enters Ruska (density) zero value

```
*******  MESSAGE FOR TANK 2003 BATCH 108  *******   23-Sep-78  11:10 PM
PROCESS TEMPERATURE COMPARISION IS OUT-OF-LIMITS
TJR-108-10 =  38.4857   AND   TI-109    =  24.2249
```

Tl-109 bad; TJR OK

```
*******  MESSAGE FOR TANK 2003 BATCH 108  *******   23-Sep-78  11:11 PM
SUPERVISOR IS REQUIRED TO PROCEED.
ENTER PASSWORD
```

Supervisor password entered (non-printing)

```
*******  MESSAGE FOR TANK 2003 BATCH 108  *******   23-Sep-78  11:11 PM
POSSIBLE OPTIONS ARE:  1 = PROCEED WITH MEASUREMENT
                       2 = REMEASURE
ENTER OPTION ( 1 OR 2 )
1
ADVANCE PAPER TO TOP OF PAGE AND <CR>
```

Program provides operator with options.
Operator enters Option 1 and program proceeds with calculation of A-T quantities
Program prints ADVANCE PAPER, etc., indicating A-T calcs. are complete and Batch Summary is ready to print.

BATCH SUMMARY FOR

02003 - 103 23-Sep-78 11:11 PM

	BEFORE RECEIPT	BEFORE SAMPLE	AFTER SAMPLE	AFTER TRANSFER	EXPLANATORY NOTES
					INSTRUMENT READINGS:
LR-125	2.1	121.84	121.84	22.22	Taylor level in "H_2O
LR-125-R	2.78	304.49	304.49	53.887	Ruska level in cmH_2O
ZERO	-.42	-.42	-.4	-.43	Ruska level zero reading-cmH_2O
DR-166	9.08	15.351	15.352	15.331	Taylor density in "H_2O
DR-166-R	-.022	266.115	266.077	15.54	Ruska density-cmH_2O above med. probe
ZERO	-.11	-.09	-.07	-.11	Ruska density zero reading-cmH_2O
TJR-108-10	43.8	39.1	39	38.5	Temperature in °C
TI-109	20.1	24.5	24.7	24.2	Temperature in °C
SAMPLE RESULTS					**ANALYTICAL RESULTS:**
LOG NO.	19689	NA	19722	NA	
DENSITY	1.0114	NA	1.5456	NA	
U (G/L)	-2.348	NA	388.869	NA	
H+	.423	NA	.79	NA	
					SOLUTION QUANTITIES:
VOLUME	19.617	4677.501	4677.178	637.894	
KGS SOLN	19.84	7229.546	7229.045	985.93	

BATCH QUANTITIES:

RECEIVED	4661.265 LITERS	TRANSFERRED	4039.283 LITERS
	7213.124 KGS SOLN		6243.116 KGS SOLN
	1818.975 KGS U		1570.754 KGS U

MEASUREMENT CONTROL COMPARISONS:

PROCESS LEVEL COMPARISION					
	-2.141	-4.554	-4.574	-2.13	Ruska-Taylor in cmH_2O
LAB/PROCESS DENSITY (RUSKA) COMPARISION					In g/ml
	.0112				
TEMPERATURE COMPARISION					
	23.8	14.5	14.3	14.3	In °C (TJR-108-10 minus TI-109)
LAB/PROCESS DENSITY (TAYLOR) COMPARISION					
	.0011				In g/ml
PROCESS DENSITY COMPARISION					
	-.0115	-.0101			Ruska-Taylor in g/ml (Before-sampling and After-sampling)
A.T./B.R. QUANTITY COMPARISION					
	-3.418				In kilograms solution
B.S./A.S. QUANTITY COMPARISION					
	.5				In kilograms solution

******* MESSAGE FOR TANK 2003 BATCH 103 ******* 23-Sep-78 11:13 PM
MEASUREMENT FOR THIS BATCH IS COMPLETE.
CALL ME WHEN READY FOR NEXT BATCH.

EXHIBIT 4-2

PRODUCT MEASUREMENT PROGRAM DIALOGUE
URANIUM PRODUCT SAMPLE TANK - MEASUREMENT POINT 02009

	EXPLANATORY NOTES
BEGIN ENTER MEASUREMENT POINT? 02009 PROGRAM STARTED	Operator enters BEGIN to access measurement programs Operator enters 02009 - Program initializes next U product sample ~~tank~~ batch
Bye	
******* MESSAGE FOR TANK 2009 BATCH 104 ******* 27-Sep-78 10:32 PM ENTER OPERATOR INITIALS JLW	Program assigns sequential batch no. Program compares initials to authorized list
******* MESSAGE FOR TANK 2009 BATCH 104 ******* 27-Sep-78 10:33 PM ENTER SOURCE VESSEL MEASUREMENT POINT ID 02053	Operator enters measurement point no. of product source (U product catch tank)
******* MESSAGE FOR TANK 2009 BATCH 104 ******* 27-Sep-78 10:33 PM ENTER OPERATOR INITIALS JLW	
******* MESSAGE FOR TANK 2009 BATCH 104 ******* 27-Sep-78 10:33 PM I'M READY TO MEASURE BEFORE-SAMPLE DATA. RUSKA ZEROES SHOULD BE READ. SPARGER SHOULD BE OFF. INSTRUMENT PURGES SHOULD BE SET AT 0.5 SCFH. SHALL I PROCEED ? (YES OR NO) YES	Before-Sampling (B-S) Measurements: Program states prerequisites Operator enters YES to activate B-S measurement data collection
******* MESSAGE FOR TANK 2009 BATCH 104 ******* 27-Sep-78 10:34 PM ENTER RUSKA (LEVEL) ZERO VALUE 1.08	Operator enters Ruska (level) zero value
******* MESSAGE FOR TANK 2009 BATCH 104 ******* 27-Sep-78 10:34 PM ENTER RUSKA (DENSITY) ZERO VALUE -.83	Operator enters Ruska (density) zero value
******* MESSAGE FOR TANK 2009 BATCH 104 ******* 27-Sep-78 10:36 PM ENTER OPERATOR INITIALS JKL\LK\LW	Operator authorization check by program
******* MESSAGE FOR TANK 2009 BATCH 104 ******* 27-Sep-78 10:36 PM TANK CONTAINS 8055.64 KG SOLUTION TANK CONTAINS 4757.57 LITERS SOLUTION I'M GOING TO REQUEST LDS TO SAMPLE. SPARGER SHOULD BE OFF. SHALL I PROCEED ? (YES OR NO) YES	Program has completed B-S measurements; calculates and prints B-S quantities. No flags indicate measurement comparisons OK. Program asks operator if he wants sample requested. Operator enters YES. Program sends sample request to LDS, then signs off (non-printing) to wait on sample results from the LDS.

EXHIBIT 4-2
(Continued)

	EXPLANATORY NOTES
******* MESSAGE FOR TANK 2009 BATCH 104 ******* 27-Sep-78 11:31 PM SAMPLING IS COMPLETE. SAMPLE LOG NUMBER IS 20159 RESULTS SHOW DENSITY IS 1.6947 G/ML CONCENTRATION IS 497.162 G URANIUM/LITER SOLUTION AND H+ IS .93 MOLAR.	Sampling analyses completed. LDS sends results to CNMCAS. Program prints results
******* MESSAGE FOR TANK 2009 BATCH 104 ******* 27-Sep-78 11:31 PM ENTER OPERATOR INITIALS JLW	Operator authorization check by Program
******* MESSAGE FOR TANK 2009 BATCH 104 ******* 27-Sep-78 11:32 PM I'M READY TO MEASURE AFTER-SAMPLE DATA. RUSKA ZEROES SHOULD BE READ. SPARGER SHOULD BE OFF. INSTRUMENT PURGES SHOULD BE SET AT 0.5 SCFH.	After-Sampling (A-S) measurements: Program states prerequisites
SHALL I PROCEED ? (YES OR NO) YES	Operator enters YES to activate A-S measurement data collection
******* MESSAGE FOR TANK 2009 BATCH 104 ******* 27-Sep-78 11:32 PM ENTER RUSKA (LEVEL) ZERO VALUE 1.08	Operator enters Ruska (level) zero value
******* MESSAGE FOR TANK 2009 BATCH 104 ******* 27-Sep-78 11:32 PM ENTER RUSKA (DENSITY) ZERO VALUE -.83	Operator enters Ruska (density) zero value
******* MESSAGE FOR TANK 2009 BATCH 104 ******* 27-Sep-78 11:52 PM TANK CONTAINS 8051.62 KG SOLUTION TANK CONTAINS 4751.06 LITERS SOLUTION TANK CONTAINS 2362.04 KG URANIUM YOUR NEXT STEP IS TO MAKE THE TRANSFER.	Program has completed A-S measurements; Calculates and prints A-S quantities No flags indicate measurement comparisons OK
******* MESSAGE FOR TANK 2009 BATCH 104 ******* 27-Sep-78 11:52 PM POSSIBLE OPTIONS ARE: 1 = HOLD 2 = TRANSFER 3 = GO BACK TO B.S. MEASUREMENTS	Program states options available to operator
ENTER OPTION (1, 2, OR 3) 1	Operator is not ready to make transfer; enters Option 1 to put program on HOLD
******* MESSAGE FOR TANK 2009 BATCH 104 ******* 27-Sep-78 11:53 PM TANK IS NOW ON HOLD. CALL BACK WHEN DECISION HAS BEEN MADE.	Program signs off to await recall when decision to transfer is made

EXHIBIT 4-2
(Continued)

	EXPLANATORY NOTES
BEGIN\M\N ENTER MEASUREMENT POINT? 2\2\02009 PROGRAM STARTED	Operator enters BEGIN and 02009 to recall Program
Bye	
******* MESSAGE FOR TANK 2009 BATCH 104 ******* 28-Sep-78 02:09 PM ENTER OPERATOR INITIALS GKW	Operator authorization check by Program
******* MESSAGE FOR TANK 2009 BATCH 104 ******* 28-Sep-78 02:09 PM TANK CONTAINS 8051.62 KG SOLUTION TANK CONTAINS 4751.06 LITERS SOLUTION TANK CONTAINS 2362.04 KG URANIUM YOUR NEXT STEP IS TO MAKE THE TRANSFER.	Program restates A-S quantities
******* MESSAGE FOR TANK 2009 BATCH 104 ******* 28-Sep-78 02:09 PM POSSIBLE OPTIONS ARE: 1 = HOLD 2 = TRANSFER 3 = GO BACK TO B.S. MEASUREMENTS	Program restates options available to operator
ENTER OPTION (1, 2, OR 3) 2	Operator ready to make transfer, enters Option 2
******* MESSAGE FOR TANK 2009 BATCH 104 ******* 28-Sep-78 02:09 PM SUPERVISOR IS REQUIRED TO PROCEED. ENTER PASSWORD	Supervisor password entered (nonprinting) to approve transfer action
******* MESSAGE FOR TANK 2009 BATCH 104 ******* 28-Sep-78 02:10 PM ENTER DESTINATION VESSEL MEASUREMENT POINT ID 02001	Operator entered destination ID; 02001 (Feed Surge Tank)
******* MESSAGE FOR TANK 2009 BATCH 104 ******* 28-Sep-78 02:10 PM CALL BACK WHEN TRANSFER IS COMPLETE AND SPARGER IS OFF. BEGIN ENTER MEASUREMENT POINT? 02009 PROGRAM STARTED	Program signs off to await recall when transfer is completed. TRANSFER complete. Operator enters BEGIN and 02009 to recall program
Bye	
******* MESSAGE FOR TANK 2009 BATCH 104 ******* 28-Sep-78 02:11 PM ENTER OPERATOR INITIALS GKW	Operator check by Program
******* MESSAGE FOR TANK 2009 BATCH 104 ******* 28-Sep-78 02:11 PM I'M READY TO MEASURE AFTER-TRANSFER DATA. RUSKA ZEROES SHOULD BE READ. SPARGER SHOULD BE OFF. INSTRUMENT PURGES SHOULD BE SET AT 0.5 SCFH.	After-Transfer (A-T) measurements Program states prerequisites
SHALL I PROCEED ? (YES OR NO) YES	Operator enters YES to activate A-T measurement data collection
******* MESSAGE FOR TANK 2009 BATCH 104 ******* 28-Sep-78 02:11 PM ENTER RUSKA (LEVEL) ZERO VALUE +1.08	Operator enters Ruska (level) zero value
******* MESSAGE FOR TANK 2009 BATCH 104 ******* 28-Sep-78 02:11 PM ENTER RUSKA (DENSITY) ZERO VALUE -.87	Operator enters Ruska (density) zero value

EXHIBIT 4-2

(Continued)

ADVANCE PAPER TO TOP OF PAGE AND <CR>
CR

BATCH SUMMARY FOR

02009 - 104   28-Sep-78 02:14 PM

	BEFORE RECEIPT	BEFORE SAMPLE	AFTER SAMPLE	AFTER TRANSFER
LR-239	NA	79.5	79.47	24.69
LR-239-R	NA	199.88	199.79	62.55
ZERO	NA	1.08	1.08	1.08
DR-273	NA	17.102	17.104	17.028
DR-273-R	NA	154.877	154.777	17.575
ZERO	NA	-.83	-.83	-.87
TJR-206-17	NA	47.1	47	50.5
SAMPLE RESULTS				
LOG NO.	20099	NA	20158	NA
DENSITY	1.6971	NA	1.6947	NA
U (G/L)	458.943	NA	497.162	NA
H+	2.6	NA	.93	NA
VOLUME	NA	4753.287	4751.061	1086.087
KGS SOLN	NA	8055.395	8051.623	1840.592

RECEIVED 4262.893 LITERS   TRANSFERRED 3664.973 LITERS
7223.148 KGS SOLN   6211.031 KGS SOLN
2138.089 KGS U   1822.084 KGS U

PROCESS LEVEL COMPARISION
NA -3.136 -3.15 -1.23

LAB/PROCESS DENSITY (RUSKA) COMPARISION
.0143

LAB/PROCESS DENSITY (TAYLOR) COMPARISION
.0012

PROCESS DENSITY COMPARISION
-.0132 -.0131

B.S./A.S. QUANTITY COMPARISION
3.7725

******* MESSAGE FOR TANK 2009 BATCH 104 ******* 28-Sep-78 02:15 PM
MEASUREMENT FOR THIS BATCH IS COMPLETE.
CALL ME WHEN READY FOR NEXT BATCH.

EXPLANATORY NOTES

Program prints ADVANCE PAPER, etc. indicating A-T measurements and quantity calculations are complete and Batch Summary is ready to print.
No flags indicate measurement comparisons OK.

INSTRUMENT READINGS:

Taylor level in "H_2O
Ruska level in cmH_2O
Ruska level zero reading-cmH_2O
Taylor density in "H_2O
Ruska density-cmH_2O above med. probe
Ruska density zero reading-cmH_2O
Temperature in °C

ANALYTICAL RESULTS:

SOLUTION QUANTITIES

BATCH QUANTITIES

MEASUREMENT CONTROL COMPARISONS

Ruska-Taylor in cmH_2O
In g/ml

In g/ml

Ruska-Taylor in g/ml (Before-sampling and After-sampling)

In kilograms solution

Program prints batch complete statement

EXHIBIT 4-3

WASTE MEASUREMENT PROGRAM DIALOGUE
HWW SAMPLE TANK - MEASUREMENT POINT 02023

Dialogue	EXPLANATORY NOTES
BEGIN ENTER MEASUREMENT POINT? 02023 PROGRAM STARTED Bye	Operator enters BEGIN to access measurement program Operator enters 02023 - Program initializes next HWW sample tank batch
******* MESSAGE FOR TANK 2023 BATCH 91 ******* 27-Sep-78 03:16 AM ENTER OPERATOR INITIALS WCS	Program assigns sequential batch no. Program compares initials to authorized list
******* MESSAGE FOR TANK 2023 BATCH 91 ******* 27-Sep-78 03:16 AM ENTER SOURCE VESSEL MEASUREMENT POINT ID 02056	Operator enters measurement point no. of waste source (HWW catch tank)
******* MESSAGE FOR TANK 2023 BATCH 91 ******* 27-Sep-78 03:16 AM ENTER OPERATOR INITIALS WCS	
******* MESSAGE FOR TANK 2023 BATCH 91 ******* 27-Sep-78 03:16 AM I'M READY TO MEASURE BEFORE-SAMPLE DATA. SPARGER SHOULD BE OFF. INSTRUMENT PURGES SHOULD BE SET AT 0.5 SCFH. SHALL I PROCEED ? (YES OR NO) YES	Before-Sampling (B-S) measurements: Program states prerequisites Operator enters YES to activate B-S measurement data collection
******* MESSAGE FOR TANK 2023 BATCH 91 ******* 27-Sep-78 03:19 AM PROCESS DENSITY COMPARISION IS MARGINAL DR-430 = 1.22893 AND DR-430-W = 1.24299	Program has collected B-S data. Taylor density comparison marginal- Prompts check of instruments by operator
******* MESSAGE FOR TANK 2023 BATCH 91 ******* 27-Sep-78 03:20 AM ENTER OPERATOR INITIALS WCS	Operator authorization check by program
******* MESSAGE FOR TANK 2023 BATCH 91 ******* 27-Sep-78 03:20 AM TANK CONTAINS 3393.68 KG SOLUTION TANK CONTAINS 2730.26 LITERS SOLUTION I'M GOING TO REQUEST LDS TO SAMPLE. SPARGER SHOULD BE ON. SHALL I PROCEED ? (YES OR NO) YES	Program calculates and prints B-S quantities Program asks operator if he wants sample requested. Operator answers YES. Program sends sample request to LDS, then signs off (non-printing) to wait on sample results from LDS.
******* MESSAGE FOR TANK 2023 BATCH 91 ******* 27-Sep-78 06:09 AM SAMPLING IS COMPLETE. SAMPLE LOG NUMBER IS 20071 RESULTS SHOW DENSITY IS 1.2292 G/ML CONCENTRATION IS 11.3895 G URANIUM/LITER SOLUTION AND H+ IS 6.28 MOLAR.	Sampling, analyses completed. LDS sends results to CNMCAS. Program prints results.
******* MESSAGE FOR TANK 2023 BATCH 91 ******* 27-Sep-78 06:09 AM ENTER OPERATOR INITIALS WCS	Operator authorization check by Program.

EXHIBIT 4-3

(Continued)

EXPLANATORY NOTES

```
******* MESSAGE FOR TANK 2023 BATCH 91 ******* 27-Sep-78 06:09 AM
I'M READY TO MEASURE AFTER-SAMPLE DATA.
SPARGER SHOULD BE OFF.
INSTRUMENT PURGES SHOULD BE SET AT 0.5 SCFH.
SHALL I PROCEED ? (YES OR NO)
YES
```

After-Sampling (A-S) measurements:
Program states prerequisites

Operator enters YES to activate A-S measurement data collection

```
******* MESSAGE FOR TANK 2023 BATCH 91 ******* 27-Sep-78 06:13 AM
PROCESS/LAB DENSITY COMPARISION IS MARGINAL
 DR-430-W = 1.24641 AND LAB ANALYSIS = 1.2292
```

Program has collected A-S data
Westinghouse to Lab density comparison is marginal.
Other measurement comparisons OK

```
******* MESSAGE FOR TANK 2023 BATCH 91 ******* 27-Sep-78 06:13 AM
TANK CONTAINS   3396.06  KG SOLUTION
TANK CONTAINS   2724.69  LITERS SOLUTION
TANK CONTAINS   31033  GRAMS URANIUM
YOUR NEXT STEP IS TO MAKE THE TRANSFER.
```

Program calculates/prints A-S quantities

```
******* MESSAGE FOR TANK 2023 BATCH 91 ******* 27-Sep-78 06:13 AM
POSSIBLE OPTIONS ARE:  1 = HOLD
                       2 = TRANSFER
                       3 = GO BACK TO B.S. MEASUREMENTS
ENTER OPTION ( 1, 2, OR 3 )
2
```

Program states options available to Operator

Operator is ready to make transfer, enters Option 2

```
******* MESSAGE FOR TANK 2023 BATCH 91 ******* 27-Sep-78 06:13 AM
SUPERVISOR IS REQUIRED TO PROCEED.
ENTER PASSWORD
```

Supervisor password entered (nonprinting) to approve transfer action

```
******* MESSAGE FOR TANK 2023 BATCH 91 ******* 27-Sep-78 06:14 AM
ENTER DESTINATION VESSEL MEASUREMENT POINT ID
02029
```

Operator enters destination ID-02029 (sump collection tank - waste to be reworked - high in uranium)

```
******* MESSAGE FOR TANK 2023 BATCH 91 ******* 27-Sep-78 06:14 AM
CALL BACK WHEN TRANSFER IS COMPLETE AND SPARGER IS OFF.
```

Program signs off to await recall when transfer is completed

```
BEGIBN\NB\N
ENTER MEASUREMENT POINT? 02023
PROGRAM STARTED

Bye
```

Transfer complete. Operator enters BEGIN and 02023 to recall program

```
******* MESSAGE FOR TANK 2023 BATCH 91 ******* 27-Sep-78 07:48 AM
ENTER OPERATOR INITIALS
WCS
```

Operator authorization check by program

```
******* MESSAGE FOR TANK 2023 BATCH 91 ******* 27-Sep-78 07:48 AM
I'M READY TO MEASURE AFTER-TRANSFER DATA.
SPARGER SHOULD BE OFF.
INSTRUMENT PURGES SHOULD BE SET AT 0.5 SCFH.
SHALL I PROCEED ? (YES OR NO)
YES
ADVANCE PAPER TO TOP OF PAGE AND <CR>
```

After-Transfer (A-T) measurements:
Program states prerequisites

Operator enters YES to activate A-T measurement data collection
Program prints ADVANCE PAPER, etc. indicating A-T measurements and quantity calculations are complete and Batch Summary is ready to print. No flags indicate measurement comparisons OK.

EXHIBIT 4-3
(Continued)

EXPLANATORY NOTES

BATCH SUMMARY FOR

02023 - 91 27-Sep-78 07:50 AM

	BEFORE RECEIPT	BEFORE SAMPLE	AFTER SAMPLE	AFTER TRANSFER	
					INSTRUMENT READINGS:
LR-419	NA	156.17	156.2	16.53	Taylor level in "H_2O
LR-419-W	NA	154.245	154.339	15.415	Westinghouse level in "H_2O
DR-430	NA	11.675	11.701	11.693	Taylor density in "H_2O
DR-430-W	NA	11.808	11.841	11.819	Westinghouse density in "H_2O
TJR-414-5	NA	52.4	51.5	51.2	Temperature in °C
SAMPLE RESULTS					**ANALYTICAL RESULTS:**
LOG NO.	19948	NA	20071	NA	
DENSITY	1.2555	NA	1.2292	NA	
U (G/L)	16.5	NA	11.39	NA	
H+	7.19	NA	6.28	NA	
VOLUME	NA	2730.264	2724.694	387.805	**SOLUTION QUANTITIES**
KGS SOLN	NA	3393.684	3396.082	483.363	

BATCH QUANTITIES

RECEIVED	2395.367 LITERS	TRANSFERRED	2336.889 LITERS
	2978.348 KGS SOLN		2912.719 KGS SOLN
	25599.061 GRAMS U		26616.049 GRAMS U

MEASUREMENT CONTROL COMPARISONS

PROCESS LEVEL COMPARISION
NA -1.927 -1.865 -1.117 — Westinghouse-Taylor in "H_2O

LAB/PROCESS DENSITY (WESTINGHOUSE) COMPARISION
-.0172 — In g/ml

LAB/PROCESS DENSITY (TAYLOR) COMPARISION
NA — (NA - program omission)

PROCESS DENSITY COMPARISION
.0141 .0147 — Westinghouse-Taylor in g/ml (Before-sampling and After-sampling)

B.S./A.S. QUANTITY COMPARISION
-2.3975 — In kilograms solution

******* MESSAGE FOR TANK 2023 BATCH 91 ******* 27-Sep-78 07:51 AM — Program prints batch complete statement
MEASUREMENT FOR THIS BATCH IS COMPLETE.
CALL ME WHEN READY FOR NEXT BATCH.
RATES

EXHIBIT 4-4

WASTE MEASUREMENT PROGRAM DIALOGUE
GPW CHECK TANK - MEASUREMENT POINT 02028

Dialogue	EXPLANATORY NOTES
BEGIN	Operator entry to access measurement program
ENTER MEASUREMENT POINT? 02028	Operator enters 02028 which initializes next GPW check tank batch
PROGRAM STARTED	
Bye	
******* MESSAGE FOR TANK 2028 BATCH 320 ******* 12-Sep-78 04:29 PM	Program assigns sequential batch no.
ENTER OPERATOR INITIALS	Program compares initials to authorized list
WCS	
******* MESSAGE FOR TANK 2028 BATCH 320 ******* 12-Sep-78 04:30 PM	
ENTER SOURCE VESSEL MEASUREMENT POINT ID	Operator enters measurement point of waste source
02127	
******* MESSAGE FOR TANK 2028 BATCH 320 ******* 12-Sep-78 04:30 PM	
ENTER OPERATOR INITIALS	
WCS	
******* MESSAGE FOR TANK 2028 BATCH 320 ******* 12-Sep-78 04:30 PM	
I'M READY TO MEASURE BEFORE-SAMPLE DATA.	Before-Sampling (B-S) measurements:
SPARGER SHOULD BE OFF.	Program states prerequisites
INSTRUMENT PURGES SHOULD BE SET AT 0.5 SCFH.	
SHALL I PROCEED ? (YES OR NO)	Operator enters YES to activate B-S measurement data collection
YES	Program indicates data collection is complete
******* MESSAGE FOR TANK 2028 BATCH 320 ******* 12-Sep-78 04:33 PM	
ENTER OPERATOR INITIALS	
WCS	
******* MESSAGE FOR TANK 2028 BATCH 320 ******* 12-Sep-78 04:33 PM	Program calculates/prints B-S quantities
TANK CONTAINS 680.331 KG SOLUTION	
TANK CONTAINS 539.8 LITERS SOLUTION	
I'M GOING TO REQUEST LDS TO SAMPLE. SPARGER SHOULD BE ON.	CNMCAS-LDS link not in service. Operator enters NO. Must
SHALL I PROCEED ? (YES OR NO)	manually input analytical data when available
NO	
******* MESSAGE FOR TANK 2028 BATCH 320 ******* 12-Sep-78 04:34 PM	
SPARGER IN CR (HC-420)	Program signs off to wait on sampling instructions
PURGES AT W816 EL292	
I'LL WAIT TO HEAR FROM YOU.	

EXHIBIT 4-4
(Continued)

Terminal output	EXPLANATORY NOTES
BEGIN ENTER MEASUREMENT POINT? 02028 PROGRAM STARTED	Program callup by operator
Bye	
******* MESSAGE FOR TANK 2028 BATCH 320 ******* 12-Sep-78 08:11 PM ENTER OPERATOR INITIALS WCS	Operator authorization check by Program
******* MESSAGE FOR TANK 2028 BATCH 320 ******* 12-Sep-78 08:12 PM !!!!! LDS SIMULATOR !!!!! ENTER LOG NUMBER 18845 ENTER DENSITY 1.2702 ENTER ACID 7.92 ENTER U CONC (G/L) 4.5 ENTER TEMPERATURE 25	Manual analytical data entry by Operator
******* MESSAGE FOR TANK 2028 BATCH 320 ******* 12-Sep-78 08:13 PM SAMPLING IS COMPLETE. SAMPLE LOG NUMBER IS 18845 RESULTS SHOW DENSITY IS 1.2702 G/ML CONCENTRATION IS 4.5 G URANIUM/LITER SOLUTION AND H+ IS 7.92 MOLAR.	Analytical data statement by Program
******* MESSAGE FOR TANK 2028 BATCH 320 ******* 12-Sep-78 08:13 PM ENTER OPERATOR INITIALS WCS	Operator authorization check by Program
******* MESSAGE FOR TANK 2028 BATCH 320 ******* 12-Sep-78 08:13 PM I'M READY TO MEASURE AFTER-SAMPLE DATA. SPARGER SHOULD BE OFF. INSTRUMENT PURGES SHOULD BE SET AT 0.5 SCFH. SHALL I PROCEED ? (YES OR NO) YES	After-Sampling (A-S) measurements: Program states prerequisites Operator enters YES to activate A-S measurement data collection
******* MESSAGE FOR TANK 2028 BATCH 320 ******* 12-Sep-78 08:16 PM TANK CONTAINS 683.191 KG SOLUTION TANK CONTAINS 538.961 LITERS SOLUTION TANK CONTAINS 2425.32 GRAMS URANIUM YOUR NEXT STEP IS TO MAKE THE TRANSFER.	Program calculates/prints A-S quantities
******* MESSAGE FOR TANK 2028 BATCH 320 ******* 12-Sep-78 08:16 PM POSSIBLE OPTIONS ARE: 1 = HOLD 2 = TRANSFER 3 = GO BACK TO B.S. MEASUREMENTS	Program provides options to Operator
ENTER OPTION (1, 2, OR 3) 2	Operator selects transfer option
******* MESSAGE FOR TANK 2028 BATCH 320 ******* 12-Sep-78 08:17 PM SUPERVISOR IS REQUIRED TO PROCEED. ENTER PASSWORD	Supervisor password entered (nonprinting) to approve transfer action
******* MESSAGE FOR TANK 2028 BATCH 320 ******* 12-Sep-78 08:17 PM ENTER DESTINATION VESSEL MEASUREMENT POINT ID 02021	Program signs off to wait on completion of transfer
******* MESSAGE FOR TANK 2028 BATCH 320 ******* 12-Sep-78 08:17 PM CALL BACK WHEN TRANSFER IS COMPLETE AND SPARGER IS OFF.	

EXHIBIT 4-4

(Continued)

```
BEGIN
ENTER MEASUREMENT POINT? 02028
PROGRAM STARTED

Bye

*******  MESSAGE FOR TANK 2028 BATCH 320  *******   13-Sep-78  12:56 AM
ENTER OPERATOR INITIALS
WCS

*******  MESSAGE FOR TANK 2028 BATCH 320  *******   13-Sep-78  12:56 AM
I'M READY TO MEASURE AFTER-TRANSFER DATA.
SPARGER SHOULD BE OFF.
INSTRUMENT PURGES SHOULD BE SET AT 0.5 SCFH.
SHALL I PROCEED ?  (YES OR NO)
YES
RADVANCE PAPER TO TOP OF PAGE AND <CR>
```

EXPLANATORY NOTES

Program callup by Operator (Transfer has been completed)

Operator authorization check by Program

After-Transfer measurements:
Program states prerequisites

Operator enters YES to activate A-T measurement data collection

Program prints ADVANCE PAPER etc. indicating A-T measurements are complete, comparisons are satisfactory and Batch Summary is ready to print.

EXHIBIT 4-4
(Continued)

BATCH SUMMARY FOR

02028 - 320 13-Sep-78 12:59 AM

	BEFORE RECEIPT	BEFORE SAMPLE	AFTER SAMPLE	AFTER TRANSFER	EXPLANATORY NOTES
					INSTRUMENT READINGS:
LR-412	NA	46.65	46.96	6.26	Taylor level in "H_2O
LR-412-W	NA	46.585	46.784	7.121	Westinghouse level in "H_2O
DR-416	NA	12.479	12.544	7.9	Taylor density in "H_2O
DR-416-W	NA	12.427	12.499	7.694	Westinghouse density in "H_2O
TJR-415-7	NA	52.7	47.8	43.4	Temperature in °C
SAMPLE RESULTS					**ANALYTICAL RESULTS:**
LOG NO.	18786	NA	18845	NA	
DENSITY	1.2204	NA	1.2702	NA	
U (G/L)	6.8	NA	4.5	NA	U mislabled; should be mg/g
H+	5.49	NA	7.92	NA	
					SOLUTION QUANTITIES:
VOLUME	NA	539.8	538.961	60.958	
KGS SOLN	NA	680.331	683.191	77.271	

RECEIVED 259.397 LITERS
343.221 KGS SOLN
524.292 GRAMS U

TRANSFERRED 478.002 LITERS
605.92 KGS SOLN
2151.011 GRAMS U

BATCH QUANTITIES: U quantities in error; mg/g conc. multiplied by volume instead of mass

MEASUREMENT CONTROL COMPARISONS:

PROCESS LEVEL COMPARISION
NA -.067 -.173 .864 — in "H_2O

LAB/PROCESS DENSITY (WESTINGHOUSE) COMPARISION
.0026 — in g/ml

LAB/PROCESS DENSITY (TAYLOR) COMPARISION
NA — (NA - program omission)

PROCESS DENSITY COMPARISION
-.0053 -.0046 — Westinghouse-Taylor in g/ml (Before-sampling and After-sampling)

B.S./A.S. QUANTITY COMPARISION
-2.8608 — in kilograms solution

******* MESSAGE FOR TANK 2028 BATCH 320 ******* 13-Sep-78 01:01 AM
MEASUREMENT FOR THIS BATCH IS COMPLETE.
CALL ME WHEN READY FOR NEXT BATCH.

Program prints batch complete statement

EXHIBIT 4-5

MEASUREMENT PROGRAM STATUS REPORT

STAT

MEAS_REMENT PROGRAM STATUS

AS O= 27-Sep-78 02:49 AM

TANK ID	BATCH #	INITIAL	BR	BS	SAMPLE	AS	TRANSFER	AT
02003	111	F	F					
02009	101	F	NA	F	F	F	F	
02023	90	F	NA	F	F	F	F	F
02028	353	F	NA					

Bye

EXPLANATORY NOTES

Operator enter STAT whenever a printed measurement program status is desired.

STATUS program prints report.

02003 - BR measurements completed;
- BS measurements next step

02009 - Transfer in progress
- At measurements next step

02023 - Batch No. 90 completed;

02023 - Batch 353 initialized
- BS measurements next step

EXPLANATORY NOTES (CONTINUED)

(1) Tank ID - 02003, Accountability Tank (input)
- 02009, Uranium Product Sample Tank (product)
- 02023, HWW Sample Tank (waste)
- 02028, EPW Check Tank (waste)

(2) Batch # - sequential batch number assigned by Programs

(3) INITIAL - new batch initialized (started)

(4) BR — Before-Receipt measurements

(5) BS — Before-Sampling measurements

(6) Sample - Sample requested

(7) AS - After-Sampling measurements

(8) Transfer -- Batch Transfer in progress

(9) AT -- After-Transfer measurements

EXHIBIT 4-6

NMC - ACCOUNTING
INPUT/OUTPUT REPORT FOR MEASUREMENT POINT 02003
DATE OF REPORT--18-Oct-78

LOT NO.	BATCH NO.	MANUAL CHANGE	AS DATE	LOG NO.	CODE	BATCH NO.	REC. FROM	U-CONC MG-U/G	QUANTITY RECEIVED LITERS	QUANTITY RECEIVED KG SOLUT.	QUANTITY RECEIVED U-CONTENT	QUANTITY TRANSFERRED LITERS	QUANTITY TRANSFERRED KG SOLUT.	QUANTITY TRANSFERRED U-CONTENT	DEST.
BEGINNING INVENTORY									568.5	856.4	211.612				
2	83		5 9 78	18225	F	76	2009	250.300	3635.8	5495.4	1378.234	3605.8	5446.8	1363.331	2006
2	84		8 9 78	18384	F	77	2009	227.100	4393.6	6571.7	1471.436	4350.9	6515.3	1479.635	2005
2	85		8 9 78	18432	F	78	2009	244.010	4226.0	6368.5	1570.230	4384.0	6601.0	1610.699	2006
2	86		9 9 78	18463	F	79	2009	254.100	4155.7	6365.4	1624.813	4053.9	6198.7	1575.091	2005
2	87		9 9 78	18533	F	80	2009	240.000	4228.4	6366.8	1515.404	4348.1	6559.6	1574.313	2006
2	88		10 9 78	18593	F	81	2009	227.300	4860.1	7304.9	1651.489	4700.5	7067.0	1606.332	2005
2	89		10 9 78	18624	F	82	2009	224.000	4925.7	7306.0	1633.435	4937.7	7335.2	1643.095	2006
2	90		11 9 78	18649	F	83	2009	231.900	5175.6	7665.5	1784.837	5186.2	7683.8	1781.873	2006
2	91		11 9 78	18689	F	84	2009	249.600	4563.5	6974.0	1756.509	4608.0	7017.5	1751.576	2005
2	92		11 9 78	18721	F	85	2009	241.100	4022.0	5990.0	1436.964	4023.4	6009.1	1448.793	2006
2	93		12 9 78	18785	F	86	2009	246.500	4537.5	6908.7	1707.491	4669.5	7096.9	1749.377	2005
2	94		12 9 78	18825	F	87	2009	260.200	4303.0	6658.3	1741.288	4237.1	6543.7	1702.660	2006
2	95		13 9 78	18904	F	88	2009	252.100	4277.3	6489.8	1629.953	4302.2	6540.1	1648.758	2006
2	96		13 9 78	18597	F	89	2009	255.300	3889.3	5884.7	1504.629	3874.7	5865.6	1497.497	2005
2	97		13 9 78	19003	F	90	2009	255.100	4582.9	6943.0	1771.018	4437.8	6722.6	1714.924	2006
2	98		14 9 78	19048	F	91	2009	263.600	4778.3	7414.8	1962.589	4833.7	7480.7	1971.907	2005
2	99	C	14 9 78	19163	F	92	2009	255.400	4466.1	6806.5	1731.150	4250.0	6488.2	1657.089	2006
2	100		15 9 78	19205	F	93	2009	258.100	4447.8	6856.7	1772.947	4580.1	7050.0	1819.616	2005
2	101		15 9 78	19267	F	94	2009	253.700	4354.3	6636.4	1679.228	4385.1	6692.0	1697.771	2006
2	102		16 9 78	19334	F	95	2009	245.800	4910.3	7352.0	1799.609	5046.7	7572.5	1861.311	2006
2	103		17 9 78	19412	F	96	2009	233.600	4746.9	7138.8	1658.724	5216.2	7842.8	1832.072	2005
LOT TOTALS 2	83 -	103			F				93479.8	141497.8	34781.973	94031.6	142329.1	34987.723	
LOT TOTALS 2	83 -	103			F				0.0	0.0	0.000	0.0	0.0	0.000	
LOTS 2 - 2					F		2009		93479.8	141497.8	34781.977	94031.6	142329.1	34987.719	2006
SUB TOTAL					F				93479.8	141497.8	34781.977	94031.6	142329.1	34987.719	
SUB TOTAL					P				0.0	0.0	0.000	0.0	0.0	0.000	
TOTAL									93479.8	141497.8	34781.977	94031.6	142329.1	34987.719	
ENDING BALANCE												16.7	25.1	5.871	

EXHIBIT 4-7

NMC - ACCOUNTING
INPUT/OUTPUT REPORT FOR MEASUREMENT POINT 02009
DATE OF REPORT--18-Oct-78

LOT NO.	BATCH NO.	MANUAL CHANGE	AS DATE	LOG NO.	CODE	BATCH NO.	REC. FROM	U-CONC MG-U/G	QUANTITY RECEIVED LITERS	QUANTITY RECEIVED KG SOLUT.	QUANTITY RECEIVED U-CONTENT	QUANTITY TRANSFERRED LITERS	QUANTITY TRANSFERRED KG SOLUT.	QUANTITY TRANSFERRED U-CONTENT	DEST.
BEGINNING INVENTORY									562.5	846.5	313.890				
2	76		5 9 78	17789	F	76	2007	248.990	3615.6	5460.6	1256.518	3616.9	5460.4	1259.580	2003
2	77		7 9 78	18368	F	78	2053	223.500	4402.0	6561.8	1444.976	4422.3	6601.5	1475.427	2003
2	78		8 9 78	18405	F	79	2053	246.010	4163.3	6367.3	1584.592	4147.3	6325.6	1556.170	2003
2	79		8 9 78	18451	F	79	2053	254.130	4206.3	6431.9	1641.422	4207.4	6431.7	1634.480	2003
2	80		9 9 78	18493	F	80	2053	236.870	4240.3	6365.3	1493.087	4289.4	6453.0	1528.514	2003
2	81		9 9 78	18555	F	81	2053	225.050	4917.1	7387.7	1653.598	4857.7	7299.3	1642.718	2003
2	82		10 9 78	18592	F	82	2053	223.600	4932.3	7304.0	1631.937	4925.1	7304.1	1633.201	2003
2	83		10 9 78	18627	F	83	2053	232.200	5173.0	7658.6	1785.622	5172.9	7659.8	1778.606	2003
2	84		11 9 78	18650	F	84	2053	249.400	4554.6	6987.1	1757.167	4571.4	6985.7	1742.245	2003
2	85		11 9 78	18681	F	85	2053	237.900	4044.6	5995.0	1416.453	4029.2	5994.0	1425.979	2003
2	86		11 9 78	18742	F	86	2053	246.100	4497.9	6877.2	1699.448	4511.5	6877.6	1692.577	2029
2	87		12 9 78	18788	F	87	2053	260.120	4280.5	6639.7	1739.038	4289.0	6639.5	1727.079	2003
2	88		12 9 78	18847	F	88	2053	254.020	4273.7	6485.9	1642.364	4265.4	6487.3	1647.913	2003
2	89		13 9 78	18905	F	89	2053	252.710	4008.4	6057.3	1529.619	4003.5	6055.4	1530.273	2003
2	90		13 9 78	18976	F	90	2053	253.570	4579.6	6940.0	1760.507	4580.4	6939.5	1759.654	2003
2	91		14 9 78	19027	F	91	2053	267.050	4761.5	7409.9	1990.277	4775.1	7410.7	1979.040	2003
2	92		14 9 78	19147	F	92	2053	252.550	4477.2	6798.2	1704.566	4467.9	6800.0	1717.346	2003
2	93		15 9 78	19164	F	93	2053	258.150	4642.9	7170.5	1855.822	4649.1	7169.2	1850.719	2003
2	94		15 9 78	19230	F	94	2053	252.900	4354.4	6630.0	1672.275	4348.0	6629.6	1676.632	2003
2	95		15 9 78	19277	F	95	2053	244.820	4894.0	7370.2	1797.508	4898.9	7373.6	1805.201	2003
2	96		16 9 78	19363	F	96	2053	233.240	4920.1	7151.4	1658.181	4892.1	7149.5	1667.560	2003
LOT TOTALS 2	76 - 96				F				93939.3	142049.5	34714.980	93920.6	142047.3	34830.918	
LOT TOTALS 2	76 - 96				F				0.0	0.0	0.000	0.0	0.0	0.000	
LOTS 2 - 2					F		2007		93939.3	142049.5	34714.980	93920.6	142047.3	34830.918	2003
SUB TOTAL					F				93939.3	142049.5	34714.980	93920.6	142047.3	34830.918	
SUB TOTAL					P				0.0	0.0	0.000	0.0	0.0	0.000	
TOTAL									93939.3	142049.5	34714.980	93920.6	142047.3	34830.918	
ENDING BALANCE												581.2	848.7	197.953	

EXHIBIT 4-8

NMC LINE PRINTER - MEASUREMENT MESSAGE

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*******  MESSAGE FOR TANK 2003 BATCH 109  *******    24-Sep-78  07:08 AM
TRANSFER QUANTITY COMPARISION IS OUT-OF-LIMITS
YOU SHOULD HAVE   6515.07   KG SOLUTION AND
TANK CONTAINS   6536.16   KG SOLUTION
```

EXHIBIT 4-9

BATCH SUMMARY REPORTS - NMC LINE PRINTER

BATCH SUMMARY FOR

02009 - 94   15-Sep-78 12:32 PM

	BEFORE RECEIPT	BEFORE SAMPLE	AFTER SAMPLE	AFTER TRANSFER
LR-239	NA	73. 82	73. 86	13. 27
LR-239-R	NA	185. 223	185. 452	33. 487
ZERO	NA	. 73	. 73	. 73
DR-273	NA	15. 669	15. 71	12. 98
DR-273-R	NA	144. 69	144. 667	-. 413
ZERO	NA	-. 54	-. 54	-. 42
TJR-206-17	NA	34. 1	34. 8	35. 5
SAMPLE RESULTS				
LOG NO.	19164	NA	19230	NA
DENSITY	1. 5479	NA	1. 5316	NA
U (G/L)	397. 78	NA	380. 063	NA
H+	. 49	NA	. 72	NA
VOLUME	NA	4883. 615	4889. 715	554. 619
KGS SOLN	NA	7479. 745	7489. 087	849. 455

RECEIVED	4335. 055 LITERS	TRANSFERRED	4335. 096 LITERS
	6630. 528 KGS SOLN		6639. 633 KGS SOLN
	1637. 377 KGS U		1647. 612 KGS U

BATCH SUMMARY FOR

020[illegible]3 - 10[illegible]   15-Sep-78 06:28 PM

	BEFORE RECEIPT	BEFORE SAMPLE	AFTER SAMPLE	AFTER TRANSFER
LR-125	22. 6	128. 44	128. 49	21. 7
LR-125-R	54. 69	320. 89	320. 917	52. 307
ZERO	-. 36	-. 34	-. 34	-. 35
DR-166	15. 378	15. 214	15. 281	15. 283
DR-166-R	16. 18	282. 805	282. 642	14. 035
ZERO	-. 12	-. 09	-. 08	-. 11
TJR-108-10	35. 5	35. 1	35. 3	35. 6
TI-109	28. 9	26. 9	28	29
SAMPLE RESULTS				
LOG NO.	19205	NA	19267	NA
DENSITY	1. 5464	NA	1. 5337	NA
U (G/L)	396. 417	NA	384. 871	NA
H+	. 5	NA	. 585	NA
VOLUME	649. 124	4981. 266	4981. 713	617. 977
KGS SOLN	1003. 805	7639. 768	7640. 454	947. 791

RECEIVED	4332. 302 LITERS	TRANSFERRED	4363. 737 LITERS
	6636. 209 KGS SOLN		6692. 663 KGS SOLN
	1659. 883 KGS U		1679. 475 KGS U

EXHIBIT 4-10

NMC - ACCOUNTING
INPUT/OUTPUT REPORT FOR MEASUREMENT POINT 02003
DATE OF REPORT--20-Oct-78

LOT NO.	BATCH NO.	MANUAL CHANGE	AS DATE	LOG NO.	CODE	BATCH NO.	REC. FROM	U-CONC MG-U/G	QUANTITY RECEIVED LITERS	QUANTITY RECEIVED KG SOLUT.	QUANTITY RECEIVED U-CONTENT	QUANTITY TRANSFERRED LITERS	QUANTITY TRANSFERRED KG SOLUT.	QUANTITY TRANSFERRED U-CONTENT	DEST.
BEGINNING INVENTORY									568.5	356.4	211.612				
2	83		5 9 78	18225	F	76	2009	250.300	3635.8	5495.4	1378.234	3605.8	5446.8	1363.331	2006
2	84		8 9 78	18384	F	77	2009	227.100	4393.6	6571.7	1471.436	4350.9	6515.3	1479.635	2005
2	85		8 9 78	18432	F	78	2009	244.010	4226.0	6368.5	1570.230	4384.0	6601.0	1610.699	2006
2	86		9 9 78	18463	F	79	2009	254.100	4155.7	6365.4	1624.813	4053.9	6198.7	1575.091	2005
2	87		9 9 78	18533	F	80	2009	240.000	4226.4	6366.8	1515.404	4348.1	6559.6	1574.313	2006
2	88		10 9 78	18593	F	81	2009	227.300	4860.1	7304.9	1651.489	4700.5	7067.0	1606.332	2005
2	89		10 9 78	18624	F	82	2009	224.000	4925.7	7306.0	1633.435	4937.7	7335.2	1643.095	2006
2	90		11 9 78	18649	F	83	2009	231.900	5175.6	7665.5	1784.837	5186.2	7683.8	1781.873	2006
2	91		11 9 78	18689	F	84	2009	249.600	4563.5	6974.0	1756.509	4608.0	7017.5	1751.576	2005
2	92		11 9 78	18721	F	85	2009	241.100	4022.0	5990.0	1436.964	4023.4	6009.1	1448.793	2006
2	93		12 9 78	18785	F	86	2009	246.500	4537.5	6908.7	1707.491	4669.5	7096.9	1749.377	2005
2	94		12 9 78	18825	F	87	2009	260.200	4303.0	6658.3	1741.288	4237.1	6543.7	1702.660	2006
2	95		13 9 78	18904	F	88	2009	252.100	4277.3	6489.8	1629.953	4302.2	6540.1	1648.758	2006
2	96		13 9 78	18597	F	89	2009	255.300	3889.3	5884.7	1504.629	3874.7	5865.6	1497.497	2005
2	97		13 9 78	19003	F	90	2009	255.100	4582.9	6943.0	1771.018	4437.8	6722.6	1714.924	2006
2	98		14 9 78	19048	F	91	2009	263.600	4778.3	7414.8	1962.589	4833.7	7480.7	1971.907	2005
2	99	C	14 9 78	19163	F	92	2009	255.400	4466.1	6806.5	1731.150	4250.0	6488.2	1657.089	2006
2	100		15 9 78	19205	F	93	2009	258.100	4447.8	6856.7	1772.947	4580.1	7050.0	1819.616	2005
2	101		15 9 78	19267	F	94	2009	253.700	4354.3	6636.4	1679.228	4385.1	6692.0	1697.771	2006
2	102		16 9 78	19334	F	95	2009	245.800	4910.3	7352.0	1799.609	5046.7	7572.5	1861.311	2006
2	103		17 9 78	19412	F	96	2009	233.600	4746.9	7138.8	1658.724	5216.2	7842.8	1832.072	2005
LOT TOTALS 2	83 -	103			F				93479.8	141497.8	34781.973	94031.6	142329.1	34987.723	
3	104		22 9 78	19635	F	104	2003	4.560	931.7	1228.3	-0.151	934.5	1235.0	5.632	2002
3	105		23 9 78	19645	F	105	2001	0.040	7133.0	7226.7	0.206	6384.2	6471.7	0.259	2029
3	106		23 9 78	19667	F	106	2001	0.020	6418.2	6451.8	0.114	7165.6	7209.8	0.144	2029
3	107		23 9 78	19689	F	107	2001	0.020	7704.1	7738.3	0.155	7703.1	7737.3	0.155	2029
3	108		23 9 78	19722	F	97	2009	253.200	4696.1	7215.8	1831.198	4068.7	6243.9	1580.963	2006
3	109		24 9 78	19756	F	98	2009	251.400	3551.7	5529.4	1388.314	3629.5	5637.9	1417.376	2005
3	110		24 9 78	19812	F	99	2009	294.400	3889.0	6582.5	1975.714	3916.3	6560.0	1931.255	2006
3	111		27 9 78	20109	F	100	2009	210.700	4335.9	6124.2	1214.843	4431.4	6386.0	1345.540	2006
3	112		27 9 78	20160	F	102	2009	238.600	3815.5	5817.9	1406.012	3342.2	5067.6	1209.127	2005
3	113		28 9 78	20203	F	103	2009	187.800	3771.0	5144.3	895.460	4246.5	5918.7	1111.537	2005

3	104 - 113															
LOT TOTALS						F				46246.2	59059.2	8711.864	45822.0	58468.0	8601.988	
4	114	28	9	78	20249	F	105	2009	256.000	5845.5	9159.5	2386.865	5648.9	8784.3	2248.771	2006
4	115	29	9	78	20275	F	115	2001	189.500	4649.1	6410.8	1148.901	4671.2	6539.9	1239.314	2005
4	116	29	9	78	20340	F	107	2009	232.700	5482.3	8244.0	1955.638	5422.1	8096.4	1884.031	2006
4	117	29	9	78	20374	F	117	2001	162.600	5388.3	7130.5	1088.617	5342.2	7169.7	1165.787	2005
4	118	30	9	78	20403	F	118	2001	142.300	5846.0	7581.8	1059.179	5803.2	7555.7	1075.178	2005
4	119	30	9	78	20435	F	119	2001	127.600	1120.2	1370.4	160.203	1402.9	1758.8	224.422	2006
4	120	30	9	78	20472	F	120	2001	13.180	5613.1	5561.5	3.679	5266.6	5331.2	70.266	2006
4	121	1	10	78	20494	F	121	2001	1.492	7814.9	7788.6	1.813	7814.2	7799.3	11.633	2005
4	122	1	10	78	20530	F	122	2001	5.832	6293.6	6439.3	41.148	6193.5	6318.0	36.847	2006
4	123	1	10	78	20554	F	123	2001	4.000	4430.4	4542.7	16.432	4900.3	5020.2	20.081	2006
4	124	2	10	78	20568	F	124	2029	1.410	426.7	457.0	-0.577	454.1	473.9	0.668	2005
4	125	3	10	78	20602	F	125	2001	1.247	33038.8	2712.5	3.309	26799.5	2512.5	3.133	2006
4	126	4	10	78	20696	F	114	2009	4.350	-4670.4	1347.6	7.894	1990.0	1991.8	8.664	2029
4	127	5	10	78	20707	F	127	2001	0.426	1111.7	1101.4	0.427	1110.8	1100.6	0.469	2029
4	114 - 127															
LOT TOTALS						F				82390.3	69847.5	7873.525	82819.6	70452.3	7989.265	
LOTS 2 - 4																
						F		2009		124196.5	196663.1	47843.914	130727.2	197015.7	47724.984	
						F		2003		931.7	1228.3	-0.151	934.5	1235.0	5.632	
						F		2029		426.7	457.0	-0.577	454.1	473.9	0.668	
						F		2001		96561.4	72056.1	3524.182	90557.3	72524.7	3847.688	
SUB TOTAL						F				222116.3	270404.6	51367.367	222673.2	271249.4	51578.977	
SUB TOTAL						P				0.0	0.0	0.000	0.0	0.0	0.000	
TOTAL										222116.3	270404.6	51367.367	222673.2	271249.4	51578.977	
ENDING BALANCE													11.6	11.6	0.004	

4-10

EXHIBIT 4-11

NMC — ACCOUNTING
INPUT/OUTPUT REPORT FOR MEASUREMENT POINT 02009
DATE OF REPORT--20-Oct-78

LOT NO.	BATCH NO.	MANUAL CHANGE	AS DATE	LOG NO.	CODE	BATCH NO.	REC. FROM	U-CONC MG-U/G	QUANTITY RECEIVED LITERS	QUANTITY RECEIVED KG SOLUT.	QUANTITY RECEIVED U-CONTENT	QUANTITY TRANSFERRED LITERS	QUANTITY TRANSFERRED KG SOLUT.	QUANTITY TRANSFERRED U-CONTENT	DEST.
BEGINNING INVENTORY									0.0	0.0	0.000				
2	76		5 9 78	17789	F	76	2007	248.990	4178.1	6307.1	1570.408	3616.9	5460.4	1359.580	2003
2	77		7 9 78	18368	F	78	2053	223.500	4402.0	6561.8	1444.976	4422.3	6601.5	1475.427	2003
2	78		8 9 78	18405	F	79	2053	246.010	4163.3	6367.3	1584.592	4147.3	6325.6	1556.170	2003
2	79		8 9 78	18451	F	79	2053	254.130	4206.3	6431.9	1641.422	4207.4	6431.7	1634.480	2003
2	80		9 9 78	18498	F	80	2053	236.870	4240.3	6365.3	1493.087	4289.4	6453.0	1528.514	2003
2	81		9 9 78	18555	F	81	2053	225.050	4917.1	7387.7	1653.598	4857.7	7299.3	1642.718	2003
2	82		10 9 78	18592	F	82	2053	223.600	4932.3	7304.0	1631.937	4925.1	7304.1	1633.201	2003
2	83		10 9 78	18627	F	83	2053	232.200	5173.0	7658.6	1785.622	5172.9	7659.8	1778.606	2003
2	84		11 9 78	18650	F	84	2053	249.400	4554.6	6987.1	1757.167	4571.4	6985.7	1742.245	2003
2	85		11 9 78	18681	F	85	2053	237.900	4044.6	5995.0	1416.453	4029.2	5994.0	1425.979	2003
2	86		11 9 78	18742	F	86	2053	246.100	4497.9	6877.2	1699.448	4511.5	6877.6	1692.577	2003
2	87		12 9 78	18788	F	87	2053	260.120	4280.5	6639.7	1739.038	4289.0	6639.5	1727.079	2003
2	88		12 9 78	18847	F	88	2053	254.020	4273.7	6485.9	1642.364	4265.4	6487.3	1647.913	2003
2	89		13 9 78	18905	F	89	2053	252.710	4008.4	6057.3	1529.619	4003.5	6055.4	1530.273	2003
2	90		13 9 78	18976	F	90	2053	253.570	4579.6	6940.0	1760.507	4580.4	6939.5	1759.654	2003
2	91		14 9 78	19027	F	91	2053	267.050	4761.5	7409.9	1990.277	4775.1	7410.7	1979.040	2003
2	92		14 9 78	19147	F	92	2053	252.550	4477.2	6798.2	1704.566	4467.9	6800.0	1717.346	2003
2	93		15 9 78	19164	F	93	2053	258.150	4642.9	7170.5	1855.822	4649.1	7169.2	1850.719	2003
2	94		15 9 78	19230	F	94	2053	252.900	4354.4	6630.0	1672.275	4348.0	6629.6	1676.632	2003
2	95		15 9 78	19277	F	95	2053	244.820	4894.0	7370.2	1797.508	4898.9	7373.6	1805.201	2003
2	96		16 9 78	19363	F	96	2053	233.240	4920.1	7151.4	1658.181	4892.1	7149.5	1667.560	2003
LOT TOTALS 2	76 - 96				F				94501.8	142896.0	35028.867	93920.6	142047.3	34830.918	
3	97		17 9 78	19437	F	97	2053	256.920	4661.1	7227.9	1877.100	4691.0	7227.6	1856.913	2003
3	98		23 9 78	19723	F	98	2053	251.170	3554.2	5543.5	1387.485	3560.2	5543.6	1392.387	2003
3	99		24 9 78	19778	F	98	2009	300.750	3840.0	6583.0	2021.941	3882.0	6579.5	1978.773	2003
3	100		25 9 78	19838	F	100	2053	318.760	3633.3	6326.6	2032.022	3172.3	5507.7	1755.639	2001
3	101		26 9 78	20017	F	101	2056	287.370	3260.6	5371.7	1491.195	2429.3	4057.5	1166.000	2001
3	102		27 9 78	20099	F	102	2053	293.190	3390.5	5692.2	1686.275	3026.0	5072.4	1487.184	2001
3	103		27 9 78	20099	F	103	2053	293.190	-0.4	-0.0	-0.007	1659.8	2771.0	812.420	2003
3	104		27 9 78	20158	F	104	2053	297.750	4313.5	7223.7	2154.674	3706.8	6209.6	1848.908	2001
LOT TOTALS 3	97 - 104				F				26652.8	43968.7	12650.686	26127.6	42968.9	12298.226	

4	105	28	9	78	20236	F	105	2053	299.180	4265.1	7117.1	2131.938	4873.7	8134.9	2433.790	2003
4	106	28	9	78	20267	F	106	2053	300.590	2538.3	4257.6	1280.978	1980.9	3322.0	998.547	2001
4	107	29	9	78	20329	F	107	2053	306.770	3502.9	5941.3	1833.542	1980.8	3346.7	1026.670	2003
4	108	29	9	78	20347	F	108	2053	257.160	873.2	904.8	16.319	2640.3	4028.8	1036.042	4001
4	109	29	9	78	20376	F	109	2053	273.870	4133.5	6515.2	1804.994	4141.5	6491.3	1777.771	4001
4	110	30	9	78	20405	F	110	2053	264.750	4683.5	7192.9	1892.815	4929.1	7597.2	2011.358	4001
4	111	30	9	78	20466	F	111	2053	240.740	5374.0	8000.5	1905.471	5590.5	8348.7	2009.856	4001
4	112	1	10	78	20495	F	112	2053	249.670	4772.2	7214.5	1805.789	4041.0	6101.2	1523.286	4001
4	113	1	10	78	20541	F	113	2053	234.360	4925.2	7298.7	1685.696	5188.6	7717.3	1808.632	4001
4	114	2	10	78	20598	F	114	2053	206.530	4800.6	7044.1	1421.326	5082.1	7473.5	1543.506	4001
4	115	5	10	78	20734	F	115	2053	141.590	4508.1	6301.7	842.002	4313.5	6068.9	859.297	4001
4	105 -	120														
LOT TOTALS						F				44376.6	67788.5	16620.869	44767.0	68630.4	17028.756	
LOTS 2 - 4																
						F				114324.8	175308.9	44280.867	114568.2	175650.5	44331.875	2003
						F				114324.8	175308.9	44280.867	114568.2	175650.5	44331.875	2003
						F				17136.1	28871.9	8645.145	14315.4	24169.2	7256.279	2001
						F				34070.3	50472.4	11374.412	35931.6	53826.9	12569.748	4001
SUB TOTAL						F				165531.2	254653.2	64300.425	164815.2	253646.6	64157.902	
SUB TOTAL						P				0.0	0.0	0.000	0.0	0.0	0.000	
TOTAL										165531.2	254653.2	64300.425	164815.2	253646.6	64157.902	
ENDING BALANCE													715.0	1006.6	142.523	

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EXHIBIT 4-12

NMC - ACCOUNTING
INPUT/OUTPUT REPORT FOR MEASUREMENT POINT 02023
DATE OF REPORT--20-Oct-78

LOT NO.	BATCH NO.	MANUAL CHANGE	AS DATE	LOG NO.	CODE	BATCH NO.	REC. FROM	U-CONC MG-U/G	QUANTITY RECEIVED LITERS	QUANTITY RECEIVED KG SOLUT.	QUANTITY RECEIVED U-CONTENT	QUANTITY TRANSFERRED LITERS	QUANTITY TRANSFERRED KG SOLUT.	QUANTITY TRANSFERRED U-CONTENT	DEST.
BEGINNING INVENTORY									0.0	0.0	0.000				
2	63		6 9 78	18242	P	63	2056	0.353	2222.2	2743.9	0.969	1753.7	2165.0	0.765	2420
2	64		6 9 78	18289	P	64	2056	0.262	1820.7	2254.0	0.536	1828.0	2261.2	0.591	2420
2	65		7 9 78	18349	RP	65	2056	1.400	2301.6	2949.0	4.779	2629.7	3385.1	4.739	2029
2	66		8 9 78	18401	RP	66	2056	13.370	2109.7	2811.0	39.206	1772.1	2329.2	31.142	2029
2	67		9 9 78	18523	RP	67	2056	15.500	1648.0	2155.0	34.718	1705.0	2235.2	34.646	2029
2	68		9 9 78	18560	RP	68	2056	8.200	1697.1	2128.3	13.531	1685.6	2125.8	17.431	2029
2	69		10 9 78	18641	RP	69	2056	14.200	1731.6	2234.6	34.969	1728.2	2215.7	31.463	2029
2	70		11 9 78	18741	RP	70	2056	1.000	2080.7	2733.4	-4.640	2064.2	2705.5	2.705	2029
2	71		12 9 78	18826	RP	71	2056	13.100	1586.2	2050.8	33.962	1643.2	2125.1	27.839	2029
2	72		13 9 78	18912	RP	72	2056	25.000	1694.1	2221.2	61.625	1750.5	2337.2	58.431	2029
2	73		13 9 78	18980	RP	73	2056	64.098	1418.4	1925.2	138.886	1387.2	1837.7	117.793	2029
2	74		14 9 78	19040	RP	74	2056	47.225	2172.8	2621.3	115.632	2102.2	2570.0	121.369	2029
2	75		15 9 78	18170	RP	75	2056	11.200	2499.4	3139.8	15.897	2482.4	3103.8	34.763	2029
2	76		16 9 78	19361	RP	76	2056	75.600	2350.5	3179.4	277.118	1697.2	2336.0	176.598	2029
2	77		16 9 78	19400	RP	77	2056	55.651	24.8	14.8	-27.389	994.5	1292.4	71.924	2029
2	78		17 9 78	19428	RP	78	2056	3.800	733.3	800.4	-4.038	548.1	611.6	2.324	2029
2	79		18 9 78	19476	P	79	2056	1.411	1068.9	1091.1	0.763	1024.8	1045.2	1.475	2420
2	80		18 9 78	32764	P	80	2056	59.022	1063.7	1090.9	85.770	1047.0	1069.5	63.126	2420
LOT TOTALS 2	63 -	80			P				30223.6	38143.9	822.293	29843.5	37751.4	799.126	
3	81		20 9 78	19584	P	81	2056	0.968	2390.8	2502.2	-20.366	2638.5	2749.6	2.660	2420
3	82		21 9 78	19587	P	82	2056	0.000	2385.7	2614.7	-0.140	2387.6	2627.0	0.000	2420
3	83		21 9 78	19594	P	83	2056	0.000	2695.4	2884.0	0.000	2694.8	2883.3	0.000	2420
3	84		21 9 78	19602	P	84	2056	0.244	2713.6	2877.5	0.736	1953.4	2080.0	0.508	2420
3	85		22 9 78	19612	P	85	2053	0.121	152.5	159.0	-0.096	688.9	726.3	0.088	2420
3	86		23 9 78	19703	RP	86	2056	9.860	2458.8	3020.4	33.322	2282.8	2740.3	27.019	2029
3	87		24 9 78	19751	RP	87	2056	6.326	2099.7	2698.9	14.798	2244.0	2849.1	18.023	2029
3	88		25 9 78	19830	RP	88	2056	3.983	2088.5	2628.7	9.313	2105.6	2658.1	10.586	2029
3	89		25 9 78	19864	RP	89	2056	8.139	2252.1	2843.6	25.072	2179.6	2747.0	22.357	2029
3	90		26 9 78	19948	RP	90	2056	13.142	2153.9	2737.2	38.779	2263.8	2882.5	37.882	2029
3	91		27 9 78	20071	RP	91	2056	9.266	2398.1	2978.2	25.985	2342.0	2910.6	26.969	2029
3	92		28 9 78	20176	RP	92	2056	8.333	2320.2	2959.3	24.209	2324.2	2954.3	24.618	2029
LOT TOTALS 3	81 -	92			P				26109.4	30903.8	151.612	26105.2	30808.3	170.712	

4	93	29 9 78	20251	P	93	2056	11.683	2116.2	2815.1	34.524	2148.8	2837.6	33.153	2029
4	94	29 9 78	20342	P	94	2056	7.653	2265.0	2879.2	20.158	2205.6	2823.0	21.605	2029
4	95	30 9 78	20406	P	95	2056	13.890	2507.3	3235.6	48.196	2585.9	3367.7	46.777	2029
4	96	1 10 78	20499	RF	96	2056	13.846	2063.0	2847.6	39.410	1816.5	2446.3	33.871	2029
4	97	2 10 78	20553	F	97	2056	39.380	2302.0	3066.3	140.943	2550.6	3436.0	135.309	2420
4	98	2 10 78	20584	P	98	2056	8.713	2268.5	2970.2	12.964	2203.0	2875.0	25.049	2029
4	99	3 10 78	20642	RP	99	2056	3.100	2235.1	2919.2	6.151	2194.2	2872.4	8.904	2420
4	100	4 10 78	20677	P	100	2056	2.982	2154.0	2634.6	7.791	2115.5	2612.8	7.792	2420
4	101	5 10 78	20709	P	101	2056	1.366	2152.4	2583.1	2.584	2143.7	2582.1	3.527	2420
4	102	5 10 78	20729	P	102	2056	-0.594	2430.6	2627.3	1.107	2571.9	2832.2	1.681	2420
4	103	5 10 78	20738	RP	103	2056	0.198	1423.7	1479.7	0.142	1437.9	1525.7	0.302	2420
4	104	6 10 78	20745	RP	104	2037	0.059	932.8	972.6	0.011	1049.0	1091.4	0.065	2420
4	93 -	0												
LOT TOTALS				P				24850.7	31030.3	313.981	25022.5	31302.2	318.035	
LOTS 2 - 4														
				F				2302.0	3066.3	140.943	2550.6	3436.0	135.309	2420
				RF				6251.3	8175.2	63.521	6166.1	7953.6	62.481	2029
SUB TOTAL				F				8553.3	11241.5	204.464	8716.7	11389.6	197.790	
				F				23250.7	26062.2	79.653	22847.7	25634.3	82.215	2420
				RP				4591.6	5371.5	6.304	4681.1	5489.5	9.270	2420
				P				9156.9	11900.0	115.842	9143.3	11903.3	126.583	2029
				RP				35631.2	45502.9	881.623	35582.4	45445.2	872.014	2029
				P				23250.7	26062.2	79.653	22847.7	25634.3	82.215	2420
SUB TOTAL				F				72630.4	88836.5	1083.422	72254.5	88472.3	1090.083	
TOTAL								81183.7	100078.1	1287.835	80971.3	99861.9	1287.873	
ENDING BALANCE											212.5	216.2	0.013	

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3-4-3.3

EXHIBIT 4-13

NMC - SUMMARY
INPUT/OUTPUT REPORT FOR MEASUREMENT POINT 02003
DATE OF REPORT--20-Oct-78

LOT NO.	BATCH NO.	MANUAL CHANGE	AS DATE	LOG NO.	CODE	BATCH NO.	REC. FROM	U-CONC MG-U/G	QUANTITY RECEIVED LITERS	QUANTITY RECEIVED KG SOLUT.	QUANTITY RECEIVED U-CONTENT	QUANTITY TRANSFERRED LITERS	QUANTITY TRANSFERRED KG SOLUT.	QUANTITY TRANSFERRED U-CONTENT	DEST.
BEGINNING INVENTORY									568.5	856.4	211.612				
2	83 - 103														
LOT TOTALS					F				93479.8	141497.8	34781.973	94031.6	142329.1	34987.723	
3	104 - 113														
LOT TOTALS					F				46246.2	59059.2	8711.864	45822.0	58468.0	8601.988	
4	114 - 127														
LOT TOTALS					F				82390.3	69847.5	7873.525	82819.6	70452.3	7989.265	
LOTS 2 - 4															
					F		2009		124196.5	196663.1	47843.914	130727.2	197015.7	47724.984	
					F		2003		931.7	1228.3	-0.151	934.5	1235.0	5.632	
					F		2029		426.7	457.0	-0.577	454.1	473.9	0.668	
					F		2001		96561.4	72056.1	3524.182	90557.3	72524.7	3847.688	
SUB TOTAL					F				222116.3	270404.6	51367.367	222673.2	271249.4	51578.977	
SUB TOTAL					F				0.0	0.0	0.000	0.0	0.0	0.000	
TOTAL									222116.3	270404.6	51367.367	222673.2	271249.4	51578.977	
ENDING BALANCE												11.6	11.6	0.004	

EXHIBIT 4-14

NUCLEAR MATERIAL ACCOUNTING
MATERIAL BALANCE REPORT FOR PERIODS 2 - 2

DATE OF REPORT 20-Oct-78

	FROM/TO	CODE	DETAIL LITERS	DETAIL KG. SOL.	DETAIL KG U	MBR LITERS	MBR KG. SOL.	MBR KG U
BEGINNING INVENTORY								12881.000
INPUT								
02003 ACCT TANK								
	2009	F	93479.8	141497.8	34781.973			
2 - 2 - 83 THRU 2 - 2 - 103								
TOTAL FOR MBA			93479.8	141497.8	34781.973	93479.8	141497.8	34781.973
OUTPUT								
02009 PROD SAMPLE TANK								
	2003	F	93920.6	142047.3	34830.918			
2 - 2 - 76 THRU 2 - 2 - 96								
TOTAL FOR MBA			93920.6	142047.3	34830.918	93920.6	142047.3	34830.918
02023 HWW SAMPLE TANK								
	2420	P	5653.5	6540.9	65.957			
	2029	RF	24190.0	31210.5	733.169			
2 - 2 - 63 THRU 2 - 2 - 80								
TOTAL FOR MBA			29843.5	37751.4	799.126	5653.5	6540.9	65.957
02028 GPW CHECK TANK								
	2021	RF	4402.1	5438.5	71.959			
	2420	F	7995.9	9483.2	45.966			
	2036	RF	-2.6	-3.9	-0.022			
2 - 2 - 308 THRU 2 - 2 - 333								
TOTAL FOR MBA			12395.4	14917.8	117.903	7995.9	9483.2	45.966
ENDING INVENTORY								12720.132

EXHIBIT 4-15

NUCLEAR MATERIAL ACCOUNTING
MATERIAL BALANCE REPORT FOR PERIODS 2 - 3

DATE OF REPORT 20-Oct-78

			DETAIL			MBR		
	FROM/TO	CODE	LITERS	KG. SOL.	KG U	LITERS	KG. SOL.	KG U
BEGINNING INVENTORY								12881.000
INPUT								
02003 ACCT TANK								
	2009	F	124196.5	196663.1	47843.910			
	2003	F	931.7	1228.3	-0.151			
	2001	F	95449.7	70954.8	3523.754			
	2029	F	426.7	457.0	-0.577			
2 - 2 - 83 THRU 3 - 4 - 127								
TOTAL FOR MBA			221004.6	269303.2	51366.934	221004.6	269303.2	51366.934
OUTPUT								
02009 PROD SAMPLE TANK								
	2003	F	114568.1	175650.5	44331.875			
	2001	F	14315.4	24169.2	7256.279			
	4001	F	31613.1	47758.0	11710.450			
2 - 2 - 76 THRU 3 - 4 - 120								
TOTAL FOR MBA			160496.7	247577.7	63298.602	160496.7	247577.7	63298.602
02023 HWW SAMPLE TANK								
	2420	F	2550.6	3436.0	135.309			
	2420	P	22347.7	25634.3	82.215			
	2420	RP	3632.1	4398.1	9.206			
	2029	RF	6166.1	7953.6	62.481			
	2029	P	9143.3	11903.3	126.583			
	2029	RP	35582.4	45445.2	872.014			
2 - 2 - 63 THRU 3 - 4 - 32700								
TOTAL FOR MBA			79922.3	98770.5	1287.809	34541.6	40973.7	344.108
02028 GPW CHECK TANK								
	2021	RF	6248.5	7726.5	74.952			
	2420	F	19941.2	23441.9	72.568			
	2420	RF	4902.7	6334.1	9.585			
	2420	P	828.6	917.6	1.000			
	2036	RF	-2.6	-3.9	-0.022			
	2029	RF	597.5	679.6	10.295			
	2029	RP	565.1	670.1	9.247			
2 - 2 - 308 THRU 3 - 4 - 32700								
TOTAL FOR MBA			33081.1	39765.9	177.627	20769.8	24359.5	73.569
ENDING INVENTORY								531.656

EXHIBIT 4-16

ACCOUNTABILITY TANK LEVEL COMPARISONS

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**                               **
**   02003 LEVEL COMPARISONS     **
**       SUMMARY REPORT          **
** FOR BATCH   69 TO BATCH  127  **
**                               **
**                  19-Oct-78    **
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02003 LEVEL COMPARISONS PAGE 1

BATCH NO.	BEFORE RECEIPT			BEFORE SAMPLE			AFTER SAMPLE			AFTER TRANSFER		
	PRIMARY LEVEL (CM.)	PRI-TAY (CM.)	TJR-TI (C)	PRIMARY LEVEL (CM.)	PRI-TAY (CM.)	TJR-TI (C)	PRIMARY LEVEL (CM.)	PRI-TAY (CM.)	TJR-TI (C)	PRIMARY LEVEL (CM.)	PRI-TAY (CM.)	TJR-TI (C)
69	424.3	-6.12	-.36	424.26	-6.16	-.34	424.32	-6.14	-.37	165.32	-3.04	-.26
70	165.3	-3.11	.02	415.68	-5.95	-.89	415.72	-5.92	-.86	42.83	-2.18	-.51
71	42.8	-2.17	-.33	257.53	-4.19	-.81	257.52	-4.24	-.85	53.35	-2.2	-.24
72	53.34	-2.22	-.27	267.77	-4.36	-.74	267.75	-4.46	-.84	43.76	-2.16	-.32
73	43.76	-2.15	-.36	298.34	-4.77	-.98	298.34	-4.72	-1.04	48.36	-2.29	-.44
74	48.36	-2.25	-.59	275.72	-4.43	-1.01	275.69	-4.46	-.97	51.37	-2.3	-.13
75	51.46	-2.21	-.24	248.15	-4.05	-.96	248.16	-3.95	-.99	53.23	-2.28	-.6
82	326.27	-5.18	3.88	326.25	-5.2	3.91	326.23	-5.18	3.86	48.69	-2.47	4.46
83	268.59	-4.45	4.21	269.39	-4.45	4.06	267.69	-4.45	4.08	50.72	-2.45	4.04
84	314.49	-4.97	7.37	314.34	-4.99	7.37	313.74	-5.04	7.34	52.89	-2.41	7.09
85	52.89	-2.42	7.06	308.54	-4.95	7.38	308.67	-4.9	3.72	43.51	-2.32	-2.28
86	43.36	-2.21	-3.16	299.33	-4.64	2.89	299.27	-4.62	.47	50.51	-2.2	-2.52
87	50.5	-2.2	-2.54	305.86	-4.73	3.17	305.87	-4.69	1.68	42.47	-2.24	-2.22
88	42.47	-2.22	-3.16	335.68	-5.15	1.73	335.92	-5.34	.47	52.11	-2.37	-1.81
89	52.11	-2.34	-2.78	345.07	-5.32	4.32	345.05	-5.34	4.08	50.75	-2.43	1.05
90	50.76	-2.41	.38	358.27	-5.52	3.18	358.45	-5.47	3.04	49.97	-2.39	.74
91	330.97	-5.18	3.99	330.23	-5.19	2.79	330.28	-5.18	3.03	48.57	-2.34	1.66
92	48.58	-2.33	1.25	288.77	-4.66	3.96	288.8	-4.67	3.92	47.51	-2.33	2.65
93	47.53	-2.37	2.86	325.07	-5.1	3.01	323.67	-5.06	3.49	40.04	-2.65	13.15
94	40.4	-2.29	9.31	307.75	-4.73	4.48	307.49	-4.84	4.78	44.99	-2.35	4.91
95	45.01	-2.33	4.29	305.35	-4.76	5.11	42.59	-2.36	5.5	42.71	-2.28	6.14
96	42.7	-2.24	8.56	279.03	-4.46	5.13	279	-4.45	4.83	43.43	-2.32	7.62
97	43.43	-2.32	8.15	322.21	-4.93	5.75	322.2	-4.94	6.15	52.41	-2.33	7.14
98	52.67	-2.25	10.23	350.27	-5.25	6.98	350.25	-5.27	7.32	50.03	-2.3	9.82
99	50.05	-2.32	11.73	323.05	-4.95	6.54	323.03	-5.03	7.1	62.76	9.2**	7.84
100	51.21	-2.37	7.96	337.93	-5.17	5.02	337.85	-5.25	5.01	55.04	-2.4	5.41
101	55.05	-2.35	6.66	321.23	-5.02	8.24	321.26	-5.11	7.22	52.66	-2.47	6.56
102	52.66	-2.42	6.89	347.42	-5.17	5.46	347.38	-5.28	5.85	43.45	-2.26	7.79
103	43.46	-2.25	8.28	330.07	-5.11	9.02	330.11	-5.11	8.37	3.88	-2.09	10.73
104	3.87	-2.1	10.92	63.06	-2.22	8.92	63.11	-2.18	8.85	2.53	-2.04	8.69
105	2.52	-2.05	8.84	300.29	-4.18	17.25	299.48	-4.91	19.55	40.77	3.26	19.12
106	35.31	-2.15	19.24	299.42	-4.45	27.71	299.44	-4.47	26.35	2.28	-2.16	24.06
107	2.31	-2.13	23.99	320.58	-4.67	31.62	320.5	-4.66	32.38	2.51	-2.15	23.95
108	3.2	-2.14	23.78	304.91	-4.55	14.58	304.89	-4.57	14.32	54.32	-2.13	14.26
109	54.32	-2.17	14.32	276.46	-5.01	14.66	277.31	-4.25	12.46	50.08	-2.1	10.94
110	50.1	-2.12	12.27	315.51	-4.7	6.8	315.44	-4.69	6.52	52.11	-2	8.25
111	52.09	-2.36	9.28	295.75	-4.68	52.16	295.18	-4.69	46.4	39.33	-2.31	40.24
112	39.32	-2.32	36.64	273.72	-3.93	46.36	273.19	-4.5	45.6	70.45	-2.56	44.58
113	70.49	-2.48	44.04	275.59	-4.53	53.8	253.81	-26.31	52.52	37.92	-2.2	43.26
114	37.92	-2.2	42.92	407.03	-5.06	29.95	406.39	-5.75	29.73	54.63	-2.2	31.4
115	54.63	-2.2	31.82	310.4	-4.75	43.68	310.39	-4.72	43.04	47.97	-2.21	39.36
116	47.97	-2.17	38.13	379.6	-5.57	49.33	379.59	-5.55	48.13	54.83	-2.41	44.35
117	54.82	-2.44	44.57	339.41	-5.11	59.61	339.39	-5.17	59.15	51.85	-2.44	53.35
118	51.82	-2.46	51.64	355.53	-5.33	47.94	355.43	-5.33	46.58	52.52	-2.41	43.55
119	52.52	-2.36	42.56	107.23	-2.73	61.08	107.11	-2.77	48.36	36.36	-2.3	45.94
120	36.36	-2.3	46.02	257.2	-4.17	41.12	257.21	-4.22	41.88	43.4	-2.34	41.13
121	43.41	-2.34	40.11	355.52	-4.94	42.17	355.18	-5.28	41.25	42.84	-2.41	36.11
122	43.04	-2.33	33.66	301.25	-4.62	42.57	301.14	-4.62	41.76	47.96	-2.36	36.9
123	47.97	-2.33	36.76	230.15	-3.88	60.36	230.04	-3.91	59.15	28.63	-2.32	41.92
124	28.59	-2.29	41.03	47.38	-2.38	42.72	47.29	-2.4	33.59	28.18	-2.27	25.26
125	28.06	-2.25	22.28	127.84	-2.56	41.56	127.45	-2.77	34.27	27.21	-2.17	26.55

** INDICATES EXTREME VALUE OMITTED IN SUMMARY

EXHIBIT 4-16

(continued)

02003 LEVEL COMPARISONS PAGE 2

BATCH NO.	BEFORE RECEIPT			BEFORE SAMPLE			AFTER SAMPLE			AFTER TRANSFER		
	PRIMARY LEVEL (CM.)	PRI-TAY (CM.)	TJR-TI (C)	PRIMARY LEVEL (CM.)	PRI-TAY (CM.)	TJR-TI (C)	PRIMARY LEVEL (CM.)	PRI-TAY (CM.)	TJR-TI (C)	PRIMARY LEVEL (CM.)	PRI-TAY (CM.)	TJR-TI (C)
126	67.15	-2.11	40.2	90.1	-2.58	45.4	90.07	-2.53	37.62	.82	-2.26	27.98
127	.72	-2.27	23.84	54.24	-2.3	46.33	54.09	-2.28	38.69	1.19	-2.23	29.54

** INDICATES EXTREME VALUE OMITTED IN SUMMARY

EXHIBIT 4-16

(continued)

SUMMARY REPORT

	BEFORE SAMPLE			AFTER TRANSFER		
	PRIMARY LEVEL (CM.)	PRI-TAY (CM.)	TJR-TI (C)	PRIMARY LEVEL (CM.)	PRI-TAY (CM.)	TJR-TI (C)
N :	53	53	53	53	52	53
AVERAGE:	286.81	-4.57	19.46	44.49	-2.2	16.19
SIGMA:	84.79	.89	20.78	23.49	.79	16.93
EXTREME VALUE:	NA	-7	70	NA	4	70

THIS SUMMARY INCLUDES 53 BATCHES

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**                               **
**    02028 LEVEL COMPARISONS    **
**                               **
**        SUMMARY REPORT         **
**                               **
** FOR BATCH  284 TO BATCH  370  **
**                               **
**                               **
**                               **
**                 19-Oct-78     **
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EXHIBIT 4-17

GPW CHECK TANK LEVEL COMPARISONS

02028 LEVEL COMPARISONS

BATCH NO.	BEFORE RECEIPT			BEFORE SAMPLE			AFTER SAMPLE			AFTER TRANSFER		
	PRIMARY LEVEL (INCH)	PRI-TAY (INCH)	TEMP (C)	PRIMARY LEVEL (INCH)	PRI-TAY (INCH)	TEMP (C)	PRIMARY LEVEL (INCH)	PRI-TAY (INCH)	TEMP (C)	PRIMARY LEVEL (INCH)	PRI-TAY (INCH)	TEMP (C)
284	NA	NA	NA	64.18	-.07	58.37	64.78	-.1	42.42	12.03	.34	42
285	NA	NA	NA	62.88	-.16	72	63.37	-.27	54.48	6.57	.9	51.35
286	NA	NA	NA	60.26	-.39	77.77	60.69	-.56	57.39	8.61	.91	56.36
287	NA	NA	NA	65.69	-.28	76.26	65.73	-.32	56.38	1.73	1.06	47.15
288	NA	NA	NA	60.81	-.18	73.96	61.16	-.07	58.53	5.98	1.02	60.02
308	NA	NA	NA	36.69	.28	38.87	36.68	.27	37.17	6.66	.8	30.49
309	NA	NA	NA	6.78	.73	27.5	6.78	.72	27 47	1.9	.91	26.95
310	NA	NA	NA	21.07	.29	32.97	21.08	.21	32.52	4.31	1.02	31.49
311	NA	NA	NA	61.5	-.46	79.92	61.6	-.45	67.98	8.35	3.54**	51.08
312	NA	NA	NA	51.86	-.33	73.47	51.92	-.06	68.59	7.6	.79	57.54
313	NA	NA	NA	18.42	.31	54.17	21.95	.42	45.35	1.75	1.18	29.68
314	NA	NA	NA	61.95	-.26	74.14	62.1	-.2	71.5	8.11	.85	66.03
315	NA	NA	NA	23.24	.45	62.6	23.31	.11	55.2	4.02	.55	50.72
316	NA	NA	NA	63.05	-.54	81.39	63.23	-.62	68.87	11.62	.67	56.6
317	NA	NA	NA	59.69	-.31	57.68	59.54	-.32	56.29	1.8	.77	40.86
318	NA	NA	NA	23.53	.38	66.86	23.68	.32	55.32	4.71	.81	41.51
319	NA	NA	NA	23.97	.39	62.73	24.18	.28	54.57	24.23	.29	54.14
320	NA	NA	NA	46.58	-.07	52.68	46.78	-.17	47.82	7.12	.86	43.37
321	NA	NA	NA	62.51	-.08	49.47	62.63	-.2	48.25	4.2	.76	44.44
322	NA	NA	NA	60.92	-.45	74.25	61.86	-.41	50.64	7.48	.65	49.88
323	NA	NA	NA	60.24	-.34	66	60.4	-.33	59.93	8.38	.3	44.17
324	NA	NA	NA	58.15	-.46	40.74	58.33	-.38	39.93	6.35	.54	39.17
325	NA	NA	NA	27.75	.02	61.14	28	.06	56.38	1.38	.61	48.93
326	NA	NA	NA	59.16	-.55	44.92	59.27	-.51	43.42	7.73	.4	43.7
327	NA	NA	NA	59.33	-.48	45.98	59.51	-.47	45.09	1.78	.61	45.79
328	NA	NA	NA	54.6	-.5	46.38	54.73	-.42	44.36	4.43	.5	45.26
329	NA	NA	NA	61.35	-.39	56.4	61.38	-.47	56.24	1.45	.89	55.38
330	NA	NA	NA	61.21	-.55	80.48	61.17	-.51	73.91	5.42	1.15	33.22
331	NA	NA	NA	62.04	-.41	37.25	62.52	-.41	37.03	1.44	1.06	38.65
332	NA	NA	NA	53.11	-.28	68.49	53.22	-.28	62.58	5.65	1.09	57.34
333	NA	NA	NA	26.44	.18	37.44	26.54	.21	36.32	8.64	1.09	36.93
334	NA	NA	NA	54.4	-.11	39.76	54.39	-.28	38.76	1.39	1.09	37.03
335	NA	NA	NA	56.16	-.37	37.15	56.28	-.35	36.55	4.09	1	38.52
336	NA	NA	NA	65.61	-.41	38.42	65.73	-.41	37.89	1.36	.87	38.13
337	NA	NA	NA	61.99	-.42	40.31	62.66	-.27	39.41	4.55	.82	41.64
338	NA	NA	NA	58.64	-.38	39.83	58.76	-.39	38.72	.98	.8	41.71
342	NA	NA	NA	48.09	.01	26.06	48.14	-.08	24.26	1.54	1.08	28.43
347	NA	NA	NA	53.9	-.15	26.39	54.16	-.13	25.92	9.23	.61	25.94
348	NA	NA	NA	48.89	-.25	25.81	48.96	-.24	25.41	3.48	.87	29
349	NA	NA	NA	52.95	-.25	30.07	53.17	-.32	25.41	5.52	.68	26.9
350	NA	NA	NA	63.5	-.51	31.72	63.65	-.59	25.77	7.12	.76	26.08
351	NA	NA	NA	56.86	-.48	28.47	57.13	-.38	25.83	6.45	.84	26.79
352	NA	NA	NA	49.63	-.26	27.19	49.88	-.27	25.92	5.14	.15	26.94
352	NA	NA	NA	49.63	-.26	27.19	49.88	-.27	25.92	5.18	.94	26.94
353	NA	NA	NA	32.73	-.09	28.55	32.91	-.28	26.04	5.17	.7	29.08
354	NA	NA	NA	52.33	-.07	34.09	52.53	-.37	28.5	1.77	.87	30.07
355	NA	NA	NA	62.08	-.6	27.26	60.5	-.67	26.59	6.88	.42	28.79
356	NA	NA	NA	66.5	-.93	25.77	66.64	-.75	25.8	9.12	.33	25.67
357	NA	NA	NA	63.4	-.7	30.71	63.57	-.82	26.21	7	-.13	30
358	NA	NA	NA	64.31	-.62	25.85	64.42	-.73	25.85	4.73	.56	30.9
359	NA	NA	NA	38.55	-.45	26.05	38.71	-.32	26.05	5.85	.62	28.36

** INDICATES EXTREME VALUE OMITTED IN SUMMARY

EXHIBIT 4-17

(continued)

BATCH NO.	BEFORE RECEIPT			BEFORE SAMPLE			AFTER SAMPLE			AFTER TRANSFER		
	PRIMARY LEVEL (INCH)	PRI-TAY (INCH)	TEMP (C)	PRIMARY LEVEL (INCH)	PRI-TAY (INCH)	TEMP (C)	PRIMARY LEVEL (INCH)	PRI-TAY (INCH)	TEMP (C)	PRIMARY LEVEL (INCH)	PRI-TAY (INCH)	TEMP (C)
360	NA	NA	NA	60.82	-.77	29.16	61.04	-.77	26.05	7.29	.45	27.65
361	NA	NA	NA	62.13	-.8	31.47	62.19	-.81	27.38	4.05	.46	30.78
362	NA	NA	NA	51.51	-.41	26.09	51.55	-.48	25.95	7.1	.4	26.33
363	NA	NA	NA	62.61	-.61	29.02	63.63	-.87	25.02	.91	.5	33.09
364	NA	NA	NA	69.61	-.59	27.45	71.96	-.63	25.34	3.39	.44	26.5
365	NA	NA	NA	52.51	-.65	36.48	53.12	-.6	27.09	6.12	.46	29.14
366	NA	NA	NA	61.52	-.76	25.82	61.71	-.86	24.83	1.08	.55	30.92
367	NA	NA	NA	69.52	-.97	29.73	69.73	-1.02	24.5	7.18	.26	24.93
368	NA	NA	NA	52.54	-.71	38.43	52.77	-.7	24.69	4.24	.29	26.18
369	NA	NA	NA	62.35	-.79	25.87	62.61	-.82	24.6	1.48	1.27	47.63
370	NA	NA	NA	36.06	-.29	28.07	36.28	-.27	24.42	1.47	.79	27.01

** INDICATES EXTREME VALUE OMITTED IN SUMMARY

EXHIBIT 4-17

(continued)

02028 LEVEL COMPARISONS PAGE 3

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**                                **
**         SUMMARY REPORT         **
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	BEFORE SAMPLE			AFTER TRANSFER		
	PRIMARY LEVEL (INCH)	PRI-TAY (INCH)	TEMP (C)	PRIMARY LEVEL (INCH)	PRI-TAY (INCH)	TEMP (C)
N :	62	62	62	62	61	62
AVERAGE:	52. 59	-. 31	44. 78	5. 36	. 71	38. 18
SIGMA:	14. 46	. 35	18. 48	3. 7	. 29	11. 02
EXTREME VALUE:	NA	1. 3	NA	NA	1. 6	NA

THIS SUMMARY INCLUDES 62 BATCHES

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**   02003 DENSITY COMPARISONS    **
**                                **
**        SUMMARY REPORT          **
**                                **
**                                **
** FOR BATCH   69 TO BATCH  124   **
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**                                **
**                   09-Oct-78    **
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EXHIBIT 4-18

ACCOUNTABILITY TANK DENSITY COMPARISONS

02003 DENSITY COMPARISONS

BATCH NO.	BEFORE SAMPLE						AFTER SAMPLE				
	RUSKA TO TAY	LAB @ 25 TO RUSKA	LAB @ 25 TO TAY	LAB @ T TO RUSKA	LAB @ T TO TAY	LAB DENS @ 25	RUSKA TO TAY	LAB @ 25 TO RUSKA	LAB @ 25 TO TAY	LAB @ T TO RUSKA	LAB @ T TO TAY
69	-.012	.0066	-.0054	.0043	-.0077	1.4614	-.0087	.0031	-.0057	.0007	-.008
70	-.0072	.0296	.0223	.0245	.0173	1.4558	-.0052	.0284	.0232	.0233	.0181
71	-.0082	.0118	.0036	.0047	-.0035	1.5224	-.0097	.0105	.0009	.0035	-.0062
72	-.0113	.0519**	.0406	.045**	.0337**	1.5472	-.012	.0874**	.0755**	.0806**	.0686**
73	-.0092	.0689**	.0597**	.0621**	.0528**	1.5543	-.009	.0067	-.0023	-.0003	-.0093
74	-.0085	.0074	-.0012	.0005	-.008	1.5626	-.0104	.0083	-.0021	.0013	-.0091
75	-.012	.0106	-.0014	.0024	-.0097	1.5953	-.0099	.0096	-.0004	.0012	-.0087
82	-.0114	.0052	-.0063	.0013	-.0101	1.5112	-.0134	.0078	-.0055	.004	-.0094
83	-.0105	-.0569**	-.0674**	-.0647**	-.0751**	1.5185	-.011	.0077	-.0033	.0001	-.011
84	-.0101	.0078	-.0023	.0006	-.0095	1.505	-.012	.01	-.002	.0032	-.0088
85	-.0087	-.0045	-.0132	-.0115	-.0203	1.513	-.0076	-.0092	-.0168	-.0159	-.0235
86	-.01	.0075	-.0025	.0015	-.0085	1.5353	-.008	.0053	-.0027	.0001	-.0079
87	-.0078	.0072	-.0006	.0008	-.007	1.5152	-.007	.0068	-.002	.0005	-.0064
88	-.0066	.0385	.0319	.0321**	.0255	1.51	-.0081	-.0095	-.0176	-.0154	-.0235
89	-.0059	.0063	.0004	-.0008	-.0067	1.4928	-.0073	.0066	-.0007	-.0003	-.0076
90	-.007	-.0007	-.0076	-.0072	-.0142	1.4883	-.006	-.0083	-.0143	-.0146	-.0206
91	-.0068	.0097	.0029	.0032	-.0036	1.5294	-.0057	.0078	.0021	.0016	-.0041
92	-.0077	.0114	.0038	.0045	-.0032	1.5004	-.0075	.0102	.0028	.0033	-.0042
93	-.0077	-.0472	-.0549**	-.0542**	-.062**	1.5264	-.0056	.0082	.0026	.0011	-.0044
94	-.0058	.0108	.0049	.0033	-.0026	1.5519	-.0067	.0174	.0107	.0102	.0035
95	-.0073	-.0017	-.0091	-.0086	-.016	1.527	-.0082	.005	-.0031	-.0023	-.0105
96	-.0094	.0088	-.0006	.0015	-.0079	1.521	-.0102	.0092	-.001	.0019	-.0084
97	-.0078	.0071	-.0008	-.0001	-.0079	1.5219	-.0088	.0078	-.001	.0006	-.0082
98	-.0087	.0081	-.0007	.0005	-.0082	1.555	-.0107	.0101	-.0006	.0024	-.0083
99	-.0076	.0118	.0042	.0039	-.0037	1.5344	-.0097	.0116	.0019	.0036	-.0061
100	-.0106	.0115	.0009	.0043	-.0063	1.5464	-.0108	.0088	-.002	.0016	-.0092
101	-.0124	.0155	.0031	.0078	-.0046	1.5337	-.0112	.0076	-.0036	-.0002	-.0114
102	-.0082	.0085	.0003	.0006	-.0076	1.5083	-.0083	.0081	-.0002	.0002	-.008
103	-.0086	.0517**	.0432	.0423**	.0337**	1.513	-.007	.05	.043	.0404**	.0335**
104	-.7779**	.7899**	.012	.7819**	.004	1.3296	-.0069	.0183	.0115	.0102	.0033
105	-.0053	.0095	.0043	.0047	-.0005	1.0185	-.0184	.0227	.0043	.0181	-.0003
106	-.0015	.007	.0055	.0009	-.0007	1.0123	-.0024	.0072	.0048	.0011	-.0013
107	-.0033	.0105	.0073	.0035	.0003	1.0114	-.0017	.0084	.0066	.0016	-.0002
108	-.0115	.0127	.0012	.0018	-.0097	1.5456	-.0101	.0112	.0011	.0004	-.0096
109	-.0429**	.0485	.0056	.0378**	-.0051	1.5642	-.0126	.0269	.0143	.0168	.0042
110	-.0147	.0069	-.0078	-.0032	-.0179	1.6851	-.0112	.0095	-.0018	-.0005	-.0117
111	-.008	.0053	-.0027	-.0191	-.0272	1.4659	-.0091	.0256	.0165	.0023	-.0069
112	-.0058	.0212	.0154	-.0028	-.0086	1.5405	-.0102	.0258	.0156	.002	-.0082
113	-.0094	.0275	.0181	.0027	-.0067	1.419	-.8699**	.8884**	.0185	.864**	-.0059
114	-.0158	.0256	.0097	.0066	-.0093	1.5741	-.0088	.0188	.01	-.0002	-.009
115	-.0091	.0229	.0138	.0026	-.0065	1.4205	-.0083	.0221	.0138	.0019	-.0063
116	-.0091	.0256	.0165	.0012	-.0079	1.518	-.0089	.0251	.0162	.0009	-.008
117	-.0082	.0273	.0191	.0026	-.0056	1.3674	-.0048	.0252	.0204	.0009	-.0039
118	-.0042	.0196	.0154	.0004	-.0038	1.3215	-.0067	.0212	.0145	.0024	-.0043
119	-.0086	.0198	.0112	-.004	-.0126	1.28	-.0022	.0152	.0131	-.0035	-.0057
120	-.0048	.0099	.005	.0021	-.0027	1.0203	-.2658**	.2705**	.0046	.2627**	-.0031
121	.0002	.005	.0052	-.0025	-.0023	1.0057	-.0024	.0086	.0062	.0011	-.0012
122	-.0005	.0093	.0087	.0006	-.0002	1.0288	-.0023	.0105	.0082	.0023	0
123	-.0029	.0159	.013	.0043	.0014	1.0365	-.0044	.017	.0126	.0055	.0011
124	-.0049	.0159	.011	.0047	-.0002	1.0597	-.0057	.0165	.0108	.0037	.003

** INDICATES EXTREME VALUE EXCLUDED FROM SUMMARY

EXHIBIT 4-18

(continued)

02003 DENSITY COMPARISONS PAGE 2

SUMMARY REPORT

	BEFORE SAMPLE				
	RUSKA TO TAY	LAB @ 25 TO RUSKA	LAB @ 25 TO TAY	LAB @ T TO RUSKA	LAB @ T TO TAY
N :	48	45	47	42	45
AVERAGE:	-.008	.0118	.0063	.0012	-.0057
SIGMA:	.0033	.0136	.0116	.0062	.0083
EXTREME VALUE:	.03	.05	.05	.03	.03

	AFTER SAMPLE				
	RUSKA TO TAY	LAB @ 25 TO RUSKA	LAB @ 25 TO TAY	LAB @ T TO RUSKA	LAB @ T TO TAY
N :	48	47	49	46	48
AVERAGE:	-.0082	.0124	.0046	.0019	-.0061
SIGMA:	.0033	.0104	.0107	.0069	.0069
EXTREME VALUE:	.03	.05	.05	.03	.03

THIS SUMMARY INCLUDES 50 BATCHES

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**                                  **
**   02028 DENSITY COMPARISONS      **
**                                  **
**        SUMMARY REPORT            **
**                                  **
** FOR BATCH  284 TO BATCH  370     **
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**                                  **
**                                  **
**                      09-Oct-78   **
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EXHIBIT 4-19

GPW CHECK TANK DENSITY COMPARISONS

02028 DENSITY COMPARISONS

BATCH NO.		BEFORE SAMPLE								AFTER SAMPLE				
		WEST. TO TAY	LAB @ 25 TO WEST.	LAB @ 25 TO TAY	LAB @ T TO WEST.	LAB @ T TO TAY		LAB DENS @ 25		WEST. TO TAY	LAB @ 25 TO WEST.	LAB @ 25 TO TAY	LAB @ T TO WEST.	LAB @ T TO TAY
284	*	-.0308**	.0345	.0037 *	NA	NA	*	1.168	*	-.0284	.1261**	.0977***	NA	NA
285	*	-.0275	.0403**	.0128 *	NA	NA	*	1.1337	*	-.0256	.0286	.003 *	NA	NA
286	*	-.0232	.0443**	.0211 *	NA	NA	*	1.1249	*	-.0217	.0309	.0092 *	NA	NA
287	*	-.0286	.0961**	.0676***	NA	NA	*	1.1948	*	-.0324**	.0557**	.0233 *	NA	NA
288	*	-.0344**	.0448**	.0104 *	NA	NA	*	1.1621	*	-.0327**	.0362	.0036 *	NA	NA
308	*	-.0591**	.0444**	-.0147 *	NA	NA	*	1.0691	*	-.0584**	.0446**	-.0138 *	NA	NA
309	*	-.02	.289**	.269***	NA	NA	*	1.0691	*	-.0201	.2891**	.269***	NA	NA
310	*	-.065**	.0416**	-.0234 *	NA	NA	*	1.0527	*	-.0676**	.0455**	-.0221 *	NA	NA
311	*	-.0716**	.0851**	.0135 *	NA	NA	*	1.2487	*	-.0639**	.1228**	.059***	NA	NA
312	*	-.0031	.0171	.0139 *	NA	NA	*	1.2454	*	.0013	.0169	.0182 *	NA	NA
313	*	-.0017	-.0204	-.0221 *	NA	NA	*	1.2019	*	-.0019	-.0053	-.0072 *	NA	NA
314	*	-.0009	-.0323	-.0332 *	NA	NA	*	1.2233	*	.0014	-.0418**	-.0404***	NA	NA
315	*	-.0007	.0064	.0057 *	NA	NA	*	1.2346	*	-.0165	-.0056	-.0221 *	NA	NA
316	*	-.0126	.0052	-.0074 *	NA	NA	*	1.2116	*	-.012	-.0029	-.0149 *	NA	NA
317	*	-.0041	-1.2088**	-1.213***	NA	NA	*	NA	*	-.0075	-1.2032**	-1.2107***	NA	NA
318	*	-.0055	.0142	.0087 *	NA	NA	*	1.2369	*	-.0004	.0052	.0048 *	NA	NA
319	*	-.0006	.0055	.0049 *	NA	NA	*	1.2204	*	-.0006	.0043	.0037 *	NA	NA
320	*	-.0053	.0099	.0046 *	NA	NA	*	1.2702	*	-.0046	.0026	-.002 *	NA	NA
321	*	-.002	-.0068	-.0088 *	NA	NA	*	1.2175	*	-.0085	-.0009	-.0093 *	NA	NA
322	*	-.002	.0155	.0134 *	NA	NA	*	1.2262	*	.0018	-.0045	-.0027 *	NA	NA
323	*	.0024	.0094	.0118 *	NA	NA	*	1.1947	*	.0005	.0064	.007 *	NA	NA
324	*	-.0076	-.0143	-.0219 *	NA	NA	*	1.2177	*	-.002	-.0142	-.0161 *	NA	NA
325	*	-.006	.003	-.003 *	NA	NA	*	1.3176	*	-.0028	-.0042	-.007 *	NA	NA
326	*	-.0009	-.009	-.0099 *	NA	NA	*	1.0136	*	.0029	-.011	-.0081 *	NA	NA
327	*	.0014	-.0097	-.0082 *	NA	NA	*	1.0107	*	.0008	-.0097	-.0089 *	NA	NA
328	*	-.0156	-.0104	-.0259 *	NA	NA	*	1.0088	*	-.0137	-.0115	-.0253 *	NA	NA
329	*	-.0176	-.2455**	-.2631***	NA	NA	*	1	*	-.0137	-.2545**	-.2682***	NA	NA
330	*	-.0131	.0235	.0104 *	NA	NA	*	1.2409	*	-.0128	.0196	.0067 *	NA	NA
331	*	-.012	-.0103	-.0223 *	NA	NA	*	1.0936	*	-.0083	-.0122	-.0205 *	NA	NA
332	*	-.0144	.0155	.001 *	NA	NA	*	1.1389	*	-.012	.0096	-.0024 *	NA	NA
333	*	-.011	-.0103	-.0213 *	NA	NA	*	1.0207	*	-.0086	-.0142	-.0228 *	NA	NA
334	*	-.0092	-.0186	-.0278 *	NA	NA	*	1.0228	*	-.0099	-.0068	-.0167 *	NA	NA
335	*	-.0096	-.0117	-.0213 *	NA	NA	*	1.0338	*	-.0123	-.0121	-.0245 *	NA	NA
336	*	-.0066	-.0106	-.0172 *	NA	NA	*	1.0356	*	-.0039	-.0118	-.0157 *	NA	NA
337	*	-.0083	-.0078	-.0161 *	NA	NA	*	1.0352	*	-.0076	-.0106	-.0182 *	NA	NA
338	*	-.007	-.0106	-.0176 *	NA	NA	*	1.0362	*	-.006	-.0104	-.0164 *	NA	NA
342	*	-.0066	-.0169	-.0235 *	NA	NA	*	1.1598	*	-.0137	-.0163	-.0301 *	NA	NA
347	*	-.0088	.0037	-.0051 *	NA	NA	*	1.1316	*	-.0081	-.0119	-.02 *	NA	NA
348	*	-.0078	-.0161	-.024 *	NA	NA	*	1.2251	*	-.0067	-.0156	-.0223 *	NA	NA
349	*	-.0068	-.0111	-.0179 *	NA	NA	*	1.0707	*	-.0069	-.0123	-.0192 *	NA	NA
350	*	-.0057	-.0125	-.0182 *	NA	NA	*	1.2092	*	-.0062	-.0165	-.0227 *	NA	NA
351	*	-.0052	-.0142	-.0194 *	NA	NA	*	1.1083	*	-.005	-.0142	-.0192 *	NA	NA
352	*	-.0054	-.0152	-.0207 *	NA	NA	*	1.122	*	-.0062	-.0144	-.0207 *	NA	NA
352	*	-.0054	-.0151	-.0206 *	NA	NA	*	1.1221	*	-.0062	-.0143	-.0206 *	NA	NA
353	*	-.0146	-.0132	-.0279 *	NA	NA	*	1.2011	*	-.0141	-.0147	-.0288 *	NA	NA
354	*	-.0132	-.0251	-.0383 *	NA	NA	*	1.2081	*	-.0108	-.0346	-.0455***	NA	NA
355	*	-.0172	-.2143**	-.2314***	NA	NA	*	1.1657	*	-.0119	-.0193	-.0312 *	NA	NA
356	*	-.0205	-.0147	-.0352 *	NA	NA	*	1.2215	*	-.0212	-.0122	-.0334 *	NA	NA
357	*	-.017	-.0231	-.0401***	NA	NA	*	1.2507	*	-.0218	-.026	-.0478***	NA	NA
358	*	-.0175	-.0219	-.0394 *	NA	NA	*	1.2031	*	-.0191	-.0187	-.0377 *	NA	NA
359	*	-.0134	-.0153	-.0287 *	NA	NA	*	1.1911	*	-.0142	-.0135	-.0277 *	NA	NA

** INDICATES EXTREME VALUE EXCLUDED FROM SUMMARY

EXHIBIT 4-19

(continued)

0202S DENSITY COMPARISONS PAGE 2

BATCH NO.	BEFORE SAMPLE						AFTER SAMPLE				
	WEST. TO TAY	LAB @ 25 TO WEST.	LAB @ 25 TO TAY	LAB @ T TO WEST.	LAB @ T TO TAY	LAB DENS @ 25	WEST. TO TAY	LAB @ 25 TO WEST.	LAB @ 25 TO TAY	LAB @ T TO WEST.	LAB @ T TO TAY
360	-.0159	-.0142	-.0301	NA	NA	1.0617	-.0148	-.0138	-.0286	NA	NA
361	-.0174	-.035	-.0523***	NA	NA	1.1839	-.0236	-.0334	-.0569***	NA	NA
362	-.0057	-.0146	-.0202	NA	NA	1.2336	-.0096	-.0108	-.0204	NA	NA
363	-.0086	-.0152	-.0238	NA	NA	1.2052	-.0115	-.0095	-.021	NA	NA
364	-.005	-.0111	-.0161	NA	NA	1.2143	-.0116	-.0028	-.0144	NA	NA
365	-.0121	-.0116	-.0237	NA	NA	1.2201	-.0109	-.0213	-.0322	NA	NA
366	-.016	-.0141	-.0301	NA	NA	1.1218	-.0142	-.0148	-.029	NA	NA
367	-.0102	-.0105	-.0207	NA	NA	1.1975	-.0191	-.0081	-.0271	NA	NA
368	-.0163	-.0078	-.0241	NA	NA	1.2319	-.0173	-.0204	-.0376	NA	NA
369	-.0122	-.0109	-.0231	NA	NA	1.0928	-.016	-.0108	-.0268	NA	NA
370	-.014	-.0105	-.0245	NA	NA	1.1087	-.0137	-.014	-.0277	NA	NA

** INDICATES EXTREME VALUE EXCLUDED FROM SUMMARY

EXHIBIT 4-19

(continued)

02028 DENSITY COMPARISONS PAGE 3

SUMMARY REPORT

	BEFORE SAMPLE					AFTER SAMPLE				
	WEST. TO TAY	LAB @ 25 TO WEST.	LAB @ 25 TO TAY	LAB @ T TO WEST.	LAB @ T TO TAY	WEST. TO TAY	LAB @ 25 TO WEST.	LAB @ 25 TO TAY	LAB @ T TO WEST.	LAB @ T TO TAY
N :	57	51	55	NA	NA	57	53	53	NA	NA
AVERAGE:	-.01	-.0076	-.0135	NA	NA	-.0103	-.0076	-.0154	NA	NA
SIGMA:	.0069	.0138	.0156	NA	NA	.0074	.0141	.0141	NA	NA
EXTREME VALUE:	.03	.04	.04	NA	NA	.03	.04	.04	NA	NA

THIS SUMMARY INCLUDES 62 BATCHES

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**                               **
**                               **
**                               **
**                               **
**    02003 REPLICATE DATA       **
**       SUMMARY REPORT          **
**                               **
** FOR BATCH   69 TO BATCH  124  **
**                               **
**                               **
**                               **
**                  09-Oct-78    **
**                               **
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EXHIBIT 4-20

ACCOUNTABILITY TANK REPLICATE DATA

02003 REPLICATE DATA PAGE 1

BATCH NO.	PROCESS CONTROL: AT TO BR		PROCESS CONTROL: BS TO AS		ACCOUNTABILITY: AT TO BR		ACCOUNTABILITY: BS TO AS	
	KG SOL	AT-BR	KG SOL	BS-AS	KG SOL	AT-BR	KG SOL	BS-AS
69	NA	-10230**	10228.9	-1.58	NA	NA	10229.4	-1.58
70	3766.5	.5	10016.2	-.81	3767.1	.48	10017.5	-.81
71	710.9	.75	6052.8	.25	725	.23	6054.5	.25
72	954.7	-2.08	6302.3	.52	969.1	.3	6304	.52
73	711.6	-.06	7063.4	-.08	727.7	-.11	7065.1	-.13
74	824.7	NA	6496.8	.75	839.1	-.12	6498.5	.73
75	897.8	-2.37	5800.9	-.25	911.4	-2.55	5802.9	-.27
82	947.9	-6823.18**	7770.6	.38	949.9	-6801.16**	7771.5	.38
83	855.3	-5476.27**	6349.9	42.55**	856.4	-5477.17**	6351.8	42.57**
84	903.6	-6571.79**	7474.9	14.97	905	-6572.14**	7476.7	15.08**
85	960	.06	7328.1	.52	961.3	-.01	7329.8	-3.2
86	727.8	3.8	7092.8	1.58	728.8	3.88	7094.3	1.79
87	894.6	.25	7260.8	-.17	895.6	.39	7262.4	-.14
88	701.7	-.08	8006.1	-6.07	702.8	.03	8007.7	-5.96
89	939.6	NA	8244.9	.54	940.7	.14	8246.7	.58
90	910.1	-.25	8575.3	-4.58	911.4	-.2	8576.9	-4.51
91	892	-7002.05**	7865.5	-1.25	893.1	-7002.67**	7867.1	-1.19
92	848.2	-.25	6837.9	-.83	849.6	-.09	6839.6	-.83
93	828.8	-.43	7737.5	35.02**	830.5	-.58	7739.2	35.01**
94	639.6	-8.78	7298.8	6.4	642.3	-8.49	7300.6	6.49
95	755.3	-.41	7245.1	6543.13**	757	-.22	7246.8	6543.18**
96	705	.27	6589.6	.67	706.7	.15	6591.4	.66
97	723.9	NA	7667	.25	725.8	-.03	7668.8	.23
98	944.5	-6.28	8359.2	.35	946.2	-6.76	8361.1	.31
99	878.3	-.49	7684.9	.29	880.4	-.6	7686.8	.27
100	912.1	0	8053.5	2.04	1198.6	284.54**	8055.3	2.03
101	1003.6	-.25	7639.8	-.69	1005.3	-.31	7641.7	-.71
102	947.8	-.14	8299.6	1	949.6	-.03	8301.6	1
103	727.3	-.16	7865.6	-11.33	729.1	-.41	7867.9	-.85
104	25.2	.05	1251.5	-1.16	25.1	.04	1253.4	-1.18
105	18.4	.04	7243.9	20.13**	18.4	-.05	7245	20.17**
106	772.3	134.51**	7223.7	-.58	773.4	134.56**	7225.2	-.57
107	15.4	-.1	7752	2	15.4	-.1	7753.7	2.04
108	16.4	-3.42	7229.5	.5	16.4	-3.4	7232.2	.52
109	985.9	-.08	6515.1	-21.09**	988.3	-.22	6517.7	-20.95**
110	877.6	-.37	7459.8	1.66	879.8	-1.02	7462.3	1.69
111	900.1	.57	7020.5	14.14	902.3	1.71	7026.5	14.4
112	635.8	.25	6452.4	13.23	640.4	-.08	6458.3	13.27
113	1385.4	-.97	6528.9	543.56**	1390.7	-.06	6535	543.66**
114	611.6	-.02	9771.1	15.97	616.3	-.93	9775.8	15.98**
115	987.3	NA	7397.3	.25	991.5	1	7402.3	.29
116	858.1	-.06	9100.4	.33	862.4	-.55	9106.4	.38
117	1004.8	.08	8134.4	.58	1010	1.3	8140.5	.69
118	965.8	.74	8547.9	2.41	970.8	1.31	8552.6	2.51
119	992.9	0	2361.3	2.99	996.9	.57	2367.2	4.38
120	604.6	-.02	6168	-.25	608.4	3.25	6169.9	-.25
121	837	-.19	8625.5	8.65	838.7	-.05	8627.3	8.67
122	826.4	-5	7265.2	2.66	828	-5.16	7267.3	2.73
123	947.6	-.25	5489.1	2.87	949.3	-.26	5491.9	2.91
124	469.7	1.12	926.1	2.14	471.7	.88	928.7	2.93

** INDICATE EXTREME VALUE EXCLUDED IN SUMMARY

EXHIBIT 4-20

(continued)

02003 REPLICATE DATA PAGE 2

SUMMARY REPORT

	PROCESS CONTROL				ACCOUNTABILITY			
	AT TO BR		BS TO AS		AT TO BR		BS TO AS	
	KG SOL	AT-BR	KG SOL	BS-AS	KG SOL	AT-BR	KG SOL	BS-AS
N :	50	44	50	44	50	44	50	42
AVERAGE:	825	-.55	7153.4	1.62	834	-.38	7155.9	1.2
SIGMA:	514.1	2	1755.6	5.06	516.9	2.13	1755.4	3.78
EXTREME VALUE:	NA	20	NA	20	NA	15	NA	15

THIS SUMMARY INCLUDES 50 BATCHES

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02023 REPLICATE DATA
SUMMARY REPORT
FOR BATCH 50 TO BATCH 104

09-Oct-78

EXHIBIT 4-21

HWW SAMPLE TANK REPLICATE DATA

02023 REPLICATE DATA PAGE 1

BATCH NO.	PROCESS CONTROL				ACCOUNTABILITY			
	AT TO BR		BS TO AS		AT TO BR		BS TO AS	
	KG SOL	AT-BR	KG SOL	BS-AS	KG SOL	AT-BR	KG SOL	BS-AS
50	NA	NA	3393.9	9.36	NA	NA	3393.9	9.36
51	NA	NA	2777.2	-.35	NA	NA	2777.2	-.35
52	NA	NA	2775.1	4.9	NA	NA	2775.1	4.9
53	NA	NA	3297.2	-.28	NA	NA	3297.2	-.28
54	NA	NA	3462.7	-2.03	NA	NA	3462.7	-2.03
63	NA	NA	2743.9	.74	NA	NA	2743.9	.74
64	NA	NA	2832.9	-.27	NA	NA	2832.9	-.27
65	NA	NA	3520.7	2.32	NA	NA	3520.7	2.32
66	NA	NA	2946.6	-1.62	NA	NA	2946.6	-1.62
67	NA	NA	2772.4	2.16	NA	NA	2772.4	2.16
68	NA	NA	2665.5	-.66	NA	NA	2665.5	-.66
69	NA	NA	2774.3	-.77	NA	NA	2774.3	-.77
70	NA	NA	3291.9	.88	NA	NA	3291.9	.88
71	NA	NA	2637.3	-1.44	NA	NA	2637.3	-1.44
72	NA	NA	2733.4	.23	NA	NA	2733.4	.23
73	NA	NA	2321.3	-.9	NA	NA	2321.3	-.9
74	NA	NA	3104.9	4.23	NA	NA	3104.9	4.23
75	NA	NA	3674.6	.65	NA	NA	3674.6	.65
76	NA	NA	3750.1	.71	NA	NA	3750.1	.71
77	NA	NA	1429	1.03	NA	NA	1429	1.03
78	NA	NA	936.9	3.09	NA	NA	936.9	3.09
79	NA	NA	1416.4	1.34	NA	NA	1416.4	1.34
80	NA	NA	1462.1	4.38	NA	NA	1462.1	4.38
81	NA	NA	2894.7	-2.69	NA	NA	2894.7	-2.69
82	NA	NA	2759.8	-3.44	NA	NA	2759.8	-3.44
83	NA	NA	3016.8	3.8	NA	NA	3016.8	3.8
84	NA	NA	3010.9	3.37	NA	NA	3010.9	3.37
85	NA	NA	1089.9	.91	NA	NA	1089.9	.91
86	NA	NA	3384	4.56	NA	NA	3384	4.56
87	NA	NA	3342.6	-1.25	NA	NA	3342.6	-1.25
88	NA	NA	3122.2	1.52	NA	NA	3122.2	1.52
89	NA	NA	3307.7	.58	NA	NA	3307.7	.58
90	NA	NA	3297.9	-.4	NA	NA	3297.9	-.4
91	NA	NA	3393.7	-2.4	NA	NA	3393.7	-2.4
92	NA	NA	3442.4	.79	NA	NA	3442.4	.79
93	NA	NA	3303.1	-3.22	NA	NA	3303.1	-3.22
94	NA	NA	3344.7	-7.39	NA	NA	3344.7	-7.39
95	NA	NA	3757.2	-.06	NA	NA	3757.2	-.06
96	NA	NA	3237.1	1.57	NA	NA	3237.1	1.57
97	NA	NA	3857.1	-2.3	NA	NA	3857.1	-2.3
98	NA	NA	3391.3	-2.11	NA	NA	3391.3	-2.11
99	NA	NA	3435.5	2.53	NA	NA	3435.5	2.53
100	NA	NA	3197.7	-1.06	NA	NA	3197.7	-1.06
101	NA	NA	3168	-1.63	NA	NA	3168	-1.63
102	NA	NA	3213.2	.04	NA	NA	3213.2	.04
103	NA	NA	1860.7	1.02	NA	NA	1860.7	1.02
104	NA	NA	1307.6	1.69	NA	NA	1307.6	1.69

** INDICATE EXTREME VALUE EXCLUDED IN SUMMARY

<u>**EXHIBIT 4-21**</u>

(continued)

02023 REPLICATE DATA PAGE 2

SUMMARY REPORT

	PROCESS CONTROL				ACCOUNTABILITY			
	AT TO BR		BS TO AS		AT TO BR		BS TO AS	
	KG SOL	AT-BR	KG SOL	BS-AS	KG SOL	AT-BR	KG SOL	BS-AS
N :	NA	NA	47	47	NA	NA	47	47
AVERAGE:	NA	NA	2890.5	.47	NA	NA	2890.5	.47
SIGMA:	NA	NA	732.4	2.73	NA	NA	732.4	2.73
EXTREME VALUE:	NA	NA	NA	-20	NA	NA	NA	10

THIS SUMMARY INCLUDES 47 BATCHES

PRODUCT/INPUT COMPARISONS

SUMMARY REPORT

FOR BATCH 76 TO BATCH 99

19-Oct-78

EXHIBIT 4-22

PRODUCT/INPUT COMPARISONS

PRODUCT BATCH			INPUT BATCH			TRANSFERRED - RECEIVED	
BATCH NO.	SOLUTION (KG)	URANIUM (KG)	BATCH NO.	SOLUTION (KG)	URANIUM (KG)	SOLUTION (KG)	URANIUM (KG)
76	5455.095	1358.264	83	5494.566	1378.027	-39.471	-19.762
77	5612.212	1254.329	84	6571.306	1471.381	-959.093**	-217.051**
78	6323.784	1555.714	85	6368.039	1570.099	-44.254	-14.385
79	6371.987	1619.313	86	6365.022	1624.696	6.965	-5.383
80	6452.88	1528.494	87	6366.217	1515.278	86.664**	13.216
81	7304.869	1643.961	88	7304.462	1651.393	.406	-7.432
83	7672.413	1781.534	90	7665.203	1784.75	7.21	-3.216
84	6990.319	1743.386	91	6973.56	1756.388	16.759	-13.003
85	5982.717	1423.288	92	5989.619	1436.887	-6.902	-13.599
86	6878.927	1692.904	93	6908.683	1707.466	-29.756	-14.562
87	6639.712	1727.122	94	6659.156	1741.475	-19.444	-14.354
88	6481.746	1646.493	95	6489.769	1629.952	-8.022	16.541
89	5891.777	1488.911	96	5884.637	1504.604	7.14	-15.693
90	6941.625	1760.188	97	6943.128	1771.047	-1.504	-10.859
91	7801.611	2083.42	98	7414.692	1962.541	386.918**	120.879**
92	6802.198	1717.895	99	6806.552	1731.191	-4.354	-13.296
93	7144.182	1844.271	100	7141.452	1845.671	2.73	-1.401
94	6639.633	1679.163	101	6636.209	1679.191	3.423	-.028
95	7385.21	1808.047	102	7351.844	1799.596	33.366	8.452
97	7232.782	1858.246	108	7213.124	1830.521	19.658	27.726
98	5540	1391.482	109	5529.142	1388.252	10.858	3.23
99	6572.887	1976.796	110	6582.175	1975.53	-9.288	1.266

** INDICATES EXTREME VALUE EXCLUDED FROM SUMMARY

PRODUCT/INPUT COMPARISONS

SUMMARY REPORT

TRANSFERRED- RECEIVED

	SOLUTION (KG)	URANIUM (KG)
N :	19	21
AVERAGE:	-2.867	-3.351
SIGMA	19.596	12.469
EXTREME VALUE	50	30

THIS SUMMARY INCLUDES 29 BATCHES

```
**************************************
**************************************
**                                  **
**                                  **
**   CONCENTRATION COMPARISONS      **
**        SUMMARY REPORT            **
**                                  **
** FOR BATCH   83 TO BATCH   103    **
**                                  **
**                                  **
**                   05-Oct-78      **
**                                  **
**************************************
**************************************
```

EXHIBIT 4-23

INPUT URANIUM ANALYTICAL METHOD
COMPARISON DATA
ISOTOPIC DILUTION/MASS SPEC (U-ID-) VS POTENTIOMETRIC (U-VP)

CONCENTRATION COMPARISONS

U-ID VS. U-VP FOR ACCOUNTABILITY TANK

BATCH NO.	U-ID (MG U/G)	U-VP (MG U/G)	DIFFERENCE (MG U/G)
83	250.3	249.07	1.23
84	227.1	229.03	-1.93
85	244.01	244.68	-.67
86	254.1	252.83	1.27
87	240	239.66	.34
88	227.3	227.05	.25
89	224	223.85	.15
90	231.9	230.83	1.07
91	249.6	248.13	1.47
92	241.1	239.79	1.31
93	246.5	245.03	1.47
94	260.2	259.02	1.18
95	252.1	252.74	-.64
96	255.3	254.74	.56
97	255.1	254.04	1.06
98	263.6	263.84	-.24
99	255.4	254.7	.7
100	258.1	257.16	.94
101	253.7	253.6	.1
102	245.8	245.73	.07
103	233.6	233.53	.07

** INDICATES EXTREME VALUE EXCLUDED FROM SUMMARY

EXHIBIT 4-23

(continued)


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***********************************
***********************************
**                               **
**                               **
**        SUMMARY REPORT         **
**                               **
**                               **
***********************************
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```

AVERAGE U-ID CONCENTRATION IS 246.134 MG U/G

AVERAGE DIFFERENCE IS .465 MG U/G

STANDARD DEVIATION FOR THE DIFFERENCE IS .861

EXTREME VALUE FOR THE DIFFERENCE IS 3

THIS SUMMARY INCLUDES 21 BATCHES

5.0 REMOTE DATA ACQUISITION SYSTEM PERFORMANCE

5.1 Introduction

Measurement instrumentation associated with the Computerized Nuclear Materials Control and Accounting System (CNMCAS) are interfaced to the central processing unit (CPU) through the remote data acquisition system (referenced to herein as the RTP system). The RTP system is composed of real-time peripheral/preprocessor equipment. The configuration of the RTP system, as demonstrated during the FY 1978 Uranium Input/Output Demonstration Program, included the following major components:

- Preprocessor - PDP 11/04, Digital Equipment Corporation
- Analog Controller - RTP Wide Range Analog Controller, Computer Products, Inc.
- Digital Controller - RTP Universal Controller, Computer Products, Inc.
- Temperature Compensator - RTP Uniform Temperature Reference Assembly, Computer Products, Inc.

The RTP system scans selected process instrumentation, collects, stores, and manipulates instrument signals, and transmits instrument data to the CNMCAS CPU.

5.2 Software Development

A description of the RTP system and the basic software required was completed in February 1978 with the assistance of a computer services vendor.* The description is included as Appendix B. Using the description as a guide, the vendor prepared a software (control) specification (refer to Appendix D). The original software specification was completed in April 1978. However, during software preparation, installation, and testing significant revisions to the specification were required. The revised specification appears in Appendix D.

Software preparation incorporating ASSEMBLY language started in May 1978. Major software elements** included:

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*Scientific Systems Services, Melbourne, Florida.

**A detailed list of programs and modules appears in Appendix E.

- RTP Data Base Structure
- System Software Loading
- Data Acquisition
- Data Conversion
  - Conversion of Standard Instrument Readings
  - Conversion of Thermocouple Class Readings
- Temperature Computation incorporating the RTP Uniform Temperature Reference Assembly
- Automatic Voltage Calibration
- Alarm Limits Checking and Reporting
- CNMCAS-RTP Communications
- Power Fail/Restore Procedures

No major problems were encountered during software installation and testing other than the faulty serial formatter card described in Section 3.2.

5.3 Performance Summary

The overall performance of the RTP system was excellent considering the lack of spares for critical components in the PDP 11/04 preprocessor. All elements of the system underwent a comprehensive acceptance test, and operation was completely satisfactory until apparent hardware problems started to develop in the preprocessor. The problem ultimately shut the system down at the end of Campaign 3 and has been tentatively diagnosed as a faulty memory board.

During the period of the developing hardware problem, data acquisition routines periodically stalled and required time-consuming program manipulation for restart. In addition, erroneous instrument signal values were sometimes found in stored data during frequent checks of the data base. Efforts were made to double check data sent to the measurement programs to flag and/or edit erroneous readings.

A supplemental program which prints all or selected instrument data in the preprocessor data base was also installed and proved extremely useful during the Uranium Input/Output Demonstration Program. Expanded use of this feature will require a faster input/output device than the teletype used during the demonstration.

Manual and RTP Ruska readings from measurement data collected during Campaign 2 were compared to check the accuracy of the RTP system. Results were excellent and are summarized below.

Accountability Tank: (Manual - RTP) = d

Before-Sampling Readings

N = 18
$\bar{d}$ = 0.006 centimeter H_2O
s = 0.063 centimeter H_2O

After-Sampling Readings

N = 16
$\bar{d}$ = 0.033 centimeter H_2O
s = 0.077 centimeter H_2O

After-Transfer Readings

N = 18
$\bar{d}$ = 0.007 centimeter H_2O
s = 0.049 centimeter H_2O

Uranium Product Sample Tank: (Manual - RTP) = d

Before-Sampling Readings

N = 17
$\bar{d}$ = 0.014 centimeter H_2O
s = 0.039 centimeter H_2O

After-Sampling Readings

N = 16
$\bar{d}$ = 0.016 centimeter H_2O
s = 0.037 centimeter H_2O

After-Transfer Readings

N = 17
$\bar{d}$ = 0.007 centimeter H_2O
s = 0.0111 centimeter H_2O

Tables 5-1 and 5-2 present typical manual versus RTP reading comparisons for liquid level measurements in the accountability tank and uranium product sample tank. Comparisons of manual versus RTP temperature readings are also shown.

Tables 5-3 and 5-4 present typical manual versus RTP liquid level reading comparisons for the Westinghouse and Taylor instruments on the HWW sample tank and GPW check tank. The Westinghouse instrument loops incorporate a digital readout while the Taylor instrument loop readout is via strip chart. As expected, indications of offset and increased variability are shown for the Taylor strip chart readings.

5.4 Future Improvements

Based on experience gained during the Uranium Input/Output Demonstration Program, the following improvements will be made:

- Spares for critical preprocessor components will be procured
- PDP 11/04 control panel will be procured to simplify troubleshooting
- Preprocessor memory will be increased to allow longer retention of stored measurement data
- RTP input/output teletype will be replaced with a DEC writer to improve the use of the alarm reporting and "data base dump" features.

TABLE 5-1

MANUAL READINGS VERSUS RTP READINGS

ACCOUNTABILITY TANK

Batch Number	BEFORE-SAMPLING* Manual Ruska	BEFORE-SAMPLING* RTP Ruska	BEFORE-SAMPLING* Difference	AFTER-SAMPLING* Manual Ruska	AFTER-SAMPLING* RTP Ruska	AFTER-SAMPLING* Difference	AFTER-TRANSFER* Manual Ruska	AFTER-TRANSFER* RTP Ruska	AFTER-TRANSFER* Difference	TEMPERATURE °C** TJR	TEMPERATURE °C** RTP	TEMPERATURE °C** Difference
83	268.70	269.19	***	267.48	267.49	(0.01)	50.55	50.49	0.06	39	35.3	3.7
84	314.23	314.09	0.14	316.04	313.49	***	52.64	52.64	0.00	36	34.4	1.6
85	308.32	308.30	0.02	308.38	308.43	(0.05)	43.21	43.28	0.07	34	29.3	4.7
86	299.12	299.09	0.03	299.42	299.03	0.39	50.23	50.25	(.02)	35	31.8	3.2
87	305.61	305.61	0.00	305.60	305.62	(0.02)	42.21	42.21	0.00	35	33.6	1.4
89	344.83	344.82	0.01	344.81	344.79	0.02	50.54	50.49	0.05	36	34.6	1.4
90	357.98	358.00	(.02)	358.41	358.19	0.22	49.73	49.69	0.04	35	30.8	4.2
91	329.95	329.95	0.00	330.00	330.02	(0.02)	48.35	48.29	0.06	34	33.2	0.8
92	288.65	288.49	0.16	288.62	288.52	0.10	47.24	47.21	0.03	36	34.4	1.6
93	324.67	324.79	(0.12)	323.45	323.38	0.07	40.05	40.07	(0.02)	35	34.3	0.7
94	307.39	307.46	(0.07)	307.39	307.20	0.19	44.57	44.68	(0.11)	35	34.3	0.7
95	305.01	305.04	(0.03)	304.90	---	--	42.30	42.38	(0.08)	35	35.0	0.0
96	278.67	278.69	(0.02)	278.67	278.68	(0.01)	43.14	43.09	0.05	36	34.8	1.2
97	321.85	321.87	(0.02)	321.87	321.87	0.00	52.09	52.09	0.00	36	34.7	1.3
98	349.92	349.93	(0.01)	349.94	349.93	0.01	49.65	49.68	0.03	36	35.2	0.8
99	322.69	322.69	0.00	322.68	322.68	0.00	62.40	50.84	11.64***	36.5	35.6	0.9
100	337.59	337.60	0.01	337.57	337.53	0.04	54.72	54.69	0.03	35	34.5	0.5
102	347.09	347.07	0.02	347.08	347.08	0.00	43.08	43.11	(0.03)	36.8	35.7	1.1
103	329.73	329.72	0.01	329.72	329.76	(0.04)	3.47	3.50	(0.03)	38	36.9	1.1
			N = 18 $\bar{d}$ = 0.006 s = 0.063			N = 16 $\bar{x}$ = 0.033 s = 0.077			N = 18 $\bar{d}$ = 0.007 s = 0.049			N = 19 $\bar{x}$ = 1.63 s = 1.32

*Liquid Level in Centimeters of H_2O

**After-Sampling Readings

***Excluded Values

TABLE 5-2

MANUAL READINGS VERSUS RTP READINGS

URANIUM PRODUCT SAMPLE TANK

Batch Number	BEFORE-SAMPLING* Manual Ruska	BEFORE-SAMPLING* RTP Ruska	BEFORE-SAMPLING* Difference	AFTER-SAMPLING* Manual Ruska	AFTER-SAMPLING* RTP Ruska	AFTER-SAMPLING* Difference	AFTER-TRANSFER* Manual Ruska	AFTER-TRANSFER* RTP Ruska	AFTER-TRANSFER* Difference	TEMPERATURE °C** TJR	TEMPERATURE °C** RTP	TEMPERATURE °C** Difference
76	157.38	157.51	0.13	157.39	157.49	(0.10)	33.04	33.04	0.00			(3.8)
77	183.24	183.25	0.01	183.25	160.14	23.11***	31.71	31.71	0.00			(2)
78	177.61	177.60	0.01	177.59	177.58	0.01	33.19	33.20	(0.01)			(2)
79	179.24	179.67	0.45***	178.80	178.78	0.02	33.20	33.20	0.00			(11)***
80	178.54	178.54	0.00	178.53	178.55	(0.02)	33.25	30.27	3.02***			(2)
81	203.09	203.09	0.00	203.09	203.09	0.00	33.19	33.19	0.00			(2.7)
83	215.59	215.60	0.01	215.63	215.65	(0.02)	33.11	33.13	(0.02)			(1.8)
84	194.06	194.09	(0.03)	194.15	194.16	(0.01)	33.32	33.34	(0.02)	32	34	(2)
85	169.81	169.78	0.03	169.56	169.55	0.01	33.23	33.25	(0.02)	33	34.6	(1.6)
86	191.34	191.35	(0.01)	191.34	191.34	0.00	33.35	33.37	(0.02)	32	33.6	(1.6)
87	185.37	185.38	(0.01)	185.28	185.39	(0.11)	33.45	33.45	0.00	31	33.8	(2.8)
88	181.53	181.63	0.00	181.50	181.50	0.00	33.33	33.35	(0.02)	32	33.9	(1.9)
89	167.8	171.42	(3.62)***	167.75	167.76	(0.01)	33.38	33.38	0.00	31	33.9	(2.9)
90	193.06	193.09	(0.03)	193.08	19.09	***	33.40	33.42	(0.02)	31.5	33.8	(2.3)
91	205.48	205.44	0.04	205.48	205.48	0.00	33.52	33.53	0.01	32	34	(2)
92	189.40	189.40	0.00	189.41	189.43	(0.02)	33.39	33.38	0.01	32.5	34.5	(2)
93	198.18	198.24	0.06	198.19	198.20	(0.01)	33.50	33.50	0.00	31	33.6	(2.6)
95	205.21	205.26	0.05	204.70	205.43	0.27*	33.40	--	--	33.2	35	(1.8)
96	199.89	199.89	0.00	199.88	199.87	0.01	33.21	33.22	(0.01)	33.2	35.7	(2.5)
			N = 17 $\bar{x}$ = 0.014 s = 0.039			N = 16 $\bar{x}$ = -0.016 s = 0.037			N = 17 $\bar{x}$ = -0.007 s = 0.0111			N = 18 $\bar{x}$ = -2.24 s = 0.55

*Liquid Level in Centimeters of H_2O

**Before-Sampling Readings

***Excluded Values

TABLE 5-3

MANUAL READINGS VERSUS RTP READINGS

HWW SAMPLE TANK

(Liquid Level in Inches of H_2O)

Batch Number	WESTINGHOUSE RTP	WESTINGHOUSE Manual	WESTINGHOUSE Difference	TAYLOR RTP	TAYLOR Manual	TAYLOR Difference
63	123.34	123.4	(0.06)	125.11	122.4	2.71
64	127.53	127.5	0.03	129.34	127.1	2.24
65	160.09	160.1	(0.01)	162.38	159.7	2.68
66	132.59	132.6	(0.01)	134.36	132.6	1.76
67	124.13	124.1	0.03	125.75	124.4	1.35
68	119.40	119.4	0.00	120.99	119.1	1.89
69	124.42	124.4	0.02	126.13	124.4	1.73
70	148.94	148.9	0.04	151.04	148.9	2.14
71	117.84	117.8	0.04	119.40	118.3	1.10
72	122.34	122.4	(0.06)	124.00	122.4	1.60
73	102.64	102.6	0.04	103.98	102.0	1.98
74	140.35	140.3	0.05	142.17	140.6	1.57
75	167.54	167.5	0.04	169.80	167.3	2.50
76	170.64	170.6	0.04	172.97	171.4	1.57
77	60.36	60.3	0.06	61.41	59.8	1.61
78	37.92	38.0	(0.08)	39.10	37.7	1.40
79	61.24	61.2	0.04	62.42	61.2	1.22
80	63.23	63.2	0.03	64.39	63.2	1.19
82	153.78	153.8	(0.02)	155.63	153.0	2.63
86	125.15	125.2	0.05	126.91	125.1	1.81
			$\underline{N}$ = 20 $\bar{d}$ = 0.0135 s = 0.0409			N = 20 $\bar{d}$ = 1.834 s = 0.5056

TABLE 5-4

MANUAL READINGS VERSUS RTP READINGS

GPW CHECK TANK

(Liquid Level in Inches of H_2O)

Batch Number	WESTINGHOUSE			TAYLOR		
	RTP	Manual	Difference	RTP	Manual	Difference
308	36.68	36.6	0.08	36.41	36.9	(0.49)
311	61.6	61.5	0.10	62.05	61.8	0.25
312	51.92	51.8	(0.12)	51.98	52.2	(0.22)
313	21.95	21.8	0.15	21.53	22.1	(0.57)
314	62.10	61.9	0.20	62.30	62.0	0.30
315	23.31	23.3	0.01	23.20	23.5	(0.30)
316	63.23	63.1	0.13	63.85	63.5	0.35
317	59.54	59.6	(0.06)	59.86	60.1	(0.24)
318	23.68	23.7	(0.02)	23.36	23.5	(0.14)
319	24.18	24.1	0.08	23.90	24.2	(0.30)
320	46.78	46.6	0.18	46.95	46.7	0.25
321	62.63	62.5	0.13	62.83	62.0	0.83
322	61.86	61.0	0.86	62.27	61.3	0.97
323	60.40	60.8	(0.40)	60.73	61.3	(0.57)
324	58.33	58.1	0.23	58.71	58.6	0.11
325	28.00	28.0	0.00	27.94	28.4	(0.46)
326	59.27	59.1	0.17	59.78	59.7	0.08
327	59.51	59.4	0.11	59.98	59.7	0.28
			N = 20 $\bar{d}$ = 0.0945 s = 0.228			N = 20 d = -0.057 s = 0.472

6.0 AUXILIARY PROGRAMS

Certain CNMCAS auxiliary programs were developed and tested during the FY 1978 integrated uranium run.

- In-Process Inventory Program
- HA Feed Flow Rate Program
- Calculation programs for manual data.

6.1 In-Process Inventory Program

6.1.1 Introduction

During FY 1978 integrated uranium run, a computer-based program to estimate in-process inventory was developed. An in-process inventory measurement is a necessary step towards development of a real-time inventory capability for an operating reprocessing plant.

6.1.2 Technique

The integrated uranium runs offer an opportunity to assess performance capabilities divorced from the effects of input and product measurements. There is always a known quantity of uranium in the Separation Facility as calculated from the receipt quantities (from the UF_6 Facility) and waste transfers. This allows calculation of measurable in-process inventory and comparison to "actual" in-process quantities.

The computer-based program for in-process inventory estimates stressed timeliness of measurements. It asks for and makes use of the best currently available measurement data and calculates the rest of the values based on related process-measured quantities and flowsheet parameters.

Unfortunately, the computer-based program in its final form was not developed until late in the FY 1978 integrated uranium run. It was not available in time to collect adequate information to complete a performance evaluation. However, specifics of the program and its implementation can be discussed.

In-process inventory, or process holdup, is defined as the difference between input and output at any given time. In-process inventory is composed of quantities of material in measurable locations and a quantity of unmeasurable inventory. During steady-state operations, quantities of material in major surge points are "measurable." The remaining unmeasurable quantities should be reasonably consistent with some degree of randomness in historical determinations. Thus, by measuring the basic "in" versus "out" quantities of a routine material balance determination and by estimating the "measurable" holdup in major surge points, the "unmeasured holdup" can be calculated. Analysis of this "unmeasured holdup" quantity is the key to real-time inventory capability. Analysis of unmeasured holdup, its variations and trends, allows judgment about inventory on a real-time basis without plant shutdown and inventory.

6.1.3 Program

Table 6-1 is an example of a computer generated in-process inventory estimate (of measurable process holdup). It considers 16 major surge points; however, the four marked with asterisks are not included in the totals since their value is still being studied.

The program uses available measurement data for each of the points. It begins by asking the operator for any data available (acid, density, and uranium concentration). When no information is provided, it defaults to normal process parameters for acid, uses instrument densities, and calculates uranium concentrations. If data are provided, the program substitutes these data in the calculations.

For the example in Table 6-1, the program was started and it asked for any available measurement data. For the dissolver flush accumulator, density and uranium concentrations were available and entered. Since no acid result was available, the program defaults to the flowsheet value. For the accountability tank, the acid and density results were available and entered, but a uranium concentration was not entered, and so forth, for the other tanks.

After all available data have been entered, the program substitutes missing data and calculates the remaining values. It prints the summary of uranium content at the surge points and the various parameters (H , uranium, and density) used in the calculations. This is seen, for example, with the dissolver flush accumulator. The density and uranium concentration used shows in the summary as does the acid concentration which was not entered. For the accountability tank, the summary shows the acid and density and the uranium concentration calculated. For the No. 1 feed adjustment tank, the acid concentration was entered, but the density was measured from process instruments and the uranium concentration calculated. The summary shows 6566 kilograms uranium in the major surge points. (It does not include the four points designated with asterisks as the value of these measurements is still being investigated.)

At the time of this estimate, the input versus output measurements showed a total in-process inventory of 8175 kilograms uranium. Thus, the estimated "unmeasured" process holdup is 1909 kilograms uranium. In actual application, this quantity would be compared to the most recent measurements. Analysis of trend of the "unmeasured" process holdups would be used to identify measurement problems and/or accumulating holdup.

6.1.4 Results

Results show the unmeasurable holdup is 2 to 3 MTU. Data analysis is incomplete and no judgment on variability can be made. The technique shows promise but will require extensive additional development and testing directed at improving the quality of "measured" process holdup estimates and reducing the "unmeasured" process holdup.

6.2 HA Feed Flow Rate Program

6.2.1 Introduction

A major requirement for plant operation, and indirectly for safeguards measurements, is knowledge of the plant processing rate or throughput. This is determined by measurement of feed rates from the HA feed tank to the solvent extraction system. A computer program was developed to calculate this feed rate using process instrumentation and CNMCAS hardware.

Feed solution for the solvent extraction system is prepared alternately in the two feed adjustment tanks. The acid of the input feed solutions is adjusted to 2.5 molar in the feed adjustment tanks and the adjusted feed solution is transferred through the centrifuge to the HA feed tank. From the HA feed tank, the solution is metered to the solvent extraction system and this rate represents the plant feed rate.

6.2.2 Technique

The feed rate calculation includes the rate of transfer from the HA feed tank. The transfer jets from the feed adjustment tanks to the HA feed tank are typically slow (<1000 liters/hour) and must also be considered in the calculation of feed rate, since transfer from one or the other feed adjustment tanks is in near continuous operation and this influences the indicated rate of decrease in the HA feed tank.

6.2.3 Program

The program, as implemented, routinely calculates the feed rate (every 30 minutes). As discussed in Appendix B, a 12-minute history of volume measurement data is always available for the HA feed tank in the RTP system. A 20-minute history is always available for the two feed adjustment tanks. The CNMCAS CPU, at the 30-minute intervals, requests the most recent data for the three tanks and calculates the rate of change in volume for each of the tanks. It takes the rate of change of the HA feed tank and if the feed adjustment tank rates are within 0 to 1000 liters/hour, it includes this rate in the calculation. If the feed adjustment tank rates are not within this range, it assumes that transfers into the tank(s) or transfer to some tank other than the HA feed tank are occurring and ignores these rates of change in the feed rate calculation. The program also includes a factor for steam jet dilution in the feed adjustment tank transfers for the calculation.

The net rate of transfer is expressed in liters/hour. The current uranium concentration in the HA feed tank is calculated using the measured density and the assumed acid concentration of 2.5 molar. From this concentration and the transfer rate, the feed rate in MTU/day is calculated.

When the calculation is complete on the 30-minute interval, the program stores the data in a table. The table contains an 8-hour history of the calculations. Each time a new calculation is added to the table, it discards the oldest.

6.2.4 Results

The HA feed flow rate program required considerable testing and modification. The final version of the program produced results consistent with manually calculated feed rates. Performance was significantly influenced by probe plugging problems in the feed adjustment tanks and the HA feed tank. When probe plugging is solved, the program should operate reliably.

6.3 Calculation Programs for Manual Data

During the FY 1978 integrated uranium run, CNMCAS was also used to process and store manually collected measurement data. Measurement data were manually recorded on measurement forms. The data were then entered to a measurement data calculation program in CNMCAS. Batchwise summaries were generated as the data were entered. The data are stored within CNMCAS for later recall in batch summaries, summaries of groups of batches, or for recall in measurement control calculation programs.

6.3.1 Measurement Calculation Programs

A separate measurement calculation program was developed and implemented for each of the four input/output accountability points (input, product, HWW waste, GPW waste). Each of the programs was specific for the individual measurement point, but the basic operation for each was the same. The input measurement calculation program for the accountability tank is used as the example.

Each time the program is run, it provides the option of (1) printing a summary of a group of batches, (2) adding data for a new batch, (3) printing a summary report of data for specific individual batches, or (4) changing data for a batch that has already been stored. An example of this option selection is included as Exhibit 6-1.

When measurement data are available for an individual batch, the program is run and the "add-a-batch" option is specified. Exhibit 6-2 is an example of the "add-a-batch" option. The program first asks the batch number of the batch to be added; in this case, 76 was the response. The program then asks for the individual measurement data, using the "?" as the prompt. (Note the "$" after each number is the device echo of the delimiter used in entering data.) When the program has received all data, the program calculates the solution quantities and transfer quantities and prints this information. It than calculates and prints the measurement control data. The program finally stores the data in CNMCAS for future calculations and report preparation.

The "change" option is run the same as the "add-a-batch" option; however, if no data is entered after a prompt (?), the program retains the data it has. It only changes data that is input under the "change" option.

To reprint the data for a specific batch, the program is run and the "detailed record" option is selected. The computer responds by asking which batch and then prints the batch summary as shown in Exhibit 6-3.

The "summary" option is selected when a summary of a group of batches is desired. The program asks for starting and ending batch numbers, then it prints a summary as in Exhibit 6-4.

6.3.2 Measurement Control Calculation Programs

Summaries of comparisons of redundant measurements provide the basis of the measurement control calculation programs. The CNMCAS CPU was used to provide summaries of these comparisons for manually collected data. A separate measurement control calculation program was provided for each of the four input/output measurement points. The program for input measurements is described here, but the programs for product and waste are similar.

The programs provide summaries of redundant liquid level and density measurement. Exhibit 6-5 shows input density measurement comparisons for the accountability tank. Process density measurements were made with a Taylor instrument and calculated from Ruska instrument measurements. Density was also analyzed by the laboratory on accountability samples. On Exhibit 6-5, the "1-3" column compares Taylor density measurements to laboratory analyses. The "2-3" column compares Ruska density measurements to laboratory analyses. Both of these comparisons are also expressed as percent. These comparisons provide an indication of sampling or mixing problems. The "1-2" column compares Ruska and Taylor measurements. This comparison provides an indication of measurement equipment or instrument reading problems.

Exhibit 6-6 shows comparisons of after-sampling and after-transfer level measurements in the accountability tank. Level measurements in the accountability tank are provided by a Taylor instrument and two Ruska instruments (primary and backup) on normal size batches (i.e., the volume in the tank after sampling). For heel measurements, the liquid level falls below the range of the backup Ruska instrument; therefore, it cannot be used for comparison. These comparisons indicate measurement equipment problems or instrument reading errors plus Taylor instrument calibration shift.

TABLE 6-1

MEASURABLE IN-PROCESS INVENTORY ESTIMATE

INSERT ANALYTICAL RESULTS, IF AVAILABLE

TANK	H+	DENSITY	U CONC
DIS FLS ACC	? $	? 1.4401$	? 281.5$
ACCT	? 1.73$	? 1.4659$	? $
1 FAT	? 2$	? $	? $
2 FAT	? 2.37$	? 1.4205$	? $
OFF SPEC	? $	? $	? 150$
U PROD	? 2.6$	? 1.6971$	? $
HWW	? $	? 1.2290$	? 14.15$
GPW	? $	? 1.1221$	? 16.85$
SUMP COLL	? $	? $	? 16$
U PROD CTH	? 2.6$	? $	? $
HWW CTH	? $	? $	? 16$

TANK	KGS U	CONC	DENS	ACID
DIS FLS ACC	310	.2815	1.4401	1.6
ACCT	145	.306666	1.4659	1.73
1 FAT	1262	.236314	1.38059	2
2 FAT	380	.257334	1.4205	2.37
OFF SPEC	800	.15	1.22782	2
PU REWORK*	132	.242037	1.35943	1.1
U PROD	1416	.458943	1.6971	2.6
1BP SURG*	26	.612519E-1	1.1148	1
HWW	6	.01415	1.229	3
GPW	4	.01605	1.1221	3
SUMP COLL	35	.016	1.15447	4.5
HAFT	1225	.369047	1.57385	2.5
U PROD CTH	954	.183421	1.32922	2.6
HWW CTH	29	.016	1.20057	3
1CU CONC*	3	.291147	1.40582	.5
2EU CONC*	412	.396622	1.54667	.5

TOTAL: 6566

Ready

EXHIBIT 6-1

MEASUREMENT CALCULATION PROGRAM OPTION SELECTION

```
RUN
ACCT1    13:04            24-Oct-78
IS THIS SUMMARY(1), ADD-A-BATCH(2), DETAILED RECORD(3), OR CHANGE(4)? 1
SUMMARY FOR WHAT BATCHES
CAMPAIGH #1 STARTS WITH 61 ;  #2 WITH 83  ;#3 WITH  104
          START WITH BATCH? 61
          END WITH BATCH? 76


SET PAPER TO START PAGE THEN PRESS RETURN?
```

EXHIBIT 6-2

MEASUREMENT CALCULATION PROGRAM "ADD-A-BATCH" OPTION

24-Oct-78 12:38

ACCOUNTABILITY TANK BATCH RECEIPT

BATCH NO.? 76

	BEFORE RECEIPT	BEFORE SAMPLE	AFTER SAMPLE	AFTER TRANSFER
DATE	? 082478$	? 082478$	? 082578$	? 082570$
LR-125	? 10$	? 51.5$	? 51.3$	? 8$
ZERO	? -.08$	? -.06$	? -.08$	? -.09$
LR-125-R	? 53.19$	? 278.87$	? 278.75$	? 41.95$
DR-166	? 65.5$	? 63$	? 62.5$	? 63.5$
ZERO	? -.06$	? -.04$	? -.04$	? -.06$
DR-166-R	? 13.24$	? 239.46$	? 239.45$	? 2.43$
TJR-108-10	? 40$	? 40$	? 42$	? 36$
SAMPLE RESULTS				
LOG NO.	17399	NA	? 17448$	NA
DENSITY	1.5954	NA	? 1.5673$	NA
U(MG/G)	275.3	NA	? 266.41$	NA
H+	.455	NA	? .38$	NA
VOLUME	601	4229	4232	437
KGS SOL	951.6	6578.7	6576.6	681.4

RECEIVED 3631 LITERS 1490.1 KGS U — TRANS 3795 LITERS 1570.6 KGS U

MEASUREMENT CONTROL STUFF

RUSKS-TAYLOR LEVEL (BEFORE RECEIPT)= -1.34 CM (-2.52 %)
(AFTER SAMPLE)= -1.32 CM (-.47 %)

RUSKA-TAYLOR DENSITY= -.0138 G/ML (-.01 %)

RUSKA-LAB DENSITY= .004 G/ML (.26 %)
TAYLOR-LAB DENSITY= .0177 G/ML (1.14 %)

EXHIBIT 6-3

MEASUREMENT CALCULATION PROGRAM "DETAILED RECORD" OPTION

24-Oct-78 13:32

ACCOUNTABILITY TANK BATCH RECEIPT

BATCH NO.? 76

	BEFORE RECEIPT	BEFORE SAMPLE	AFTER SAMPLE	AFTER TRANSFER
DATE	08/24/78	08/24/78	08/25/78	08/25/78
LR-125	10	51.5	51.3	8
ZERO	-.08	-.06	-.08	-.09
LR-125-R	53.19	278.87	278.75	41.95
DR-166	65.5	63	62.5	63.5
ZERO	-.06	-.04	-.04	-.06
DR-166-R	13.24	239.46	239.45	2.43
TJR-108-10	40	40	42	36
SAMPLE RESULTS				
LOG NO.	17399	NA	17448	NA
DENSITY	1.5954	NA	1.5673	NA
U(MG/G)	275.3	NA	266.41	NA
H+	.455	NA	.38	NA
VOLUME	601	4229	4232	437
KGS SOL	951.6	6578.7	6576.6	681.4

RECEIVED 3631 LITERS TRANS 3795 LITERS
1490.1 KGS U 1570.6 KGS U

MEASUREMENT CONTROL STUFF

RUSKS-TAYLOR LEVEL (BEFORE RECEIPT)= -1.34 CM (-2.52 %)
(AFTER SAMPLE)= -1.32 CM (-.47 %)

RUSKA-TAYLOR DENSITY= -.0138 G/ML (-.01 %)

RUSKA-LAB DENSITY= .004 G/ML (.26 %)
TAYLOR-LAB DENSITY= .0177 G/ML (1.14 %)

EXHIBIT 6-4

MEASUREMENT CALCULATION PROGRAM "SUMMARY" OPTION

24-Oct-78 13:04

FOR CAMPAIGN #3
ACCOUNTABILITY TANK BATCH INPUT SUMMARY
MEASUREMENT POINT 2-03
VESSEL 18-D-101

BATCH 02-003-	DATE	LITERS	SOLUTION KGS.	URANIUM KGS.
61	08/10/78	2154	2145.6	.3
62	08/11/78	2038	2031	0
63	08/12/78	6228	9126.4	1979.9
64	08/15/78	6308	9526.3	2196.3
65	08/15/78	6262	9500.6	2218.5
66	08/16/78	6229	9465.7	2215
67	08/17/78	0	0	0
68	08/17/78	6541	9521.6	1958.8
69	08/17/78	6582	9563.9	1947
70	08/21/78	4339	6258.7	1250.7
71	08/22/78	3503	5331.2	1293.2
72	08/22/78	3467	5338.1	1380.1
73	08/23/78	4109	6338.8	1669.9
74	08/23/78	3646	5659.3	1488.7
75	08/24/78	3084	4892.1	1352.6
76	08/25/78	3631	5625	1490.1
CAMPAIGN TOTAL		68121	100324	22441.2
TOTAL THIS RUN		68121	100324	22441.2

EXHIBIT 6-5

24-Oct-78 13:36

ACCOUNTABILITY TANK
DENSITY MEASUREMENT
COMPARISONS
LAB DENSITY AT TANK TEMP

BATCH NO	TAYLOR DENS (1)	RUSKA DENS (2)	LAB DENS (3)	1-3 G/ML	2-3 G/ML	1-3/3 %	2-3/3 %	1-2 G/ML	DATE
61	1.006	1.0007	.9996	.0064	.0011	.64	.11	.0053	08/10
62	1.006	.9996	.999	.007	.0005	.7	.05	.0064	08/11
63	1.4841	1.4673	1.4643	.0197	.003	1.34	.2	.0167	08/12
64	1.5221	1.5104	1.5069	.0152	.0035	1	.23	.0116	08/15
65	1.5311	1.5188	1.5166	.0145	.0022	.95	.14	.0123	08/15
66	1.5357	1.5207	1.5194	.0162	.0012	1.06	.07	.0149	08/16
67	1.5357	1.5247	1.5193	.0163	.0054	1.07	.35	.0109	08/17
68	1.4813	1.4613	1.4577	.0235	.0036	1.61	.24	.0199	08/17
69	1.4723	1.4574	1.4534	.0189	.0039	1.3	.26	.0149	08/17
70	1.475	1.4526	1.4466	.0284	.006	1.96	.41	.0224	08/21
71	1.5311	1.5124	1.5125	.0185	-.0002	1.22	-.02	.0187	08/22
72	1.5139	1.4827	1.5349	-.021	-.0522	-1.37	-3.41	.0312	08/22
73	1.5628	1.5457	1.542	.0207	.0036	1.34	.23	.0171	08/23
74	1.5674	1.5552	1.551	.0163	.0041	1.05	.26	.0121	08/23
75	1.599	1.5865	1.5805	.0184	.006	1.16	.37	.0124	08/24
76	1.5719	1.558	1.554	.0178	.0039	1.14	.25	.0139	08/24
77	1.5402	1.5207	1.5224	.0177	-.0018	1.16	-.12	.0195	08/26
78	1.4967	1.4847	1.484	.0127	.0006	.85	.04	.012	08/26
79	1.4967	1.4831	1.4831	.0135	0	.91	0	.0135	08/27
80	1.4949	1.4875	1.4864	.0084	.001	.56	.06	.0074	08/27
81	1.5058	1.4934	1.4921	.0137	.0012	.91	.08	.0124	08/28
82	1.513	1.5041	1.5027	.0103	.0013	.68	.08	.0089	08/29
83	1.5221	1.512	1.5082	.0138	.0037	.91	.24	.0101	09/05
84	1.4949	1.5001	1.4967	-.0019	.0033	-.13	.22	-.0053	09/08
85	1.5311	1.5215	1.5217	.0094	-.0003	.61	-.02	.0096	09/08
86	1.5311	1.5287	1.528	.0031	.0006	.2	.03	.0024	09/08
87	1.5185	1.5089	1.5078	.0106	.0011	.7	.07	.0095	09/09
88	1.5311	1.5251	1.5036	.0275	.0214	1.82	1.42	.006	09/10
89	1.5031	1.4867	1.4848	.0183	.0019	1.23	.12	.0163	09/10
90	1.504	1.5065	1.4813	.0226	.0252	1.52	1.7	-.0026	09/10
91	1.5311	1.5211	1.5226	.0084	-.0016	.55	-.11	.0099	09/11
92	1.5067	1.4966	1.4924	.0142	.0041	.95	.27	.0101	09/11
93	1.5311	1.5215	1.5189	.0121	.0025	.79	.16	.0096	09/12
94	1.5492	1.5425	1.5442	.005	-.0017	.32	-.12	.0067	09/12
95	1.5402	1.5235	1.5204	.0197	.003	1.29	.19	.0167	09/13
96	1.5239	1.5116	1.5128	.0111	-.0012	.73	-.08	.0123	09/13
97	1.5248	1.5152	1.5138	.0109	.0013	.72	.08	.0095	09/13
98	1.5583	1.5453	1.5467	.0116	-.0014	.74	-.1	.013	09/14
99	1.5302	1.5211	1.5258	.0044	-.0047	.28	-.31	.009	09/14
100	1.542	1.537	1.5389	.0031	-.002	.2	-.13	.005	09/15
101	1.5402	1.5259	1.5254	.0147	.0004	.96	.02	.0142	09/15
102	1.504	1.5005	1.4996	.0043	.0008	.28	.05	.0034	09/15
103	1.4678	1.4609	1.4612	.0066	-.0004	.45	-.03	.0069	09/16
104	1.322	1.3104	1.3193	.0026	-.009	.19	-.69	.0116	09/22

EXHIBIT 6-6

24-Oct-78 13:40

INPUT ACCOUNTABILITY TANK
LEVEL MEASUREMENT
COMPARISONS

BATCH NO.	DATE	AFTER SAMPLE RUSKA LEVEL (1)	AFTER SAMPLE BACKUP LEVEL (2)	AFTER SAMPLE TAYLOR LEVEL (3)	(1-3) CM.	(2-3) CM.	AFTER TRANSFER RUSKA LEVEL (4)	AFTER TRANSFER TAYLOR LEVEL (5)	(4-5) CM.
61	08/10	186.7	186.7	186.8	.1	-.1	186.7	186.8	-.1
62	08/11	268.1	268.1	268.7	-.6	-.6	46.8	46.4	.4
63	08/12	380.6	380.5	382.8	-2.2	-2.3	42.7	44.8	-2.1
64	08/15	425.3	425.2	428.7	-3.4	-3.5	41.1	43.7	-2.6
65	08/15	422.4	422.4	425.4	-3	-3	40.9	43.7	-2.8
66	08/16	420.8	420.8	424.9	-4.1	-4.1	342.3	344	-1.7
67	08/17	342.3	342.1	344	-1.7	-1.9	26.9	28.9	-2
68	08/17	409.2	409.1	409.6	-.4	-.5	40.9	43.7	-2.8
69	08/17	424.6	424.5	426	-1.4	-1.5	165.3	163.8	1.5
70	08/21	416	415.9	416.7	-.7	-.8	42.8	43.7	-.9
71	08/22	257.5	257.5	259.4	-1.9	-1.9	53.4	54.6	-1.2
72	08/22	267.8	269.1	269.8	-2	-.7	43.7	44.8	-1.1
73	08/23	298.3	298.2	300.4	-2.1	-2.2	48.4	49.1	-.7
74	08/23	275.7	275.6	278.5	-2.8	-2.9	51.4	54.6	-3.2
75	08/24	248.2	248	251.2	-3	-3.2	53.3	54.6	-1.3
76	08/25	278.8	278.7	280.1	-1.3	-1.4	42	43.7	-1.7
77	08/26	268.2	268.2	269.2	-1	-1	43.7	43.7	0
78	08/26	292.4	292.4	295.4	-3	-3	49.1	49.1	0
79	08/27	315.8	315.8	317.8	-2	-2	51.5	53.5	-2
80	08/27	285.8	285.8	288.9	-3.1	-3.1	41.8	43.7	-1.9
81	08/28	282.9	282.9	284	-1.1	-1.1	54.8	54.6	.2
82	08/29	326.5	326.4	327.7	-1.2	-1.3	48.7	54.6	-5.9
83	09/05	267.7	267.6	270.3	-2.6	-2.7	50.8	53.5	-2.7
84	09/08	314.5	314.4	316.2	-1.7	-1.8	52.9	54.6	-1.7
85	09/08	308.6	308.6	311.3	-2.7	-2.7	43.5	46.4	-2.9
86	09/09	299.7	299.6	300.4	-.7	-.8	50.5	51.9	-1.4
87	09/09	305.9	305.8	306.9	-1	-1.1	42.5	45.3	-2.8
88	09/10	336	335.5	338.6	-2.6	-3.1	52.1	54.6	-2.5
89	09/10	345.1	345	346.2	-1.1	-1.2	50.8	53.5	-2.7
90	09/10	358.7	358	360.4	-1.7	-2.4	50	53	-3
91	09/11	330.3	330.3	333.1	-2.8	-2.8	48.6	49.7	-1.1
92	09/11	288.9	288.8	289.4	-.5	-.6	47.5	48.1	-.6
93	09/12	323.7	323.7	326.6	-2.9	-2.9	40.4	43.7	-3.3
94	09/12	307.7	307.7	310.7	-3	-3	44.9	48.6	-3.7
95	09/13	305.2	305.1	306.9	-1.7	-1.8	42.6	48.6	-6
96	09/13	279	279	279.6	-.6	-.6	43.5	44.8	-1.3
97	09/13	322.2	322.2	323.3	-1.1	-1.1	52.4	54.6	-2.2
98	09/14	350.3	350.3	352.2	-1.9	-1.9	50	49.1	.9
99	09/14	323	323.1	323.8	-.8	-.7	51.2	54.6	-3.4
100	09/15	337.9	337.9	339.7	-1.8	-1.8	55.1	54.6	.5
101	09/15	321.3	321.2	322.2	-.9	-1	52.7	54.6	-1.9
102	09/16	347.4	347.4	349.5	-2.1	-2.1	43.4	46.4	-3
103	09/17	330.1	330.1	333.1	-3	-3	3.9	5.5	-1.6
104	09/22	63.1	63.3	65	-1.9	-1.7	2.5	5.5	-3

7.0 CONCLUSIONS

This section provides a summary of the conclusions drawn from the evaluation of the Computerized Nuclear Materials Control and Accounting System (CNMCAS) development work during FY 1978.

7.1 Uranium Input/Output Demonstration Program

Viewed in total, the Uranium Input/Output Demonstration Program (in conjunction with the remote data acquisition system*) produced excellent results and will serve as a sound basis for future CNMCAS development work.** The value of pursuing selected CNMCAS elements through all stages of development and implementation was fully demonstrated. Although several problems remain to be corrected, the overall performance of the measurement, accounting, and measurement control programs was satisfactory. Specific conclusions include:

- Coordination of measurement activities by the measurement programs was demonstrated.
- Measurement data produced by the measurement programs showed excellent agreement with manual data except during problem periods. Over 100 comparisons of manual Ruska readings versus RTP Ruska readings were examined and showed an average difference in readings of 0.005 centimeter H_2O with a standard deviation of ± 0.064 centimeter H_2O.
- Measurement control program summary reports were generated which demonstrated the methods and data needed to determine control limits and to estimate random error variances associated with bulk measurements.
- Accounting program performance was demonstrated by the generation of various accounting reports from measurement data in the data base.
- Integration of measurement control comparisons to flag marginal and out-of-control conditions was demonstrated.
- Operator acceptance was excellent.

---

*Referred to herein as the RTP system.

**Documentation is an essential requirement of CNMCAS development work. In addition to the software specifications and program listings shown in the Appendices, the software vendor provided Operator's Guides and Programmer's Manuals.

- The value of the data produced by the measurement programs for process control use was demonstrated.

- Transmission of sample requests and analytical results between CNMCAS and the LDS CPU's was demonstrated.

Problem areas include:

- Typical software "bugs."

- Hardware failures, specifically the lack of spare components for the preprocessor in the RTP system.

- Lack of modularity in the design of the accounting program.

- Inadequate reliability of the CNMCAS-LDS communications link.

- Limited capability of the data base edit program.

- The RSTS/E operating system provided slower response time than desired and periodically showed overload symptoms. RSTS/E is a time-sharing system and its ability to handle additional CNMCAS development work is highly suspect. Conversion to a real-time operating system, e.g., RSX-11M, offers real advantages for future development work.

7.2 RTP System

The overall performance of the RTP system was excellent considering the lack of spares for critical components in the PDP 11/04 preprocessor. Operation was completely satisfactory until apparent hardware problems started to develop in the preprocessor. The problem ultimately shut the system down at the end of the demonstration period and has been tentatively diagnosed as a faulty memory board. Spares for critical components in the preprocessor are an absolute necessity to maintain operating continuity of the RTP system.

7.3 Auxiliary Programs

Auxiliary CNMCAS programs were developed and tested with results ranging from promising to excellent. These programs included:

- In-Process Inventory Program

  A computer-based program to estimate in-process inventory quantities was developed which incorporates 16 major surge (process holdup) points. The program accumulates bulk measurement data for these points via the RTP system. Pertinent analytical data (if available) are entered, or programmed flowsheet/historical values are used for calculation of uranium quantity at each surge point. Inadequate time and periods of equilibrium operation were available to fully evaluate the program. Based on limited test results, unmeasured process holdup was estimated at 2 to 3 MTU.

- HA Feed Flow Rate Program

  A program was developed in CNMCAS to measure the feed flow rate from the HA feed tank to the solvent extraction system. The final version of the program operated successfully and showed reasonable agreement with manually calculated flow rate. However, performance was significantly affected by probe plugging problems.

- Calculation Programs for Manually Collected Data

  Measurement and measurement control calculation programs for manually collected data were developed and produced excellent results. Extensive use of program output reports were made in accounting and measurement control activities.

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8.0 RECOMMENDATIONS

This section provides recommendations applicable to the Computerized Nuclear Materials Control and Accounting System (CNMCAS) development work planned in FY 1979. The recommendations represent planned actions.

8.1 Real-Time Operating System

The CNMCAS software developed in FY 1978 incorporated RSTS/E, a time-sharing system. The RSTS/E operating system provided slower response than desired and periodically showed overload symptoms. Conversion of CNMCAS software to a real-time operating system, e.g., RSX-11M would provide faster response time and minimize the overload problem. CNMCAS software will be converted to RSX-11M in FY 1979.

8.2 RTP Preprocessor Component Spares

The RTP system is vital to CNMCAS development work. Without the RTP system, CNMCAS demonstrations are impossible. Spares for critical components will be procured in FY 1979.

8.3 CNMCAS-LDS Communications Link

Software and possibly hardware problems exist in the CNMCAS-LDS communications link. Corrective action will be taken to improve the reliability of the link.

8.4 Measurement Programs

The measurement programs will be refined to provide more information to CNMCAS operators on a real-time basis (e.g., instrument readings used in quantity calculations, printout of all measurement data comparisons, etc.).

8.5 Accounting Program

The modularity of the accounting program will be increased to make program modifications easier.

8.6 Ruska Zero Operation

To obtain the best possible data from a Ruska DDR-6000 precision pressure gauge, the instrument must be valved out of service and a "zero" reading obtained before a measurement is made. This "zeroing" operation is currently performed manually, and the "zero" readings are entered at the CNMCAS input/output (I/O) terminal for adjusting Ruska readings collected via the RTP system. The necessary hardware/software to control the Ruska "zero" operation by computer will be installed. The measurement programs will direct the "zeroing" operation and CNMCAS will record and store zero readings. This will eliminate the manual "zeroing" operation and the manual entry of zero readings at the CNMCAS I/O terminal.

8.7 Data Base Edit Program

The data base edit program was designed for limited capability to prevent tampering with source data. As a result, correction of measurement data errors, which were caused by various problems, was difficult and time consuming. A more flexible, but closely controlled, data base edit program will be developed.

8.8 Limits-of-Error Program

A limits-of-error program for input and output measurement data will be developed.

8.9 FY 1979 Uranium Input/Output Demonstration Program

The recommendations above will point toward a refined and enhanced uranium input/output demonstration to be conducted in conjunction with the FY 1979 integrated uranium run. An objective of this demonstration is a test of the CNMCAS as the primary nuclear materials control and accounting system with a minimum of manual data collection and processing.

REPORT NO. AGNS-1040-2.2-9

COMPUTERIZED NUCLEAR MATERIALS CONTROL AND ACCOUNTING SYSTEM DEVELOPMENT EVALUATION REPORT - 1978

APPENDIX A

URANIUM INPUT/OUTPUT DEMONSTRATION PROGRAM - DETAILED DESCRIPTIONS

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Michael H. Ehinger
Charles Joseph
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October 1978

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EXHIBITS:

1.0 INTRODUCTION

An integrated process run using natural uranium will be performed at the BNFP during August and September 1978. An objective of this run is the use of the Computerized Nuclear Materials Control and Accounting System (CNMCAS) hardware for measurement, accounting, and measurement control functions required for the following process steps of primary concern to nuclear materials control and accounting:

Input uranium feed to process
Product uranium produced
Liquid waste discarded.

This objective will be accomplished by the Uranium Input/Output Demonstration Program described in this document.

The Uranium Input/Output Demonstration Program is extremely important to the evolution of the CNMCAS. The demonstration program will carry selected elements of the measurement, accounting, and measurement control subsystems through all stages of CNMCAS development and implementation, i.e.,

Description
Software specifications
Software preparation
Software/hardware on-line testing.

The experience and knowledge gained from the Uranium Input/Output Demonstration Program should be invaluable in the continuing effort to develop and implement the CNMCAS.

The Uranium Input/Output Demonstration Program is composed of six interrelated computer programs as follows:

(1) Input Measurement Program
(2) Product Measurement Program
(3,4) Waste Measurement Programs (GPW and HWW)
(5) Nuclear Materials Accounting Program
(6) Measurement Control Program.

Detailed descriptions of these programs are provided in Sections 2.0 through 6.0. Calculations used in the programs are consolidated in Section 7.0.

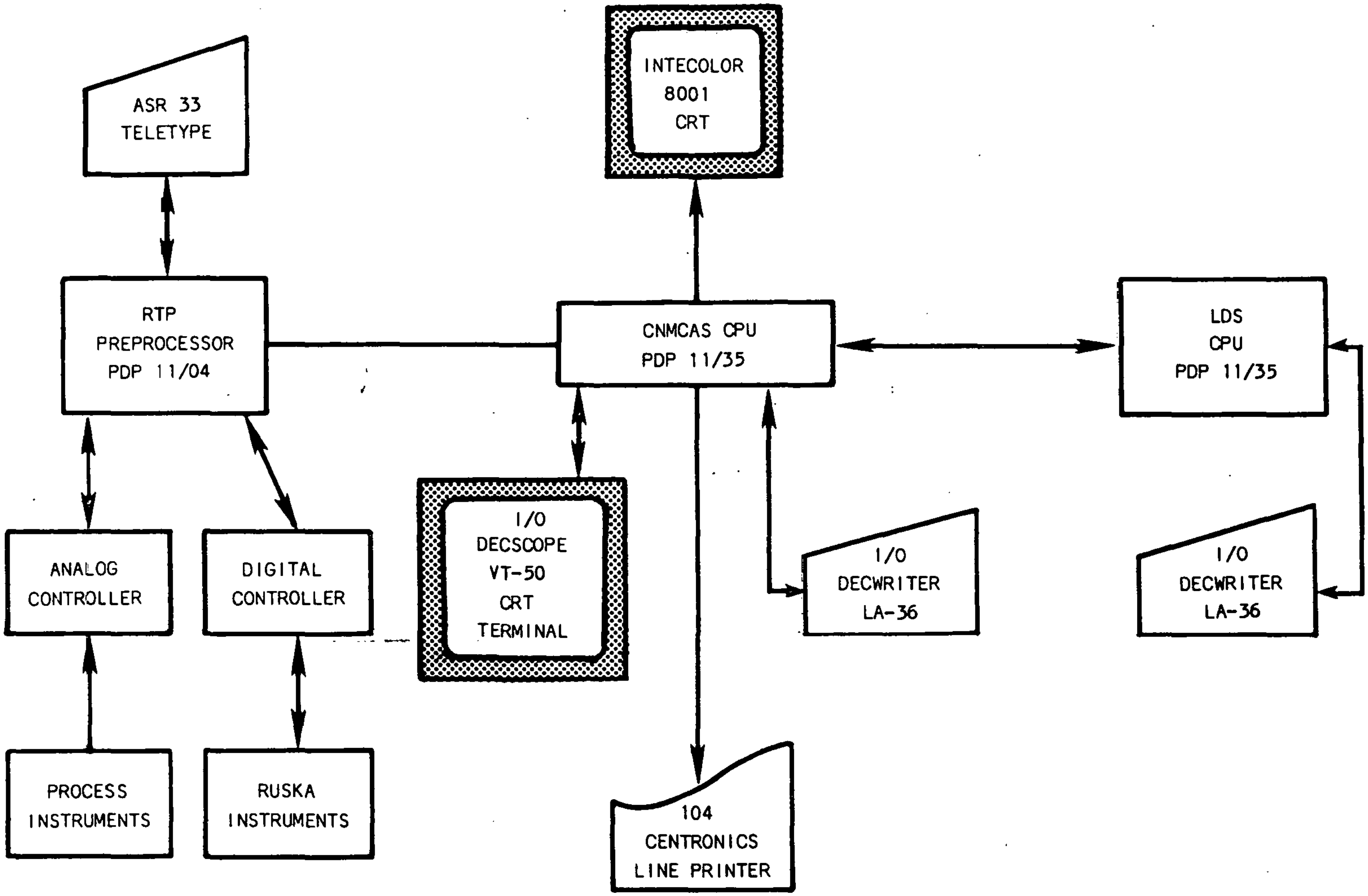
Certain terms used in the detailed description of the Uranium Input/Output Demonstration Program warrant explanation:

Ruska Instrumentation refers to Ruska DDR-6000 precision pressure gauges used to measure liquid level and density.

- Taylor Instrumentation refers to installed Taylor instrument loops composed of differential pressure transducers with strip chart readouts for liquid level and density measurements.
- RTP System* refers to the remote (RTP) data acquisition system which scans selected process instrumentation, collects, stores, and manipulates instrument signals, and transmits instrument data to the CNMCAS central processing unit. RTP is the abbreviation for real-time peripheral equipment manufactured by Computer Products, Inc.

The basic CNMCAS hardware used for the Uranium Input/Output Demonstration Program is presented in Figure 1-1.

*The RTP system is described in detail in Appendix B.



BASIC CNMCAS HARDWARE FOR THE URANIUM INPUT/OUTPUT DEMONSTRATION PROGRAM

FIGURE A1-1

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2.0 INPUT MEASUREMENT PROGRAM

2.1 General Description

This program coordinates input measurement activities. It acquires input measurement data, examines data for gross errors and potential measurement problems, calculates quantities for use by operations in process control, and moves data to storage at the completion of batch measurement and transfer activities.

Input measurement data are generated for each batch of uranium feed solution received in and transferred through the accountability tank (18-D-101), Measurement Point 2-03. The program provides specific instructions to the operator to accomplish the measurement and transfer in the proper sequence. It receives measurement data from remote terminals and the RTP system* which is linked to process instrumentation. Measurement data is retained in a "temporary storage file." Batch measurement data accumulates in this file until the batch measurement is complete. The program then moves the data to the "permanent file" for long-term data storage and resets the "temporary file" for the next batch.

The entire batch measurement sequence takes four hours or more. During this time, the terminal and operator cannot be dedicated to this measurement only. For this reason, the program must "sign off" after each step of the measurement sequence. This allows access to the terminal for other measurement activities while input measurement activities not involving the computer are carried out. This can be accomplished by using a "sequence code." This code is stored as part of the temporary data file. It indicates current status of the measurement sequence. When the measurement program is activated, the sequence code is called and the program moves to the appropriate sequence in the measurement. The code is updated and the program signs off when the sequence is complete.

The program is addressable from remote terminals located in the control room or operating areas of the facility. For the Uranium Input/Output Demonstration Program, every effort should be made to minimize operator/computer dialogue for program access. The operator initiates the measurement program using a short code word. The program starts by asking the operator for his initials and verifies the initials to a list of approved initials. It then calls the sequence code and moves to the program. In future applications, it may be possible to simplify the terminals to a few preprogrammed function keys which further simplify this access routine. Additional personnel identification schemes, such as badge readers, may be applied to fulfill the security requirements on measurement program use.

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*Remote (RTP) data acquisition system.

An additional activity required for input measurements during the Uranium Input/Output Demonstration is checking on "receiver-shipper differences" between the accountability tank and the uranium product sample tank (24-D-204). A part of the product measurement sequence (described in Section 4.0) is to calculate the "quantity transferred" from product measurement data and place this quantity in a "suspense file." After receipt of a batch of solution from the product tank, the input measurement program calculates the quantity received and calls the data from the "suspense file" for comparison.

The specific sequences associated with the input measurement program are described in Section 2.2. A description of the temporary data file contents are included in Section 2.3 and the permanent data file in Section 2.4. The specific calculation routines for input measurement sequences are detailed in Section 7.1.

2.2 Sequence Descriptions

For input measurements, the quantities received in the accountability tank (referred to as the input tank), as well as the quantities transferred to process, are measured. The operator starts the input measurement program by entering the appropriate code at the terminal. The program responds by asking for the operator initials and verifies these initials to the list of approved initials. It then opens the temporary file and reads the sequence code. The program jumps to the current sequence as indicated by the code. The specific sequences are as follows:

Sequence 1 This sequence opens by incrementing the Batch ID number for a new batch and setting up the data block reserved for this batch in the base data file. It now informs the operator:

I'M READY TO MEASURE BEFORE-RECEIPT DATA. YOU SHOULD HAVE THE SPARGE OFF AND INSTRUMENT PURGES AT 0.5 SCFH. ARE YOU READY (YES OR NO)?

The operator answers with a "YES" or (CR), if preparation has been completed and the program moves to Sequence 3. He answers "NO" to stop the sequence until he has completed preparations and the program moves to Sequence 2.

Sequence 2 If the answer was "NO," the computer responds with:

SPARGER AT W835 EL 300*
PURGES AT W835 EL 308*
I'LL WAIT TO HEAR FROM YOU.

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*Refers to sparger and instrument air purge valving coordinates in the operating gallery.

It assigns the status code to bring it back to this sequence when the operator calls back and closes the temporary file.

To reinitiate the program, the operator again codes in the input measurement program. It opens the temporary file and reads the sequence code which returns the program back to this sequence. The program asks the operator:

READY FOR MEASUREMENTS NOW (YES OR NO)?

An affirmative response by the operator allows the program to proceed to the next sequence. A negative response returns to the start of this sequence for the operator to perform the necessary preparations.

Sequence 3 When the sparge and purge rates are set, the program asks the operator for Ruska "zero" information. It then calls the RTP system for the "Before-Receipt" measurement data and stores it in the temporary data file. Measurements of the solution "heel" quantity from the previous batch, including analytical data, are still available in the temporary file.

The program performs appropriate measurement comparisons to check instrument performance and compares the two heel measurements (the current heel measurement and the measurement from the previous batch). If the comparisons show no apparent problems, the program proceeds to Sequence 5. If a problem is indicated, the program proceeds to Sequence 4.

Sequence 4 If a problem is indicated from measurement comparisons, the program prints an error message to the operator and to the Nuclear Materials Control (NMC) line printer. The computer establishes the course of action based on magnitude of the problem and importance of the measurement. The Measurement Control Section (Section 6.0) outlines potential errors and the appropriate course of action.

If the magnitude and importance dictates that the measurement sequences should be stopped, the program informs the operator of the specifics of the indicated problem. It then updates the sequence code in the temporary file to return the program to this sequence and signs off.

Halting of the measurement program requires supervisory approval to restart. When the program is reinitiated after corrective action, it asks for this supervisory approval. The program provides options to proceed based upon the corrective action taken after review of the problem. In this case, the program allows proceeding to Sequence 5 which essentially overrides the error indication, or sends the program back to the start of Sequence 3 which records new "Before-Receipt" measurement data. It also includes the option to continue the hold and further investigate the indicated problem.

Sequence 5 With "Before-Receipt" measurement data recorded, the program calculates the appropriate heel quantities and informs the operator:

THE INPUT ACCOUNTABILITY TANK CONTAINS _____ KGS OF SOLUTION WITH _____ KG U AS THE HEEL QUANTITY. YOUR NEXT STEP IS TO BRING IN THE NEW BATCH. IT WILL BE BATCH 02-003-____. AFTER RECEIPT, MIX THE BATCH FOR 10 MINUTES. THEN SHUT DOWN SPARGE, SET PURGES, AND CALL BACK.

The program sets the sequence code to move the program to Sequence 6 when the program is next initiated.

Sequence 6 When the operator next addresses the program, after the batch has been received, the program again opens the temporary file, reads the status code, and prints the following message to the operator:

YOU SHOULD HAVE COMPLETED THE TRANSFER, SPARGED FOR 10 MINUTES, THEN SHUT DOWN THE SPARGE AND SET INSTRUMENT AIR PURGES TO 0.5 SCFH. SHALL I TAKE MEASUREMENTS (YES OR NO)?

With a negative response, the program proceeds to Sequence 7. With an affirmative response, the program proceeds to Sequence 8.

Sequence 7 If "NO" was the response, the program responds with:

SPARGE LOCATED W835 EL 300
PURGES LOCATED W835 EL 308
REMEMBER 10 MINUTES MINIMUM SPARGE TIME THEN SHUT IT OFF.
I'LL WAIT TO HEAR FROM YOU.

The appropriate sequence code is assigned to the temporary file to bring the program back to this point after the operator corrects the situation and calls back.

When the operator recalls the program, the program responds with:

MIXING COMPLETED, SPARGE OFF. SHALL I PROCEED WITH MEASUREMENT (YES OR NO)?

A "NO" response sends the program back to the start of this sequence. With a "YES" response, the program moves to the next sequence.

Sequence 8 — The program now asks the operator for Ruska "zero" readings and then takes "Before-Sampling" measurement data from the RTP system. Measurement control comparisons to check instrument performance are again applied. In addition to the instrument performance checks, a preliminary comparison of solution quantity received to solution quantity sent is made. The program calls information on the quantity sent from the uranium product sample tank (referred to as the product tank) from the "suspense file." It compares these data to kilograms of solution received as calculated from the available measurement data for the input tank. If a measurement problem is indicated, the program moves to Sequence 9. If comparisons show the measurement data is acceptable, the program proceeds to Sequence 10.

Sequence 9 — When a problem is indicated, an error message is printed to the operator and to the NMC line printer. As in Sequence 4, the magnitude of the problem and the importance of the measurement, with respect to material balance calculations, dictate the course of action. When the problem dictates halting the measurement sequence, supervisory approval to restart is required.

When the program is restarted with proper approvals, the options are provided to continue the measurement program, continue the hold for further investigation, or to return to Sequence 8 for remeasurement of "Before-Sampling" data.

Sequence 10 — The program now calculates appropriate quantities and prints the following message to the operator:

INPUT BATCH 02-003-____ NOW CONTAINS APPROXIMATELY ___ KGS OF SOLUTION (____ LITERS). TURN ON THE SPARGE FOR SAMPLING. I WILL LET YOU KNOW WHEN SAMPLING IS COMPLETE.

The program now moves to Sequence 11.

Sequence 11 — The CNMCAS must now communicate with the LDS to inform it that sampling can begin. The LDS assumes the responsibility of directing analytical activities to sample the batch and perform analyses. The CNMCAS must wait until sampling is complete. The LDS makes the judgment that sampling is complete when duplicate density analyses fall within acceptable limits and acid analysis is complete. The LDS reports the density and acid results to the CNMCAS which then informs the operator that sampling is complete and he may proceed with the following message:

ACCOUNTABILITY TANK SAMPLING IS COMPLETE. LOG NUMBER __________ RESULTS SHOW _____ G/ML DENSITY, _____ M ACID. SHUT THE SPARGE OFF FOR NEXT SET OF MEASUREMENTS. LET ME KNOW WHEN YOU ARE READY.

The sequence code is set to return to Sequence 12. The available analytical data is stored in the temporary file and the program signs off.

NOTE: A number of different analyses are required on each batch, to include mass spectrometer determination of concentration and isotopic distribution. This information must be communicated to the CNMCAS for storage in the base data file, but time is a factor since these analyses may be delayed considerably. For this reason, the LDS must communicate directly with the base data file to store this information when it does become available, independent of the measurement sequences. This communication should be tied to final approval of analytical results.

Sequence 12 When the operator completes setup for the measurement, he recalls the program. The program responds with:

THE SPARGE SHOULD NOW BE SHUT DOWN. SHALL I PROCEED WITH MEASUREMENTS (YES OR NO)?

An affirmative response moves the program to Sequence 13. With a negative response, the following is printed:

SPARGE LOCATED W835 EL 300
PURGES LOCATED W835 EL 308.

The sequence code is set to return the program to this sequence. The program shuts down to await operator action.

Sequence 13 The program asks for Ruska "zero" readings from the operator and then calls for "After-Sampling" measurements from the RTP system. The appropriate measurement comparisons to check instrument performance are made. Several comparisons of "Before-Sampling" to "After-Sampling" measurements are made. In addition, the solution quantity received is recalculated using the available analytical data and comparisons are remade to data in the "suspense file." If comparisons indicate a problem, the program moves to Sequence 14. If measurement data are acceptable, the program moves to Sequence 15.

Sequence 14 As with previous measurements when a problem is indicated, the error message is printed to the operator and the NMC line printer. The course of action is again dependent on the magnitude of the problem and the importance to material balance. If a program halt occurs after supervisory approval, the options are provided, (1) to continue, (2) return to "Before-Sampling" measurements with a new sample being required (Sequence 8), or (3) remeasure "After-Sample" data (Sequence 13).

Sequence 15 With "After-Sample" measurement data acceptable, the program makes the appropriate calculations and prints the following message to the operator:

CURRENT CONTENTS OF THE ACCOUNTABILITY TANK ARE _____ KG U (_____ KG _____ LITERS SOLUTION). YOU HAVE RECEIVED _____ KG U IN THIS BATCH. YOU MAY NOW PROCEED WITH TRANSFER AFTER RESTORING SPARGE. CALL BACK WHEN TRANSFER IS COMPLETED AND SPARGE IS OFF.

The program sets the sequence code to return the program to Sequence 16 when the program is next started. It then signs off.

Sequence 16 When the operator restarts the program after the transfer is complete, the program responds with:

THE SPARGE SHOULD BE OFF. ARE YOU READY FOR AFTER TRANSFER MEASUREMENTS?

The affirmative response moves the program to Sequence 17. With a negative response, the following is printed:

SPARGE LOCATED AT W835 EL 300
PURGES LOCATED AT W835 EL 308
CALL BACK WHEN READY.

With the negative response, the sequence code is set to return to this sequence and the program signs off.

Sequence 17 The program again asks the operator for Ruska "zero" readings. It then calls for "After-Transfer" measurement data from the RTP system. Appropriate measurement comparisons are applied to these data. If comparisons indicate the data is acceptable, the program moves on to Sequence 19. If a problem is indicated, the program moves to Sequence 18.

Sequence 18 As before when problems are indicated, the error message is printed to NMC. If a program halt is required, the options provided at restart are to continue or remeasure "After-Transfer" data by returning to Sequence 17.

Sequence 19 With measurement data acceptable, the program prints the following message to the operator:

YOU HAVE TRANSFERRED _____ KG U IN _____ KG, _____ LITERS OF SOLUTION WITH A CALCULATED CONCENTRATION OF _____ G U/L AND H+ OF _____ M.

The program now prints a batch transfer summary sheet at the NMC line printer. This summary includes all measurement data and timing of the various measurement activities recorded in the temporary data file. It moves the data from the temporary file to the base data file. It then resets the temporary file to accept measurement data for the next batch and signs off.

2.3 Temporary File Description

The following information will be filed in the temporary data file:

1. Lot Number
2. Sequence code
3. Batch number
4. Date of Before-Receipt (BR) measurement
5. Time of Before-Receipt measurement
6. Operator initials (Op. Init.) addressing program at PR measurement
7. LR-125 (BR)
8. LR-125-R (BR)
9. DR-166 (BR)
10. DR-166-R (BR)
11. TJR-108-10 (BR)
12. Sample log number for previous batch
13. Lab density result
14. Lab acid result
15. Time the operator notifies the computer that receipt is complete and 10 minutes mixing complete
16. Date of Before-Sampling (BS) measurements
17. Time of Before-Sampling (BS) measurements
18. Op. Init. addressing the program at BS measurements
19. LR-125 (BS)
20. LR-125-R (BS)
21. DR-166 (BS)
22. DR-166-R (BS)
23. TJR-108-10 (BS)
24. Time of sign-off of the BS measurement sequence which becomes time mixing starts for sampling
25. Time CNMCAS requests LDS to sample
26. Sampling time
27. Sample log number
28. Lab density results
29. Lab acid concentration results
30. Time sampling complete notification given
31. Time operator addresses program signaling sparge off
32. Date of After-Sampling (AS) measurement
33. Time of After-Sampling (AS) measurement

34. Operator initials addressing the program at AS measurements
35. LR-125 (AS)
36. LR-125-R (AS)
37. DR-166 (AS)
38. DR-166-R (AS)
39. TJR-108-10 (AS)
40. Time operator informs that transfer is complete
41. Date of After-Transfer (AT) measurement
42. Time of After-Transfer (AT) measurements
43. Operator initials addressing the program at AT measurements
44. LR-125 (AT)
45. LR-125-R (AT)
46. DR-166 (AT)
47. DR-166-R (AT)
48. TJR-108-10 (AT)

49-53. Codes indicating remeasurement, etc., to be determined later.

2.4 Base File Data Description

1. Lot number
2. Batch number
3. Date of BS measurements
4. Time of BS measurements
5. LR-125 (BS)
6. LR-125-R (BS)
7. DR-166 (BS)
8. DR-166-R (BS)
9. TJR-108-10 (BS)
10. Sample log number
11. Density (LAB)
12. Acid
13. Uranium concentration mass specification (perhaps duplicate analyses)
14. Uranium concentration VP (if applicable)

15-18. Uranium isotopic results

19. Date of AS measurements
20. Time of AS measurements
21. LR-125 (AS)
22. LR-125-R (AS)
23. DR-166 (AS)
24. DR-166-R (AS)
25. TJR-108-10 (AS)
26. Date of AT measurements
27. Time of AT measurements
28. LR-125 (AT)
29. LR-125-R (AT)
30. DR-166 (AT)
31. DR-166-R (AT)
32. TJR-108-10 (AT)

33-37. Codes indicating remeasurement, etc.

2.5 Output Format

A preliminary example of measurement data output format is presented as Exhibit 2.5.

EXHIBIT 2.5

INPUT ACCOUNTABILITY MEASUREMENT RECORD
Vessel No. 18-D-101, Measurement Point 2-03

Input Accountability Batch I.D.__________ Date__________

		BEFORE RECEIPT	BEFORE SAMPLING	AFTER SAMPLING	AFTER TRANSFER
Date/Time/Op. Inst.		/ /	/ /	/ /	/ /
LEVEL	LR-125				
	Level Ruska "Zero"				
	LR-125R				
DENSITY	DR-166				
	Density Ruska "Zero"				
TEMPERATURE	TJR-108-10				
SAMPLE RESULTS	Log No.				
	U Conc				
VOLUME					

Volume Received		Volume Transferred	
kg U Received		kg U Transferred	

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3.0 PRODUCT MEASUREMENT PROGRAM

3.1 General Description

Measurements of uranium product solutions are made in the uranium product sample tank (24-D-204), Measurement Point 2-09. The product measurement program will be developed for the computer to direct operator activities to set up measurement sequences and accomplish batch transfers. The program takes and records measurement data through the RTP System*. At each stage of measurement, the program provides appropriate measurement information to the operator, receives measurement data from the RTP System, provides cursory measurement data review, accumulates measurement data, and moves data to storage at completion of the measurement transfer sequences.

The sequences to accomplish a product batch measurement transfer take place over a period of four hours or more. During this time, additional operator activities preclude dedication of terminal equipment and operator attention to this activity alone. Thus, the program must be established to keep the operator abreast of the status of the measurement sequences. He must be able to address the program as each of the sequences progress with a minimum of computer/operator dialogue. The program must be able to ascertain the status of the measurement activity and inform the operator, and must sign off between specific measurement sequences to allow use of the terminals for other activities.

Program development must also consider the requirement to provide "shipper-receiver comparison" data for the batch transfer. Measurement data associated with this batch transfer must be placed in a "suspense file" for comparison to quantities measured in the tank receiving the transfer. These comparisons are used to flag transfer or measurement problems.

Specific calculation routines applicable to the uranium product sample tank are included in Section 7.2.

3.2 Sequence Descriptions

Product batch measurement sequences are described below. In each case, the operator codes in the program from the terminal to initiate the program. It asks for operator initials. The program interrogates the current status code stored in the data file to indicate the next specific sequence in the measurement routine. It jumps to the appropriate sequence in the program and communicates the status and applicable instructions to the operator.

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*Remote (RTP) data acquisition system.

Sequence 1 — This sequence opens the measurement routine. When the operator codes the product measurement program and the code brings it to this sequence, the routine updates the Batch ID for a new batch. The program resets the temporary file to accept measurement data for the new batch, and sets up the data file for the batch in the base data file.

Sequence 2 — The program now informs the operator:

BATCH _____ IS READY TO START. THE BATCH SHOULD HAVE BEEN MIXED A MINIMUM OF 10 MINUTES PRIOR TO THIS INITIAL MEASUREMENT. SPARGE SHOULD NOW BE OFF AND PURGES AT 0.5 SCFH, SHALL I PROCEED WITH MEASUREMENT?

An affirmative response ("YES") sends the program to Sequence 3. A negative response results in a message to the operator as follows:

SPARGER IN CR (HC-275)*
PURGES W920 EL 300*
CALL ME WHEN YOU'RE READY.

The program then sets the sequence code, closes the file, and signs off to await operator action. When the operator recalls the program, it returns to the start of this sequence.

Sequence 3 — When the batch is properly mixed, the spargers off, and purges set, the batch is ready for measurement. The program asks the operator for Ruska "zero" data, then calls for "Before-Sampling" measurement data from the RTP system. Appropriate measurement comparisons are made to check instrument performance. If problems are indicated, the program moves to Sequence 4. If measurement data are acceptable, the program moves to Sequence 5.

Sequence 4 — When a measurement problem is indicated, an error message is printed to the operator and to the NMC line printer. Depending on the magnitude of the indicated problem or the importance of the measurement to material balance calculations, the program may halt the measurement sequence with supervisory review and approval required to restart. The details of the actions dictated by results of measurement comparisons are in Section 6.0, Measurement Control.

If an indicated problem dictates halting of the measurement sequence, the program provides options after restart

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*Refers to sparger and instrument air purge valving location.

by supervisory approval. It allows proceeding with the sequence which sends the program to Sequence 5 or remeasurement of "Before-Sampling" data by returning the program to Sequence 3.

Sequence 5 — With proper "Before-Sampling" measurement data recorded, the program calculates current tank contents and informs the operator:

THE U PRODUCT SAMPLE TANK BATCH _____ NOW CONTAINS APPROXIMATELY _____ LITERS OF PRODUCT. I AM GOING TO REQUEST THE LAB TO SAMPLE. PLEASE TURN ON THE SPARGE AND LEAVE IT ON UNTIL SAMPLING IS COMPLETE. WE'LL LET YOU KNOW WHEN SAMPLING IS COMPLETE.

The sequence code is updated and the program interfaces to LDS to request sampling of this batch. The program then signs off to await LDS signal that sampling is completed.

Sequence 6 — Sampling procedures for product require analysis of the first two bottles for density and the results must agree within specified limits as a criterion for acceptability. An acid analyses on one of the first two bottles is also required. When density and acid results are available and the proper number of sample bottles are pulled, the LDS informs the CNMCAS that sampling is complete.

The product measurement program informs the operator:

SAMPLING IS COMPLETE FOR THE PRODUCT TANK. SAMPLE LOG NUMBER IS _____. SHUT DOWN THE SPARGE AND SET PURGES SO I CAN TAKE AFTER-SAMPLING MEASUREMENTS. CALL ME WHEN PREPARATIONS ARE COMPLETE.

The program updates the status code and signs off to await operator response.

Sequence 7 — When the operator recalls the program after he has set the sparge and purges, the computer responds:

SHALL I PROCEED WITH AFTER-SAMPLING MEASUREMENTS NOW (YES OR NO)?

With a "YES" response, the program proceeds to Sequence 8. With a "NO" response, the program signs off and returns to Sequence 7 when next addressed.

Sequence 8 — With sparge off and purges set, the program requests Ruska "zero" data from the operator. The program then calls the RTP system for "After-Sample" measurement data. Again, appropriate measurement comparisons are made to check instrument performance. In addition, comparisons of certain "Before-Sample" to "After-Sample" measurement data are made. If problems are indicated the program moves to Sequence 9. If measurements are acceptable it moves to Sequence 10.

Sequence 9 — When a measurement problem is indicated, an error message is printed to the operator and the NMC line printer. As with other comparisons, the magnitude of the error or importance of the measurement may dictate stopping the measurement sequences. Supervisory approval is required to restart the program. The option is provided after restart to proceed, to remeasure the "After-Sample" data by going to Sequence 7, or to start over with "Before Sample" measurements in Sequence 2.

Sequence 10 — When After-Sampling measurement data are in order, the program responds to the operator:

YOU HAVE APPROXIMATELY _____ KG U (_____ LITERS, _____ KGS SOL) IN PRODUCT BATCH 02-009-_____. YOU ARE READY TO MAKE THE TRANSFER NOW. TURN THE SPARGE ON DURING THE TRANSFER, THEN SHUT THE SPARGE DOWN, AND SET PURGES WHEN THE TRANSFER IS COMPLETE BEFORE YOU CALL ME BACK.

The program then updates the status codes and signs off to await completion of the transfer.

Sequence 11 — When the operator completes the transfer and recalls the program, the program responds as follows:

DID THIS GO TO UF_6 (ENTER UF_6), INPUT ACCOUNTABILITY (ENTER INPUT) OR OFF-SPEC. U (ENTER OFF-SPEC.)?

The program files this response in the temporary file and continues to Sequence 12.

Sequence 12 — The program now asks:

SPARGE SHOULD BE OFF AND PURGES SET FOR AFTER-TRANSFER MEASUREMENTS. SHALL I PROCEED (YES OR NO)?

An affirmative response continues to Sequence 13; a negative response triggers:

SET THEM AND LET ME KNOW WHEN YOU'RE READY.

Sequence 13 — The program now asks the operator to provide Ruska "zero" readings. It then calls the RTP system for current "After-Transfer" measurement data. Appropriate data comparisons are made to check instrument performance. If measurements are acceptable, the program proceeds to Sequence 15.

Sequence 14 Appropriate error messages are printed to the operator and to the NMC line printer. If program stoppage is required, options are provided to continue or remeasure "After-Transfer" data after restart by supervisory approval.

Sequence 15 With measurements acceptable, the program calculates appropriate quantities, including quantities transferred. The following message is printed:

THE HEEL QUANTITIES NOW IN THE TANK ARE _____ LITERS SOLUTION AND _____ KG U. YOU HAVE TRANSFERRED _____ LITERS OF SOLUTION WITH _____ KG U, IN BATCH _____ TO _____ THE TRANSFER IS NOW COMPLETE AND THE DATA RECORDED. YOU MAY NOW PROCEED WITH THE NEXT BATCH.

The calculated quantities transferred are placed in a "suspense file." Programs measuring quantities received call on this "suspense file" for the information to make comparison receipt measurements.

The program now prints a copy of the measurement/transfer data to the NMC line printer. It copies the product measurement data from the temporary file to the base data file and resets the file to accept measurement data for the next batch.

3.3 Temporary File Description

The following data are included in the temporary file:

1. Sequence code
2. Lot number
3. Batch number
4. Date of Before-Sampling (BS) measurement
5. Time of Before-Sampling (BS) measurement
6. Op. Init. at time of BS measurement
7. LR-239 (BS)
8. LR-239-R (BS)
9. DR-273 (BS)
10. DR-273-R (BS)
11. TJR-206-17 (BS)
12. Sample request time
13. Sample time
14. Sample log number
15. Density analysis
16. H^+ analysis
17. "Sampling complete" notification
18. Date of After-Sampling (AS) measurement
19. Time of After-Sampling (AS) measurement
21. Op. Init. at time of AS measurement
21. LR-239 (BS)
22. LR-239-R (BS)

23. DR-273 (BS)
24. DR-273-R (BS)
25. TJR-206-17 (BS)
26. "Transfer to" code
27. Date of After-Transfer (AT) measurement
28. Time of After-Transfer (AT) measurement
29. Op. Init. at time of AT measurement
30. LR-239 (AT)
31. LR-239-R (AT)
32. DR-273 (AT)
33. DR-273-R (AT)
34. TJR-206-17 (AT)
35-39. Codes indicating remeasurement, etc., to be determined later.

3.4 Base Data File Description

1. Lot number
2. Batch number
3. Date of BS measurement
4. Time of BS measurement
5. LR-239 (BS)
6. LR-239-R (BS)
7. DR-273 (BS)
8. DR-273-R (BS)
9. TJR-206-17 (BS)
10. Date of AS measurement
11. Time of AS measurement
12. LR-239 (AS)
13. LR-239-R (AS)
14. DR-273 (AS)
15. TJR-206-17 (AS)
16. Sample log number
17. Density
18. H^+
19. Uranium concentration
20-25. Uranium ISO
26. Date of AT measurement
27. Time of AT measurement
28. LR 239 (AT)
29. LR-239-R (AT)
30. DR-273
31. DR-273-R (AT)
32. TJR-206-17 (AT)
33. Codes indicating remeasurement, etc., to be determined later.

3.5 Output Format

A preliminary example of measurement data output is presented as Exhibit 3.5.

EXHIBIT 3.5

URANIUM PRODUCT SAMPLE TANK MEASUREMENT RECORD
Vessel No. 24-D-302, Measurement Point 2-09

Batch No.: ______________________

Date: ______________________

		BEFORE SAMPLING	AFTER SAMPLING	AFTER TRANSFER
Date/Time/Op. Inst.		/ /	/ /	/ /
LEVEL	LR-239			
	Level Ruska "Zero"			
	LR-239R			
DENSITY	DR-273			
	Density Ruska "Zero"			
	DR-273 R			
	TJR-206-17			
TEMPERATURE				
SAMPLE RESULTS	Log No.	NA		NA
	(Density)	NA		NA
	(G/L)	NA		NA
VOLUME				
	(Calc. Using After Sampling Data and Calib. Tables)			
			Volume Transferred	
			kg U Transferred	

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4.0 WASTE MEASUREMENT PROGRAM

Liquid waste measurements are made in either of two tanks; the GPW check tank (43-D-409) or the HWW sample tank (41-D-405). The measurement sequences for each tank are the same with differences only in measurement instruments and calculation procedures. Measurement programs for these tanks are described below. The specific measurement control routines are described in Section 6.0. Calculation routines are included in Section 7.0

In this section, the sequences specifically describe GPW check tank measurements. Measurements in the HWW sample tank are not specifically detailed. However, since the measurement routines for both tanks are the same, the routines described in this section are used to develop the HWW sample tank measurement program. The only changes are to instrument numbers and calculation routines.

4.1 General Description

This program directs measurement of solutions in the GPW check tank. These solutions are subsequently transferred to the spare HLLW/ILLW storage tank (40-D-420) or recycled to process, depending on the uranium content. The sequences involved include "Before-Sampling" measurements, sampling and analysis, "After-Sampling" measurements transfer, and "After-Transfer" measurements. The program leads the operator through these sequences, accumulates measurement data, performs necessary calculations for measurement evaluation and process control information, and stores the appropriate information associated with the batch transfer in the base data file at the completion of the measurement sequence.

The program should be addressable by the operator with a minimum of computer dialogue. He simply codes the program at the terminal and gives his initials. Like previously described measurement programs, it opens a temporary data storage file which is used to accumulate measurement data until the transfer sequence is complete. It reads the sequence indicator code which indicates where in the measurement sequence the current batch is and jumps to the appropriate sequence in the program. The program advises the operator of the current status, performs its necessary functions, and advises him of the next scheduled activities associated with the measurement.

4.2 Sequence Descriptions

The specific batch measurement sequences are as follows. The operator codes in the program from the terminal and gives his initials. The program responds by opening the temporary data file and reading the sequence code. Depending on the code, the program moves to the appropriate sequence.

Sequence 1 This represents the start of the measurement sequence. The program increments the Batch ID number and sets aside storage space for the measurements associated with this batch in the base data file.

Sequence 2 The program now informs the operator:

I'M READY TO TAKE BEFORE-SAMPLING MEASUREMENTS. THE BATCH SHOULD HAVE BEEN MIXED FOR A MINIMUM OF 10 MINUTES. THE SPARGE SHOULD BE OFF NOW AND INSTRUMENT AIR PURGE RATES AT 0.5 SCFH. SHALL I PROCEED (YES or NO)?

With an affirmative response, the program moves to Sequence 3. A negative response results in the following message to the operator:

SPARGER IN CR (HV-420) PURGES LOCATED W815 EL290*. CALL ME WHEN YOU ARE READY.

After this message is transmitted, the program updates the sequence code to return the program to this sequence when the program is restarted. It then signs off to await operator action.

Sequence 3 The program now calls the RTP system** for "Before-Sampling" measurement data. As with measurements in Sections 2.0 and 3.0, a number of measurement comparisons are made to check instrument performance. If the comparisons show the data are acceptable, the program moves to Sequence 5. If a problem is indicated, Sequence 4 is activated.

Sequence 4 The appropriate error message is transmitted to the operator and to the NMC line printer. The details of potential errors and the computer actions for each type of error are discussed in Section 6.0. If the indicated problem requires the program to be halted for corrective action, supervisory approval is required to restart. After this restart, the program provides the option to continue to Sequence 5 or return to Sequence 3 for remeasurement of "Before-Sampling" data.

Sequence 5 With measurement data acceptable, the program calculates the solution quantity and prints the following message:

---

*Refers to sparger and instrument air purge valving locations.

**Remote (RTP) data acquisition system.

YOU'VE GOT APPROXIMATELY _____ LITERS OF SOLUTION. WE NEED A SAMPLE. TURN THE SPARGER ON NOW AND I'LL LET THE LAB KNOW TO BEGIN. I'LL LET YOU KNOW WHEN I AM DONE.

The program initiates communication with the LDS System. It informs the system that the GPW check tank, Measurement Point 2-28 is ready for sampling and gives the Batch ID. The LDS initiates the sampling routine by passing on the information to the laboratory analysts.

This sequence now increments the sequence code to 6, stores the codes and time of sample request in the temporary file, and signs off to await completion of sampling.

Sequence 6 The sampling sequence for liquid waste measurements requires the analyst to pull a specified number of samples; the first two samples are analyzed for density and the results must agree within limits. Analyses for acid molarity and uranium concentration are also performed. When these results are available, the laboratory system informs the GPW waste measurement program that sampling is complete. The program receives the results, stores them in the temporary file, and informs the operator to proceed.

SAMPLING IS COMPLETE. SHUT DOWN THE SPARGER AND ADJUST INSTRUMENT AIR PURGES SO I CAN TAKE MEASUREMENT DATA. CALL ME WHEN YOU'RE READY.

The program then updates the code sequence, closes the temporary file, and signs off to await notification from the operator.

Sequence 7 After the operator sets the purges and shuts down the sparger, he recalls the program. The sequence code directs the program to this sequence. The program responds to the operator with:

I'M READY TO TAKE READINGS. SPARGES SHOULD BE OFF AND PURGES SET. STOP ME NOW IF THINGS AREN'T SET. SHALL I PROCEED (YES OR NO)?

The affirmative response sends the program to Sequence 8. With a negative response, the program prints:

SET THINGS UP AND CALL ME BACK.

The program then signs off with the sequence code set to bring it back to this sequence.

Sequence 8 The program now calls for "After-Sampling" measurement data from the RTP system. Comparisons are again made to check instrument performance. These comparisons also include

"Before-Sampling" to "After-Sampling" data checks. With measurement data acceptable, the program skips to Sequence 10. With problems indicated, Sequence 9 is initiated.

Sequence 9 The appropriate error message is printed to the operator and to the NMC line printer. If a program half is required, supervisory approval to restart is required. The options provided are: (1) to continue to Sequence 10, (2) return to Sequence 8 to remeasure "After-Sampling" data, or (3) return to Sequence 3 to remeasure "Before-Sampling" data and resample the batch.

Sequence 10 With measurements acceptable, the program calculates appropriate quantities and informs the operator:

YOU HAVE ______ LITERS OF SOLUTION CONTAINING ______ GRAMS OF URANIUM.

It now moves directly to Sequence 11.

Sequence 11 The program now asks:

WHERE ARE YOU SENDING THIS--TO THE WASTE TANK (ENTER "W"), TO RECYCLE ("R"), OR ENTER "H" FOR HOLD IF YOU WANT TIME TO THINK. WHAT WILL IT BE?

a) If "W" is entered, the program responds with:

BE SURE YOU HAVE THE SPARGE ON DURING THE TRANSFER. LET ME KNOW WHEN THE TRANSFER IS COMPLETE AND YOU HAVE SHUT DOWN THE SPARGE AGAIN AND SET PURGES.

It then updates the code to return to the next sequence, closes the file, and signs off.

An option should also be provided, if "W" is entered, to check the quantity of material that will be transferred against a preprogrammed limit. It should be noted that a uranium concentration analysis was required in Sequence 6 before "sampling was complete," unlike the sampling measurements for measurements described in Sections 2.0 and 3.0. This allows calculation of uranium content of the batch from a measured concentration. This quantity is compared to a preprogrammed limit for batch quantity that can be transferred to waste. If the quantity exceeds the limit, an error message is printed to the operator and the NMC line printer and supervisory approval is required to proceed. An option is also provided at this step for the operator to go back to the start of Sequence 9 and reassign the transfer route.

b) If "R" is entered, the program responds with:

BE SURE YOU LEAVE THE SPARGE OFF TO MINIMIZE TRANSFER OF SOLIDS TO RECYCLE. LET ME KNOW WHEN THE TRANSFER IS COMPLETE.

It then updates the codes to return to the next sequence, closes the file, and signs off.

c) If "H" is entered, the sequence code is set to return the program to this sequence after the operator decides on the transfer route. It then signs off to await his action.

Sequence 12 When the transfer is complete, the operator restarts the measurement program and it returns to this sequence. The program asks the operator:

I'M READY TO TAKE AFTER-TRANSFER MEASUREMENTS. YOU SHOULD HAVE SPARGER OFF AND PURGES SET. SHALL I PROCEED (YES OR NO)?

Again, depending on response, the program either proceeds to Sequence 13 or signs off and awaits the operator to make the appropriate settings after printing:

SHUT DOWN SPARGE, SET PURGES, AND CALL ME BACK.

Sequence 13 The program calls for "After-Transfer" measurement data from the RTP system. Appropriate comparisons are again made and the program moves to Sequence 15 if data are acceptable. If problems are indicated, Sequence 14 is started.

Sequence 14 The appropriate error message is printed to the operator and to the NMC line printer. As with all previous measurements, the program may be halted and supervisory approval to continue is required. The options provided here are to continue to Sequence 15 or return to Sequence 13 to remeasure "After-Transfer" data.

Sequence 15 The program calculates "After-Transfer" quantities in the waste tank and calculates the quantities transferred. The program informs the operator that:

YOU HAVE TRANSFERRED ________ LITERS OF SOLUTION WITH ________ GRAMS OF URANIUM. I WILL RECORD APPROPRIATE INFORMATION AND RESET THE PROGRAM TO AWAIT THE NEXT BATCH.

The program now copies the appropriate information from the temporary file to the base data file. It then prints the Batch Transfer record to the NMC line printer. The program resets the temporary file to accept the data for the next batch and signs off.

4.3 Temporary Data File Description

The following data are recorded in the temporary file for the GPW check tank. Similar data are recorded for the HWW sample tank with applicable instrument number changes.

1. Sequence Code
2. Lot No.
3. Batch No.
4. Date of Before-Sampling (BS) measurements
5. Time of Before-Sampling (BS) measurements
6. Operator Initials (Op. Init.) addressing program at time of BS Measurements
7. LR-412 (BS)
8. LR-412-W (BS)
9. DR-416 (BS)
10. DR-416-W (BS)
11. TJR-415-7 (BS)
12. Time of notification to LDS to sample
13. Sampling Time
14. Sample Log Number
15. Lab density result
16. Lab acid analysis result
17. Lab uranium concentration analysis result
18. Time of notification of sampling complete
19. Time operator notifies that sparge off--ready to measure
20. Date of After-Sampling (AS) measurement
21. Time of After-Sampling (AS) measurements
22. Op. Init. addressing program at time of (AS) measurement
23. LR-412 (AS)
24. LR-412-W (AS)
25. DR-416 (AS)
26. DR-416-W (AS)
27. TJR-413-7 (AS)
28. Time operator informs that transfer is complete
29. Date of After-Transfer (AT) measurements
30. Time of After-Transfer (AT) measurements
31. Op. Init. addressing program at time of (AT) measurement
32. LR-412 (AT)
33. LR-412-W (AT)
34. DR-416 (AT)
35. DR-416-W (AT)
36. TJR-415-7 (AT)
37. Transfer code (to waste or recycle)

38-42. Codes indicating remeasurement, etc., to be determined later.

4.4 Base Data File Description

1. Batch No.
2. Lot No.
3. Date of BS Measurement
4. Time of BS Measurement
5. LR-412 (BS)
6. LR-412-W (BS)
7. DR-416 (BS)
8. DR-416-W (BS)
9. TJR-415-7 (BS)
10. Sample Log No.
11. Laboratory Density
12. Laboratory H^+
13. Laboratory Uranium Concentration
14. LR-412 (AS)
15. LR-412-W (AS)
16. DR-416 (AS)
17. DR-416-W (AS)
18. TJR-415-7 (AS)
19. Date of AS Measurement
20. Time of AS Measurement
21. Date of (AT) Measurement
22. Time of AT Measurement
23. LR-412 (AT)
24. LR-412-W (AT)
25. DR-416 (AT)
26. DR-416-W (AT)
27. TJR-415-7 (AT)

28-33. Codes Indicating Remeasurement, Etc.

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5.0 NUCLEAR MATERIALS ACCOUNTING PROGRAM

The nuclear materials accounting program is used to define accounting control units and to produce accounting, summary, and material balance reports. The accounting control units consist of individual measurement batches, lots consisting of several batches, and inventory period consisting of several lots. Each batch measured is automatically incremented by the measurement programs to provide sequentially numbered batches. A central measurement point data base file is utilized by the accounting program. This data base file services all the programs, i.e., accounting, measurement, and measurement control programs. The accounting program is subdivided as follows:

(1) Lot/Inventory Period Programs
(2) MBA Transfers
(3) Input/Output Accounting:
- Accounting Report
- Summary Report
- Material Balance Reports.

5.1 Lot/Inventory Period Program

5.1.1 Lot Control

The primary accounting control unit will be by lot, which consists of several batches. Establishment of lots is determined from special grouping needs such as analysis of input/output quantities or to facilitate referencing a group of data in place of individual items. The Nuclear Materials Control (NMC) accounting office will designate lots and will accomplish this via input/output device by manually inputting the start of each lot with the corresponding batch number.

5.1.2 Inventory Period Control

The accounting period for nuclear materials control is that period of time between physical inventories. Several lots are usually included in one inventory period and a lot terminates with the taking of a physical inventory. The NMC office establishes the inventory periods by defining the lots included in an inventory period. Inventory periods are sequentially numbered as are lots. This information is entered into the data base file via input/output terminals by NMC personnel. The program allows for entering only the beginning lot number for an inventory period pending taking of a physical inventory which establishes the ending lot number. The inventory period designation separates the files for producing material balance reports (MBR's). When an MBR is requested, the program requests the inventory period it is for and provides the MBR for those lots which are in the data base file for that period.

The lot number then becomes associated with all applicable batches and samples. Requests for data and status will be accomplished usually by lot number and may be lot summaries or listings of individual batches within the lot.

5.1.3 Other Routines

A need to correct entries should be provided. Since this may occur after several batches have been completed, it will require changing the base data file for those batches involved. This routine could also be used to structure the batches into different lot groupings for the purposes of analyzing various input/output combinations.

5.2 Material Balance Area Transfers

5.2.1 General Description

Transfer of material from the uranium product sample tank to the accountability tank will be used to demonstrate transfers of solutions via pipelines between Material Balance Areas (MBA's). The objective of this routine is to accomplish verification and acceptance of quantities with a minimum of participation by MBA custodians.

The computer will make a comparison to determine if the two quantities are within acceptable limits. It will alarm when the transfer is not within the established band. The alarm will print out in the control room advising them of the condition and a need for an overcheck. For each transfer that occurs, there will be a hard copy transfer record issued for the NM accounting office via the NMC line printer which shows the quantities transferred and received, the difference, the acceptance limit, and if the data were accepted or rejected.

Two comparisons for the mass (kilogram) of solution transferred versus the mass of solution received are calculated. The first or preliminary comparison is based on a received quantity calculated from before-sampling measurement data. The second or final comparison is based on a received quantity calculated from after-sampling measurement data.

5.3 Input/Output Accounting

5.3.1 General Description

Four primary measurement points will be used to demonstrate accounting and material balance routines. Because the turnaround time for obtaining analytical results of samples can be untimely, output data will be based on preliminary results, as well as final results. The use of less accurate preliminary results, however, will offer a means of reporting status as near real time as possible. Each reported quantity, therefore, must be coded as preliminary (P) or final (F). Additionally, each summary total must be segregated by (P) or (F) status to advise the user accordingly.

Other needs include reporting the points to which material is transferred and points from which material is received. Batches recycled back into process are excluded from input/output material balances; and consequently, these must be segregated for that purpose. All line items, therefore, will also be segregated by "received from" and "transfer to" points.

Quantitative data to be reported includes liters of solution, kilograms of solution, and grams of uranium. These will be reported on all reports even though the liters or kilograms of solution do not enter into material balance determinations.

Other items to be reported are the sample log number for reference purposes, the uranium concentration as milligrams uranium/gram for overchecking and evaluation needs, and the time of year applicable to the measurements used.

Three basic input/output (I/O) reports will be provided. These include a detailed report for each measurement point, which lists all the individual batches and lots. The second is a summary-type report for each measurement point which only shows lot totals without the individual batch details.

The third report is a Material Balance Report, which is a consolidated report of the individual I/O reports except the quantities recycled, i.e., rerouted back into the process from output points, are excluded from the output totals when calculating the ending balance.

All output reports show the beginning inventory, total receipts, total removals, and ending balance. This applies to each measurement point report, as well as the Consolidated Material Balance Report.

5.3.2 Detailed Description - I/O Reports

Two types of output format will be requested. One consists of input/output reports for each measurement point and the other is the material balance for the four I/O points.

5.3.2.1 I/O Reports for Each Point

I/O reports for each point will consist of the type detailed report shown in Figure 5-1 or summary-type reports as explained in Section 5.4. The format for these reports is similar. Explanations of columnar headings and contents follow:

(1) Batch Number - the consecutively numbered batch number which is assigned to each tank of solution measured.

(2) AS Measurement Date - date the after-sampling measurement was made.

(3) Sample Log Number - the log number assigned by the analytical laboratory.

(4) Received From - the measurement point from which the material was received and the batch number for the quantity transferred. It is used to provide a ready means for comparing quantities transferred and received between two points.

(5) U Conc. - Mg U/g - the uranium concentration calculated for the preliminary results or the results from the analytical determinations for the final values.

(6) Code - There will be two types of calculations made. One will be the preliminary (P), which is based on density and acidity level; and the second is final (F), which is based on the reported uranium concentrations. Whenever a report is requested, the program will go to the final uranium concentrations first to make the calculations. If they are available, they will be used and coded as (F) on the report. If not, the preliminary data are used and coded (P) on the report.

(7) Quantity Received - three quantities are reported consisting of liters, kilograms of solution, and grams of uranium. Values are reported to the nearest tenth of a liter or kilogram of solution and whole gram of uranium.

(8) Quantity Transferred - the three quantities transferred from the reporting point are recorded as in the quantity received.

(9) Destination - the measurement point to which the material was transferred. It will also be coded with an (R) when material is recycled.

(10) Beginning Balance - the Ending Balance from the prior lot not requested on the report. These values are entered manually by the requestor.

(11) Lot Number and Batches - identifies the lot number and subdivides the report into lot groupings.

(12) Batch Listing - below the lot heading, each batch number and all the detail, Items (2) through (9), are recorded.

(13) Lot Totals - the quantities received and transferred are summed for all the batches in the lot. These totals are subdivided into the "received from" points for quantity received, "destination" points for quantity transferred and by (P) or (F) codes.

(14) Cumulative Lot Totals

- Subtotals - This section consists of the summations of the lot totals by subtotals for preliminary and final results and by each "received from" measurement point and destination point.

- Grand Total - This is the total of all receipts and removals for all the batches listed on the report.

(15) Ending Balance - the difference between the Beginning Inventory plus receipts less the quantity transferred.

5.4 Input/Output Summary Report

The format for the Summary Report is similar to the Input/Output Report for a measurement, except it only shows summaries by lots without any batch detail. In addition, the following sections are not required:

- Batch Number
- After-Sampling Measurement Date
- Sample Log Number
- Uranium Concentration -- milligram uranium/gram.

The Beginning Balance is the same as for the Input/Output Report for each point, i.e., Section 5.3.2. The lot totals are provided in the same manner, i.e., by "received from" points and "destination" points for receipts and transfers, respectively. The appropriate (P) or (F) code is shown for each line entry.

The only difference between the input/output and the Summary Report is that the individual batches are not listed or shown on the Summary Report. All of the lots on record for the inventory interval are reported unless otherwise specified

5.5 Input/Output Material Balance Report (MBR) (Figure 5-2)

The material balance is primarily a consolidated report of the input/output reports for the four measurement points. Portions of the routines for the summary reports (Section 5.4) are performed as follows:

(1) A beginning balance will have to be entered by NMC via the I/O terminal from inventory reports and stored in the program for use as needed.

(2) The input accountability point (2003) will derive the quantities as calculated and summarized from the summary report routine (Section 5.4) for the quantity received. These received subtotals provided for Section 5.4 summary reports will be the same used in the MBR.

(3) The output points will also derive the quantities as obtained in (Section 5.4) summary reports. Since some of the batches at

output points will be of a recycled (R) category, these are not output quantities for the MBR. The (R) batches will be included in the detail section and shown as (R) in the "To" section. The totals recorded in the MBR section, however, will not have these (R) quantities included.

5.6 Report Format

(1) The report period is for the time of year from the beginning date to inventory date requested and the date of the following inventory.

(2) Date of report is the time of year the report was prepared.

(3) "From" and "To" are the points from which the material was received as input and the destination points for the output. Reports are summarized for each "To" and "From" within an input or output point.

(4) The code is the standard (P) and (F) for preliminary or final. Each of the "To" and "From" points are also subdivided for this status. All totals and details are always coded by (P) or (F) to advise the user accordingly.

(5) The volumes and quantities are shown in a detail column, as well as in a total MBR column which shows the totals of the detail.

(6) Beginning inventory is the starting quantity for the MBR interval.

(7) Input -- Accountability Tank - In this section, the lots and batches are included in the report. Since lots and batches are sequentially numbered, only inclusive numbers need be shown, e.g., Lot 1, Batch 1, through Lot 6, Batch 62. The total input is the summation of all the "From" points and (P) and (F) status. If any (P) status is shown, then the total is (P).

(8) Output - This is the same as described in the input for lots and batches. An additional category is shown, which is the "R" for recycle. The total for the MBR, however, does not have the recycle included in it.

(9) The ending balance is the difference between the beginning inventory plus the input less the output.

INPUT/OUTPUT REPORT FOR MEASUREMENT POINT______
DATE OF REPORT________________

	1 Batch No.	2 Date	3 Log No.	4 Received From	5 U Conc. Mg.U/G	6 Code	7 Quantity Received Liters	 Kg.Sol.	 gU	8 Quantity Transferred Liters	 Kg.Sol.	 gU	9 Destination
10.	Beginning Balance												
11.	Lot No.												
12.													
13.	Lot Total												
	Lot No.												
	Lot Total												
14.	Cumulative Totals:												
14-1.	Subtotals F												
	Total F												
	Subtotal P												
	Total P												
14-2.	GRAND TOTAL												
15-0.	ENDING BALANCE												

REPORT FORMAT 5.3 - NMC ACCOUNTING

FIGURE A5-1

Material Balance Report for Period ________

Date of Report ________

	"From" or "To"	Code	Detail Liters	Detail Kg. Sol.	Detail g. U	MBR Liters	MBR Kg. Sol.	MBR g. U
Beginning Inventory								xx
Input								
2003 Acct. Tk.								
Lots 1-1 to 6-62	2001	P	xx	xx	xx			
	2001	F	xx	xx	xx			
2003-Total for MBR						xx	xx	xx
Output								
2009 Prod. Samp. Tk.	2003	P	xx	xx	xx			
Lots 1-1 to 8-56	2003	F	xx	xx	xx			
	2005	PR	xx	xx	xx			
	2005	FR	xx	xx	xx			
2009-Total for MBR						xx	xx	xx
2023 HWW Samp. Tk.	xx	x	xx	xx	xx			
Lots 1-1 to 5-45	xx	x	xx	xx	xx			
	xx	xx	xx	xx	xx			
	xx	xx	xx	xx	xx			
2023-Total for MBR						xx	xx	xx
2028 GPW Check Tk.	xx	x	xx	xx	xx			
Lots 1-1 to 10-85	xx	x	xx	xx	xx			
	xx	xx	xx	xx	xx			
	xx	xx	xx	xx	xx			
2028-Total for MBR						xx	xx	xx
Ending Balance								xx

REPORT FORMAT 5.5 - NMC ACCOUNTING

FIGURE A5-2

6.0 MEASUREMENT CONTROL PROGRAM

6.1 General

The measurement control program provides for various checks and comparisons of measurement data to control measurement anomalies, prior to acceptance into the base file, for trend and error analysis of stored measurement data and for propagation of errors into limits of error for material balance calculation. The various checks and comparisons used to ensure reliable data are an integral part of the measurement sequence. These are specifically included in the discussions of measurement sequences. They are presented here for continuity of measurement control discussions. The methods, procedures, and output formats for the trend and error analysis programs are specifically discussed below.

Software development for propagation of errors into limits of error will not be included in the Uranium Input/Output (U I/O) Demonstration Program.

6.2 Controlling Measurement Anomalies

Comparisons of measurement data are made to maintain measurement anomalies at a minimum. These comparisons are made at the time of data generation using available measurement data. This allows timely application of these comparisons and associated limits. Notification of indicated problems is provided to initiate supervisory corrective action and ensure proper measurement data are recorded.

The comparisons applied to control measurement anomalies are discussed below. Methods to assign control limits are also presented, and levels of action to respond to indicated problems are outlined.

6.2.1 Specific Comparisons Within an Individual Measurement

Specific instrument comparisons can be made within the data collected for an individual measurement. Timely evaluation of these data and notification to supervision when problems are indicated can indicate instrument or measurement problems. Investigation and corrective actions provide the control of measurement anomalies within individual measurements.

6.2.1.1 Redundant Instrument Comparisons

Specific instrument comparisons are made at the time of measurement where two or more instruments are installed in parallel and are reading the same differential pressure (whether level or density indications). These comparisons are used to flag potential instrument problems. In these cases, the second instrument is considered backup to the primary; and comparison is made to the primary.

Example: Ruska and Taylor instruments in parallel reading pressure differential indicating liquid level. The Ruska instrument is considered primary and the Taylor in considered backup.

This comparison consists of:

$|(\text{Ruska}) - \bar{D}) - (\text{Taylor})| \leq$ control limit

$\bar{D}$ is the average difference experienced between instrument readings in equivalent units. It should also be noted that the control limits are specific to the instrument application. They may change from measurement point to measurement point.

6.2.1.2 Process Density to Lab Density Comparisons

Process density to lab density (at 25°C) comparisons are made to provide timely assurances that tank solution is mixed and that both instrument and associated purge lines are functioning satisfactorily. The calculated density from the primary density instrument(s) is compared to the laboratory density result (at 25°C).

Process density is calculated as follows:

$$\text{Process Density} = \frac{\text{(differential pressure across density probes)*}}{\text{(probe separation)}}$$

*Note that differential pressure across the density probes may be obtained in two ways depending on instrument hookups. A differential pressure transmitter installed across the two density probes measures the differential pressure directly. A second method uses Ruska instruments to measure differential pressure from the in-tank reference to the high pressure density probe (the same as level measurement) and to measure differential pressure from the in-tank reference probe to the low pressure density probe. The difference between these two measurements is the differential pressure across the density probes.

Process density is now compared to lab density (at 25°C) as follows:

$|(\text{process density}) - (\text{average density difference}) - (\text{lab density})| \leq$ control limit

6.2.1.3 Process Density to Process Density

When process density is measured by the second method, as described in Section 6.2.1.2 above, using Ruska instruments, Taylor determined density from direct measurement of differential pressure across the density probes will also be available. Comparison of these two determinations of density provides an additional check on instrument performance.

The comparison between the two densities is as follows:

$|(\text{Taylor density}) - (\text{Ruska density})| \leq$ control limits

6.2.2 Comparisons Between Measurements

During the routine measurement sequences, a number of "remeasurement" situations occur, where a specific quantity of solution is remeasured at a later time and comparison of the two quantities can be made. These may take the form of "Before-Sampling" to "After-Sampling" measurement comparisons and "After-Transfer" to "Before-Receipt" measurement comparisons (referred to as replicate measurements), or between tank transfer comparisons (referred to as redundant measurements).

Timely application of these comparisons and supervisory review of indicated problems serve to further control measurement anomolies or indicate operational problems which may invalidate measurements.

6.2.2.1 Mass of Solution Comparisons - Replicate Measurements

Repeat measurements are provided in before-sampling to after-sampling data and after-transfer to before-receipt data when it is available. The mass of solution is calculated from data associated with each individual measurement. These repeat measurements and associated repeat determinations of solution quantities form the basis of solution comparisons to evaluate measurement system performance.

Comparison of repeat measurements of solution masses involves the following calculations:

(1) Calculation of process density from process instrument data[1]:

$$D = \text{process density} = \frac{(\text{differential pressure})}{(\text{probe separation})}$$

(2) Calculation of "true" liquid level from primary liquid level measurement data:

$$L = \text{liquid level} = \frac{(\text{liquid level differential pressure})^{(2)}}{(\text{process density})}$$

(3) Calculation of solution mass:

$$M = \text{mass (kg sol)} = [a_0+a_1(L)+a_2(L)^2+a_3(L)^3 \ldots][D]$$

where a_0, a_1, a_2,..., are coefficients of vessel calibration equations.

The comparison of the initial measurement (M_1) and the remeasurement (M_2) is as follows:

---

(1) In the case of comparison of heel measurements (after-transfer to before-receipt) solution level may be below density probes and after-sample measurement of density from previous batch will have to be used for both calculations.

(2) Usually in inches of water.

$|M_1 - M_2| \leq$ control limits.

6.2.2.2 Mass of Solution Comparisons - Redundant Measurements

Redundant measurements are provided when a batch of solution is transferred from one tank to another. Quantities sent are calculated from measurement data of the sending tank. Quantities received are independently measured and calculated in the receiving tank. These redundant measurements and comparisons allow timely review and indication of potential problems with transfer mechanisms/procedures or individual measurement performance.

For the Uranium Input/Output Program, this comparison is only to be applied in the uranium product sample tank to accountability tank transfer sequence. The specific calculations used in this comparison are provided in Section 7.1.

6.2.3 Establishing Control Limits

For each type of measurement comparison, specific control limits are established at the 0.05 and 0.01 levels of significance. These control limits are based on historical comparison data when available (or are assigned by NMC when data are not available). Data for each comparison are summarized over an inventory period (or a period determined by NMC). By their nature, the comparison data are paired. The differences between the pairs are subjected to statistical analysis to calculate random error variance. This random error variance is the basis for calculation of the specific control limit.

The random error variance estimate for the paired data is calculated by the following formula:

$$s^2 = \frac{n \sum_{i=1}^{n} \left(d_i\right)^2 - \left(\sum_{i=1}^{n} d_i\right)^2}{n(n-1)}$$

where: d_i = difference between original and repeat or replicate measurement i.

n = number of measurements.

$\bar{d} = \sum_{i=1}^{n} d_i / n$

s = standard deviation for the difference between measurements.

NOTE: $s/\sqrt{2}$ = standard deviation for an individual measurement.

Alternately, the variance may be calculated on a relative basis as follows:

$$\hat{\gamma}^2 = \frac{n \sum_{i=1}^{n} \left(d_{ri}\right)^2 - \left(\sum_{i=1}^{n} d_{ri}\right)^2}{n(n-1)}$$

where: d_{ri} = relative difference between original (O) and replicate (R) measurement.

$$d_{ri} = \frac{O_i - R_i}{(O_i + R_i)/2}$$

n = number of measurements.

γ = coefficient of variation for the difference between two measurements.

$\bar{d}r = \sum_{i=1}^{n} d_{ri} \Big/ n$

NOTE: $\hat{\gamma}/\sqrt{2}$ = coefficient of variation for an individual measurement.

After calculation of the applicable s or $\hat{\gamma}$, a confidence interval of $\bar{d} \pm 3s$ (or $\bar{d}_r \pm 3\hat{\gamma}$) is established. A comparison of each d_i or d_{ri} is made to the appropriate interval. Any d_i or d_{ri} that exceeds the limit is "flagged." If any "flags" are encountered, the appropriate statistics are recalculated excluding the "flagged" value and the interval recalculated. Remaining d_i or d_{ri} quantities are compared. This iterative process is applied until all remaining d_i or d_{ri} fall within the confidence interval.

Control limits are then set at 0.05 and 0.01 levels of significance corresponding to 2 and 3 times the final calculated standard deviation or coefficient of variation. This calculation is applied to historical data for each of the measurement comparisons detailed above at the end of an inventory period. The resulting control limits are used during the subsequent period for measurement comparisons. Specific control limits and calculation parameters are identified in Section 6.3 below.

6.2.4 Response Levels of Action

The above calculated control limits are applied to measurement data as it is generated to effect timely review and indication of potential problems. This allows supervisory review and timely corrective action when required to control measurement anomolies.

Specific applications of the various measurement comparisons detailed above are included in discussions of measurement sequences, when control limits at the 0.05 and 0.01 levels of significance alarm and corrective action may be indicated. They are specific for each type of comparison. The level of response depends on the importance of the measurement to NMC calculations. For example, an instrument comparison between a Ruska and a Taylor which is outside the established control limit may result in a calibration request for the Taylor. However, a before-sampling to after-sampling measurement comparison which is outside the control limit would require a remeasurement or other corrective action.

For each measurement comparison, the difference (d_i or d_{ri}) is calculated and compared to the applicable control limit.

(1) If d_i or $d_{ri} \leq$ confidence interval at the 0.05 level of significance, data are acceptable and stored in appropriate file;

(2) If d_i or $d_{ri} >$ confidence interval at 0.05 level of significance but $\leq$ control limit at 0.01 level of significance, data are acceptable for storage into the appropriate file. However, the measurement is flagged and a message is printed to the NMC line printer and to the Operations output terminal;

(3) If consecutive d_i or d_{ri} exceed confidence interval at the 0.05 level of significance; or

(4) If d_i or d_{ri} exceed confidence interval at the 0.01 level of significance, the measurement data are not acceptable for use in the materials control and accounting program. A message is printed to the NMC line printer and to the Operations output terminal. These out-of-control situations may require immediate corrective action depending on their importance to NMC measurements.

The level of response is dependent upon the type of comparison and the importance of the measurement with respect to Nuclear Material Control calculations. In general, four levels of response can be identified for measurement comparison:

(1) The first level corresponds to data being acceptable. No action is required and measurement sequences continue.

(2) At the second level of response, a problem is indicated. The problem, in relation to importance in nuclear material control calculations, is of a minor nature. It does not directly impact measurement performance but warrants attention in future comparisons. This level of response requires notification to the Central NMC office and to Operations similar to the following:

"THE MEASUREMENT COMPARISONS FOR BATCH ______ ARE MARGINALLY ACCEPTABLE. FURTHER INVESTIGATION AND CORRECTIVE ACTION MAY BE REQUIRED IF PROBLEM PERSISTS."

Further operator response is not required. The measurement sequences continue.

(3) At the third level, a problem is indicated that may well impact measurement performance from an NMC standpoint. Notification is provided to NMC via the NMC line printer and to Operations as follows:

"MEASUREMENT COMPARISONS FOR BATCH ______ INDICATE A POTENTIAL PROBLEM. DATA SHOULD BE REVIEWED FOR INDICATED CORRECTIVE ACTION."

This level of response requires supervisor approval with initials and nonprinting code to continue sequences. He may initiate corrective actions in remeasurement, resample, etc. However, with supervisor approval, measurement sequences may proceed despite the indicated out-of-control comparison.

(4) The fourth level of response results when a problem that impacts nuclear material measurements has been detected. Notification is provided to the NMC and to Operations as follows:

"MEASUREMENT COMPARISONS FOR BATCH ______ INDICATE OUT-OF-CONTROL. CORRECTIVE ACTION IS REQUIRED."

The message to Operations includes blank space for the supervisor to document his finding and report corrective action to NMC. He must investigate and resolve the discrepancy in the comparison prior to restarting the sequence. Restart requires supervisor initials and nonprinting code. The measurement sequences may not proceed until resolution of the out-of-control comparison is accomplished by remeasurement, resample, etc.

6.2.5 Specific Measurement Comparisons

Tables 6.2-1 through 6.2-4 detail the specific measurement comparisons as detailed in Sections 6.2.1 and 6.2.2 as they are to be applied to input, product, and waste measurements during the Uranium Input/Output Demonstration Program. The table shows the specific level of response (as detailed in Section 6.2.4) to be applied when comparisons meet or exceed applicable 0.05 or 0.01 confidence intervals.

6.3 Measurement Control Summary Output Reports

Summary reports of measurement control activities are required on a routine basis to:

(1) allow assessment of measurement performance,
(2) to establish control limits for the measurement comparisons, and
(3) to generate applicable random error estimates for application to limits-of-error calculations.

Each of the output summary programs include protection codes to allow access by NMC only. Each of the programs allows summaries to be generated by:

(1) batch numbers or series of batch numbers,
(2) lot numbers, or
(3) entire summary for an inventory period.

The output is structured to allow listings by batch in the summary as well as summary totals.

These output summaries repeat the measurement control comparisons described in Section 6.2. This must be accomplished to establish control limits. Most of the summaries also recalculate the same comparisons and additional comparisons using additional measurement data not available at the initial measurement. This allows review and evaluation of measurement performance and estimates of random error components.

6.3.1 Accountability Tank

The accountability tank used for input measurements is fitted with Taylor and Ruska level measurement instruments. The Taylor instrument, reading in % of full scale, provides the backup determination. Primary level determination is provided by a Ruska instrument, installed across the reference and high pressure probes. Backup measurement is also provided by a second Ruska installed between the reference and low pressure (density) probe. Both Ruska instruments provide measurement in centimeters of water.

Primary density determination is from laboratory analysis of a process sample. Backup determination is from Taylor instrumentation and Ruska measurements. Again, Taylor instrument output is in % of range while Ruska output is in centimeters of water. Laboratory results are in grams per milliliter.

6.3.1.1 Accountability Tank Level

For the accountability tank level, calculations are as follows. Summary reports of the comparisons as outlined in Section 6.2.1.1 are presented. The specific calculations for the input tank are as follows:

(1) Taylor Level

$$L_T = (\text{LR-125 in }\%) \times (2.15) \times (2.54) = \underset{\text{xxx.xx}}{\underline{\qquad}} \text{ cm.}$$

(2) Ruska (primary)

$$L_R = \text{direct read from LR-125-R, in cm.} = \underset{\text{xxx.xx}}{\underline{\qquad}} \text{ cm.}$$

Liquid level measurement data is recorded for before-receipt, before-sampling, after-sampling, and after-transfer on each input batch measured in the accountability tank. Comparison of level measurements for each of these measurements is provided in the output.

(1) Ruska (primary) to Taylor

$$C_1 = (L_R) - (L_T) = \underset{\text{xx.xx}}{\underline{\qquad}} \text{ cm.}$$

C_1 calculated for BR, BS, AS, and AT measurements.

For before-sampling data and for after-transfer data, summary statistics for the batches contained in the report are calculated. Calculation of these statistics is as detailed in Section 6.2.3.

The format of the output report is shown in Table 6.3-1. The format includes individual batch comparisons and summary statistics as shown.

"Flagged" batches as described in Section 6.2.3 are also shown in the Summary Report.

6.3.1.2 Accountability Tank Temperature

The input accountability tank is fitted with redundant temperative instrumentation. For each measurement these are compared. The primary temperature measurement is TJR-108-10. The backup measurement uses TI-109. The comparison is as follows:

$$C_2 = (\text{TJR-108-10}) - (\text{TI-109}) = \underset{\text{xx.x}}{\underline{\qquad}}\ ^\circ\text{C}$$

The summary is included with the level measurement summary as shown in Table 6.3-1.

6.3.1.3 Accountability Tank Density

For the accountability tank density comparisons, calculations are as follows. The Summary Report includes comparison of lab density at 25°C to process densities to establish the control limits for controlling measurement anomolies (see Section 6.2). It also includes comparisons of lab density adjusted to tank temperature to process measured densities to evaluate measurement performance. Adjustment of the lab density to tank temperature is accomplished using an empirically derived relationship.

(1) Taylor Density

$$D_T = \frac{(\text{DR-166 in \% x .09 + 10}}{9.94} = \underset{\text{x.xxxx}}{\underline{\qquad}}\ \text{g/ml}$$

(2) Ruska Density

$$D_R = \frac{(\text{LR-125-R})-(\text{DR-166-R})}{25.25} = \underset{\text{x.xxxx}}{\underline{\qquad}}\ \text{g/ml}$$

(3) Lab Density at 25°C

D_L at 25°C = direct from lab results = $\underset{\text{x.xxxx}}{\underline{\qquad}}$ g/ml

This quantity is the average of two lab density analyses.

(4) Lab Density at tank temperature

D_L at T = adjusted from lab result = $\underset{\text{x.xxxx}}{\underline{\qquad}}$ g/ml

The above relationships may be calculated in before-sampling (BS) or after-sampling (AS) measurements.

To control measurement anomalies as described in Section 6.2, comparison of lab density at 25°C to the after-sampling Ruska and Taylor densities is made. The summary report details these comparisons. To establish measurement performance, several additional comparisons are made and included in the summary.

(1) Lab Density at 25°C to After-Sample Ruska Density
$C_1 = (D_L \text{ at } 25) - (D_R) = \underset{x.xxxx}{\underline{\qquad}}$ g/ml

For After Sample (AS) measurement only.

(2) Lab Density at 25°C to After-Sample Taylor Density
$C_2 = (D_L \text{ at } 25) - (D_T) = \underset{x.xxxx}{\underline{\qquad}}$ g/ml

For After-Sample (AS) measurement only.

(3) Ruska Density to Taylor Density
$C_3 = D_R - D_T = \underset{x.xxxx}{\underline{\qquad}}$ g/ml

For both Before-Sampling (BS) and After-Sampling (AS) data.

(4) Lab Density at Tank Temperature to Ruska Density
$C_4 = (D_L \text{ at } T) - (D_R) = \underset{x.xxxx}{\underline{\qquad}}$ g/ml

For both Before-Sampling (BS) and After-Sampling (AS) data.

(5) Lab Density at Tank Temperature to Taylor Density
$C_5 = (D_L \text{ at } T) - (D_T) = \underset{x.xxxx}{\underline{\qquad}}$ g/ml

For both Before-Sampling (BS) and After-Sampling (AS) data.

For each of the above comparisons summary statistics are calculated as described in Section 6.2.3.

Table 6.3-2 shows the output report format for the Input Tank Density Measurement Summary. "Flagged" batches identified during the calculation of summary statistics are indicated following the statistics.

6.3.1.4 Accountability Tank Replicate Measurements

For the accountability tank, repeat measurement data is available. After-transfer measurements are made on the heel quantity remaining. The heel is remeasured prior to receiving the next batch. Comparison of these two measurements allows assessment of measurement performance and detection of measurement problem at the heel level of measurement in the accountability tank. Likewise, after a batch of input solution is received, volume measurements are recorded. Samples of the process solutions are then drawn for analytical determinations. The filled tank is remeasured after sampling. This repeat measurement is again used to assess performance and detect errors on full tank measurements.

These comparisons are made for both process control measurement anomalies and to assess random error components. In this sense, the summary report must include both types of comparisons. The specific calculation methods to be employed for these comparisons are as follows:

(1) Ruska Level (primary)
L_R = direct from LR-125-R in cm. = ______ cm.
xxx.xx

For AT, BR, BS, and AS measurements.

(2) Lab Density at 25°C
D_L at 25 = direct from lab results = ______ g/ml
x.xxxx

Note that D_L at 25 for the (AT) measurement and (BR) measurement is the same and is the analytical result from the previous batch density determination. D_L at 25 for BS and AS are the same but as analyzed for the current batch.

(3) Lab Density at Tank Temperature
D_L at T = adjusted from lab result = ______ g/ml
x.xxxx

These densities are calculated AT, BR, BS, and AS from appropriate lab densities using appropriate tank temperature measurement data.

(4) Process Control Solution Quantity
$LL_{PC} = L_R/D_L$ at 25°C = ______ cm
xxx.xx

$$V_{PC} = 9.4 + 0.9791(LL_{PC}) + 0.73154\ (LL_{PC}) - 0.00644532\ (LL_{PC})^3 \quad \text{if } 0 \leq LL_{PC} < 23.1$$

$$V_{PC} = -217.62 + 24.010061(LL_{PC}) + 0.011118(LL_{PC})^2 - 0.000046(LL_{PC})^3 \quad \text{if } 23.1 \leq LL_{PC} < 85$$

$$V_{PC} = -245.24 + 24.9569\ (LL_{PC}) \quad \text{if } 85 \leq LL_{PC} \leq 325$$

= ______ liters
XXXX

$W_{PC} = V_{PC} \times D_L$ at 25°C = ______ kg
xxxx.x

calculate W_{PC} for AT, BR, BS, and AS.

(5) Accountability Solution Quantity

$LL_A = L_R/D_L$ at T = $\underset{xxx.xx}{\underline{\qquad}}$ cm

$$V_A = 9.4 + 0.9791(LL_A) + 0.73154(LL_A)^2 - 0.0064532(LL_A)^3 \quad \text{if } 0 \leq LL_A \leq 23.0 \text{ cm}$$

$$= -217.62 + 24.0100061(LL_A) + 0.0011118(LL_A)^2 - 0.000046(LL_A)^3 \quad \text{if } 23.1 \leq LL_A < 85 \text{ cm}$$

$$= -245.24 + 24.9569(LL_A) \quad \text{if } 85.0 \leq LL_A \leq 325 \text{ cm}$$

$$= \underset{xxxx}{\underline{\qquad}} \text{ liters}$$

$$W_A = V_A \times D_L \text{ at T} = \underset{xxxx.x}{\underline{\qquad}} \text{ kg}$$

calculate W_A for AT, BR, BS, and AS.

For control of measurement anomalies, the process control measurement comparisons are used. Random error variances are estimated from accountability measurement comparisons. The specific solution quantity comparisons and calculations are as follows:

(1) After-Transfer to Before-Receipt - Process Control

$C_1 = (W_{PC} \text{ for AT}) - (W_{PC} \text{ for BR}) = \underset{xx.x}{\underline{\qquad}}$ kg

(2) Before-Sample to After-Sample - Process Control

$C_2 = (W_{PC} \text{ for BS}) - (W_{PC} \text{ for AS}) = \underset{xx.x}{\underline{\qquad}}$ kg

(3) After-Transfer to Before-Receipt - Accountability

$C_3 = (W_A \text{ for AT}) - (W_A \text{ for BR}) = \underset{xx.x}{\underline{\qquad}}$ kg

(4) Before-Sample to After-Sample - Accountability

$C_4 = (W_A \text{ for BS}) - (W_A \text{ for AS}) = \underset{xx.x}{\underline{\qquad}}$ kg

The summary report details these comparisons for each batch. Summary statistics are calculated as detailed in Section 6.2.3. Table 6.3-3 shows the format for the summary report. "Flagged" batches as described in Section 6.2.3 are identified in the summary report.

6.3.1.4 Product-Input Comparison

For the Uranium Input/Output Demonstration Program, the quantities transferred from the product tank are usually received in the accountability tank. These comparisons are based on independent measurements and provide for timely review of potential measurement problems in the transfer system, procedures, and on measurement systems. These comparisons are summarized in the format of Table 6.3-4.

6.3.2 Uranium Product Sample Tank

The uranium product sample tank is fitted with Taylor and Ruska level measurement instruments. The Taylor instrument reads in % of full scales and is installed for backup determination of level. Primary level determination is provided by a Ruska instrument installed across the reference probe and high pressure probe. A second Ruska instrument installed across the reference and low pressure (density) probes provides a second backup level measurement. Both Ruska instruments read in centimeters of water.

Primary density determination is by laboratory analysis on process samples. Backup determination is from a Taylor instrument across the high pressure and low pressure (density) probe. This Taylor instrument also reads in % of full scale. A second backup density measurement is provided by the Ruska instruments.

For each Ruska measurement discussed below, it is assumed the measurement has been adjusted for zero. That is the "zero" reading has been subtracted from the measurement.

6.3.2.1 Uranium Product Sample Tank Level

The specific calculations used in level measurements for the uranium product sample tank are as follows:

(1) Taylor Level

$$L_T = (\text{LR-239 in \%}) \times (.97) \times (2.54) = \underset{\text{xxx.xx}}{\underline{\qquad}} \text{ cm}$$

(2) Ruska (primary)

$$L_R = \text{direct read from LR-239-R} = \underset{\text{xxx.xx}}{\underline{\qquad}} \text{ cm}$$

Each of the above quantities are calculated for before-sampling (BS), after-sampling (AS), and after-transfer (AT) measurements for each batch of product solution. The following comparisons are made for each batch of product measured and are printed in the summary.

(1) Ruska (primary) to Taylor

$$C_1 = (L_R) - (L_T) = \underset{\text{xx.xx}}{\underline{\qquad}} \text{ cm}$$

C_1 calculated for BS, AS, and AT measurements.

Summary statistics are calculated for each of the above comparisons as described in Section 6.2.3. The format in the output report is shown in Table 6.3-1. "Flagged" batches as described in Section 6.2.3 are indicated.

6.3.2.2 Uranium Product Sample Tank Density

The specific calculations for density determination comparisons in the uranium product sample tank are as follows. The summary report includes comparisons of lab density at 25°C to process density measurements to establish control limits for the process comparisons described in Section 6.2. It also shows summaries of lab densities adjusted to tank temperature compared to process measurements to establish random error estimates.

(1) Taylor Density

$$D_T = \frac{[(DR\text{-}273 \text{ in } \%) \times .09] + 10}{10.1} = \underset{x.xxxx}{\underline{\qquad}} \text{ g/ml}$$

(2) Ruska Density

$$D_R = \frac{(LR\text{-}239\text{-}R)-(DR\text{-}273\text{-}R)}{25.65} = \underset{x.xxxx}{\underline{\qquad}} \text{ g/ml}$$

(3) Lab Density at 25°C

D_L at 25°C = direct from lab results = $\underset{x.xxxx}{\underline{\qquad}}$ g/ml

This quantity is the average of two reported lab densities.

(4) Lab Density at Tank Temperature

D_L at T = adjusted from lab results = $\underset{x.xxxx}{\underline{\qquad}}$ g/ml

Density measurements are made in before-sampling and after-sampling measurements. D_L at T may be calculated for each of these measurements using appropriate tank temperature measurement. Calculation of the comparisons applied to density determinations is as follows:

(1) Lab Density at 25°C to After-Sample Ruska Density

$C_1 = (D_L \text{ at } 25) - (D_R) = \underset{x.xxxx}{\underline{\qquad}}$ g/ml

C_1 is calculated for AS only.

(2) Lab Density at 25°C to After-Sample Taylor Density

$C_2 = (D_L \text{ at } 25) - (D_T) = \underset{x.xxxx}{\underline{\qquad}}$ g/ml

C_2 is calculated for AS only.

(3) Ruska Density to Taylor Density

$C_3 = (D_R) - (D_T) = \underset{x.xxxx}{\underline{\qquad}}$ g/ml

C_3 is calculated for BS and AS.

(4) Lab Density at Tank Temperature to Ruska Density

$C_4 = (D_L \text{ at } T) - (D_R) = \underset{x.xxxx}{\underline{\qquad}}$ g/ml

C_4 is calculated for BS and AS.

(5) Lab Density at Tank Temperature to Taylor Density

$C_5 = (D_L \text{ at } T) - (D_T) = \underset{x.xxxx}{\underline{\qquad}}$ g/ml

C_5 is calculated for BS and AS.

For each of the above comparisons, summary statistics are calculated as described in Section 6.2.3. Table 6.3-2 shows the format for the output summary. "Flagged" batches identified during the calculation of summary statistics are identified.

6.3.2.3 Uranium Product Sample Tank Replicate Measurements

For the uranium product sample tank, repeat measurements in the form of before-sampling measurements and after-sampling measurements are available for comparison. This comparison is made at the time of measurement using "process control" measurements to control measurement anomalies. The comparison is made using accountability calculated quantities to assess measurement performance and establish random error estimates. The specific calculations used in these comparisons are as follows:

(1) Ruska Level (primary)

L_{R_1} = direct from LR-239-R in cm. = $\underset{xx.xx}{\underline{\qquad}}$ cm

(2) Lab Density at 25°C

D_L at 25 = direct from lab results = $\underset{x.xxxx}{\underline{\qquad}}$ g/ml

(3) Lab Density at Tank Temperature

D_L at T = adjusted from lab result = $\underset{x.xxxx}{\underline{\qquad}}$ g/ml

This quantity must be calculated for BS and AS using the lab density analytical result and appropriate measurement of tank temperature.

(4) Process Control Solution Quantity

$LL_{PC} = L_{R_1}/D_L$ at 25°C

$$V_{PC} = 68.63 + 10.80859(LL_{PC})^1 + 0.7543094(LL_{PC})^2 - 0.0092121(LL_{PC})^3$$

for $0 \leq LL_{PC} \leq 22.1$ cm

$= 2.613 + 18.63934(LL_{PC}) + 0.36537(LL_{PC})^2 - 0.0015362(LL_{PC})^3$

for $22.1 < LL_{PC} \leq 92.5$ cm

$= 651.938 + 0.79564(LL_{PC}) + 0.523177(LL_{PC})^2 - 0.001977(LL_{PC})^3$

for $92.5 < LL_{PC} \leq 153.8$ cm

= ______ liters
xxxx.x

$W_{PC} = V_{PC} \times D_L$ at 25°C = ______ kg
xxxx.x

The above quantities are calculated for BS and AS.

(5) Accountability Solution Quantity

$LL_A = L_R / D_L$ at T = ______
xx.xx

$V_A = 68.63 + 10.80859(LL_A) + 0.7543094(LL_A)^2 - 0.009221(LL_A)^3$

for $0 \leq LL_A \leq 22.1$ cm

$= 2.613 + 18.63934(LL_A) + 0.36537(LL_A)^2 - 0.0015362(LL_A)^3$

for $22.1 < LL_A \leq 92.5$ cm

$= 651.938 + 0.79564(LL_A) + 0.523177(LL_A)^2 - 0.001977(LL_A)^3$

for $92.5 < LL_A \leq 153.8$ cm

= ______ liters
xxxx.x

$W_A = V_A \times D_L$ at T = ______ kg's
xxxx.x

The above quantities are calculated for BS and AS.

The specific comparisons made on these calculated solution quantities are as follows:

(1) Before Sampling to After Sampling - Process Control

$C_6 = (W_{PC}$ for BS) - (W_{PC} for AS) = ____ kg
xx.x

(2) Before Sampling to After Sampling - Accountability

$C_7 = (W_A$ for BS) - (W_A for AS) = ____ kg
xx.x

Summary statistics for these quantities are also calculated as described in Section 6.2.3. Summaries are included in the format shown in Table 6.3-3 with "flagged" batches identified.

6.3.3 Liquid Waste Measurements (GPW Check Tank and HWW Sample Tank)

Liquid waste measurements are made in the GPW check tank or the HWW sample tank. Both tanks are instrumented with Westinghouse transmitters, as primary level and density indications, and Taylor instruments as backup. All of these instruments provide readout in % of full scale. For these tanks laboratory density results are considered as backup.

6.3.3.1 Liquid Waste Level Measurements

The specific calculations to be applied for liquid waste level measurements are as follows:

(1) Westinghouse Level

for HWW Sample Tank

$$L_W = (LR\text{-}419\text{-}W) \times (2.50) = \underset{xxx.x}{\underline{\quad}} \text{ inches}$$

for GPW Check Tank

$$L_W = (LR\text{-}412\text{-}W) \times \text{direct} = \underset{xx.x}{\underline{\quad}} \text{ inches}$$

(2) Taylor level

for HWW Sample Tank

$$L_T = (LR\text{-}419) \times (2.04) = \underset{xx.x}{\underline{\quad}} \text{ inches}$$

for GPW Check Tank

$$L_T = (LR\text{-}412) \times (.713) = \underset{xx.x}{\underline{\quad}} \text{ inches}$$

Each of the above quantities are calculated for Before-Sampling (BS), After-Sampling (AS), and After-Transfer (AT) measurements for each batch of waste transferred. The following level measurement comparisons are made for each waste batch.

(1) Westinghouse to Taylor

$$C_1 = (L_W) - (L_T) = \underset{xx.x}{\underline{\quad}} \text{ inches}$$

Summary statistics as described in Section 6.2.3 are calculated. The summary is included in the summary report shown in Table 6.3-1.

6.3.3.2 Liquid Waste Density Measurements

The specific calculations to be applied for liquid waste density measurements follow. Primary density determination is with the Westinghouse instrument. Taylor instruments and lab density provide backup.

(1) Westinghouse Density
for HWW Sample Tank

$$D_W = \frac{[(\text{DR-430-W in \%}) \times (.50)]}{9.50} = \underset{\text{x.xxxx}}{\underline{\hspace{3em}}} \text{ g/ml}$$

for GPW Check Tank

$$D_W = \frac{[(\text{DR-416-W in \%}) \times (.50)]}{9.86} = \underset{\text{x.xxxx}}{\underline{\hspace{3em}}} \text{ g/ml}$$

(2) Taylor density
for HWW Sample Tank

$$D_T = \frac{[(\text{DR-430 in \%}) \times .9] + 10}{9.50} = \underset{\text{x.xxxx}}{\underline{\hspace{3em}}} \text{ g/ml}$$

for GPW Check Tank

$$D_T = \frac{[(\text{DR-416 in \%}) \times .9] + 10}{9.86} = \underset{\text{x.xxxx}}{\underline{\hspace{3em}}} \text{ g/ml}$$

(3) Lab density at 25°C

D_L at 25 = direct from lab result = $\underset{\text{x.xxxx}}{\underline{\hspace{3em}}}$ g/ml

Density measurements from Taylor and Westinghouse instruments are calculated for BS and AS measurement data. Measurement comparisons applicable to density determinations are as follows.

(1) Taylor to Westinghouse

$C_2 = (D_W) - (D_T) = \underset{\text{x.xxxx}}{\underline{\hspace{3em}}}$ g/ml

C_2 is calculated for BS and AS data.

(2) Westinghouse to Lab

$C_3 = (D_W) - (D_L \text{ at } 25) = \underset{\text{x.xxxx}}{\underline{\hspace{3em}}}$ g/ml

C_3 is calculated for AS data.

(3) Taylor to Lab

$C_4 = (D_T) - (D_L \text{ at } 25) = \underset{\text{x.xxxx}}{\underline{\hspace{3em}}}$ g/ml

C_4 is calculated for BS and AS data.

Summary statistics are calculated as described in Section 6.2.3 and the summary report output format is included in Table 6.3-2.

6.3.3.3 Liquid Waste Replicate Measurements

For each of the liquid waste measurement points, as with the previous measurement points, before-sampling measurement data are recorded; and the batch is remeasured after-sampling. Comparison of these quantities provides the estimate of the random error and assists in controlling measurement anomalies. The specific calculations for these measurements are as follows:

(1) Calculation of Solution Quantity (W)

for HWW Sample Tank

$LL = L_W/D_W = \underset{xxx.x}{\underline{\qquad}}$ inches

where L_W and D_W as defined for HWW Sample Tank above.

$V = 128.511103 + 20.966280 \text{ X } LL = \underset{xxxx.x}{\underline{\qquad}}$ liters

$W = V \text{ X } D_W = \underset{xxxx.x}{\underline{\qquad}}$ kg

for GPW Check Tank

$LL = L_W/D_W = \underset{xx.x}{\underline{\qquad}}$ inches

where L_W and D_W as defined for GPW Check Tank above.

$V = 24.86 + 15.2765415 \text{ X } LL = \underset{xxx.x}{\underline{\qquad}}$ liters

$W = V \text{ X } D_W = \underset{xxx.x}{\underline{\qquad}}$ kg

W as defined above is calculated for BS and AS data.

For each batch of waste the following solution quantity comparison is made:

(1) Before-Sampling to After-Sampling

$C_5 = (W \text{ for BS}) - (W \text{ for AS}) = \underset{xx.x}{\underline{\qquad}}$ kg

Summary statistics are calculated and the summaries printed in the format presented in Table 6.3-3.

6.4 Measurement - Measurement Control Relationship

The measurement sequences described in Sections 6.3, 6.3.2, and 6.3.3 include various comparisons. For each of these comparisons, a control limit needs to be stored and accessible with the computer data system. A listing of the limits to be used in the Uranium Input/Output

Demonstration Program is presented in Table 6.4-1. These limits will be periodically updated. Access to the update routine is to be restricted.

The measurement sequences should provide for error messages, as described in Section 6.2.2.(2) (3) (4), whenever applicable control limits are exceeded.

6.5 Measurement Control Output Programs

The format for outputting various measurement comparisons used to establish control limits and/or develop appropriate error estimates is provided in Tables 6.3-1 through 6.3-4. The data for these comparison calculations are obtained from the base data file. The calculation routines for these data are described in Section 6.3.

6.5.1 Sequence Description

To obtain a measurement control program output, the following sequences would be followed:

Sequence 1

The user would input a code assigned for measurement control activities. This would initiate the program which would request user's initials.

Sequence 2

Appropriate initials would result in a request for authorization code. This should be a nonprinting code. If proper code is input, go to next sequence; otherwise, return to Sequence 1.

Sequence 3

The program prompts for type of report needed as follows:

Report types are:
LV = Level
DN = Density
RP = Replicate
PI = Product to Input
UC = Uranium Concentration
Carriage Return = End of Reports

Enter Report Type ?.

Sequence 4

The programs prompt for measurement point as follows:

Enter Tank ID or "All."

Sequence 5

The programs prompt for beginning and ending batch for the measurement point selected as follows:

```
For Tank ***************
Enter Beginning Batch #      ?
Enter Ending Batch #         ?
```

Sequence 6

Program is executed and printed out on the NMC line printer.

TABLE A6.2-1

INPUT MEASUREMENT COMPARISONS

Reference	Comparison	Difference < 2s	Difference > 2s & < 3s	Consecutive Differences > 2s & < 3s	Difference > 3s
6.2.1.1	Redundant Inst. Comparison, Level (use Ruska to Taylor)	a	b	c	c
6.2.1.1	Redundant Inst. Comparison, Density	NA	NA	NA	NA
6.2.1.1	Temperature to Temperature	a	b	c	c
6.2.1.2	Lab Density to Process Density (use Taylor)	a	b	c	c
6.2.1.3	Process Density to Process Density	a	b	b	b
6.2.2.1	After-Transfer to Before-Receipt	a	b	d	d
6.2.2.1	Before-Sample to After-Sample	a	b	d	d
6.2.1.2	Quantity Sent to Quantity Received	a	b	d	d

(a) Comparison good, no action required.
(b) Flag result for investigation - measurement sequence continues.
(c) Flag result for investigation supervisory approval needed before proceeding.
(d) Out-of-control - correction action taken to be documented and approved by supervision.

TABLE A6.2-2

PRODUCT MEASUREMENT COMPARISONS

Reference	Comparison	Difference $< 2s$	Difference $> 2s$ & $< 3s$	Consecutive Differences $> 2s$ & $< 3s$	Difference $> 3s$
6.2.1.1	Redundant Inst. Comparison, Level (use Ruska to Taylor)	a	b	c	c
6.2.1.1	Redundant Inst. Comparison, Density	NA	NA	NA	NA
6.2.1.2	Lab Density to Process Density (use Taylor)	a	b	c	c
6.2.1.3	Process Density to Process Density	a	b	b	b
6.2.2.1	After-Transfer to Before-Receipt	NA	NA	NA	NA
6.2.2.1	Before-Sample to After-Sample	a	b	d	d
6.2.1.2	Quantity Sent to Quantity Received	NA	NA	NA	NA

(a) Comparison good, no action required.
(b) Flag result for investigation - measurement sequence continues.
(c) Flag result for investigation supervisory approval needed before proceeding.
(d) Out-of-control - correction action taken to be documented and approved by supervision.

TABLE A6.2-3

GPW MEASUREMENT COMPARISONS

Reference	Comparison	Difference $< 2s$	Difference $> 2s$ & $< 3s$	Consecutive Differences $> 2s$ & $< 3s$	Difference $> 3s$
6.2.1.1	Redundant Inst. Comparison, Level (use Taylor to Westing-House)	a	b	c	c
6.2.1.1	Redundant Inst. Comparison, Density (use Taylor to West-inghouse)	a	b	b	b
6.2.1.2	Lab Density to Process Density (use Westinghouse)	a	b	c	c
6.2.1.3	Process Density to Process Density	NA	NA	NA	NA
6.2.2.1	After-Transfer to Before-Receipt	NA	NA	NA	NA
6.2.2.1	Before-Sample to After-Sample	a	b	d	d
6.2.1.2	Quantity Sent to Quantity Received	NA	NA	NA	NA

(a) Comparison good, no action required.
(b) Flag result for investigation - measurement sequence continues.
(c) Flag result for investigation supervisory approval needed before proceeding.
(d) Out-of-control - correction action taken to be documented and approved by supervision.

TABLE A6.2-4

HWW MEASUREMENT COMPARISONS

Reference	Comparison	Difference < 2s	Difference > 2s & < 3s	Consecutive Differences > 2s & < 3s	Difference > 3s
6.2.1.1	Redundant Inst. Comparison, Level (use Taylor to Westing-House)	a	b	c	c
6.2.1.1	Redundant Inst. Comparison, Density (use Taylor to Westinghouse)	a	b	c	c
6.2.1.2	Lab Density to Process Density (use Westinghouse)	a	b	c	c
6.2.1.3	Process Density to Process Density	NA	NA	NA	NA
6.2.2.1	After-Transfer to Before-Receipt	NA	NA	NA	NA
6.2.2.1	Before-Sample to After-Sample	a	b	d	d
6.2.1.2	Quantity Sent to Quantity Received	NA	NA	NA	NA

(a) Comparison good, no action required.
(b) Flag result for investigation - measurement sequence continues.
(c) Flag result for investigation supervisory approval needed before proceeding.
(d) Out-of-control - correction action taken to be documented and approved by supervision.

TABLE A6.3-1

TANK LEVEL COMPARISONS
SUMMARY REPORT FOR BATCH-TO-BATCH DATE

Batch No.	Before-Receipt			Before-Sample			After-Sample			After-Transfer		
	Primary Level cm.	Pri-Tay cm.	TJR-TI °C	Primary Level cm.	Pri-Tay cm.	TJR-TI °C	Primary Level cm.	Pri-Tay cm.	TJR-TI °C	Primary Level cm.	Pri-Tay cm.	TJR-TI °C

The following items are printed (BR = Before-Receipt, BS = Before-Sample, AS = After-Sample, AT = After-Transfer).

$BR-L_R$	$BR-C_1$	$BR-C_2$	$BS-L_R$	$BS-C_1$	$BS-C_2$	$AS-L_R$	$AS-C_1$	$AS-C_2$	$AT-L_R$	$AT-C_1$	$AT-C_2$
xxx.xx	xx.xx	xx.xx	xxx.xx	xx.xx	xx.xx	xxx.xx	xx.xx	xx.xx	xxx.xx	xx.xx	xx.xx

Summaries are provided for Before-Sample and After-Transfer Data Only.

Summaries:

N =	xxx	xxx	xxx	xx	xx	xx	xxx	xxx	xxx	xxx	xxx	xxx
avg =	xx.xx	xx.xx	xx.xx	xx.xx	xx.xx	xx.xx	xx.xx	xx.xx	xx.xx	xx.xx	xx.xx	xx.xx
S =	xx.xx	xx.xx	xx.xx	xx.xx	xx.xx	xx.xx	xx.xx	xx.xx	xx.xx	xx.xx	xx.xx	xx.xx

TABLE A6.3-2

TANK DENSITY COMPARISONS
SUMMARY REPORT
FOR BATCH-TO-BATCH

Date: ____________________

Batch No.	Before Sampling							After Sampling				
	Ruska To Taylor	Lab at 25 To Ruska	Lab at 25 To Taylor	Lab at T To Ruska	Lab at T To Taylor	Lab Den at T	Lab Den at 25	Ruska To Taylor	Lab at 25 To Ruska	Lab at 25 To Taylor	Lab at T To Ruska	Lab at T To Taylor

The following items are printed under these headings.

C_3 for BS	C_1 for BS	C_2 for BS	C_4 for BS	C_5 for BS	D_L at T	D_L at 25	C_3 for AS	C_2 for AS	C_1 for AS	C_4 for AS	C_5 for AS
x.xxxx	x.xxxx	x.xxxx	x.xxxx	x.xxxx	x.xxxx	x.xxxx	x.xxxx	x.xxxx	x.xxxx	x.xxxx	x.xxxx

Summary statistics are provided for each of the comparisons.

N =	xxx	xxx	xxx	xxx	xxx			xxx	xxx	xxx	xxx	xxx
Avg =	x.xxxx	x.xxxx	x.xxxx	x.xxxx	x.xxxx			x.xxxx	x.xxxx	x.xxxx	x.xxxx	x.xxxx
S =	x.xxxx	x.xxxx	x.xxxx	x.xxxx	x.xxxx			x.xxxx	x.xxxx	x.xxxx	x.xxxx	x.xxxx

TABLE A6.3-3

MEASUREMENT POINT REPLICATE DATA
SUMMARY REPORT
FOR BATCH-TO-BATCH

Date: ____________________

Batch No.	Process Control				Accountability			
	AT to BR		BS to AS		AT to BR		BS to AS	
	Kg Sol	AT-BR	Kg Sol	BS-AS	Kg Sol	BS-AS	Kg Sol	BS-AS

The following items are printed under these headings.

W_{PC} at AT	C_1	W_{PC} at BS	C_2	W_A at AT	C_3	W_A at BS	C_4
xxxx.x	xx.x	xxxx.x	xx.x	xxxx.x	xx.x	xxxx.x	xx.x

Summary statistics are provided for each of the comparisons.

N =	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
Avg =	xxxxx.x	xx.x	xxxxx.x	xx.x	xxxxx.x	xx.x	xxxxx.x	xx.x
S =	xxx.x	xx.xx	xxx.x	xx.xx	xxx.x	xx.xx	xxx.x	xx.xx

TABLE A6.3-4

PRODUCT/INPUT COMPARISONS

Date: ____________________

Product Batch			Input Batch			Transferred-Received	
Batch No.	kg Sol	kgU	Batch No.	kg Sol	kgU	kg Sol	kgU

SUMMARY:

N =

Mean =

S =

TABLE A6.4-1

MEASUREMENT CONTROL
BASE DATA FILE BY
MEASUREMENT POINT

Date: ____________________

Description	Measurement Points							
Factors for Control Limits[1] For	2-03		2-09		2-23		2-28	
	$\bar{D}$	s	$\bar{D}$	s	$\bar{D}$	s	$\bar{D}$	s
0 Ruska-Taylor Comparisons	X	X	X	X	--	--	--	--
1 Westinghouse-Taylor Comparisons	--	--	--	--	X	X	X	X
2 After Transfer-Before Receipt	X	X	--	--	--	--	--	--
3 Before Sampling-After Sampling	X	X	X	X	X	X	X	X
4 Lab Density-Ruska Density	X	X	X	X	--	--	--	--
5 Lab Density-West. Density	--	--	--	--	X	X	X	X
6 Lab Density-Taylor Density	X	X	X	X	X	X	X	X
7 Ruska Density-Taylor Density	X	X	X	X	--	--	--	--
8 West. Density-Taylor Density	--	--	--	--	X	X	X	X
9 Input-Product kg Sol	X	X	X	X	--	--	--	--
10 Input-Product kgU	X	X	X	X	--	--	--	--
11 Ruska Level - Ruska Density	X	X	X	X	--	--	--	--

---

(1) These limits require periodic changing. Restricted access to this update routine is required.

7.0 CALCULATION PROGRAMS

This section provides the detailed calculation routines to be applied throughout the Uranium I/O Demonstration Program. For this section the term "Process Control" is used to describe calculations that are made on measurement data at the time it is generated. The term "Accountability" is used to describe the equations to provide the most accurate data to be applied to material balance calculations.

7.1 Input Measurements - Accountability Tank

7.1.1 Measurement Parameter Calculations

(1) Taylor Level

L_T = (Direct Read LR-125) X (2.54) = $\underset{xxx.xx}{\underline{\qquad}}$ cm

(2) Ruska (primary)

L_{R_1} = direct read from LR-125-R1 in cm. = $\underset{xxx.xx}{\underline{\qquad}}$ cm

Note Ruska measurement corrected for zero.

(3) Ruska (backup)

L_{R_2} = direct result on LR-125-R2 in cm. = $\underset{xxx.xx}{\underline{\qquad}}$ cm

Note Ruska measurement corrected for zero.

(4) Taylor Density

$$D_T = \frac{\text{(Direct Read From DR-166)}}{9.94} = \underset{x.xxxx}{\underline{\qquad}} \text{ g/ml}$$

(5) Ruska Density

$$D_R = \frac{\text{(LR-125R - DR-166R)}}{25.25} = \underset{x.xxxx}{\underline{\qquad}} \text{ g/ml}$$

Note both Ruskas corrected for zero.

(6) Lab density at 25°C

D_L at 25 - direct from lab results = $\underset{x.xxxx}{\underline{\qquad}}$ g/ml

This quantity is the average of two lab density analyses.

(7) Lab density at Tank Temperature

D_L at T = adjusted from lab result = $\underset{x.xxxx}{\underline{\qquad}}$ g/ml

(8) Tank Temperature (primary)
TJR-108-10 direct read in °C = ____ °C
xx.x

(9) Tank Temperature (backup)
T1-109 direct read in °C = ____ °C
xx.x

7.1.2 Liquid Level Calculation - Process Control

(1) For Before-Receipt
LL_{PC} for BR = L_{R_1} for BR/D_L at 25 (from previous batch) = ______ cm.
xxx.xx

(2) For Before-Sampling
LL_{PC} for BS = L_{R_1} for BS/(D_T for BS) = ______ cm
xxx.xx

LL_{PC} for BS = L_{R_1} for BS/D_L at 25 for this batch = ______ cm
xxx.xx

when lab data available.

(3) For After-Sampling
LL_{PC} for AS = L_{R_1} for AS/(D_L at 25 for this batch) = ______ cm
xxx.xx

(4) For After-Transfer
LL_{PC} for AT = L_{R_1} for AT/D_L at 25 for this batch) = ______ cm
xxx.xx

7.1.3 Liquid Level - Accountability

(1) For Before-Receipt
LL_A for BR = L_{R_1} for BR/D_L at BR-TJR from previous batch =
______
xxx.xx

(2) For Before-Sampling
LL_A for BS = L_{R_1} for BS/D_L at BS-TJR for this batch = ______
xxx.xx

(3) For After-Sampling
LL_A for AS = L_{R_1} for AS/D_L at AS-TJR for this batch = ______
xxx.xx

(4) For After-Transfer
LL_A for AT = L_{R_1} for AT/D_L at AT-TJR for this batch = ______
xxx.xx

(5) Liquid Level using Backup Ruska

$$LL = \frac{L_{R_2}}{D_L \text{ at tank temp.}} + (25.25)$$

for any calculation (BS, AS, etc.) = $\underline{\quad\quad}$ cm.
xxx.xx

or

$$LL = \frac{L_{R_2}}{D_L \text{ at Tank Temp.}}$$ and use alternate calibration equations (not included in this section).

7.1.4 Volume - Process Control

$$V_{PC} = 9.4 + 0.9791(LL_{PC}) + 0.73154\ (LL_{PC}) - 0.00644532\ (LL_{PC})^3$$
if $0 \leq LL_{PC} < 23.1$

$$V_{PC} = -217.62 + 24.010061(LL_{PC}) + 0.011118(LL_{PC})^2 - 0.000046(LL_{PC})^3$$
if $23.1 \leq LL_{PC} < 85$

$$V_{PC} = -245.24 + 24.9569\ (LL_{PC})$$
if $85 \leq LL_{PC} \leq 325$

= $\underline{\quad\quad}$ liters
xxxx

Use appropriate LL_{PC} for BR, BS, AS, and AT to calculate V_{PC} for BR, BS, AS, and AT.

7.1.5 Volume - Accountability

$$V_A = 9.4 + 0.9791(LL_A) + 0.73154(LL_A)^2 - 0.0064532(LL_A)^2$$
if $0 \leq LL_A \leq 23.0$ cm

$$= -217.62 + 24.0100061(LL_A) + 0.0011118(LL_A)^2 - 0.000046(LL_A)^3$$
if $23.1 \leq LL < 85$ cm

$$= -245.24 + 24.9569(LL_A)$$
if $85.0 \leq LL_A \leq 325$ cm

= $\underline{\quad\quad}$ liters
xxxx

Use appropriate LL_A for BR, BS, AS, and AT to calculate V_A for BR, BS, AS, and AT.

7.1.6 Solution Quantity - Process Control

(1) For Before-Receipt
W_{PC} for BR = (V_{PC} for BR) X (D_L at 25 from Previous Batch) = $\underline{\quad\quad}$ kg
xxxx.x

(2) For Before-Sampling

W_{PC} for BS = (V_{PC} for BR) X (D_T for BS) = ______ kg
xxxx.x

or

W_{PC} for BS = (V_{PC} for BS) X (D_L at 25 for this batch) = ______ kg
xxxx.x

when analytical results become available.

(3) For After-Sampling

W_{PC} for AS = (V_{PC} for AS) X (D_L at 25 for this batch) = ______ kg
xxxx.x

(4) For After-Transfer

W_{PC} for AT = (V_{PC} for AT) X (D_L at 25 for this batch) = ______ kg
xxxx.x

7.1.7 Solution Quantities - Accountability

(1) For Before-Receipt

W_A for BR = (V_A for BR) X (D_L at BR-TJR for previous batch) = ______ kg
xxxx.x

(2) For Before-Sampling

W_A for BS = (V_A for BS) X (D_L at BS-TJR for this batch) = ______ kg
xxxx.x

(3) For After-Sampling

W_A for AS = (V_A for AS) X (D_L at AS-TJR for this batch) = ______ kg
xxxx.x

(4) For After-Transfer

W_A for AT = (W_A for AT) X (D_L at AT-TJR for this batch) = ______ kg
xxxx.x

7.1.8 Uranium Concentrations

(1) For Process Control

$$U_{PC} = \left[\frac{(D_L \text{ at } 25 - 1.001) + .032 \text{ (Acid Molarity)}}{.318}\right] \times 238.12 =$$

______ g/1
xxx.xx

(2) For Accountability

U_A = direct from lab results = ______ mg/g
xxx.xx

7.1.9 Uranium Quantities

(1) For Process Control

$M_{PC} = V_{PC} \times U_{PC} \times .001 = \underline{\hspace{2em}}$ kg U
xxxx.x

Calculate M_{PC} for BR from U_{PC} from previous batch. Calculate M_{PC} for BS, AS, and AT from U_A for this batch.

(2) For Accountability

$M_A = W_A \times U_A = \underline{\hspace{2em}}$ kg U
xxxx.x

Calculate M_A for BR from U_A from previous batch. Calculate M_A for BS, AS, and AT from U_A for this batch.

7.1.10 Uranium Quantities Transferred/Received

(1) For PC quantities received

Q_{PC-R} = (M_{PC} from this batch BS) - (M_{PC} for previous batch AT) = ______ kg U
xxxx.x

(2) For PC Quantities Sent

Q_{PC-S} = (M_{PC} from this batch BS) - (M_{PC} from this batch AT) = ______ kg U
xxxx.x

(3) For A Quantities Received

Q_{A-R} = (M_A from this batch BS) - (M_A from previous batch AT) = ______ kg U
xxxx.x

(4) For A Quantities Sent

Q_{A-S} = (M_A from this batch BS) - (M_A from this batch AT) = ______ kg U
xxxx.x

7.1.11 Solution Quantities Transferred/Received

(1) For PC Quantities Received

S_{PC-R} = (W_{PC} from the batch BS) - (W_{PC} from previous batch AT) = ______ kg's sol
xxxx.x

Note W_{PC} for this batch BS may be calculated either of two ways from Section 7.1.6(2).

(2) For PC Quantities Transferred

S_{PC-S} = (W_{PC} from this batch BS) - (W_{PC} for this batch AT) = ______ kg's sol

xxxx.x

Note W_{PC} for this quantity is only calculated by the second method of Section 7.1.6(2).

(3) In A Quantities Received

S_{A-R} = (W_A for this batch BS) - (W_A from previous batch AT) = ______ kg's sol

xxxx.x

(4) For A Quantities Transferred

S_{A-S} = (W_A for the batch BS) - (W_A from this batch AT) = ______ kg's sol

xxxx.x

7.1.12 Solution Volumes Transferred/Received

(1) For PC Quantities Received

R_{PC-R} = (V_{PC} from this batch BS) - (V_{PC} from previous batch AT) = ____ liters

xxxx

(2) For PC Quantities Transferred

R_{PC-S} = (V_{PC} from this batch BS) - (V_{PC} from this batch AT) = ____ liters

xxxx

(3) For A Quantities Received

R_{A-R} = (V_A for this batch BS) - (V_A for previous batch AT) = ____ liters

xxxx

(4) For A Quantities Transferred

R_{A-S} = (V_A for this batch BS) - (V_A for this batch AT) = ____ liters

xxxx

7.1.13 Measurement Control Calculations

(1) Ruska (primary) to Taylor

$C_1 = (L_{R_1}) - (L_T) =$ _____ cm.
xx.xx

C_1 calculated for BR, BS, AS, and AT measurements.

(2) Lab density at 25°C to After Sample Ruska

$C_2 = (D_L \text{ at } 25) - (D_R) =$ ______ g/ml
x.xxxx

For after sample (AS) measurement only.

(3) Temperature
C_3 = (TJR-108-10) - (T1-109) = $\underline{\quad\quad}$ °C
xx.x

(4) Lab density at 25°C to After Sample Taylor
$C_4 = (D_L \text{ at } 25) - (D_T)$ = $\underline{\quad\quad}$ g/ml
x.xxxx

For after sample (AS) measurement only.

(5) Ruska density to Taylor density
$C_5 = D_R - D_T$ = $\underline{\quad\quad}$ g/ml
x.xxxx

For both before-sampling (BS) and after-sampling (AS) data.

(6) Lab density at Tank Temperature to Ruska
$C_6 = (D_L \text{ at } T) - (D_R)$ = $\underline{\quad\quad}$ g/ml
x.xxxx

For both before-sampling (BS) and after-sampling (AS) data.

(7) Lab density at Tank Temperature to Taylor
$C_7 = (D_L \text{ at } T) - (D_T)$ = $\underline{\quad\quad}$ g/ml
x.xxxx

For both before-sampling (BS) and after-sampling (AS) data.

(8) After-Transfer to Before-Receipt - Process Control
$C_8 = (W_{PC} \text{ for AT}) - (W_{PC} \text{ for BR})$ = $\underline{\quad\quad}$ kg
xx.x

(9) Before-Sample to After-Sample - Process Control
$C_9 = (W_{PC} \text{ for BS}) - (W_{PC} \text{ for AS})$ = $\underline{\quad\quad}$ kg
xxx

(10) After-Transfer to Before-Receipt - Accountability
$C_{10} = (W_A \text{ for AT}) - (W_A \text{ for BR})$ = $\underline{\quad\quad}$ kg
xx.x

(11) Before-Sample to After-Sample - Accountability
$C_{11} = (W_A \text{ for BS}) - (W_A \text{ for AS})$ = $\underline{\quad\quad}$ kg
xx.x

7.2 Product Measurement Uranium Product Sample Tank

7.2.1 Measurement Parameter Calculation

(1) Taylor Level
L_T = (Direct Read From LR-239) X (2.54) = $\underline{\quad\quad}$ cm
xxx.xx

(2) Ruska (primary)

L_{R_1} = direct read from LR-239R = $\underline{\quad\quad}$ cm
xxx.xx

(3) Ruska (backup)

L_{R_2} = (DR-239R in cm) = $\underline{\quad\quad}$ cm
xx.xx

(4) Taylor Density

$$D_T = \frac{\text{(Direct Read From DR-273)}}{10.15} = \underline{\quad\quad} \text{ g/ml}$$
x.xxxx

(5) Ruska Density

$$D_R = \frac{\text{(LR-239R) - (DR-239R)}}{25.78} = \underline{\quad\quad} \text{ g/ml}$$
x.xxxx

(6) Lab Density at 25°C

D_L at 25°C = direct from lab results = $\underline{\quad\quad}$ g/ml
x.xxxx

This quantity is the average of two reported lab densities.

(7) Lab Density at Tank Temperature

D_L at T = adjusted from lab results = $\underline{\quad\quad}$ g/ml
x.xxxx

(8) Temperature

T = TJR-208-17 direct read = $\underline{\quad\quad}$ °C
xx.x

(9) Liquid Level Using Backup Ruska

$$LL = \frac{L_{R_2}}{D_L \text{ at tank temp.}} + (25.78) = \underline{\quad\quad} \text{ cm}$$
xxx.xx

or

$$LL = \frac{L_{R_2}}{D_L \text{ at tank temp.}}$$ and use alternate calibration equations (not included in this section).

7.2.2 Liquid Level - Process Control

(1) For Before-Sampling

LL_{PC} for BS = L_{R_1} for BS/D_T = $\underline{\quad\quad}$ cm
xxx.xx

or

LL_{PC} for BS = L_{R_1} for BS/D_L at 25 = $\underline{\quad\quad}$ cm
xxx.xx

when analytical density available.

(2) For After-Sampling
LL_{PC} for AS = L_{R_1} for AS/D_L at 25 = ______ cm
xxx.xx

(3) For After-Transfer
LL_{PC} for AT = L_{R_1} for AT/D_L at 25 = ______ cm

7.2.3 Liquid Level - Accountability

(1) For Before-Sampling
LL_A for BS = L_{R_1} for BS/D_L at TJR-BS = ______ cm
xxx.xx

(2) For After-Sampling
LL_A for AS = L_{R_1} for AS/D_L at TJR-BS = ______ cm
xxx.xx

(3) For After-Transfer
LL_A at AT = L_A for AT/D_L at TJR-AS = ______ cm.
xxx.xx

7.2.4 Volume - Process Control

$$V_{PC} = 68.63 + 10.80859(LL_{PC}) + 0.7543094(LL_{PC})^2 - 0.0092211(LL_{PC})^3$$
for $0 \le LL_{PC} \le 22.1$ cm

$$= 2.613 + 18.63934(LL_{PC}) + 0.36537(LL_{PC})^2 - 0.0015362(LL_{PC})^3$$
for $22.1 < LL_{PC} \le 92.5$ cm

$$= 651.938 + 0.79564(LL_{PC}) + 0.523177(LL_{PC})^2 - 0.001977(LL_{PC})^3$$
for $92.5 < LL_{PC} \le 153.8$ cm

= ______ liters
xxxx.x

Use appropriate LL_{PC} for BS, AS, and AT to calculate V_{PC} for BS, AS, and AT.

7.2.5 Volume - Accountability

$$V_A = 68.63 + 10.80859(LL_A) + 0.7543094(LL_A)^2 - 0.009221(LL_A)^3$$
for $0 \le LL_A \le 22.1$ cm

$$= 2.613 + 18.63934(LL_A) + 0.36537(LL_A)^2 - 0.0015362(LL_A)^3$$
for $22.1 < LL_A \le 92.5$ cm

$$= 651.938 + 0.79564(LL_A) + 0.523177(LL_A)^2 - 0.001977(LL_A)^3$$

for $92.5 < LL_A \leq 153.8$ cm

= ______ liters
xxxx.x

Use appropriate LL_A for BS, AS, and AT to calculate V_A for BS, AS, and AT.

7.2.6 Solution Quantity - Process Control

(1) For Before-Sampling
W_{PC} for BS = (V_{PC} for BS) X (D_T for BS) = ______ kg
xxxx.x

or

W_{PC} for BS = (V_{PC}) X (D_L at 25 for this batch) = ______ kg
xxxx.x

when analytical results become available.

(2) For After-Sampling
W_{PC} for AS = (V_{PC} for AS) X (D_L at 25 for this batch) = ______ kg
xxxx.x

(3) For After-Transfer
W_{PC} for AT = (V_{PC} for AT) X (D_L at 25 for this batch) = ______ kg
xxxx.x

7.2.7 Solution Quantities - Accountability

(1) For Before-Sampling
W_A for BS = (V_A for BS) X (D_L at BS-TJR for this batch) =
______ kg
xxxx.x

(2) For After-Sampling
W_A for AS = (V_A for AS) X (D_L at AS TJR for this batch) =
______ kg
xxxx.x

(3) For After-Transfer
W_A for AT = (W_A for AT) X (D_L at AT-TJR for this batch) =
______ kg
xxxx.x

7.2.8 Uranium Concentrations

(1) For Process Control

$$U_{PC} = \frac{(D_L \text{ at } 25 - 1.001) + .032 \text{ (Acid Molarity)}}{.318} \times 238.12 =$$

______ g/l
xxx.xx

(2) For Accountability
U_A = direct from lab results = ______ mg/g
xxx.xx

7.2.9 Uranium Quantities

(1) For Process Control
$M_{PC} = V_{PC} \times U_{PC} \times .001$ = ______ kg U
xxxx.x

Calculate M_{PC} for BS, AS, and AT.

(2) For Accountability
$M_A = W_A \times U_A$ = ______ kg U
xxxx.x

Calculate M_A for BS, AS, and AT.

7.2.10 Uranium Quantities - Transferred/Received

(1) For PC Quantities Received
Q_{PC-R} = (M_{PC} from this batch BS) - (M_{PC} from previous batch AT) =
______ kg U
xxxx.x

(2) For PC Quantities Sent
Q_{PC-S} = (M_{PC} from this batch BS) - (M_{PC} from this batch AT) =
______ kg U
xxxx.x

(3) For A Quantities Received
Q_{A-R} = (M_A from this batch BS) - (M_A from previous batch AT) =
______ kg U
xxxx.x

(4) For A Quantities Sent
Q_{A-S} = (M_A from this batch BS) - (M_A from this batch AT) =
______ kg U
xxxx.x

7.2.11 Solution Quantities - Transferred/Received

(1) For PC Quantities Received

S_{PC-R} = (W_{PC} from this batch BS) - (W_{PC} from previous batch AT) = ____ kg's sol
xxxx.x

Note W_{PC} for this batch BS may be calculated either of two ways from Section 7.2.6(2).

(2) For PC Quantities Transferred

S_{PC-S} = (W_{PC} from the batch BS) - (W_{PC} for this batch AT) = ____ kg's sol
xxxx.x

Note W_{PC} for this quantity is only calculated by the second method of Section 7.2.6(2).

(3) For A Quantities Received

S_{A-R} = (W_A for this batch BS) - (W_A for previous batch AT) = ____ kg's sol
xxxx.x

(4) For A Quantities Transferred

S_{A-S} = (W_A for this batch BS) - (W_A for this batch AT) = ____ kg's sol
xxxx.x

7.2.12 Solution Volumes - Transferred/Received

(1) For PC Quantities Transferred

R_{PC-S} = (V_{PC} from this batch BS) - (V_{PC} from this batch AT) = ____ liters
xxxx

(2) For A Quantities Received

R_{A-R} = (V_A for this batch BS) - (V_A for previous batch AT) = ____ liters
xxxx

(3) For A Quantities Transferred

R_{A-S} = (V_A for this batch BS) - (V_A for this batch AT) = ____ liters
xxxx

7.2.13 Measurement Control Calculations

(1) Ruska (primary) to Taylor

$C_1 = (L_{R_1}) - (L_T) =$ ____ cm.
xx.xx

C_1 calculated for BS, AS and AT measurements.

(2) Lab Density at 25°C to After Sample Ruska Density

$C_2 = (D_L \text{ at } 25) - (D_R) = \underline{}$ g/ml
x.xxxx

C_2 is calculated for AS only.

(3) Lab Density at 25°C to After Sample Taylor

$C_3 = (D_L \text{ at } 25) - (D_T) = \underline{}$ g/ml
x.xxxx

C_3 is calculated for AS only.

(4) Ruska Density to Taylor Density

$C_4 = (D_R) - (D_T) = \underline{}$ g/ml
x.xxxx

C_4 is calculated for BS and AS.

(5) Lab Density at Tank Temperature to Ruska Density

$C_5 = (D_L \text{ at } T) - (D_R) = \underline{}$ g/ml
x.xxxx

C_5 is calculated for BS and AS.

(6) Lab Density at Tank Temperature to Taylor Density

$C_6 = (D_L \text{ at } T) - (D_T) = \underline{}$ g/ml
x.xxxx

C_6 is calculated for BS and AS.

(7) Before Sampling to After Sampling - Process Control

$C_7 = (W_{PC} \text{ for BS}) - (W_{PC} \text{ for AS}) = \underline{}$ kg
xx.x

(8) Before Sampling to After Sampling - Accountability

$C_8 = (W_A \text{ for BS}) - (W_A \text{ for AS}) = \underline{}$ kg
xx.x

7.3 Liquid Waste Measurement (HWW Sample Tank and GPW Check Tank

7.3.1 Measurement Parameter Calculations

(1) Westinghouse Level

for HWW Sample Tank

L_W = Direct from LR-419W = ______ inches
xxx.x

for GPW Check Tank

L_W = Direct from LR-412W = ______ inches
xx.x

(2) Taylor Level

for HWW Sample Tank

L_T = Direct from LR-419 = ____ inches
xx.x

for GPW Check Tank

L_T = Direct from LR-412 = ____ inches
xx.x

(3) Westinghouse Density

for HWW Sample Tank

$$D_W = \frac{(\text{Direct from DR-430W})}{9.50} = \underline{\quad} \text{ g/ml}$$
x.xxxx

for GPW Check Tank

$$D_W = \frac{(\text{Direct from DR-416W})}{9.86} = \underline{\quad} \text{ g/ml}$$
x.xxxx

(4) Taylor Density

for HWW Sample Tank

$$D_T = \frac{(\text{Direct from DR-430})}{9.50} = \underline{\quad} \text{ g/ml}$$
x.xxxx

for GPW Check Tank

$$D_T = \frac{(\text{Direct from DR-416})}{9.86} = \underline{\quad} \text{ g/ml}$$
x.xxxx

(5) Lab Density at 25°C

D_L at 25 = direct from lab result = ____ g/ml
x.xxxx

(6) Temperature

for HWW Sample Tank

TJR = direct from TJR-414-5 = ____ °C
xx.x

for GPW Check Tank

TJR = direct from TJR-415-7 = ____ °C
xx.x

7.3.2 Calculation of Liquid Level, Solution Volume, and Solution Weight

(1) For HWW Sample Tank

LL = L_W/D_W = ____ inches
xxx.x

where L_W and D_W as defined for HWW Sample Tank above.

V = 128.511103 + 20.966280 X LL = ____ liters
xxxx.x

$W = V \times D_W = \underset{xxxx.x}{\underline{\qquad}}$ kg

(2) For GPW Check Tank

$LL = L_W/D_W = \underset{xx.x}{\underline{\qquad}}$ inches

where L_W and D_W as defined for GPW Check Tank above.

$V = 24.86 + 15.2765415 \times LL = \underset{xxx.x}{\underline{\qquad}}$ liters

$W = V \times D_W = \underset{xxx.x}{\underline{\qquad}}$ kg's

W as defined above is calculated for BS, AS, and AT data.

These quantities are used for PC and A applications.

7.3.3 Uranium Concentrations

U = direct from lab results = $\underset{xx.xx}{\underline{\qquad}}$ mg U/g

7.3.4 Uranium Quantities

$M = W \times U = \underset{xxx.x}{\underline{\qquad}}$ grams

Calculate M for BS, AS, and AT quantities.

7.3.5 Uranium Quantities Transferred/Received

(1) Quantity Received

Q_S = M for BS this batch - M for AT last batch = $\underset{xxx.x}{\underline{\qquad}}$ grams

(2) Quantity Transferred

Q_S = M for BS this batch - M for AT last batch = $\underset{xxx.x}{\underline{\qquad}}$ grams

7.3.6 Solution Quantities - Transferred/Received

(1) Quantity Received

S_R = W for BS this batch - W for AT last batch = $\underset{xxxx.x}{\underline{\qquad}}$ kg's

(2) Quantity Transferred

S_R = W for BS this batch - W for AT this batch = $\underset{xxxx.x}{\underline{\qquad}}$ kg's

7.3.7 Solution Volumes - Transferred/Received

(1) Quantity Received

R_R = V for BS this batch - V for AT last batch = $\underline{\quad}$ liters
xxxx

R_S = V for BS this batch - V for AT this batch = $\underline{\quad}$ liters
xxxx

7.3.8 Measurement Control Calculations

(1) Westinghouse to Taylor Level

$C_1 = (L_W) - (L_T) =$ inches
xx.x

(2) Taylor to Westinghouse Density

$C_2 = (D_W) - (D_T) = \underline{\quad\quad}$ g/ml
x.xxxx

C_2 is calculated for BS and AS data.

(3) Westinghouse to Lab Density

$C_3 = (D_W) - (D_L \text{ at } 25) = \underline{\quad\quad}$ g/ml
x.xxxx

C_3 is calculated for AS data.

(4) Before-Sampling to After-Sampling

C_4 = (W for BS) - (W for AS) = $\underline{\quad}$ kg
xx.x

7.4 MBA Transfer Calculations

The only MBA transfer of concern is from the uranium product sample tank to the accountability tank. The equations for this transfer comparison are as follows.

7.4.1 First Pass Comparison

This comparison uses available before-sampling data in the accountability tank and available transfer data in the uranium product sample tank.

$MBAC_1$ = [W_{PC} for BS (in acc't tank) - W_{PC} for AT of previous batch] - [S_{PC-S} for product tank]

NOTE: W_{PC} for BS is described in Section 7.1.6(2), first method.
W_{PC} for AT is described in Section 7.1.6(4).
S_{PC-S} is described in Section 7.2.10(2).

7.4.2 Second Pass Comparison

This comparison used lab results in accountability tank to make a refined comparison.

$MBAC_2$ = [S_{PC-R} for acc't tank] - [S_{PC-S} for product tank]

NOTE: S_{PC-R} is described in Section 7.1.11(1).
S_{PC-S} is described in Section 7.2.11(2).

7.4.3 Third Pass Comparisons

When all data is available a final comparison using accountability calculations is made. This comparison is made on solution quantities and total uranium transferred.

$MBAC_3$ = [S_{A-R} for acc't tank] - [S_{A-S} for product tank]

NOTE: S_{A-R} is described in Section 7.1.11(3).
S_{A-S} is described in Section 7.2.11(4).

and

$MBAC_4$ = [Q_{A-R} for acc't tank] - [Q_{A-S} for product tank]

NOTE: Q_{A-R} is described in Section 7.1.10(3).
Q_{A-S} is described in Section 7.2.10(4).

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APPENDIX B

REMOTE (RTP) DATA ACQUISITION SYSTEM - DETAILED DESCRIPTION

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1.0 INTRODUCTION

Measurement instrumentation associated with the Computerized Nuclear Materials Control and Accounting System (CNMCAS) will be interfaced to the central processing unit (CPU) through the remote (RTP) data acquisition system (referred to herein as the RTP system). The RTP system is composed of real-time peripheral/preprocessor equipment including:

- Preprocessor - PPP 11/04, Digital Equipment Corporation
- Analog Controller - RTP Wide Range Analog Controller, Computer Products, Inc.
- Digital Controller - RTP Universal Controller, Computer Products, Inc.
- Temperature Compensator - RTP Uniform Temperature Reference Assembly, Computer Products, Inc.

The RTP system scans selected process instrumentation, collects, stores, and manipulates instrument signals, and transmits instrument data to the CNMCAS CPU.

2.0 INSTRUMENTATION CONNECTED TO THE RTP SYSTEM

The RTP system currently receives and processes signals from four major types of measurement instrumentation.

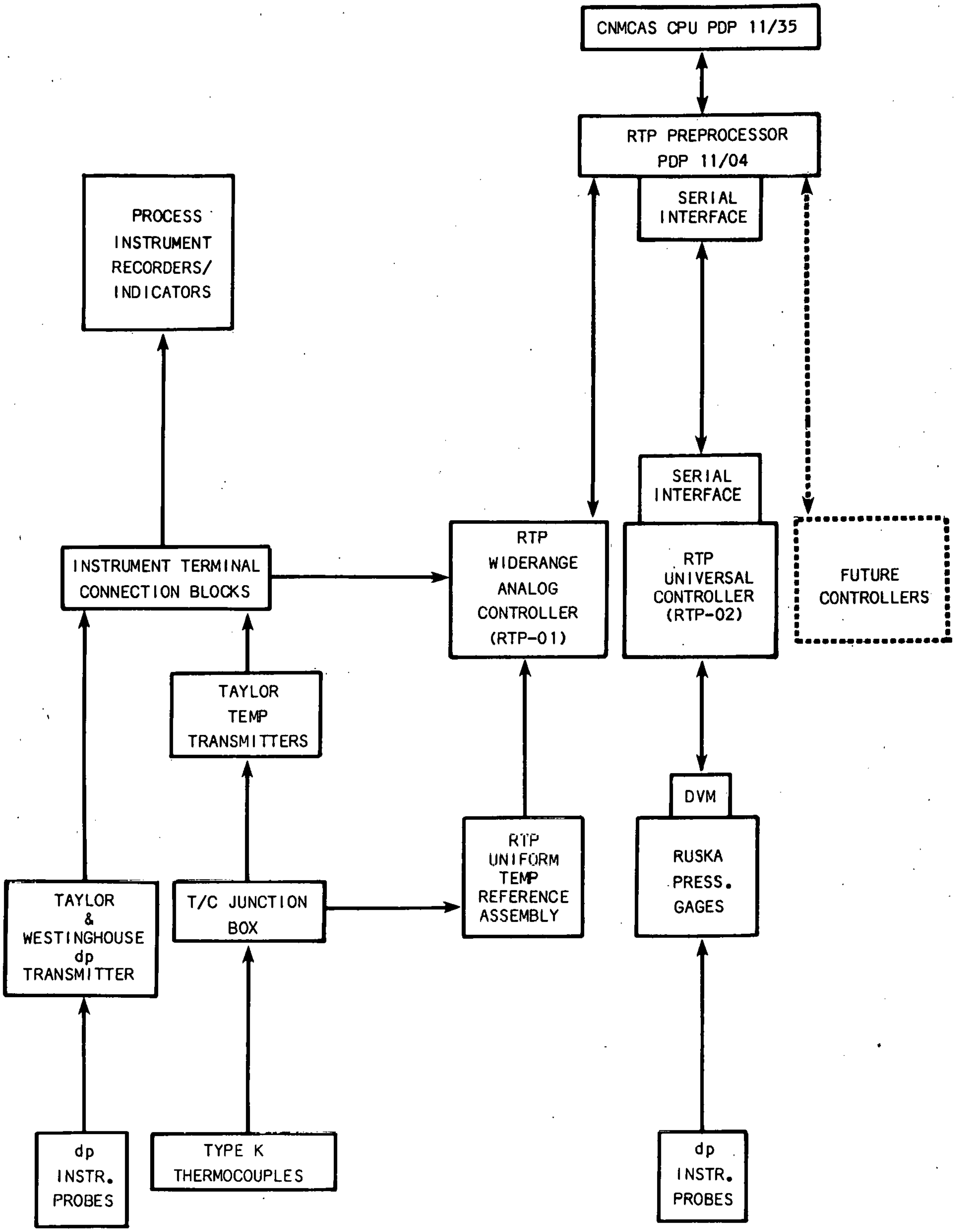
(1) Taylor and Westinghouse differential pressure transmitters - the pressure signals are converted to current (4 to 20 milliamperes). The current is passed through a 62.5 ohm resistor which generates a voltage signal (0.25 to 1.25 volts) which serves as the input signal to the analog controller.

(2) Taylor Temperature transmitters - also input to the analog controller as a voltage signal.

(3) Type K thermocouples - the thermocouple signals are routed to a temperature compensation unit, then input to the analog controller as voltage signals.

(4) Ruska DDR-6000 precision pressure gauges - differential pressure signals are routed from the Ruska DVMs as binary coded digital signals to the digital controller. Signals are routed from the digital controller to the preprocessor through back-to-back serial interface units. The preprocessor must signal the Ruskas to "lock-up" or stabilize via the digital controller prior to accepting each Ruska signal.

Figure B2-1 presents a schematic of the RTP system.



RTP SYSTEM - FY 1978

FIGURE B2-1

3.0 RTP SCAN MODES

Three scan modes are required for initial operation of the RTP system.

3.1 Scan Mode 1

Scan mode is the basic scan made for sampling all process instrument signals connected to the RTP system. The RTP system cycles through all points continuously (except for higher scan mode interruption) and stores only the latest instrument signal values.

3.2 Scan Mode 2

Scan mode 2 is activated at a programmed frequency and continues for a programmed duration. Selected instruments requiring "averaged" signal values and short-term storage of these are included in scan mode 2. To support the Uranium Input/Output Demonstration Program a scan frequency of four minutes and a scan duration of twenty seconds will be used. All of the signal values from the instruments in scan mode 2 are collected over the twenty-second duration, and the averaged value stored in the core of the preprocessor. The last five "averaged" values are stored.

3.3 Scan Mode 3

Scan mode 3 is similar in purpose and operation to scan mode 2 except the scan duration will be set at ten seconds and the last three "averaged" values stored. Scan frequency will also be set at four minutes. Scan mode 3 is activated two minutes after scan mode 2.

4.0 OTHER RTP SYSTEM REQUIREMENTS

4.1 Conversion to Engineering Units

The preprocessor converts analog instrument signal values (0.25 to 1.25 volts) to engineering units applicable to the particular parameter being measured. The range of the instrument generating the signal is incorporated in the conversion process. Engineering units for the four instrument types are as follows:

- Taylor/Westinghouse differential pressure transmitters - inches of water.
- Taylor temperature transmitters - °C
- Type K thermocouples - °C
- Ruska gauges - centimeters of water.

The separation of the high pressure and medium pressure instrument probes is required to calculate density from density readout instrumentation. The relationship is as follows:

$$\text{Density} = \frac{\text{(Density Instrument Reading) + (Range Offset From 0)}}{\text{Probe Separator}}$$

This relationship should be used in conversion of density signal values to engineering units.

4.2 Alarm Points

Low and/or high alarm points for certain instruments are retained in the preprocessor. At a programmed frequency, current instrument signal values are compared to the alarm points and out-of-limit values printed out.

Alarm status can also be requested.

5.0 RTP SYSTEM DATA

The tables contained in this section provide pertinent data on process instruments connected to the RTP system, corresponding RTP connection data, and cross-referencing information.

Table B5-1 - RTP Data Acquisition System RTP - Instrument Identification and Parameter Data.

Table B5-1 presents the following:

- Measurement point number for the process vessel (or stream), vessel (or stream) name, and vessel equipment number.
- Instrument numbers for the associated vessel (or stream) instruments connected to the RTP system.
- Process instruments connected to the RTP system and their symbols are:

  (1) Liquid level recorders and indicators - LR, LI*

  (2) Density recorders and indicators - DR, DI*

  (3) Temperature recorders and indicators - TR, TI, TJR

*Ruska instruments are identified with the suffix "R" after the instrument number. Westinghouse instruments are identified with the suffix "W" after the instrument number.

(4) Weight recorders and indicators - WR, WI

(5) Pressure recorders and indicators - PR, PI

(6) In-line monitors on process streams

   (a) Alpha count rate recorders and indicators - AR, AI

   (b) Neutron count rate recorders and indicators - AR, AI

   (c) Uranium concentration recorder - AR

   (d) Gamma count rate recorders and indicators - RR, RI

   (e) Flow rate (solution) recorders and indicators - FR, FI

   (f) Nitrite (NO_2^-) concentration recorder - AR

   (g) Conductivity (electrical) recorder - CR

   (h) Gadolinium concentration recorder (count rate from η source monitored) - AR.

- Instrument type
- Instrument range
- Scan mode
- Probe separation (for density instruments)
- Low and high alarm points.
- RTP connection data, i.e., the terminal board and channel number in the analog controller to which the leads from a particular instrument are connected.

  The analog controller is identified as RTP-01; the digital controller as RTP-02. The digital controller channel numbers from the Ruska instruments are noted in the "Comments" column.

Table B5-2 RTP-01 Channel Numbers Versus Instrument Identification Numbers

Table B5-2 is used to correlate RTP-01 (analog controller) channel numbers with applicable process instruments. The channels assigned to the autocalibration board and RTD and REF signals from the RTP Uniform Temperature Reference Assembly are also included. In addition, the scan mode for each instrument is indicated.

Table B5-3 RTP Correlation Table

Table B5-3 lists the process instruments connected to the RTP system by type in ascending numerical order. The table is used to correlate instruments with measurement point numbers and RTP-01 channel numbers.

TABLE B5-1

RTP DATA ACQUISITION SYSTEM
RTP-INSTRUMENT IDENTIFICATION AND PARAMETER DATA

MEAS. PT. NO./NAME TANK EQUIP. NO.	INSTR. NUMBER	INSTR. TYPE	INSTR. RANGE	SCAN MODE	PROBE SEP.	LOW ALARM	HIGH ALARM	RTP-01 TB NO.	RTP-01 CH NO.	COMMENTS
2-01	LR-121	Taylor	0-135"H_2O	3			105"H_2O	11	81	
Feed Surge Tank	DR-164	Taylor	10-19"H_2O	3	10.47"			12	90	
17-D-113	TJR-108-9	Type K		1				45	356	
2-02	LR-128	Taylor	0-290"	3				10	78	
Dissolver Flush	DR-167	Taylor	10-19"	3	9.93"			11	83	
Accumulator	TJR-108-11	Type K		1				45	358	
17-D-111										
2-03	LR-125	Taylor	0-215"H_2O	2			183"H_2O	9	66	
Accountability	LR-125R	Ruska	0-10 psi	2						RTP-02 (2512)
Tank	DR-166	Taylor	10-19"H_2O	2	9.94"			11	82	
18-D-101	DR-166R	Ruska	0-10 psi	2	9.94"					RTP-02 (2513)
	TJR-108-10	Type K		1				45	357	
	TI-109	Type K	0-150°C	1				10	79	
2-04	LR-420	Taylor	0-129"H_2O	3			102"H_2O	32	261	
1 SF Tank	DR-439	Taylor	9-14"H_2O	3	9.93"			33	258	
42-D-433	AR-401	α Monitor		1				33	259	
	AR-402	NO_2 Monitor		1				33	260	
2-05	LR-129	Taylor	0-285"H_2O	2				10	76	
No. 1 Feed	DR-168	Taylor	10-19"H_2O	2	9.95"			10	74	
Adjustment Tank	TJR-108-12	Type K		1				45	359	
17-D-103										
2-06	LR-130	Taylor	0-285"H_2O	2				9	65	
No. 2 Feed	DR-169	Taylor	10-19"H_2O	2	10.12"			9	68	
Adjustment Tank	TJR-108-13	Type K		1				46	360	
17-D-104										
2-07	LR-235	Taylor	0-130"H_2O	2			75"H_2O	15	117	
Off-Spec. Uranium	DR-269	Taylor	10-19"H_2O	2	9.83"			16	120	
Product Tank	TI-									
24-D-204										
2-08	LR-309	Taylor	0-150"H_2O	3			90"H_2O	18	140	
Plutonium	DR-335	Taylor	10-18"H_2O	3	9.93"			18	143	
Rework Tank	TJR-305-3	Type K		1				49	384	
32-D-301										

TABLE B5-1

(continued)

RTP DATA ACQUISITION SYSTEM

RTP-INSTRUMENT IDENTIFICATION AND PARAMETER DATA

MEAS. PT. NO./NAME TANK EQUIP. NO.	INSTR. NUMBER	INSTR. TYPE	INSTR. RANGE	SCAN MODE	PROBE SEP.	LOW ALARM	HIGH ALARM	RTP-01 TB NO.	RTP-01 CH NO.	COMMENTS
2-09	LR-239	Taylor	0-97"H_2O	2		7.3"	73"H_2O	17	129	
Uranium Product	LR-239R	Ruska	0-10 psi	2						RTP-02 (2514)
Sample Tank	DR-273	Taylor	10-19"H_2O	2	10.10"			17	130	
24-D-203	DR-273R	Ruska	0-10 psi	2	10.10"					RTP-02 (2515)
	TJR-206-17	Type K		1				47	370	
2-10	LR-326	Taylor	0-105"H_2O	2			100"H_2O	21	161	
Plutonium Product	LR-326R	Ruska	Not Installed	2						
Sample Tank	DR-374	Taylor	12.5- 20.5"H_2O	2	10.0"			21	162	
34-D-303	TJR-305-8	Type K		1				49	389	
2-11	LR-301	Taylor	0-190"H_2O	2		10"H_2O	180"H_2O	21	165	
No. 1	LR-301R	Ruska	Not Installed	2						
Plutonium Product	DR-304	Taylor	12.5-20.5"H_2O	2	8.98			21	160	
Storage Tank	TJR-305-9	Type K		1				49	390	
35-D-304										
2-12	LR-302	Taylor	0-190"H_2O	2		10"H_2O	180"H_2O	21	164	
No. 2	LR-302R	Ruska	Not Installed	2						
Plutonium Product	DR-312	Taylor	12.5-20.5	2	9.26			22	171	
Storage Tank	TJE-305-10	Type K		1				49	391	
35-D-305										
2-13	LR-303	Taylor	0-190"H_2O	2		10"H_2O	180"H_2O	25	198	
No. 3	LR-303R	Ruska	Not Installed	2						
Plutonium Product	DR-321	Taylor	12.5-20.5"H_2O	2	8.80			25	199	
Storage Tank	TJR-305-11	Type K		1				50	392	
35-D-306										
2-15	LR-522	Taylor	0-160"H_2O	3			110"H_2O	32	248	
No. 1 Solvent	DR-530	Taylor	8-10"H_2O	3	9.90"			31	245	
System Feed Tank	TJR-504-5	Type K		1				47	375	
51-D-502										
2-16	LR-507	Taylor	0-155"H_2O	3			110"H_2O	26	200	
No. 2 Solvent	DR-510	Taylor	6-10"H_2O	3	9.88"			27	214	
System Feed Tank	TJR-509-8	Type K		1				48	378	
52-D-503										
2-17	LR-305	Taylor	0-120"H_2O	3		18"H_2O	90"H_2O	17	131	
IBP Surge Tank	DR-329	Taylor	9-14"H_2O	3	10.22"			19	144	
32-D-307	TJR-305-1	Type K		1				48	382	

TABLE B5-1
(continued)

RTP DATA ACQUISITION SYSTEM
RTP-INSTRUMENT IDENTIFICATION AND PARAMETER DATA

MEAS. PT. NO./NAME TANK EQUIP. NO.	INSTR. NUMBER	INSTR. TYPE	INSTR. RANGE	SCAN MODE	PROBE SEP.	LOW ALARM	HIGH ALARM	RTP-01 TB NO.	RTP-01 CH NO.	COMMENTS
2-20	LR-516	Taylor	0-57"H_2O	3			40"H_2O	29	227	
Carbonate	DR-523	Taylor	13.6-17.7"H_2O	3	16.83"			30	233	
Diversion Tank	TJR-509-2	Type K		1				47	372	
51-D-501										
2-21	LR-401	Taylor	0-81.7"H_2O	3			48"H_2O	27	212	
Solvent Batch	DR-401	Taylor	15.8-20.8	3	19.80"			26	201	
Stripping Tank	TJR-509-9	Type K		1				48	379	
42-D-401										
2-22	LR-402	Taylor	0-147"H_2O	3		10"H_2O	110"H_2O	26	207	
Solvent Burner	DR-402	Taylor	16.4-24"H_2O	3	19.87"			26	204	
Feed Tank	TJR-509-12	Type K		1				48	381	
42-D-402										
2-23	LR-419	Taylor	0-204"H_2O	2			185"H_2O	33	262	
HWW Sample Tank	LR-419 W	Westinghouse	0-204"H_2O	2				4	59	
41-D-405	DR-430	Taylor	10-15"H_2O	2	9.50"			33	263	
	DR-430 W	Westinghouse	10-15"H_2O	2	9.50"			4	60	
	TJR-414-5	Type K		1				50	395	
2-24	LR-427	Taylor	0-87"H_2O	3				36	281	
LAWB Check Tank	DR-448	Taylor	9-14"H_2O	3	10.48"			35	276	
42-D-434	TJR-414-10	Type K		1				51	400	
2-25	LR-617	Taylor	0-345"H_2O	1		34.5"H_2O	310"H_2O	1	1	
Recovered Acid	DR-646	Taylor	10-16"H_2O	1	9.91"			1	0	
Storage Tank	TJR-607-1	Type K		1				45	352	
62-D-605										
2-26	LR-428	Taylor	0-57"H_2O	1		12"H_2O	43"H_2O	41	321	
Service Conc.	RR-456	γ Monitor		1				41	322	
Feed Tank										
44-D-459										
2-27	LI-431A	Taylor	0-75.2"H_2O	1				42	331	
Service Conc.	TJR-415-22	Type K		1				52	415	
Ck. Tank										
44-D-460										
2-28	LR-412	Taylor	0-71.3"H_2O	2			50"H_2O	43	340	
GPW Check Tank	LR-412 W	Westinghouse	0-71.3"H_2O	2				4	61	
43-D-409	DR-416	Taylor	8-14"H_2O	2	9.86"			43	336	
	DR-416 W	Westinghouse	8-14"H_2O	2	9.86"			4	62	
	TJR-415-7	Type K		1				52	409	

TABLE B5-1
(continued)

RTP DATA ACQUISITION SYSTEM
RTP-INSTRUMENT IDENTIFICATION AND PARAMETER DATA

MEAS. PT. NO./NAME TANK EQUIP. NO.	INSTR. NUMBER	INSTR. TYPE	INSTR. RANGE	SCAN MODE	PROBE SEP.	LOW ALARM	HIGH ALARM	RTP-01		COMMENTS
								TB NO.	CH NO.	
2-29	LR-406	Taylor	0-169"H_2O	3			100"H_2O	44	346	
Sump Collection	DR-411	Taylor	10-16"H_2O	3	9.84"			43	337	
Tank	TJR-415-4	Type K		1				51	406	
43-D-412										
2-32	LI-209	Taylor	0-61"H_2O	3			55"H_2O	5	39	
1BU Recycle Tank										
21-D-210										
2-33	LI-210	Taylor	0-41"H_2O	1		10"H_2O		5	33	
1BX Anolyte	TJR-206-6	Type K		1				46	366	
Feed Tank										
21-D-213										
2-34	LR-417	Taylor	0-117"H_2O	3			105"H_2O	30	238	
HAW Surge Tank	DR-426	Taylor	10-15"H_2O	3	10.09"			30	237	
41-D-417	TJR-414-3	Type K		1				50	393	
2-35	LR-425	Taylor	0-92"H_2O	3			75"H_2O	35	274	
LAW Concentrator	DR-445	Taylor	8-13"H_2O	3	9.91"			34	264	
Feed Tank	TJR-414-7	Type K		3				50	397	
42-D-406										
2-36	LR-405	Taylor	0-145"H_2O	3			120"H_2O	44	345	
G. P. Concentrator	DR-410	Taylor	7-12"H_2O	3	10.10"			43	342	
Feed Tank	TJR-415-2	Type K		1				51	404	
43-D-408										
2-37	LR-465	Taylor	0-49"H_2O	1			40"H_2O	37	292	
No. 1 Iodine	LI-464	Taylor	0-5-H_2O	1		4"H_2O		38	299	
Scrubber	DR-4137	Taylor	9-14"H_2O	1	9.37"	-		37	288	
45-K-425	TJR-415-9	Type K		1				52	411	
2-38	LR-470	Taylor	0-49"H_2O	1			42"H_2O	39	306	
No. 2 Iodine	LI-469	Taylor	0-5"H_2O	1		1"H_2O		37	290	
Scrubber	DR-4142	Foxboro	9-12"H_2O	1	9.92"			37	294	
45-K-425	TJR-415-3	Type K		1				51	405	
2-39	LR-530	Taylor	0-180"H_2O	1			160"H_2O	44	344	
Acid Fractionator										
Diversion Tank										
54-D-506										

TABLE B5-1
(continued)

RTP DATA ACQUISITION SYSTEM
RTP-INSTRUMENT IDENTIFICATION AND PARAMETER DATA

MEAS. PT. NO./NAME TANK EQUIP. NO.	INSTR. NUMBER	INSTR. TYPE	INSTR. RANGE	SCAN MODE	PROBE SEP.	LOW ALARM	HIGH ALARM	RTP-01 TB NO.	RTP-01 CH NO.	COMMENTS
2-40	LR-607	Taylor	0-150"H_2O	1		30"H_2O	105"H_2O	2	14	
Dissolver Acid	DR-615	Taylor	10-15"H_2O	1	10.00"			2	13	
Surge Tank	AR-605	η Monitor		1				3	18	
61-D-602	AR-606	η Monitor		1				2	15	
2-41	LR-604	Taylor	0-115"H_2O	1		24"H_2O		3	17	
Hull Rinse										
Surge Tank										
61-D-617										
2-42	LR-623	Taylor	0-149"H_2O	1		42"H_2O	78"H_2O	1	5	
UF_6 Recycle	DR-678	Taylor	10-15"H_2O	1	9.90"			1	4	
Acid Tank										
62-D-621										
2-43	LR-611	Taylor	0-80"H_2O	1			60"H_2O	3	16	
1UD/2UD Surge Tank	RR-620	γ Monitor		1				1	6	
62-D-625										
2-44	LR-101	Taylor	0-235"H_2O	1			169"H_2O	2	9	
No. 1 Dissolver	DR-101	Taylor	14-24"H_2O	1	14.21"		22.6"H_2O	2	8	
15-C-101	TR-105	Type K	50-150°C	1				2	10	
2-45	LR-102	Taylor	0-235"H_2O	1			169"H_2O	11	86	
No. 2 Dissolver	DR-102	Taylor	14-24"H_2O	1	14.43"		22.6"H_2O	11	85	
15-C-102	TR-106	Type K	50-150°C	1				11	80	
2-46	LR-103	Taylor	0-235"H_2O	1			169"H_2O	10	73	
No. 3 Dissolver	DR-103	Taylor	14-24"H_2O	1	14.56"		22.6"H_2O	12	89	
15-C-103	TR-107	Type K	50- 150°C	1				9	67	
2-48	LR-105	Taylor	0-330"H_2O	1			135.3"H_2O	2	12	
No. 1 Dissolver	DR-160	Taylor	5-10"H_2O	1	4.99"			2	11	
Transfer Tank	TJR-108-1	Type K		1				45	353	
15-D-107										
2-49	LR-109	Taylor	0-330"H_2O	1			135.3"H_2O	10	72	
No. 2 Dissolver	DR-161	Taylor	5-10"H_2O	1	5.02"			11	84	
Transfer Tank	TJR-108-2	Type K		1				45	354	
15-D-108										
2-50	LR-113	Taylor	0-330"H_2O	1			135.3"H_2O	12	88	
No. 3 Dissolver	DR-162	Taylor	5-10"H_2O	1	5.03"			11	87	
Transfer Tank	TJR-108-3	Type K		1				45	355	
15-D-109										

TABLE B5-1

(continued)

RTP DATA ACQUISITION SYSTEM
RTP-INSTRUMENT IDENTIFICATION AND PARAMETER DATA

MEAS. PT. NO./NAME TANK EQUIP. NO.	INSTR. NUMBER	INSTR. TYPE	INSTR. RANGE	SCAN MODE	PROBE SEP.	LOW ALARM	HIGH ALARM	RTP-01 TB NO.	RTP-01 CH NO.	COMMENTS
2-52	LR-201	Taylor	0-260"H_2O	3			140"H_2O	9	64	
HA Feed Tank	DR-201	Taylor	10-19"H_2O	3	9.91"			9	69	
21-D-201	TJR-206-1	Type K		1				46	361	
2-53	LR-238	Taylor	0-97"H_2O	3				17	132	
Uranium Product	DR-272	Taylor	10-19"H_2O	3	9.76"			17	133	
Catch Tank	TJR-206-16	Type K		1				47	369	
24-D-202										
2-54	LR-325	Taylor	0-93"H_2O	3		10"H_2O	85"H_2O	22	169	
Plutonium Product	DR-372	Taylor	12.5-20.5"H_2O	3	9.94"			23	178	
Catch Tank	TJR-305-7	Type K		1				49	388	
34-D-302										
2-56	LR-418	Taylor	0-200"H_2O	3				33	256	
HWW Catch Tank	DR-428	Taylor	10-15"H_2O	3	9.85"			34	268	
41-D-404	TJR-414-4	Type K		1				50	394	
2-57	LR-403	Taylor	0-25"H_2O	1				27	208	
Solvent Burner	DR-403	Taylor	8-13"H_2O	1					195	
Quench Pot	TJR-509-10	Type K		1				48	380	
42-D-440	TJR-509-11	Type K		1				51	403	
2-58	LR-413	Taylor	0-48"H_2O	1		12"H_2O	40"H_2O	43	338	
G.P. Dist.	RR-423	γ Monitor		1				36	282	
Receiver										
43-D-410										
2-59	LI-466	Taylor	0-91"H_2O	1		78"H_2O	80"H_2O	37	295	
DOG Vacuum Breaker										
45-D-432										
2-60	LR-514	Taylor	0-31"H_2O	1		10"H_2O	30"H_2O	30	232	
100 Filter										
Pump Tank										
51-D-507										
2-61	LR-504	Taylor	0-31"H_2O	1		10"H_2O	30"H_2O	28	218	
200 Filter										
Pump Tank										
52-D-509										

TABLE B5-1
(continued)

RTP DATA ACQUISITION SYSTEM
RTP-INSTRUMENT IDENTIFICATION AND PARAMETER DATA

MEAS. PT. NO./NAME TANK EQUIP. NO.	INSTR. NUMBER	INSTR. TYPE	INSTR. RANGE	SCAN MODE	PROBE SEP.	LOW ALARM	HIGH ALARM	RTP-01 TB NO.	RTP-01 CH NO.	COMMENTS
2-62	LI-529	Taylor	0-90"H_2O	1		12"H_2O	56"H_2O	35	273	
Acid Fractionator	TJR-414-13	Type K		1				51	402	
Accumulator	RR-555	γ Monitor		1				35	279	
54-D-505										
2-64	LR-612	Taylor		3				3	19	
0.01 Molar Cold										
Acid Makeup Tank										
62-D-620										
2-66	LI-203	Taylor	0-100"H_2O	1				7	53	
HAW Decanter	DR-206	Taylor	8-13"H_2O	1	9.78"			8	58	
21-D-211										
2-67	LI-221	Taylor	0-100"H_2O	1				15	119	
1CU Decanter	DR-230	Taylor	8-13"H_2O	1	9.97"			15	113	
21-D-212										
2-68	LI-230	Taylor	0-53"H_2O	1				15	115	
2EU Decanter	DR-260	Taylor	8-13"H_2O	1	9.89"			15	112	
22-D-209										
2-69	LI-409	Taylor	0-57"H_2O	1				43	339	
Sump Collector	DI-412	Taylor	7-12"H_2O	1	9.90"			42	335	
Tank Decanter	TJR-415-5	Type K		1				51	407	
43-D-411										
2-70	LI-515	Taylor	0-57"H_2O	1			45"H_2O	31	240	
Solvent Treat	DR-522	Taylor	36-50"H_2O	1	47.00"			31	244	
Waste Decanter										
51-D-511										
2-75	FR-241	Taylor	0-29.84"H_2O	1				5	38	
HAF Headpot										
21-D-241										
2-76	DR-207	Taylor	8-10"H_2O	1				8	57	
HAP Headpot										
21-D-242										
2-78	LI-241	Taylor	0-29"H_2O	1		3"H_2O		7	48	
1SP Metering										
Headpot										
21-D-271										
2-79	FR-205	Taylor	0-22.6"H_2O	1		13"H_2O		6	41	
1BP Metering										
Headpot										
21-D-273										

TABLE B5-1
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RTP DATA ACQUISITION SYSTEM
RTP-INSTRUMENT IDENTIFICATION AND PARAMETER DATA

MEAS. PT. NO./NAME TANK EQUIP. NO.	INSTR. NUMBER	INSTR. TYPE	INSTR. RANGE	SCAN MODE	PROBE SEP.	LOW ALARM	HIGH ALARM	RTP-01		COMMENTS
								TB NO.	CH NO.	
2-84	TJR-305-6	Type K		1				49	387	
3PD K.O. Pot	AR-306	α Monitor	-	1				23	177	
34-D-378										
2-86	LI-468	Taylor	0-9"H_2O	1			6"H_2O	37	289	
Vessel Off-Gas										
K.O. Pot										
45-D-441										
2-87	PR-462	Masoneilan	3-15 psig	1				38	302	
Dissolver Off-Gas										
K.O. Pot										
45-D-442										
2-88	LI-523	Taylor	0-24"H_2O	1			12"H_2O	32	249	
No. 1 Solvent										
Overflow Headpot										
51-D-552										
2-94	LI-510	Taylor	0-24"H_2O	1		6"H_2O	18"H_2O	27	211	
No. 2 Solvent										
Overflow Headpot										
52-D-562										
2-103	WR-208	Taylor	300-500"H_2O	1				5	35	
HS Column	LR-205	Taylor	15.5-24"H_2O	1				5	34	
21-C-201	LT-206	Taylor	0-40"H_2O	1			22"H_2O	7	51	
	DR-209	Taylor	7-11"H_2O	1	9.59"			5	37	
	AR-208	α Monitor		1				5	32	
2-104	WR-224	Taylor	320-520"H_2O	1				6	40	
1BX Column	LR-216	Taylor	14-23.4"H_2O	1				6	42	
21-C-202	DR-223	Taylor	7-11"H_2O	1	9.93"			6	44	
2-105	WR-227	Taylor	275to425"H_2O	1				6	46	
1C Column	LR-219	Taylor	14.1to22.4"H_2O	1				14	106	
21-C-203	DR-226	Taylor	6-11"H_2O	1	9.83"			14	108	
2-106	WR-215	Taylor	0-165"H_2O	1				6	45	
1BX Electrocell	LR-212	Taylor	3-11"H_2O	1				6	47	
21-C-275	DR-220	Taylor	7-11"H_2O	1	9.84"			7	50	
	AR-209	α Monitor		1				7	54	

TABLE B5-1
(continued)

RTP DATA ACQUISITION SYSTEM
RTP-INSTRUMENT IDENTIFICATION AND PARAMETER DATA

MEAS. PT. NO./NAME TANK EQUIP. NO.	INSTR. NUMBER	INSTR. TYPE	INSTR. RANGE	SCAN MODE	PROBE SEP.	LOW ALARM	HIGH ALARM	RTP-01 TB NO.	RTP-01 CH NO.	COMMENTS
2-107	WR-252	Taylor	300-545"H_2O	1				13	96	
2D Column	LR-225	Taylor	14.1-22.4"H_2O	1				13	100	
22-C-204	L -224	Taylor	0-24"H_2O	1			22"H_2O	13	101	
	DR-251	Taylor	7-11"H_2O	1	9.6"			14	107	
2-108	WR-256	Taylor	280-420"H_2O	1				16	122	
2E Column	LR-228	Taylor	14.6-21.8"H_2O	1				14	105	
22-C-205	DR-257	Taylor	6-11"H_2O	1	10.01"			15	114	
2-109	WR-334	Taylor	0-548.5"H_2O	1				20	153	
2A Column	LR-308	Taylor	7.5-27.5"H_2O	1				19	149	
32-C-301	LI-307	Taylor	0-20"H_2O	1			15"H_2O	19	150	
	DR-333	Taylor	7-10"H_2O	1	9.10"			19	146	
2-110	WR-341	Taylor	0-430"H_2O	1				19	147	
2B Column	LI-314	Taylor	0-22"H_2O	1						
32-C-302	LR-313	Taylor	7.3-10.9"H_2O	1			10.7"H_2O	19	151	
	DR-340	Taylor	7-10"H_2O	1	9.9"			18	141	
	AR-303	α Monitor		1				19	148	
2-111	WR-347	Taylor	0-548.5"H_2O	1				23	180	
3A Column	LR-316	Taylor	13.6-24.4"H_2O	1				22	168	
33-C-303	LI-315	Taylor	0-45"H_2O	1			15"H_2O	24	185	
	DR-346	Taylor	7-10"H_2O	1	9.92"			23	181	
	TJR-305-5	Type K		1				49	386	
2-112	WR-352	Taylor	0-650"H_2O	1				22	170	
3B Column	LR-320	Taylor	7.3-11"H_2O	1			9.5"H 0	24	186	
33-C-306	LI-327	Taylor	0-20"H_2O	1				23	183	
	DR-351	Taylor	7-10"H_2O	1	9.97"			24	184	
2-113	WR-358	Taylor	0-196"H_2O	1				23	182	
3PS Diluent	LR-323	Taylor	12.1-22.4"H_2O	1				21	163	
Wash Column	LI-322	Taylor	0-20"H_2O				15"H_2O	23	176	
33-C-309	DR-357	Taylor	6-10"H_2O	1	9.97"			23	179	

TABLE B5-1
(continued)

RTP DATA ACQUISITION SYSTEM
RTP-INSTRUMENT IDENTIFICATION AND PARAMETER DATA

MEAS. PT. NO./NAME TANK EQUIP. NO.	INSTR. NUMBER	INSTR. TYPE	INSTR. RANGE	SCAN MODE	PROBE SEP.	LOW ALARM	HIGH ALARM	RTP-01 TB NO.	RTP-01 CH NO.	COMMENTS
2-114	WR-442	Taylor	225-375"H_2O	1				34	265	
1S Column	LR-422	Taylor	13.4-22.2"H_2O	1				34	271	
42-C-401	LI-421	Taylor	0-20"H_2O	1			15"H_2O	35	272	
	DR-441	Taylor	7-12"H_2O	1	10.03"			35	278	
2-115	WR-520	Taylor	250-340"H_2O	1				25	193	
1O Column	LR-513	Taylor	14.2-21.4"H_2O	1				25	194	
51-C-501	LI-511	Taylor	0-20"H_2O	1			16"H_2O	25	196	
	DR-518	Taylor	5-10"H_2O	1	9.49"			27	210	
2-116	WR-524	Taylor	0-235"H_2O	1				31	246	
1P Column	LR-518	Taylor	16.4-20.2"H_2O	1				31	243	
51-C-502	LI-517	Taylor	0-20"H_2O	1			15"H_2O	31	242	
	DR-525	Taylor	6-10"H_2O	1	9.74"			30	239	
2-117	WR-527	Taylor	250-389.5"H_2O	1				29	225	
1R Column	LR-520	Taylor	14.2-21.4"H_2O	1				29	228	
51-C-503	LI-519	Taylor	0-20"H_2O	1			16"H_2O	30	236	
	DR-526	Taylor	5-10"H_2O	1	10.4"			29	226	
2-118	WR-504	Taylor	250-389.5"H_2O	1				28	216	
2O Column	LR-503	Taylor	14.2-21.4"H_2O	1				26	206	
52-C-504	LI-502	Taylor	0-20"H_2O	1			16"H_2O	27	209	
	DR-502	Taylor	5-10"H_2O	1	10.5"			27	215	
2-119	WR-508	Taylor	0-225"H_2O	1				28	217	
2P Column	LR-506	Taylor	15-19"H_2O	1				26	202	
52-C-505	LI-505	Taylor	0-20"H_2O	1			11"H_2O	27	213	
	DR-509	Taylor	6-10"H_2O	1	9.6"			26	205	
2-120	LR-222	Taylor	0-138.7"H_2O	3		55"H_2O	105"H_2O	13	102	
1CU Concentrator	DR-249	Taylor	10-19"H_2O	3	9.93"		14.88"H_2O	14	109	
21-E-261	TR-204	Type K	75-125°C	1				13	103	
2-121	LR-240	Taylor	0-125.4"H_2O	3		55"H_2O	95"H_2O	15	118	
2EU Concentrator	DR-267	Taylor	10-19"H_2O	3	10.04"		14.88"H_2O	16	121	
24-E-260	TR-205	Type K	75-125°C	1				14	111	

TABLE B5-1
(continued)

RTP DATA ACQUISITION SYSTEM
RTP-INSTRUMENT IDENTIFICATION AND PARAMETER DATA

MEAS. PT. NO./NAME TANK EQUIP. NO.	INSTR. NUMBER	INSTR. TYPE	INSTR. RANGE	SCAN MODE	PROBE SEP.	LOW ALARM	HIGH ALARM	RTP-01 TB NO.	RTP-01 CH NO.	COMMENTS
2-122	LR-324	Taylor	0-115"H_2O	1		80"H_2O	94"H_2O	22	173	
3P Concentrator	DR-368	Taylor	12.5-20.5"H_2O	1	9.91"			21	167	
34-E-360	TR-303	Taylor	50-150°C	1			115°C	22	172	
2-123	LR-414	Taylor	0-88"H_2O	1			85"H_2O	32	250	
HAW Concentrator	DR-424	Taylor	10-15"H_2O	1	9.74"		14.3"H_2O	30	234	
41-E-460	TR-405	Taylor	50-150°C	1			118°C	31	241	
2-124	LR-426	Taylor	0-75"H_2O	1		21"H_2O	66"H_2O	34	269	
LAW Concentrator	DR-446	Taylor	8-13"H_2O	1	10.18"			34	267	
42-E-461	TJR-414-8	Type K		1				50	398	
	TJR-414-9	Type K		1				50	399	
2-125	LR-411	Taylor	0-62"H_2O	1		32"H_2O	46"H_2O	42	328	
General Purpose	DR-414	Taylor	8-13"H_2O	1	9.84"			42	329	
Concentrator	TJR-415-6	Type K		1				52	408	
43-E-445										
2-126	LR-430	Taylor	0-110"H_2O	1		66"H_2O	90"H_2O	41	325	
Service	DR-458	Taylor	9-14"H_2O	1	9.90"			42	332	
Concentrator	TJR-415-21	Type K		1				52	414	
44-E-462										
2-127	LI-131	Taylor	0-66"H_2O	1				10	77	
Feed Centrifuge	AR-101	γ Monitor		1				10	75	
16-K-153										
2-129	LR-467	Taylor	0-31.1"H_2O	1			24"H_2O	38	297	
NO_2 Absorber	DR-4140	Taylor	9-14"H_2O	1	9.97"			37	293	
45-C-490	TJR-415-10	Type K		1				52	412	
2-130	LR-528	Taylor	0-65"H_2O	1				35	277	
Acid Fractionator	DR-551	Taylor	10-15"H_2O	1	10.48"			36	280	
54-C-550	TJR-414-12	Type K		1				51	401	
2-131	LR-531	Taylor	0-36"H_2O	1			27"	41	327	
Acid Fractionator										
Overhead Vaporizer										
54-E-502										

TABLE B5-1
(continued)

RTP DATA ACQUISITION SYSTEM
RTP-INSTRUMENT IDENTIFICATION AND PARAMETER DATA

MEAS. PT. NO./NAME TANK EQUIP. NO.	INSTR. NUMBER	INSTR. TYPE	INSTR. RANGE	SCAN MODE	PROBE SEP.	LOW ALARM	HIGH ALARM	RTP-01 TB NO.	RTP-01 CH NO.	COMMENTS
2-133 HAF Stream	TJR-206-2	Type K		1				46	362	
2-134 HAP	TJR-206-4	Type K		1				46	364	
	TR-202	Type K	0-100°C	1				7	52	
	FR-242	Taylor		1				7	49	
2-135 HAW	TJR-206-3	Type K		1				46	363	
2-136 HSP	TJR-206-5	Type K		1				46	365	
	RR-242	γ Monitor		1				5	36	
2-137 1BP	TI-304	Type K	0-100°C	1				18	136	
	AR-201	α Monitor		1				6	43	
2-139 1CU	FR-222	Taylor		1				14	110	
	AI-207	α Monitor		1				7	55	
2-140 1UD	TJR-206-11	Type K		1				46	367	
2-142 2DF	TI-203	Type K	0-100°C	1				13	97	
2-143 2DW	AR-205	μ Monitor		1				9	71	
2-146 2EU	FR-229	Taylor		1				14	104	
	RR-255	γ Monitor		1				13	98	
2-147 2UD	TJR-206-14	Type K		1				47	368	
2-149 Uranium Product	RR-270	γ Monitor		1				13	99	
2-150 2AF	TJR-305-2	Type K		1				48	383	
2-152 2AW	AR-302	α Monitor		1				18	137	
2-153 3PD	TJR-305-4	Type K		1				49	385	
2-155 2BX	CR-667	Cond. Monitor		1				1	3	

TABLE B5-1
(continued)

RTP DATA ACQUISITION SYSTEM
RTP-INSTRUMENT IDENTIFICATION AND PARAMETER DATA

MEAS. PT. NO./NAME TANK EQUIP. NO.	INSTR. NUMBER	INSTR. TYPE	INSTR. RANGE	SCAN MODE	PROBE SEP.	LOW ALARM	HIGH ALARM	RTP-01 TB NO.	RTP-01 CH NO.	COMMENTS
2-156 3AF	TI-302	Type K	0-100°C	1				18	139	
2-157 3AW	AR-304	α Monitor		1				20	152	
2-158 2AS	CR-666	Cond. Monitor		1				1	2	
2-160 3BW	AR-305	α Monitor		1				22	174	
2-161 3BP	RR-364	γ Monitor		1				22	175	
2-162 POR	AR-307	α Monitor		1				20	154	
2-166 HWD	TJR-414-6	Type K		1				50	396	
2-167 GPD	TJR-415-8	Type K		1				52	410	
	FR-404	Taylor		1				41	323	
	FR-405	Taylor		1				41	324	
2-168 1SW	AR-403	α Monitor		1				33	257	
2-170 Diss. OG Condensate	TI-407	Type K	0-100°C	1				39	305	
2-171 VOG Condensate	TJR-415-12	Type K		1				52	413	
2-172 10F	TJR-509-1	Type K		1				47	371	
2-173 10W	TJR-509-3	Type K		1				47	373	
2-175 1PO	TJR-509-4	Type K		1				47	374	
2-176 Poisoned Cooling Water	RR-601	γ Monitor		1				1	7	
2-178 HAX	TR-505	Type K	0-100°C	1				31	247	
2-179 20F	TJR-509-6	Type K		1				48	376	
2-180 2PF	TJR-509-7	Type K		1				48	377	

TABLE B5-1
(continued)

RTP DATA ACQUISITION SYSTEM
RTP-INSTRUMENT IDENTIFICATION AND PARAMETER DATA

MEAS. PT. NO./NAME TANK EQUIP. NO.	INSTR. NUMBER	INSTR. TYPE	INSTR. RANGE	SCAN MODE	PROBE SEP.	LOW ALARM	HIGH ALARM	RTP-01		COMMENTS
								TB NO.	CH NO.	
2-181	TI-507	Type K	0-100°C	1				35	275	
Rec. Acid										
2-182	TI-508	Type K	0-100°C	1				34	266	
AF Condensate	FR-532	Taylor		1				43	343	
	FR-531	Taylor		1				43	341	

TABLE B5-2

RTP-01 CHANNEL NUMBERS VS INSTRUMENT IDENTIFICATION NUMBERS

RTP T B No.	RTP Ch. No.	Instr. Ident. SM	Instr. Ident. No.	RTP T B No.	RTP Ch. No.	Instr. Ident. SM	Instr. Ident. No.	RTP T B No.	RTP Ch. No.	Instr. Ident. SM	Instr. Ident. No.	RTP T B No.	RTP Ch. No.	Instr. Ident. SM	Instr. Ident. No.
	0	1	DR-646		32	1	AR-208		64	3	LR-201		96	1	WR-252
	1	1	LR-617		33	1	LI-210		65	2	LR-130		97	1	TI-203
	2	1	CR-666		34	1	LR-205		66	2	LR-125		98	1	RR-255
1	3	1	CR-667	5	35	1	WR-208	9	67	1	TR-107	13	99	1	RR-270
	4	1	DR-678		36	1	RR-242		68	2	DR-169		100	1	LR-225
	5	1	LR-623		37	1	DR-209		69	3	DR-201		101	1	LR-224
	6	1	RR-620		38	1	FR-241		70				102	3	LR-222
	7	1	RR-601		39	3	LI-209		71	1	AR-205		103	1	TR-204
	8	1	DR-101		40	1	WR-224		72	1	LR-109		104	1	FR-229
	9	1	LR-101		41	1	FR-205		73	1	LR-103		105	1	LR-228
	10	1	TR-105		42	1	LR-216		74	2	DR-168		106	1	LR-219
2	11	1	DR-160	6	43	1	AR-201	10	75	1	AR-101	14	107	1	DR-251
	12	1	LR-105		44	1	DR-223		76	2	LR-129		108	1	DR-226
	13	1	DR-615		45	1	WR-215		77	1	LI-131		109	3	DR-249
	14	1	LR-607		46	1	WR-227		78	3	LR-128		110	1	FR-222
	15	1	AR-606		47	1	LR-212		79	1	TI-109		111	1	TR-205
	16	1	LR-611		48	1	LI-241		80	1	TR-106		112	1	DR-260
	17	1	LR-604		49	1	FR-242		81	3	LR-121		113	1	DR-230
	18	1	AR-605		50	1	DR-220		82	2	DR-166		114	1	DR-257
3	19	1	LR-612	7	51	1	LI-206	11	83	3	DR-167	15	115	1	LI-230
	20				52	1	TR-202		84	1	DR-161		116		
	21				53	1	LI-203		85	1	DR-102		117	2	LR-235
	22				54	1	AR-209		86	1	LR-102		118	3	LR-240
	23				55	1	AI-207		87	1	DR-162		119	1	LI-221
	24		Cal.Bd.		56				88	1	LR-113		120	2	DR-269
	25		Cal.Bd.		57	1	DR-207		89	1	DR-103		121	3	DR-267
	26		Cal.Bd.		58	1	DR-206		90	3	DR-164		122	1	WR-256
4	27		Cal.Bd.	8	59	2	LR-419W	12	91			16	123		
	28		Cal.Bd.		60	2	DR-430W		92				124		
	29		Cal.Bd.		61	2	LR-412W		93				125		
	30		Cal.Bd.		62	2	DR-416W		94				126		
	31				63				95				127		

TABLE B5-2
(continued)

RTP-01 CHANNEL NUMBERS VS INSTRUMENT IDENTIFICATION NUMBERS

RTP		Instr. Ident.		RTP		Instr. Ident.		RTP		Instr. Ident.		RTP		Instr. Ident.	
T B No.	Ch. No.	SM	No.	T B No.	Ch. No.	SM	No.	T B No.	Ch. No.	SM	No.	T B No.	Ch. No.	SM	No.
	128				160	2	DR-304		192				224		
	129	2	LR-239		161	2	LR-326		193	1	WR-520		225	1	WR-527
	130	2	DR-273		162	2	DR-374		194	1	LR-513		226	1	DR-526
17	131	3	LR-305	21	163	1	LR-323	25	195	1	DR-403	29	227	3	LR-516
	132	3	LR-238		164	2	LR-302		196	1	LI-511		228	1	LR-520
	133	3	DR-272		165	2	LR-301		197				229		
	134				166				198	2	LR-303		230		
	135				167	1	DR-368		199	2	DR-321		231		
	136	1	TI-304		168	1	LR-316		200	3	LR-507		232	1	LR-514
	137	1	AR-302		169	3	LR-325		201	3	DR-401		233	3	DR-523
	138				170	1	WR-352		202	1	LR-506		234	1	DR-424
18	139	1	TI-302	22	171	2	DR-312	26	203			30	235		
	140	3	LR-309		172	1	TR-303		204	3	DR-402		236	1	LI-519
	141	1	DR-340		173	1	LR-324		205	1	DR-509		237	3	DR-426
	142				174	1	AR-305		206	1	LR-503		238	3	LR-417
	143	3	DR-335		175	1	RR-364		207	3	LR-402		239	1	DR-525
	144	3	DR-329		176	1	LI-322		208	1	LR-403		240	1	LI-515
	145				177	1	AR-306		209	1	LI-502		241	1	TR-405
	146	1	DR-333		178	3	DR-372		210	1	DR-518		242	1	LI-517
19	147	1	WR-341	23	179	1	DR-357	27	211	1	LI-510	31	243	1	LR-518
	148	1	AR-303		180	1	WR-347		212	3	LR-401		244	1	DT-522
	149	1	LR-308		181	1	DR-346		213	1	LI-505		245	3	DR-530
	150	1	LI-307		182	1	WR-358		214	3	DR-510		246	1	WR-524
	151	1	LR-313		183	1	LI-327		215	1	DR-502		247	1	TR-505
	152	1	AR-304		184	1	DR-351		216	1	WR-504		248	3	LR-522
	153	2	WR-334		185	1	LI-315		217	1	WR-508		249	1	LI-523
	154	1	AR-307		186	1	LR-320		218	1	LR-504		250	1	LR-414
20	155			24	187			28	219			32	251		
	156				188				220				252		
	157				189				221				253		
	158				190				222				254		
	159				191				223				255		

TABLE B5-2
(continued)

RTP-01 CHANNEL NUMBERS VS INSTRUMENT IDENTIFICATION NUMBERS

RTP T B No.	RTP Ch. No.	Instr. Ident. SM	Instr. Ident. No.	RTP T B No.	RTP Ch. No.	Instr. Ident. SM	Instr. Ident. No.	RTP T B No.	RTP Ch. No.	Instr. Ident. SM	Instr. Ident. No.	RTP T B No.	RTP Ch. No.	Instr. Ident. SM	Instr. Ident. No.
	256	3	LR-418		288	1	DR-4137		320				352	1	TJR-607-1
	257	1	AR-403		289	1	LI-468		321	1	LR-428		353	1	TJR-108-1
	258	3	DR-439		290	1	LI-469		322	1	RR-456		354	1	TJR-108-2
33	259	1	AR-401	37	291			41	323	1	FR-404	45	355	1	TJR-108-3
	260	3	AR-402		292	1	LR-465		324	1	FR-405		356	1	TJR-108-9
	261	1	LR-420		293	1	DR-4140		325	1	LR-430		357	1	TJR-108-10
	262	2	LR-419		294	1	DR-4142		326				358	1	TJR-108-11
	263	2	DR-430		295	1	LR-466		327	1	LR-531		359	1	TJR-108-12
	264	3	DR-445		296				328	1	LR-411		360	1	TJR-108-13
	265	1	WR-442		297	1	LR-467		329	1	DR-414		361	1	TJR-206-1
	266	1	TI-508		298				330				362	1	TJR-206-2
34	267	1	DR-446	38	299	1	LI-464	42	331	1	LI-431A	46	363	1	TJR-206-3
	268	3	DR-428		300				332	1	DR-458		364	1	TJR-206-4
	269	1	LR-426		301				333				365	1	TJR-206-5
	270				302	1	PR-462		334				366	1	TJR-206-6
	271	1	LR-422		303				335	1	DI-412		367	1	TJR-206-11
	272	1	LI-421		304				336	2	DR-416		368	1	TJR-206-14
	273	1	LI-529		305	1	TI-407		337	3	DR-411		369	1	TJR-206-16
	274	3	LR-425		306	1	LR-470		338	1	LR-413		370	1	TJR-206-17
35	275	1	TI-507	39	307			43	339	1	LI-409	47	371	1	TJR-509-1
	276	3	DR-448		308				340	2	LR-412		372	1	TJR-509-2
	277	1	LR-528		309				341	1	FR-531		373	1	TJR-509-3
	278	1	DR-441		310				342	3	DR-410		374	1	TJR-509-4
	279	1	RR-555		311				343	1	FR-532		375	1	TJR-509-5
	280	1	DR-551		312				344	1	LR-530		376	1	TJR-509-6
	281	3	LR-427		313				345	3	LR-405		377	1	TJR-509-7
	282	1	RR-423		314				346	3	LR-406		378	1	TJR-509-8
36	283			40	315			44	347			48	379	1	TJR-509-9
	284				316				348				380	1	TJR-509-10
	285				317				349				381	1	TJR-509-12
	286				318				350		RTD-IN		382	1	TJR-305-1
	287				319				351		REF-IN		383	1	TJR-305-2

TABLE B5-2
(continued)

RTP-01 CHANNEL NUMBERS VS INSTRUMENT IDENTIFICATION NUMBERS

RTP T B No.	RTP Ch. No.	Instr. Ident. SM	Instr. Ident. No.	
49	384	1	TJR-305-3	
	385	1	TJR-305-4	
	386	1	TJR-305-5	
	387	1	TJR-305-6	
	388	1	TJR-305-7	
	389	1	TJR-305-8	
	390	1	TJR-305-9	
	391	1	TJR-305-10	
50	392	1	TJR-305-11	
	393	1	TJR-414-3	
	394	1	TJR-414-4	
	395	1	TJR-414-5	
	396	1	TJR-414-6	
	397	1	TJR-414-7	
	398	1	TJR-414-8	
	399	1	TJR-414-9	
51	400	1	TJR-414-10	
	401	1	TJR-414-12	
	402	1	TJR-414-13	
	403	1	TJR-509-11	
	404	1	TJR-415-2	
	405	1	TJR-415-3	
	406	1	TJR-415-4	
	407	1	TJR-415-5	
52	408	1	TJR-415-6	
	409	1	TJR-415-7	
	410	1	TJR-415-8	
	411	1	TJR-415-9	
	412	1	TJR-415-10	
	413	1	TJR-415-12	
	414	1	TJR-415-21	
	415	1	TJR-415-22	

TABLE B5-3

RTP CORRELATION TABLE
INSTRUMENT NUMBER, MEASUREMENT POINT NUMBER, RTP CHANNEL NUMBER
INSTRUMENT TYPE: LR

INSTRU. NO.	MEAS. PT. NO.	RTP CH. NO.	INSTRU. LOCATION	INSTRU. NO.	MEAS. PT. NO.	RTP CH. NO.	INSTRU. LOCATION
LR-101	2-44	9	3-1-9	LR-326	2-10	161	11-3-3
LR-102	2-45	86	4-1-2	LR-401	2-21	212	12-1-4
LR-103	2-46	73	4-1-6	LR-402	2-22	207	12-1-5
LR-105	2-48	12	3-1-8	LR-403	2-57	208	12-3-5
LR-109	2-49	72	4-1-1	LR-405	2-36	345	16-1-3
LR-113	2-50	88	4-1-5	LR-406	2-29	346	16-1-4
LR-121	2-01	81	5-1-1	LR-411	2-125	328	16-1-7
LR-125	2-03	66	5-2-1	LR-412	2-28	340	16-3-7
LR-128	2-02	78	5-1-2	LR-413	2-58	338	16-1-8
LR-129	2-05	76	5-2-2	LR-414	2-123	250	14-1-3
LR-130	2-06	65	5-3-2	LR-417	2-34	238	14-1-4
LR-201	2-52	64	5-1-5	LR-418	2-56	256	14-1-5
LR-205	2-103	34	6-1-1	LR-419	2-23	262	14-1-6
LR-212	2-106	47	6-1-8	LR-420	2-04	261	14-1-7
LR-216	2-104	42	6-1-9	LR-422	2-114	271	14-1-10
LR-219	2-105	106	7-2-1	LR-425	2-35	274	14-3-10
LR-222	2-120	102	7-1-5	LR-426	2-124	269	15-1-2
LR-225	2-107	100	7-1-8	LR-427	2-24	281	15-1-3
LR-228	2-108	105	7-1-10	LR-428	2-26	321	17-2-1
LR-235	2-07	117	8-1-6	LR-430	2-126	325	17-1-3
LR-238	2-52	132	8-2-6	LR-465	2-37	292	17-3-8
LR-239	2-09	129	8-1-7	LR-467	2-129	297	17-1-9
LR-240	2-121	118	8-1-5	LR-470	2-38	386	18-4-2
LR-301	2-11	165	11-1-4	LR-503	2-118	206	12-1-8
LR-302	2-12	164	11-3-4	LR-504	2-61	218	11-1-9
LR-303	2-13	198	11-1-5	LR-506	2-119	202	12-1-2
LR-305	2-17	131	12-2-4	LR-507	2-16	200	12-1-3
LR-308	2-109	149	9-1-7	LR-513	2-115	194	12-1-9
LR-309	2-08	140	9-1-8	LR-514	2-60	232	13-1-1
LR-313	2-110	151	9-1-9	LR-516	2-20	227	13-1-3
LR-316	2-111	168	10-1-1	LR-518	2-116	234	13-1-4
LR-320	2-112	186	10-1-4	LR-520	2-177	228	13-1-6
LR-323	2-113	163	10-1-8	LR-522	2-15	248	13-1-7
LR-324	2-122	173	11-1-2	LR-528	2-130	277	15-1-5
LR-325	2-54	169	11-1-3	LR-530	2-39	344	16-3-1

TABLE B5-3

(continued)

RTP CORRELATION TABLE
INSTRUMENT NUMBER, MEASUREMENT POINT NUMBER, RTP CHANNEL NUMBER
INSTRUMENT TYPE: LR

INSTRU. NO.	MEAS. PT. NO.	RTP CH. NO.	INSTRU. LOCATION	INSTRU. NO.	MEAS. PT. NO.	RTP CH. NO.	INSTRU. LOCATION
LR-531	2-131	327	10-1-2	LR-617	2-25	1	1-1-7
LR-604	2-41	17	3-1-6	LR-623	2-42	5	2-3-4
LR-607	2-40	14	3-3-7	LR-412-W	2-28	61	16-3-7
LR-611	2-43	16	3-1-1	LR-419-W	2-23	59	14-1-4
LR-612	2-64	19	3-1-1				

TABLE B5-3
(continued)

RTP CORRELATION TABLE
INSTRUMENT NUMBER, MEASUREMENT POINT NUMBER, RTP CHANNEL NUMBER
INSTRUMENT TYPE: LI

INSTRU. NO.	MEAS. PT. NO.	RTP CH. NO.	INSTRU. LOCATION	INSTRU. NO.	MEAS. PT. NO.	RTP CH. NO.	INSTRU. LOCATION
LI-131	2-127	77	5-2-3	LI-421	2-114	272	14-2-8
LI-203	2-66	53	5-2-9	LI-431	2-27	331	17-3-4
LI-206	2-103	51	5-3-10	LI-464	2-37	299	17-3-7
LI-209	2-32	39	6-1-4	LI-466	2-59	295	17-1-7
LI-210	2-33	33	6-1-5	LI-468	2-86	289	18-1-1
LI-221	2-67	119	7-1-1	LI-469	2-38	290	18-3-1
LI-224	2-107	101	7-3-8	LI-502	2-118	209	11-2-7
LI-230	2-68	115	8-1-2	LI-505	2-111	213	12-3-2
LI-241	2-78	48	6-3-6	LI-510	2-94	211	12-2-3
LI-307	2-109	150	9-3-7	LI-511	2-115	196	12-2-8
LI-314	2-110	NA	NA	LI-515	2-70	240	13-2-2
LI-315	2-111	185	10-1-2	LI-517	2-116	242	13-3-4
LI-322	2-113	176	10-3-8	LI-519	2-117	236	13-3-6
LI-327	2-112	183	10-3-4	LI-523	2-88	249	13-2-8
LI-409	2-69	339	10-2-5	LI-529	2-62	273	15-1-9

TABLE B5-3
(continued)

RTP CORRELATION TABLE
INSTRUMENT NUMBER, MEASUREMENT POINT NUMBER, RTP CHANNEL NUMBER
INSTRUMENT TYPE: DR/DI

INSTRU. NO.	MEAS. PT. NO.	RTP CH. NO.	INSTRU. LOCATION	INSTRU. NO.	MEAS. PT. NO.	RTP CH. NO.	INSTRU. LOCATION
DR-101	2-44	8	3-1-9	DR-351	2-112	184	10-1-4
DR-102	2-45	85	4-1-2	DR-357	2-113	179	10-1-10
DR-103	2-46	89	4-1-6	DR-368	2-122	167	11-1-2
DR-160	2-48	11	3-1-8	DR-372	2-54	178	11-7-3
DR-161	2-49	84	4-1-1	DR-374	2-10	162	11-3-3
DR-162	2-50	87	4-1-5	DR-401	2-21	201	12-1-4
DR-164	2-01	90	5-1-1	DR-402	2-22	204	12-1-5
DR-166	2-03	82	5-2-1	DR-403	2-57	195	12-3-5
DR-167	2-02	83	5-1-2	DR-410	2-36	343	16-1-3
DR-168	2-05	74	5-2-2	DR-411	2-29	337	16-1-4
DR-169	2-06	68	5-3-2	DI-412	2-69	335	16-1-5
DR-201	2-52	69	5-1-5	DR-414	2-125	329	16-1-7
DR-206	2-66	58	5-1-9	DR-416	2-28	336	16-3-7
DR-207	2-76	57	5-1-9	DR-424	2-123	234	14-1-3
DR-209	2-103	37	6-3-1	DR-426	2-34	237	14-1-4
DR-220	2-106	51	6-1-8	DR-428	2-56	268	14-1-5
DR-223	2-104	44	6-1-9	DR-430	2-23	263	14-1-6
DR-226	2-105	108	7-2-1	DR-439	2-04	258	14-1-7
DR-230	2-67	113	7-1-3	DR-441	2-114	278	14-1-8
DR-249	2-120	109	7-1-5	DR-445	2-35	264	14-3-10
DR-251	2-107	107	7-1-7	DR-446	2-124	267	15-1-2
DR-257	2-108	114	7-1-10	DR-448	2-24	276	15-1-3
DR-260	2-68	112	8-1-3	DR-458	2-126	332	17-1-3
DR-267	2-121	121	8-1-5	DR-502	2-118	214	12-1-3
DR-269	2-07	120	8-1-6	DR-509	2-119	205	12-1-2
DR-272	2-53	133	8-2-6	DR-510	2-16	214	12-1-3
DR-273	2-09	130	8-1-7	DR-518	2-115	210	12-1-8
DR-304	2-11	160	11-1-4	DR-523	2-20	233	13-1-3
DR-312	2-12	171	11-3-9	DR-525	2-116	239	13-1-4
DR-321	2-13	199	11-1-5	DR-526	2-177	226	13-1-5
DR-329	2-17	144	9-1-4	DR-530	2-15	245	13-1-7
DR-333	2-109	146	9-4-7	DR-551	2-130	280	15-1-5
DR-335	2-08	143	9-1-8	DI-552	2-70	244	13-1-2
DR-340	2-110	141	9-1-9	DR-615	2-40	13	3-3-7
DR-346	2-111	181	10-3-1	DR-646	2-25	0	1-1-7

TABLE B5-3
(continued)

RTP CORRELATION TABLE
INSTRUMENT NUMBER, MEASUREMENT POINT NUMBER, RTP CHANNEL NUMBER
INSTRUMENT TYPE: DR/DI

INSTRU. NO.	MEAS. PT. NO.	RTP CH. NO.	INSTRU. LOCATION	INSTRU. NO.	MEAS. PT. NO.	RTP CH. NO.	INSTRU. LOCATION
DR-678	2-42	4	2-3-4	DR-4142	2-38	294	18-4-2
DR-4137	2-37	288	17-3-8	DR-416-W	2-28	62	16-3-7
DR-4140	2-129	293	17-1-9	DR-430-W	2-23	60	14-1-6

TABLE B5-3
(continued)

RTP CORRELATION TABLE
INSTRUMENT NUMBER, MEASUREMENT POINT NUMBER, RTP CHANNEL NUMBER
INSTRUMENT TYPE: TR/TI

INSTRU. NO.	MEAS. PT. NO.	RTP CH. NO.	INSTRU. LOCATION	INSTRU. NO.	MEAS. PT. NO.	RTP CH. NO.	INSTRU. LOCATION
TR-105	2-44	10	3-3-10	TI-109	2-03	79	5-3-1
TR-106	2-45	80	4-3-3	TI-203	2-142	97	7-1-9
TR-107	2-46	67	4-3-7	TI-302	2-156	139	9-1-10
TR-202	2-134	52	5-1-10	TI-304	2-137	136	9-1-5
TR-204	2-120	103	7-3-4	TI-407	2-170	305	17-1-5
TR-205	2-121	111	8-3-4	TI-507	2-181	275	15-1-6
TR-303	2-122	172	11-3-1	TI-508	2-182	266	15-1-7
TR-405	2-123	241	14-1-2				
TR-505	2-178	247	--				

TABLE B5-3
(continued)

RTP CORRELATION TABLE
INSTRUMENT NUMBER, MEASUREMENT POINT NUMBER, RTP CHANNEL NUMBER
INSTRUMENT TYPE: TJR

INSTRU. NO.	MEAS. PT. NO.	RTP CH. NO.	INSTRU. LOCATION	INSTRU. NO.	MEAS. PT. NO.	RTP CH. NO.	INSTRU. LOCATION
TJR-108-1	2-49	352	6	TJR-414-6	2-166	396	15
TJR-108-2	2-49	354	6	TJR-414-7	2-35	397	15
TJR-108-3	2-50	355	6	TJR-414-8	2-124	398	15
TJR-108-9	2-01	356	6	TJR-414-9	2-124	399	15
TJR-108-10	2-03	357	6	TJR-414-10	2-24	400	15
TJR-108-11	2-02	358	6	TJR-414-12	2-130	401	15
TJR-108-12	2-05	359	6	TJR-414-13	2-62	402	15
TJR-108-13	2-06	360	6	TJR-415-2	2-36	404	16
TJR-206-1	2-52	361	7	TJR-415-3	2-38	405	16
TJR-206-2	2-133	362	7	TJR-415-4	2-29	406	16
TJR-206-3	2-135	363	7	TJR-415-5	2-69	407	16
TJR-206-4	2-134	364	7	TJR-415-6	2-125	408	16
TJR-206-5	2-136	365	7	TJR-415-7	2-28	409	16
TJR-206-6	2-33	366	7	TJR-415-8	2-167	410	16
TJR-206-11	2-140	367	7	TJR-415-9	2-37	411	16
TJR-206-14	2-147	368	7	TJR-415-10	2-129	412	16
TJR-206-16	2-53	369	7	TJR-415-12	2-171	413	16
TJR-206-17	2-09	370	7	TJR-415-21	2-126	414	16
TJR-305-1	2-17	382	10	TJR-415-22	2-27	415	16
TJR-305-2	2-150	383	10	TJR-509-1	2-172	371	12
TJR-305-3	2-08	384	10	TJR-509-2	2-20	372	12
TJR-305-4	2-153	385	10	TJR-509-3	2-173	373	12
TJR-305-5	2-111	386	10	TJR-509-4	2-175	374	12
TJR-305-6	2-84	387	10	TJR-509-5	2-15	375	12
TJR-305-7	2-54	388	10	TJR-509-6	2-178	376	12
TJR-305-8	2-10	389	10	TJR-509-7	2-180	377	12
TJR-305-9	2-11	390	10	TJR-509-8	2-16	378	12
TJR-305-10	2-12	391	10	TJR-509-9	2-21	379	12
TJR-305-11	2-13	392	10	TJR-509-10	2-57	380	12
TJR-414-3	2-34	393	15	TJR-509-11	2-57	403	12
TJR-414-4	2-56	394	15	TJR-509-12	2-22	381	12
TJR-414-5	2-23	395	15	TJR-607-1	2-25	352	2

TABLE B5-3
(continued)

RTP CORRELATION TABLE
INSTRUMENT NUMBER, MEASUREMENT POINT NUMBER, RTP CHANNEL NUMBER
INSTRUMENT TYPE: MISCELLANEOUS

INSTRU. NO.	MEAS. PT. NO.	RTP CH. NO.	INSTRU. LOCATION	INSTRU. NO.	MEAS. PT. NO.	RTP CH. NO.	INSTRU. LOCATION
			- AR -				
AR-101	2-127	75	5-3-3	AR-305	2-160	174	10-1-5
AR-201	2-137	43	6-1-2	AR-306	2-84	177	10-1-5
AR-205	2-143	71	5-1-4	AR-307	2-162	154	9-4-10
AR-208	2-103	32	6-1-2	AR-401	2-04	259	14-3-7
AR-209	2-106	54	6-1-10	AR-402	2-04	260	14-4-7
AR-302	2-152	137	9-2-6	AR-403	2-168	257	14-3-7
AR-303	2-110	148	9-2-6	AR-605	2-40	18	3-3-5
AR-304	2-157	152	9-4-10	AR-606	2-40	15	3-3-5
			- AI -				
AI-207	2-139	55	6-3-10				
			- CR -				
CR-666	2-158	2	2-1-4	CR-667	2-154	3	2-4-4
			- FR -				
FR-205	2-79	41	6-1-7	FR-404	2-167	323	16-4-9
FR-222	2-139	110	7-1-4	FR-405	2-167	324	16-1-9
FR-229	2-140	104	8-1-4	FR-531	2-182	341	16-1-1
FR-241	2-78	38	5-1-8	FR-532	2-182	343	16-1-1
FR-242	2-134	49	5-1-8				
			- PR -				
PR-462	2-87	302	17-1-6				
			- RR -				
RR-242	2-136	36	6-1-3	RR-456	2-26	322	17-1-1
RR-255	2-146	98	6-1-3	RR-555	2-62	279	15-3-6
RR-270	2-149	99	7	RR-601	2-176	7	2-1-10
RR-364	2-161	175	10-3-10	RR-620	2-43	6	12-1-10
RR-423	2-58	282	15-3-6				

TABLE B5-3
(continued)

RTP CORRELATION TABLE
INSTRUMENT NUMBER, MEASUREMENT POINT NUMBER, RTP CHANNEL NUMBER
INSTRUMENT TYPE: MISCELLANEOUS

INSTRU. NO.	MEAS. PT. NO.	RTP CH. NO.	INSTRU. LOCATION	INSTRU. NO.	MEAS. PT. NO.	RTP CH. NO.	INSTRU. LOCATION
- WR -							
WR-208	2-103	35	6-1-1	WR-358	2-113	182	10-1-8
WR-215	2-106	45	6-2-3	WR-442	2-114	265	14-1-10
WR-224	2-104	40	6-2-10	WR-504	2-118	216	11-1-8
WR-227	2-105	46	6-4-10	WR-508	2-119	217	12-1-1
WR-252	2-107	96	7-1-7	WR-520	2-115	193	12-1-9
WR-256	2-108	122	8-3-2	WR-524	2-116	246	13-3-3
WR-334	2-109	153	9-4-7	WR-527	2-117	225	13-1-6
WR-341	2-110	147	9-4-9				
WR-347	2-111	180	10-1-1				
WR-352	2-112	170	10-1-7				

REPORT NO. AGNS-1040-2.2-9

COMPUTERIZED NUCLEAR MATERIALS CONTROL AND ACCOUNTING SYSTEM DEVELOPMENT EVALUATION REPORT -1978

APPENDIX C

URANIUM INPUT/OUTPUT DEMONSTRATION PROGRAM SOFTWARE SPECIFICATIONS

Prepared by:
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October 1978

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CONTROL SPEC®

FOR

URANIUM INPUT/OUTPUT DEMONSTRATION PROGRAM

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SECTION I

INTRODUCTION

This CONTROL SPEC® is written in response to Allied-General Nuclear Services purchase order #A7-5106-00. It provides a complete definition of the Uranium Input/Output Demonstration Program.

This software described is intended to run on a DEC PDP11/35 computer system using the RSTS/E operating system. All programs will be written in Basic Plus language wherever practical.

This CONTROL SPEC® includes the following sections:

Section II provides a functional description of the vessel measurement programs. There are four vessels (tanks) being measured during the Input/Output Demonstration Program: Input, Product, HWW waste, and GPW waste.

Section III provides a detailed description of all calculation processes used throughout the system.

Section IV provides a functional description of the Nuclear Materials Accounting programs.

Section V provides a functional description of the Measurement Control program.

Section VI provides a functional description of the Lab Data System (LDS) Driver/File update program, Data Acquisition System (RTP) Driver, Data Base Maintenance program, and the Data Base Edit program.

Section VII provides a detailed layout of the Data Base.

Section VIII provides an implementation plan.

Section IX provides a description of the deliverable items.

SECTION II

PROGRAM DESCRIPTIONS

2.1 VESSEL MEASUREMENT PROGRAMS

There are four (4) vessel measurement programs associated with the Uranium Input/Output Demonstration. These programs are Input, Product, General Purpose Waste, and Hi-Level Waste. Since all four vessel measurement procedures have common elements, a set of building blocks called STATES have been constructed to satisfy particular functions. Selection of a particular combination of building blocks or STATES will satisfy most individual vessel measurement criteria.

These STATES consist of executable code, modularized so that each module performs a particular function (for example, writes a message to the terminal). Data tables and message tables are used to support these functions. Each module or function is identified as a STATE module with a STATE number.

Since more measurements are taken on the Input tank measurement program than on any other, it is used as the reference program for constructing the total set of STATES to be used. By using a state driven program, new states can be added with minimal or no impact to existing programs.

Data tables are used to minimize the number of state programs required to satisfy the total Computerized Nuclear Materials Control and Accounting System (CNMCAS) program. These tables are described in Section 2.1.2.

2.1.1 STATE Descriptions

During the processing of the Uranium Input/Output (U I/O) Demonstration Program, the quantity of material received in a tank, as well as the quantity transferred, must be measured. These measurements are accomplished by a group of measurement programs.

Because these measurement programs have many common elements, a series of STATES has been constructed to satisfy these common elements.

This section is not intended to show the details of any unique measurement program. The sections of this document which describe individual measurement programs include each program's unique characteristics.

The purpose of this section is to provide STATE descriptions of the common elements of the measurement programs. The processing sequence is in the STATE order presented in the following text.

The messages referenced are typical rather than specific. Only the message numbers are valid. Message numbers referenced are defined in Section 2.1.1.1, Typical Messages.

STATE 1

The operator activates the program at the terminal. The program first retrieves the temporary data file and copies it into the temporary data area. (See Figure 2-1.) Control is then transferred to the routine pointed to by the current state pointer.

STATE 2

The sequence opens by getting operator initials (Message #22) and a new Batch ID number from the Batch ID processor, and saving them in the temporary data area. Using the MCA transfer table, the program determines if this vessel is a candidate for an MCA transfer. If so, Message #20 is written to the terminal, and waits for operator response. The state pointer is updated to STATE 3, and control is passed to that STATE.

STATE 3

The program now writes Messages #1, #26, #27, #1A on the terminal and waits for the operator to respond. The operator answers with a "YES" or (CR), if preparation has been completed. He answers "NO" to stop the sequence until he has completed preparation. If the answer is "NO", the program responds with Message #2.

The state pointer is unchanged in order to bring the program back to STATE 3 when it is next activated.

The program now signs off.

STATE POINTER
BATCH NUMBER
MISC PROGRAM PARAMETERS
OPR INITIALS (4)
TIME OF YEAR (4)
LEVEL READINGS (4)
DENSITY READINGS (4)
TEMPERATURE READINGS (4)
QUANTITY OF SOLUTION (4)
SIGNIFICANT EVENTS TIME OF YEAR(6)
UNIQUE PROGRAM PARAMETERS
TOY-LDS TO SAMPLE
SAMPLE LOG NUMBER
LAB DENSITY
LAB ACID CONCENTRATION
TOY-LDS SAMPLE COMPLETE

NOTE: NUMBERS IN PARENTHESES INDICATE THE QUANTITY OF ITEMS IN AN ENTRY

FIGURE 2-1. TYPICAL TEMPORARY DATA AREA

STATE 4

When sparge and purges are set, the program calls the RTP system for before-receipt (BR) measurement data (liquid level, density, and temperature). Enough liquid level samples are retrieved to determine that the tank level is constant. If the liquid level is determined to be changing, an error Message #3 is printed on the terminal and the current state pointer is set to 5. The program now signs off.

STATE 5

When the operator reactivates the program after an exit from STATE 4, Message #10 is written to the terminal.

The supervisor enters his password, which is checked against a predefined list. In the event no match is found, the program transfers control to the beginning of this state. When a password match is found, the state pointer is updated to STATE 6 and control is passed to that STATE.

STATE 6

The program now makes the appropriate instrument performance tests based on the Control Limits Table (described in Section 2.1.2, Figure 2-3).

The program then proceeds according to the results of the comparison. When the difference is:

≤2s, the state pointer is updated to STATE 8, and control is passed to that STATE.

>2s ≤3s, Message #23 is written to the terminal and the NMC office. Measurement is marked as marginal in the temporary data area; the state pointer is updated to STATE 8; and control is passed to that STATE. Two contiguous measurements in this range are treated as being in the following range (>3s).

>3s, Message #24 is written to the terminal and the NMC office. The state pointer is updated to STATE 7, and the program signs off.

NOTE: See appropriate measurement program for specific details.

STATE 7

When the program is restarted, Messages #10 and #24 are written to the terminal.

The supervisor now enters his password, which is checked against an internal password list. If this check fails, the program signs off leaving the state pointer, at STATE 7.

When the password check passes the data, the operator has the following options:

1) Proceed with measurements
2) Recycle to STATE 3 for remeasurement
3) Use after-transfer measurement data

These options are activated in the program via the terminal. The program writes Message #28 to the terminal and waits for the operator to enter one of the following decimal digits:

1 = Proceed with measurements
2 = Remeasure
3 = Use after-transfer measurement data

STATE 8

The program calculates the mass (Kg) solution currently in the heel, and compares it with the calculated mass (Kg) solution that was left in the heel of the last Batch. If the heel quantities differ by more than the control limit, the program prints Message #4.

The STATE pointer is updated to point to STATE 8A and control is passed to that STATE.

STATE 8A

When the program is restarted, Messages #10 and #24 are written to the terminal.

The supervisor now enters his password, which is checked against an internal password list. If this check fails, the program signs off leaving the state pointer, at STATE 7. When the password check passes the data, the operator has the following options:

1) Proceed with measurements
2) Recycle to STATE 3 for remeasurement
3) Use after-transfer measurement data

These options are activated in the program via the terminal. The program writes Message #28 to the terminal, and waits for the operator to enter one of the following decimal digits:

1 = Proceed with measurements

2 = Remeasure

3 = Use after-transfer measurement data

STATE 9

With BR measurements made, the program writes Message #5 and #6 on the terminal.

The BR measurement data is saved in temporary storage, the state pointer is set to STATE 10, and the program signs off.

STATE 10

When the operator next activates the program, after the Batch has been received, the program again opens the file, and transfers program control to STATE 10. Message #7 is written to the terminal, and waits for operator response.

With a "NO" response, the program proceeds to STATE 11.

With a "YES" response, the program proceeds to STATE 12.

STATE 11

If "NO" was the response, the program writes Message #8 on the terminal.

The state pointer is updated to point to STATE 10, to bring the program back to that point after the operator corrects the situation and calls back. The program now signs off.

STATE 12

The program begins the before-sample (BS) measurements by writing Message #26 and #27 (zero Ruska) to the terminal, and waits for a response. The program communicates with the RTP system to acquire the transducer readings (Figure 2-3, Section 2.1.2) for measuring liquid level, density, and temperature. This raw data is recorded in temporary storage for later use.

Using the data just acquired, a test is made for constant liquid level in the vessel. If the liquid level is found to be constant, the state pointer is updated to STATE 14 and control is passed to that STATE. If the liquid level is not constant, Message #9 is written to the terminal.

The state pointer is updated to STATE 13 and the program signs off.

STATE 13

When the operator reactivates the program after an exit from STATE 12, Message #10 is written to the terminal.

The supervisor enters his password. The password is checked against a predefined list. In the event no match is found the program will transfer control to the beginning of this STATE. When a password match is found, the operator has the following options:

1) Proceed with measurements
2) Recycle to STATE 12 for remeasurement

These options are activated in the program via the terminal. The program writes Message #28 to the terminal, and waits for the operator to enter one of the following:

1 = Proceed with measurements
2 = Remeasure

STATE 14

The program makes the appropriate instrument performance tests based on the Control Limits Table (described in Section 2.1.2, Figure 2-3).

The program then proceeds according to the results of the comparison. When the difference is:

≤2s, the state pointer is updated to STATE 16, and control is passed to that STATE.

>2s ≤3s, Message #23 is written to the terminal and the NMC office. Measurement is marked as marginal in the temporary data area; the state pointer is updated to STATE 16; and control is passed to that STATE. Two contiguous measurements in this range are treated as being in the following range.

>3s, Message #24 is written to the terminal and the NMC office. The state pointer is updated to STATE 15, and the program signs off.

NOTE: See appropriate measurement program for specific details.

STATE 15

When the program is restarted, Message #10 is written to the terminal.

The supervisor now enters his password, which is checked against an internal password list. If this check fails, the program signs off leaving the state pointer at STATE 15.

If the password check passes the data stored in the temporary area, it is written to the ERROR file for later disposition. The state pointer is updated to STATE 12 and control is passed to that STATE for re-measurement using the same Batch number.

STATE 16

The kilograms and liters of solution are now calculated, and Messages #17 and #12 are printed on the terminal. The program now accesses the MCA transfer file to determine if an MCA transfer was made. If it was, it compares the quantity of solution sent against the quantity received, and prints a report on the terminal and in the NMC office. It also determines if the difference is within limits. If the difference is outside the predetermined limit, the program indicates this in the report and prints Message #13 on the terminal.

The program now updates the state pointer to STATE 17 and transfers control to that STATE.

STATE 17

The program prints Message #10 on the terminal. When the operator enters an acceptable password, the operator has the following options:

1) Proceed with measurements
2) Recycle to STATE 12 for remeasurement

These options are activated in the program via the terminal. The program writes Message #28 to the terminal, and waits for the operator to enter one of the following decimal digits:

1 = Proceed with measurements

2 = Remeasure

STATE 18

The program now prints Message #15 on the terminal. At this time the supervisor enters his password, and if accepted by the system, the state pointer is updated to point to STATE 19 and the hold condition is released in the measurement program.

STATE 19

When the comparison between the two quantities is satisfied (quantity of solution sent compared to quantity received), the program communicates with the LDS system requesting it to begin sampling. The state pointer is now updated to point to STATE 20, and control passes to that STATE.

STATE 20

The program suspends itself for 1 minute intervals, waiting for word from the LDS system to confirm that sampling is complete. When the LDS signals that sampling is complete, the proper data is received from the LDS and saved in the temporary data area. Message #16 is printed on the terminal at this time. The state pointer is updated to point to STATE 21, and the program now signs off.

STATE 21

The program begins the after-sample (AS) measurements by writing Message # 21 on the terminal, and waits for operator response.

If "NO" is the response, the program signs off. If "YES" is the response, the state pointer is updated to point to STATE 22 and control is passed to that STATE.

STATE 22

The program writes Messages #26 and #27 (zero Ruska) to the terminal and waits for operator response. The program communicates with the RTP system to acquire the transducer readings (Figure 2-3, Section 2.1.2) for measuring liquid level, density, and temperature. This raw data is recorded in temporary storage for later use.

Using the data just acquired, a test is made for constant liquid level in the vessel. If the liquid level is found to be constant, the state pointer is updated to STATE 24 and control is passed to that STATE. If the liquid level is not constant, Message #9 is written to the terminal. The state pointer is updated to STATE 23 and the program signs off.

STATE 23

When the operator restarts the program after an exit from STATE 22, Message #10 is written to the terminal. The supervisor enters his password, and the password is checked against a predefined list. In the event no match is found, the program transfers control to the beginning of this STATE. When a password match is found, the operator has the following options:

1) Proceed with measurements
2) Recycle to STATE 12 for remeasurement
3) Recycle to STATE 21 for remeasurement

These options are activated in the program via the terminal. The program writes Message #28 to the terminal, and waits for the operator to enter one of the following decimal digits:

1 = Proceed with measurements
2 = Remeasure
3 = Recycle to before-sample

STATE 24

The program now makes the appropriate instrument performance tests based on the Control Limits Table (described in Section 2.1.2, Figure 2-3).

The program then proceeds according to the results of the comparison. When the difference is:

$\leq 2s$, the state pointer is updated to STATE 26, and control is passed to that STATE.

$>2s \leq 3s$, Message #23 is written to the terminal and the NMC office. Measurement is marked as marginal in the temporary data area; the state pointer is updated to STATE 26; and control is passed to that STATE. When two contiguous measurements fall within this range, it is treated as the next range.

$>3s$, Message #24 is written to the terminal and the NMC office. The state point is updated to STATE 25, and the program signs off.

NOTE: See appropriate measurement program for specific details.

STATE 25

When the program is restarted, Message #10 is written to the terminal. The supervisor now enters his password, which is checked against an internal password list. If this check fails, the program signs off leaving the state pointer at STATE 25.

When the password check passes, the operator has the following options:

1) Proceed with measurements

2) Recycle to STATE 12 for remeasurement

3) Recycle to STATE 21 for remeasurement

These options are activated in the program via the terminal. The program writes Message #28 to the terminal, and waits for the operator to enter one of the following decimal digits:

1 = Proceed with measurements

2 = Remeasure

3 = Recycle to before-sample

STATE 26

The kilograms and liters of solution are now calculated, and Messages #12, #18, and #19 are printed on the terminal. The state pointer is updated to point to STATE 27. The program now signs off.

STATE 27

When the program is next activated, it accesses the source/destination table to determine if transfer routing information is required. If so, the program writes Message #25 to the terminal and waits for operator response. The operator response is used to determine the next state to be executed, which could be unique to each vessel measurement program. After execution of the unique STATE, the state pointer is set to STATE 28 and control is passed to that STATE. When transfer routing information is not required, the state pointer is set to STATE 28, and control is passed to that STATE.

STATE 28

The program begins the after-transfer measurements by writing Messages #26 and #27 to the terminal, and waits for operator response. The program communicates with the RTP system to acquire the transducer readings (Figure 2-3, Section 2.1.2) for measuring liquid level, density, and temperature. This raw data is recorded in temporary storage for later use.

Using the data just acquired, a test is made for constant liquid level in the vessel. If the liquid level is found to be constant, the state pointer is updated to STATE 30 and control is passed to that

STATE. If the liquid level is not constant, Message #9 is written to the terminal. The state pointer is updated to STATE 29 and the program signs off.

STATE 29

When the operator restarts the program after an exit from STATE 28, Message #10 is written to the terminal.

The supervisor enters his password, which is checked against a predefined list. In the event no match is found, the program transfers control to the beginning of this STATE. When a password match is found, the operator has the following options:

1) Proceed with measurements
2) Recycle to STATE 28 for remeasurement

These options are activated in the program via the terminal. The program writes Message #28 to the terminal, and waits for the operator to enter one of the following decimal digits:

1 = Proceed with measurements

2 = Remeasure

STATE 30

The program new makes the appropriate instrument performance tests based on the Control Limits Table.

The program then proceeds according to the results of the comparison. When the difference is:

≤2s, the state pointer is updated to STATE 32 and control is passed to that STATE.

>2s≤3s, Message #23 is written to the terminal, and the NMC office. Measurement is marked as marginal in the temporary data area; the state pointer is updated to STATE 32; and control is passed to that STATE. When two contiguous measurements fall within the range, it is treated as the next range (>3s).

>3s, Message #24 is written to the terminal and the NMC office. The state pointer is updated to STATE 31, and the program signs off.

NOTE: See appropriate measurement program for specific details.

STATE 31

When the program is restarted, Message #10 is written to the terminal. The supervisor now enters his password, which is checked against an internal password list. If this check fails, the program signs off leaving the start pointer at STATE 31.

When the password check passes the data, the operator has the following options:

1) Proceed with measurements
2) Recycle to STATE 28 for remeasurement

These options are activated in the program via the terminal. The program writes Message #28 to the terminal, and waits for the operator to enter one of the following decimal digits:

1 = Proceed with measurements
2 = Remeasure

STATE 32

The kilograms and liters of solution are now calculated and Messages #19 and #28 are printed on the terminal. The program waits for the operator response. If the response is "Y," the program continues to terminate this Batch. If the response is "N,: the STATE pointer is updated to point to STATE 33 and control is passed to that STATE.

At this point the program prints a Batch summary (see Figure 2-2) in the NMC office. Using data from the temporary data area, the Batch Index, Raw Data, and Analytical Data files are updated. The Analytical Data file entry for this Batch is examined for completion of all Lab analysis data. If all data are in the file, the Batch Index File is marked Final. If all data are not in the Analytical Data File, it is marked Preliminary. The files are closed at this time. The temporary data area is initialized to a new Batch condition; the state pointer is updated to point to STATE 2; and the program signs off.

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INPUT ACCOUNTABILITY MEASUREMENT RECORD
VESSEL NO. 18-D-101 MEASUREMENT POINT 2-03

INPUT ACCOUNTABILITY
BATCH ID 2-03-123

DATE 13-MAR-78

	BEFORE-RECEIPT	BEFORE-SAMPLE	AFTER-SAMPLE	AFTER-TRANSFER
DATE/TIME	______	______	______	______
LEVEL LR-125	______	______	______	______
RUSKA (LR-125R)	______	______	______	______
RUSKA ZERO	______	______	______	______
DENSITY DR-156	______	______	______	______
RUSKA	______	______	______	______
RUSKA ZERO	______	______	______	______
TEMPERATURE TJR-108-10	______	______	______	______
TI-109	______	______	______	______
SAMPLE RESULTS				
LOG NO.	______	______	______	______
DENSITY	______		______	
U CONC	______		______	

VOLUME

VOLUME RECEIVED	______	VOLUME TRANSFERRED	______
Kg RECEIVED	______	Kg TRANSFERRED	______
Kg U RECEIVED	______	Kg U TRANSFERRED	______

BATCH STATUS =

FIGURE 2-2. TYPICAL NMC BATCH REPORT FORMAT

STATE 33

The terminal is put in a read mode and waits for the operator to enter a KEYWORD. When the correct entry is made, the program recycles to just after Batch number assignment and begins a total remeasurement.

STATE 40

If the response in STATE 27 was "W," the program now calculates the U concentration quantity. If it is greater than a predetermined limit, the following message is written to the terminal:

U CONCENTRATION ____G U/L EXCEEDS LIMIT FOR WASTE

The state pointer is now updated to point at STATE 27 and control is passed to that state. Otherwise, the following message is written to the terminal:

BE SURE YOU HAVE THE SPARGE ON DURING THE TRANSFER.
LET ME KNOW WHEN THE TRANSFER IS COMPLETE AND YOU
HAVE SHUT DOWN THE SPARGE AGAIN AND SET PURGES.

The state pointer is now set to STATE 28, and control is passed to that STATE.

If the response was "R", the following message is written to the terminal:

BE SURE YOU LEAVE THE SPARGE OFF TO MINIMIZE TRANSFER OF SOLIDS TO RECYCLE. LET ME KNOW WHEN THE TRANSFER IS COMPLETE.

The state pointer is now set to STATE 28, and control is passed to that STATE.

If the response was "H", the state pointer is set to STATE 27, and the program signs off.

2.1.1.1 Typical Messages

MESSAGE #1 I'M READY TO MEASURE BEFORE-RECEIPT DATA. YOU SHOULD HAVE THE SPARGE OFF AND INSTRUMENT PURGES AT 0.5 SCFH.

MESSAGE #1A ARE YOU READY (YES OR NO)?

MESSAGE #2 SPARGER AT W835 EL 300

PURGEST AT W835 EL 308

DO NOT FORGET TO ZERO THE RUSKAS

I'LL WAIT TO HEAR FROM YOU

MESSAGE #3 VESSEL LEVEL IS CHANGING

SUPERVISOR IS REQUIRED

MESSAGE #4 "HEEL QUANTITY IS DIFFERENT." YOU WERE SUPPOSED TO HAVE ____ KG SOL AND YOU'VE GOT _____ KG SOL. SUPERVISOR REQUIRED.

MESSAGE #5 YOU'VE GOT _____ KG SOL WITH ______ KG U AS THE HEEL QUANTITY.

MESSAGE #6 YOUR NEXT STEP IS TO BRING IN THE NEW BATCH. IT WILL BE BATCH 02-003-_______. WHEN RECEIVED, MIX FOR 10 MINUTES, THEN SHUT DOWN SPARGE AND CALL ME.

MESSAGE #7 YOU SHOULD HAVE COMPLETED THE TRANSFER, SPARGED FOR 10 MINUTES, THEN SHUT DOWN THE SPARGE AND SET INSTRUMENT AIR PURGES TO 0.5 SCFH. SHALL I TAKE MEASUREMENTS (YES OR NO)?

MESSAGE #8 SPARGE LOCATED W835 EL 300

PURGES LOCATED W835 EL 308

REMEMBER 10 MINUTES MINIMUM SPARGE TIME THEN SHUT IT OFF.

I'LL WAIT TO HEAR FROM YOU.

MESSAGE #9 LIQUID LEVEL IN TANK ____ IS CHANGING.

SUPERVISOR IS REQUIRED.

MESSAGE #10 SUPERVISOR PASSWORD IS REQUIRED TO PROCEED

PASSWORD>

MESSAGE #11 INSTRUMENT PERFORMANCE TEST FAILED

INSTRUMENTS LOCATED AT ____________ AND __________

SUPERVISOR IS REQUIRED.

MESSAGE #12 BATCH 02-003-n NOW CONTAINS APPROX. ______ KG, ______ LITERS OF SOLUTION. TURN ON SPARE FOR SAMPLE.

MESSAGE #13 (BELL) TRANSFER FROM PRODUCT TANK OUT-OF-LIMIT(BELL)

QTY TRANSFERRED _____ KG

QTY RECEIVED _____ KG

SUPERVISOR APPROVAL REQUIRED TO PROCEED

MESSAGE #14 DO YOU WISH THE TANK PUT ON HOLD

(YES OR NO?)

MESSAGE #15 TANK 02-003 IS IN A HOLD STATE

SUPERVISOR PASSWORD REQUIRED TO REMOVE HOLD

PASSWORD>

MESSAGE #16 LOG NUMBER ________________

RESULTS SHOW ______ G/ML DENSITY, _____M ACID

INDICATED ____G U/L

SHUT THE SPARGE OFF FOR NEXT SET OF MEASUREMENTS LET ME KNOW WHEN YOU ARE READY.

MESSAGE #17 WILL CALL WHEN SAMPLING COMPLETE

MESSAGE #18 YOU MAY NOW PROCEED WITH TRANSFER AFTER RESTORING SPARGE. CALL BACK WHEN TRANSFER IS COMPLETED AND SPARGE IS OFF.

MESSAGE #19 YOU HAVE TRANSFERRED______KG U IN______KG, _____LITERS OF SOLUTION WITH A CALCULATED CONCENTRATION OF _______G U/L AND H+ OF ______ M.

MESSAGE #20 IS THIS AN MCA TRANSFER? IF ANSWER IS YES, PLEASE ENTER SOURCE VESSEL ID
VESSEL ID> __________

MESSAGE #21 SHALL I PROCEED WITH AFTER-SAMPLE MEASUREMENTS NOW (YES OR NO)?

MESSAGE #22 OPERATORS INITIALS>

MESSAGE #23 REPLICATE MEASUREMENT DATA FOR BATCH______ ARE MARGINALLY ACCEPTABLE - INVESTIGATE TO DETERMINE AND CORRECT CAUSE.

MESSAGE #24 REPLICATE MEASUREMENT DATA FOR BATCH ______ INDICATE THAT THE MEASUREMENT SYSTEM IS OUT-OF-CONTROL. PROBLEM TO BE CORRECTED BEFORE DATA ARE ACCEPTABLE.

MESSAGE #25 DID THIS GO TO UF_6 (ENTER UF_6), INPUT ACCOUNTABILITY (ENTER INPUT) OR OFF-SPEC. U (ENTER OFF-SPEC)?

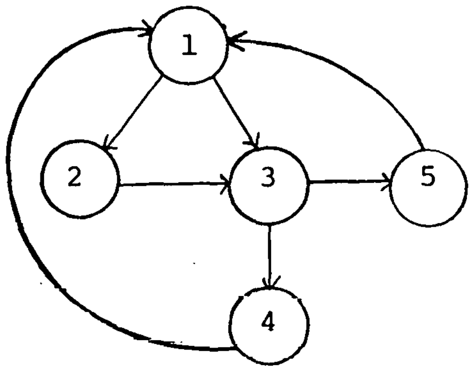
MESSAGE #26 ENTER RUSKA (LEVEL) ZERO VALUE______

MESSAGE #27 ENTER RUSKA (DENSITY) ZERO VALUE _______

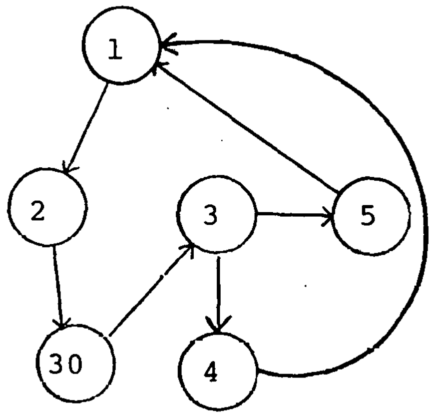
MESSAGE #28 ENTER OPTION >

2.1.1.2 State Table Definitions

The State Table is used to describe the individual functions that a measurement program is to perform. It is a list of the STATE numbers in the order that they are to be performed. These numbers may or may not be in sequential ascending order. The advantage of using a State Table is that a new function can be conceived at any time in the future and implemented into a measurement program simply by changing the STATE table. See example below.



Example 1: STATE TABLE



Example 2: REVISED STATE TABLE

In Example 1, the program moves from STATE 2 to STATE 3. It might become necessary at some future point in time to add a new function to be performed after STATE 2 and before STATE 3. As seen in Example 2, the new function is called STATE 30, and the states table is modified so that the function performed after STATE 2 is STATE 30.

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2.1.2 <u>Data/Message Tables</u>

The data/message tables used by the Vessel Measurement Programs are described in Figure 2-3. The detailed construction of these tables will be defined during program preparation.

TABLE NAME	DESCRIPTION
STATE Table	Constructed for each Vessel Measurement program. Its function is to guide the program through the prescribed sequences to satisfy the measurement criteria for that vessel.
Terminal Message Table	Used to write the unique, vessel-dependent messages to the terminal. One for each measurement program is required.
Calibration Constants Table	Contains all calibration constants required to each vessel. One for each vessel is required.
Source/Destination Table	Used when the source and/or destination of a vessel solution is not operator selectable.
MCA Transfer Table	Used to determine MCA transfer candidates.
File Names Table	Identifies to the measurement program the names of the Data Base elements associated with the unique vessel.
Vessel-Transducers Identification Table	Identifies to the measurement program all transducer numbers connected to that vessel. Used to acquire data from the RTP system.
Control Limits Table	Contains the control limits for all measurement control functions. It is organized by vessel ID and type of measurement. Allows control limits to be updated as the need arises.

FIGURE 2-3. DATA/MESSAGE TABLES DESCRIPTIONS

2.2 INPUT MEASUREMENT PROGRAM

2.2.1 Description

The Input Measurement Program provides for input measurement data acquisition, manipulation, review, and transfer to file storage. Input measurement data is generated for batches of uranium feed solution measured in and transferred through the accountability tank (18-D-101). See Figure 2-4. The program (1) directs operator actions for measurement and transfer of input solutions to be processed, and (2) receives measurement data from remote terminals or directly from RTP equipment linked to process instrumentation. The sequence of events is described in Section 2.2.2; temporary data storage and base file descriptions are presented in Section VII; and specific calculation routines are described in Section 3.2.

The Input Measurement Program is addressable from the remote terminals located in operating areas of the facility. It consists of the base program and an associated temporary data storage. The program is addressable by the operator with a minimum of computer-operator dialogue. The operator calls the program and gives his initials. The program includes an internal code that will tell the operator where he is in the measurement sequence. The program may take up to four hours

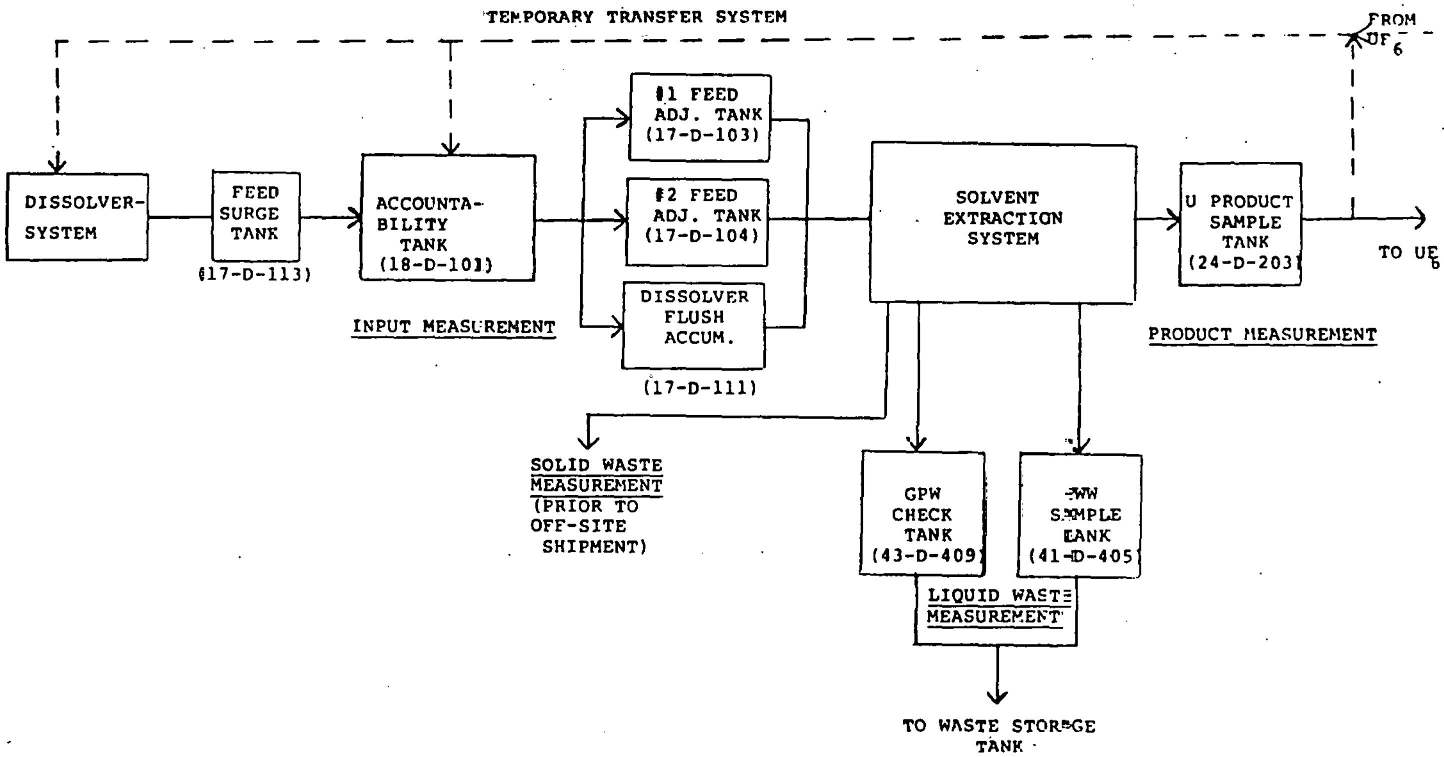

FIGURE 2-4. SIMPLIFIED PROCESS FLOWSHEET FOR URANIUM ACCOUNTABILITY

for a single complete batch measurement. During this four-hour period, there are long periods of time that the program is idling. When these idle periods occur, the program is suspended so the terminal can be used for other functions. When the operator reactivates the program, it retrieves the current measurement data from the temporary data storage area, and transfers control to the current state in the program. It advises the operator of status and the next measurement step.

During the input measurement sequence, various measurement comparisons are made to detect measurement problems. Descriptions of these comparisons, cross references to the applicable calculation routine in Section III, and appropriate levels of response are provided in Figure 2-5.

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INPUT MEASUREMENT COMPARISONS

Reference	Comparison	Difference <2s	Difference >2s & <3s	Consecutive Differences >2s & <3s	Difference >3s
3.2.13a	Redundant Inst. Comparison, Level (use Ruska to Taylor)	a	b	c	c
	Redundant Inst. Comparison, Density	NA	NA	NA	NA
3.2.13c	Temperature to Temperature	a	b	c	c
3.2.13d	Lab Density to Process Density (use Taylor)	a	b	c	c
3.2.13e	Process Density to Process Density	a	b	b	b
3.2.13b	After-Transfer to Before-Receipt	a	b	d	d
3.2.13i	Before-Sample to After-Sample	a	b	d	d
3.2.11a 3.3.11b	Quantity Sent to Quantity Received	a	b	d	d

(a) Comparison good, no action required.
(b) Flag result for investigation - measurement sequence continues.
(c) Flag result for investigation supervisory approval needed before proceeding.
(d) Out-of-control - correction action taken to be documented and approved by supervision.

FIGURE 2-5. INPUT MEASUREMENT COMPARISONS

2.2.2 State Table Summary

The following is a list of all STATES used in the Input Tank Measurement Program. For a detail description of each STATE see Section 2.1.1.

STATE 1	Initialize and transfer control to current state pointer.
STATE 2	Begin new batch.
STATE 3	Beginning of BR measurement.
STATE 4	Read RTP data and check liquid level constant.
STATE 5	Liquid level changing.
STATE 6	Instrument performance test.
STATE 7	Instrument performance failed.
STATE 8	Calculation of heel solution and compare with last batch.
STATE 8a	Allow options.
STATE 9	Print results of BR measurement.

STATE 10 Wait for receipt of new batch.

STATE 11 Tell operator what to do.

STATE 12 Begin before-sample measurements and test liquid level constant.

STATE 13 Liquid level changing.

STATE 14 Get operator initials and check instrument performance.

STATE 15 Instrument performance failed.

STATE 16 Calculate solution in tank. Test for MCA transfer, and print report in NMC office.

STATE 17 MCA transfer quantity test failed, ask operator what to do.

STATE 18 Tell operator tank is on hold.

STATE 19 Tell LDS to begin sampling.

STATE 20 Wait for LDS to complete sampling.

STATE 21 Tell operator to set-up for after-sample measurement.

STATE 22	Get data from RTP and check liquid level constant.
STATE 23	Liquid level changing.
STATE 24	Test instrument performance.
STATE 25	Instrument performance test failed.
STATE 26	Calculate solution in tank after-sample and compare with before-sample.
STATE 27	Check transfer routing.
STATE 28	Begin after-transfer measurement. Get RTP data, and check liquid level constant.
STATE 29	Liquid level changing.
STATE 30	Check instrument performance.
STATE 31	Instrument performance test failed.
STATE 32	Calculate solution in heel; print summary report in NMC; update data base; initialize for new batch.
STATE 33	Allow remeasurement.

2.2.3 Input Program Messages

Detail messages will be prepared during program preparation.

2.3 PRODUCT MEASUREMENT PROGRAM

2.3.1 Description

Measurements of uranium product solutions are made in the U product sample tank (24-D-204), measurement point 2-09. See Figure 2-4 in Section 2.2.1. The Product Measurement Program enables the computer to direct operator activities to set measurement sequences and accomplish batch transfers, with the program taking and recording measurement data through the RTP System. At each stage of measurement, the program provides appropriate measurement information to the operator, receives measurement data from the RTP System, provides cursory measurement data review, accumulates measurement data, and moves data to storage at completion of the measurement transfer sequences.

The Product Measurement Program (1) directs operator actions for measurement and transfer of input solutions to be processed, and (2) receives measurement data from remote terminals or directly from RTP equipment linked to process instrumentation. The sequence of events is described is Section 2.3.2; temporary data storage and base file descriptions are presented in Section VII; and specific calculation routines are described in Section 3.3.

The Product Measurement Program is addressable from the remote terminals located in operating areas of the facility. It consists of the base program and an associated temporary data storage. The program is addressable by the operator with a minimum of computer-operator dialogue. The operator calls the program and gives his initials. The program includes an internal code that tells the operator where he is in the measurement sequence. The program may take up to four hours for a single complete batch measurement. During this four-hour period, there are long periods of time that the program is idling. When these idle periods occur, the program is suspended so the terminal can be used for other functions. When the operator reactivates the program it retrieves the current measurement data from the temporary data storage area, and transfers control to the current state in the program. It advises the operator of status and the next measurement step.

During the product measurement sequence, various measurement comparisons are made to detect measurement problems. Descriptions of these comparisons, cross references to the applicable calculation routine in Section III, and appropriate levels of response are provided in Figure 2-6.

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PRODUCT MEASUREMENT COMPARISONS

Reference	Comparison	Difference $< 2s$	Difference $> 2s$ & $< 3s$	Consecutive Differences $> 2s$ & $< 3s$	Difference $> 3s$
3.3.13a	Redundant Inst. Comparison, Level (use Ruska to Taylor)	a	b	c	c
	Redundant Inst. Comparison, Density	NA	NA	NA	NA
3.3.13c	Lab Density to Process Density (use Taylor)	a	b	c	c
3.3.13d	Process Density to Process Density	a	b	b	b
	After-Transfer to Before-Receipt	NA	NA	NA	NA
3.3.13g	Before-Sample to After-Sample	a	b	d	d
	Quantity Sent to Quantity Received	NA	NA	NA	NA

(a) Comparison good, no action required.
(b) Flag result for investigation - measurement sequence continues.
(c) Flag result for investigation supervisory approval needed before proceeding.
(d) Out-of-control - correction action taken to be documented and approved by supervision.

FIGURE 2-6. PRODUCT MEASUREMENT COMPARISONS

2.3.2 State Table Summary

The following is a list of all STATES used in the U Product Tank Measurement Program. For a detailed description of each STATE see Section 2.1.1

STATE 1 Initialize and transfer control to current state pointer.

STATE 2 Begin new batch.

STATE 12 Begin before-sample measurements and test liquid level constant.

STATE 13 Liquid level changing.

STATE 14 Get operator initials and check instrument performance.

STATE 15 Instrument performancc failcd.

STATE 16 Calculate solution in tank. Test for MCA transfer, and print report in NMC office.

STATE 19	Tell LDS to begin sampling.
STATE 20	Wait for LDS to complete sampling.
STATE 21	Tell operator to set-up for after-sample measurement.
STATE 22	Get data from RTP and check liquid level constant.
STATE 23	Liquid level changing.
STATE 24	Test instrument performance.
STATE 25	Instrument performance test failed.
STATE 26	Calculate solution in tank after-sample and compare with before-sample.
STATE 27	Check transfer routing.
STATE 28	Begin after-transfer measurement. Get RTP data, and check liquid level constant.

STATE 29 Liquid level changing.

STATE 30 Check instrument performance.

STATE 31 Instrument performance test failed.

STATE 32 Calculate solution in heel; print summary report in NMC; update data base; initialize for a new batch.

STATE 33 Allow remeasurement.

2.3.3 Product Program Messages

Detail messages will be prepared during program preparation.

2.4 WASTE MEASUREMENT PROGRAMS

2.4.1 Description

Liquid waste measurements are made in either of two tanks: the General Purpose Waste (GPW) Check Tank, or the HI-LEVEL Waste (HWW) Sample Tank. See Figure 2-4. The GPW and HWW measurement programs for each tank are the same, with differences in measurement instruments and calculation procedures. The programs (1) direct operator actions for measurement and transfer of input solutions to be processed, and (2) receive measurement data from RTP equipment. The sequence of events is described in Section 2.4.2; temporary data storage and base file descriptions are presented in Section VII; and specific calculation routines are described in Section 3.4.

The Waste Measurement Programs are addressable from the remote terminals located in operating areas of the facility. Each program consists of the base program and an associated temporary data storage. Each program is addressable by the operator with a minimum of computer-operator dialogue. The operator calls the program and gives his initials. The program includes an internal code that will tell the operator where he is in the measurement sequence. The program may take up to four hours for a single complete batch measurement. During this four-hour period, there are long periods of time that the program is idling. When these idle periods occur, the program will be suspended so the terminal can be used for other functions. When the operator reactivates the program, it retrieves the current measurement data from the temporary data storage area, and transfers control to the current state in the program. It advises the operator of status and the next measurement step.

During the liquid waste measurement sequence, various measurement comparisons are made to detect measurement problems. Descriptions of these comparisons, cross references to the applicable calculation routine in Section III, and appropriate levels of response are provided in Figure 2-7 for the GPW Check Tank, and in Figure 2-8 for the HWW Sample Tank.

GPW MEASUREMENT COMPARISONS

Reference	Comparison	Difference <2s	Difference >2s & <3s	Consecutive Differences >2s & <3s	Difference >3s
3.4.8a	Redundant Inst. Comparison, Level (use Taylor to Westinghouse)	a	b	c	c
3.4.8b	Redundant Inst. Comparison, Density (use Taylor to Westinghouse)	a	b	b	b
3.4.8c	Lab Density to Process Density (use Westinghouse)	a	b	c	c
	Process Density to Process Density	NA	NA	NA	NA
	After-Transfer to Before-Receipt	NA	NA	NA	NA
3.4.8d	Before-Sample to After-Sample	a	b	d	d
	Quantity Sent to Quantity Received	NA	NA	NA	NA

(a) Comparison good, no action required.
(b) Flag result for investigation - measurement sequence continues.
(c) Flag result for investigation supervisory approval needed before proceeding.
(d) Out-of-control - correction action taken to be documented and approved by supervision.

FIGURE 2-7. GPW MEASUREMENT COMPARISONS

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HWW MEASUREMENT COMPARISONS

Reference	Comparison	Difference <2s	Difference >2s & <3s	Consecutive Differences >2s & <3s	Difference >3s
3.4.8a	Redundant Inst. Comparison, Level (use Taylor to Westing-House)	a	b	c	c
3.4.8b	Redundant Inst. Comparison, Density (use Taylor to Westinghouse)	a	b	c	c
3.4.3c	Lab Density to Process Density (use Westinghouse)	a	b	c	c
	Process Density to Process Density	NA	NA	NA	NA
	After-Transfer to Before-Receipt	NA	NA	NA	NA
3.4.8d	Before-Sample to After-Sample	a	b	d	d
	Quantity Sent to Quantity Received	NA	NA	NA	NA

(a) Comparison good, no action required.
(b) Flag result for investigation - measurement sequence continues.
(c) Flag result for investigation supervisory approval needed before proceeding.
(d) Out-of-control - correction action taken to be documented and approved by supervision.

FIGURE 2-8. HWW MEASUREMENT COMPARISONS

2.4.2 State Table Summary

The following is a list of all STATES used in the Waste Measurement Programs (GPW and HWW). For a detailed description of each STATE, see Section 2.1.1.

STATE	1	Initialize and transfer control to current state pointer.
STATE	2	Begin new batch.
STATE	12	Begin before-sample measurements and test liquid level constant.
STATE	13	Liquid level changing.
STATE	14	Get operator initials and check instrument performance.
STATE	15	Instrument performance failed.
STATE	16	Calculate solution in tank. Test for MCA transfer, and print report in NMC office.

STATE 19 Tell LDS to begin sampling.

STATE 20 Wait for LDS to complete sampling.

STATE 21 Tell operator to set-up for after-sample measurement.

STATE 22 Get data from RTP and check liquid level constant.

STATE 23 Liquid level changing.

STATE 24 Test instrument performance.

STATE 25 Instrument performance test failed.

STATE 26 Calculate solution and U quantity in tank after-sample and compare with before-sample.

STATE 27 Check transfer routing. (See STATE 40)

STATE 28 Begin after-transfer measurement. Get RTP data, and check liquid level constant.

STATE 29 Liquid level changing.

STATE 30 Check instrument performance.

STATE 31 Instrument performance test failed.

STATE 32 Calculate solution in heel; print summary report in NMC; update data base; initialize for new batch.

STATE 33 Allow remeasurement.

STATE 40 Determine transfer routing.
NOTE: Entered from STATE 27.

2.4.3 Waste Program Messages

Detail messages will be prepared during program preparation.

SECTION III

CALCULATION PROGRAMS

This section provides the detailed calculation routines to be applied throughout the U I/O demonstration program. For this section the term "Process Control" is used to describe calculations that are made on measurement data at the time it is generated. The term "Accountability" is used to describe the equations to provide the most accurate data to be applied to material balance calculations.

For those equations that apply to reading and converting an instrument raw data value into engineering units, that portion of the equation that changes the raw instrument reading to inches of H_2O is performed in the RTP system, and the conversion to centimeters is performed in the CNMCAS system. See example below:

EXAMPLE:

	<—— RTP ——>	<—— CNMCAS ——>
LT =	(LR-125 in %)x(2.15)	x(2.54=______ CM XXX.XX

3.1 CALCULATION PROCEDURE (D_L at T)

The specific equation to relate measured density (at 25° C) to density at specified (tank) temperature is as follows:

$$
\begin{aligned}
(D_L \text{ at } T) = & -6.822114067 \\
& -0.0001041798213(T_S) \\
& +0.006335563621(63.01287M/D_L) \\
& +0.006276193353(1.655415704U) \\
& +0.006282930580(1000-(63.01287M/D_L + 1.655415704U)) \\
& +1.025070488(D_L) \\
& +0.5183580085(0.99707(1.002987 - 2.856058177X10^{-10}(T_S) \\
& \qquad - 5.381129222X10^{-11}(T_S)^2 \\
& \qquad - 4.800801845X10^{-7}(T_S)^3 \\
& \qquad + 1.787020124X10^{-8}(T_S)^4 \\
& \qquad - 3.021031546X10^{-10}(T_S)^5 \\
& \qquad + 1.973871153X10^{-12}(T_S)^6)) \\
& -0.000001531411270(T_S(63.01287M/D_L)(D_L)) \\
& -0.0000006620118814(T_S(1.655415704U)(D_L)
\end{aligned}
$$

Where: T_S = Tank Temp in °C

M = Acid Molarity (Analysis)

D_L = Laboratory Analysis of Density at 25.0°C)

U = Uranium Concentration in Mg U/g (Analysis)

(D_L at T) = Calculated Density at Tank Temperature

3.2 INPUT TANK

3.2.1 Measurement Parameter Calculations

a) Taylor Level

$$L_T = \left[(\text{LR-125 in \%}) \times (2.15)\right] \times (2.54) = \underline{\hspace{2em}}\ \text{cm.}$$
xxx.xx

b) Ruska (primary)

L_{R1} = direct read from LR-125-R_1 in cm. = ______ cm.
xxx.xx

Note: Ruska measurement corrected for zero.

c) Ruska (backup)

L_{R2} = direct read from LR-125-R_2 in cm. = ______ cm.
xxx.xx

Note: Ruska measurement corrected for zero.

d) Taylor Density

$$D_T = \frac{\left[(\text{DR-166 in \%}) \times .09 + 10\right]}{9.94} = \underline{\hspace{2em}}\ \text{g/ml}$$
x.xxxx

e) Ruska Density

$$D_R = \frac{(\text{LR-125} - R_1) - (\text{LR-125} - R_2)}{25.25} = \underline{\hspace{2em}}\ \text{g/ml}$$
x.xxxx

Note: Both Ruskas corrected for zero.

f) Lab Density at 25°C

D_L at 25 = direct from lab results = ______ g/ml
x.xxxx

This quantity is the average of two lab density analyses.

g) Lab Density at Tank Temperature

D_L at T = adjusted from lab result = ______ g/ml
x.xxxx

NOTE: Conversion formula presented in 3.1

h) Tank Temperature (primary)

TJR = TJR-108-10 direct read in °C = ____ °C
xx.x

i) Tank Temperature (backup)

TI=TI-109 direct read in °C = ____ °C
xx.x

3.2.2 Liquid Level Calculation - Process Control (PC)

a) For Before-Receipt (BR)

LL_{PC} for BR =(L_{R1} for BR)/(D_L at 25° C from previous batch)

= ______ cm.
xxx.xx

b) For Before-Sample (BS)

LL_{PC} for BS =(L_{R1} FOR BS)/(D_T for BS) = ______ cm
xxx.xx

Or when lab data is available

LL_{PC} for BS = (L_{R1} for BS)/(D_L at 25° C for this batch)

= ______ cm.
xxx.xx

c) For After-Sample (AS)

LL_{PC} for AS = (L_{R1} for AS)/(D_L at 25° C for this batch)

= ______ cm.
xxx.xx

d) For After-Transfer (AT)

LL_{PC} for AT = (L_{R_1} for AT)/(D_L at 25° C for this batch)

= ______ cm.
xxx.xx

3.2.3 Liquid Level - Accountability

a) For Before-Receipt

LL_A for BR - (L_{R_1} for BR)/(D_L at BR-TJR from previous batch) = ______
xxx.xx

b) For Before-Sample

LL_A for BS = (L_{R_1} for BS)/(D_L at BS-TJR for this batch

= ______
xxx.xx

c) For After-Sample

LL_A for AS = (L_{R_1} for AS)/(D_L at AS-TJR for this batch)

= ______
xxx.xx

d) For After-Transfer

LL_A for AT = (L_{R_1} for AT)/(D_L at AT-TJR for this batch)

= ______
xxx.xx

e) Liquid Level using Backup Ruska

$$LL = \frac{L_{R2}}{D_L \text{ at tank temp}} + (25.25)$$

In any calculation (BS, AS etc) = $\underline{\quad}$ cm.
xxx.xx

OR

$$LL = \frac{L_{R2}}{D_L \text{ at tank temp}}$$ and use alternate calibration

equations (See Section 3.1)

3.2.4 Volume - Process Control

$V_{PC} = 9.4 + 0.9791 \times LL_{PC} + 0.73154 \times LL_{PC}^2 \; 0 - 0.00644532 \times LL_{PC}^3$

IF $0 < LL_{PC} < 23.1$

$V_{PC} = -217.62 + 24.010061 \times LL_{PC} + 0.011118 \times LL_{PC}^2 - 0.000046 \times LL_{PC}^3$

IF $23.1 \leq LL_{PC} < 85.0$

$V_{PC} = -245.9 + 24.9569 \quad LL_{PC}$

IF $85.0 \leq LL_{PC} \leq 324.9$

= $\underline{\quad}$ liters
xxxx

Use appropriate LL_{PC} for BR, BS, AS, and AT to calculate V_{PC} for BR, BS, AS, and AT.

3.2.5 Volume - Accountability

$V_A = 9.4 + 0.9791 \times LL_A + 0.73154 \times LL_A^2$ 0-0.00644532 $\times LL_A^3$

IF $0 < LL_A < 23.1$

$V_A = -217.62 + 24.010061 \times LL_A + 0.011118 \times LL_A^2 - 0.000046 \times LL_A^3$

IF $23.1 \leq LL_A < 85.0$

$V_A = -245.9 + 24.9569 \times LL_A$

IF $85.0 \leq LL_A \leq 324.9$

= ____ liters
xxxx

Use appropriate LL_A for BR, BS, AS, AT to calculate V_A for BR, BS, AS, and AT

3.2.6 Solution Quantity - Process Control

a) For Before - Receipt

W_{PC} for BR = (V_{PC} for BR) x (D_L at 25° C from previous batch) = ______ kgs
xxxx.x

b) For Before-Sample

W_{PC} for BS = (V_{PC} for BS) x (D_T for BS) = ______ kgs
xxxx.x

Or when analytical results become available.

W_{PC} for BS = (V_{PC} for BS) x (D_L at 25° C for this batch)
= ______ kgs
xxxx.x

c) For After- Sample

W_{PC} for AS = (V_{PC} for AS) x (D_L at 25° C for this batch)
= ______ kgs
xxxx.x

d) For After-Transfer

W_{PC} for AT = (V_{PC} for AT) x (D_L at 25°C for this batch)
= ______ kgs
xxxx.x

3.2.7 Solution Quantity - Accountability

a) For Before-Receipt

W_A for BR = (V_A for BR) x (D_L for previous batch
at BR-TJR) = ______ kgs
xxxx.x

b) For Before-Sample

W_A for BS = (V_A for BS) x (D_L for this batch at BS-TJR)
= ______ kgs
xxxx

c) For After-Sample

W_A for AS = (V_A for AS) x (D_L for this batch at AS-TJR)

= ______ kgs
xxxx.x

d) For After-Transfer

W_A for AT = (W_A for AT) x (D_L for this batch at AT-TJR

= ______ kgs
xxxx.x

3.2.8 U Concentrations

a) For Process Control

$$U_{PC} = \left[\frac{(D_L \text{ at } 25°C - 1.001) - (.032 \times \text{Acid Molarity})}{.318}\right] 238.12 = \underset{xxx.xx}{\underline{\hspace{2cm}}} \text{ g/l}$$

b) For Accountability

U_A = direct from lab results = ______ mg/g
xxx.xx

3.2.9 U Quantities

a) For Process Control

$M_{PC} = V_{PC} \times U_{PC} \times .001$ = ______ kg U
xxxx.x

Calculate M_{PC} for BR from U_{PC} from previous batch.

Calculate M_{PC} for BS, AS, and AT from U_{PC} for this batch.

b) For Accountability

$M_A = W_A \times U_A = \underset{xxxx.x}{\underline{\qquad}}$ kg U

Calculate M_A for BR from U_A from previous batch.

Calculate M_A for BS, AS, and AT from U_A for this batch.

3.2.10 U Quantities Transferred/Received

a) For PC quantities received

Q_{PC-R} = (M_{PC} from this batch BS) - (M_{PC} from previous batch AT) = $\underset{xxxx.x}{\underline{\qquad}}$ kg U

b) For PC quantities sent

Q_{PC-S} = (M_{PC} from this batch BS) - (M_{PC} from this batch AT) = $\underset{xxxx.x}{\underline{\qquad}}$ kg U

c) For A quantities received

Q_{A-R} = (M_A from this batch BS) - (M_A from previous batch AT) = $\underset{xxxx.x}{\underline{\qquad}}$ kg U

d) For A quantities sent

Q_{A-S} = (M_A from this batch BS) - (M_A from this batch AT) = $\underset{xxxx.x}{\underline{\qquad}}$ kg U

3.2.11 Solution Quantities Transferred/Received

a) For PC quantities received

S_{PC-R} = (W_{PC} from this batch BS) - (W_{PC} from previous batch AT) = ______ kgs Sol
xxxx.x

Note: W_{PC} for this batch BS may be calculated either of two ways from Section 3.2.6 (b)

b) For PC quantities transferred

S_{PC-S} = (W_{PC} from this batch BS) - (W_{PC} for this batch AT) = ______ kgs Sol
xxxx.x

Note: W_{PC} for this quantity only calculated by the second method of Section 3.2.6 (b)

c) For A quantities received

S_{A-R} = (W_A for this batch BS) - (W_A from previous batch AT) = ______ kgs Sol
xxxx.x

d) For A quantities transferred

S_{A-S} = (W_A for this batch BS) - (W_A from this batch AT) = ______ kgs Sol
xxxx.x

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3.2.12 Solution Volume Transferred/Received

a) For PC quantities received

R_{PC-R} = (V_{PC} from this batch BS) -(V_{PC} from previous batch AT) = $\overline{XXXX}$ liters

b) For PC quantities transferred

R_{PC-S} = (V_{PC} from this batch BS) -(V_{PC} from this batch AT) = $\overline{XXXX}$ liters

c) In A quantities received

R_{A-R} = (V_A for this batch BS) - (V_A for previous batch AT) = $\overline{XXXX}$ liters

d) For A quantities transferred

R_{A-S} = (V_A for this batch BS) - (V_A for this batch AT) = $\overline{XXXX}$ liters

3.2.13 Measurement Control Calculations

a) Ruska (primary) to Taylor

$C_1 = (L_{R1}) - (L_T) = \overline{XX.XX}$ cm.

C_1 calculated for BR, BS, AS, and AT measurements.

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b) Lab density at 25°C to After-Sample Ruska

$C_2 = (D_L \text{ at } 25°C) - (D_R) = \underline{\hspace{2cm}}$ g/ml
x.xxxx

For After-Sample (AS) measurement only.

c) Temperature

$C_3 = (TJR\text{-}108\text{-}10) - (TI\text{-}109) = \underline{\hspace{1.5cm}}$ °C
xx.x

d) Lab density at 25°C to After-Sample Taylor

$C_4 = (D_L \text{ at } 25°C) - (D_T) = \underline{\hspace{2cm}}$ g/ml
x.xxxx

For After-Sample (AS) measurement only.

e) Ruska density to Taylor density

$C_5 = D_R - D_T = \underline{\hspace{2cm}}$ g/ml
x.xxxx

For both Before-Sample (BS) and After-Sample (AS) data.

f) Lab density at Tank Temperature to Ruska

$C_6 = (D_L \text{ at } TJR) - (D_R) = \underline{\hspace{2cm}}$ g/ml
x.xxxx

For both Before-Sample (BS) and After-Sample (AS) data.

g) Lab density at Tank Temperature to Taylor

$C_7 = (D_L \text{ at } TJR) - D_T) = \underline{\hspace{2cm}}$ g/ml
x.xxxx

For both Before-Sample (BS) and After-Sample (AS) data.

h) After-Transfer to Before-Receipt - Process Control

$C_8 = (W_{PC}$ for AT) - $(W_{PC}$ for BR) = $\frac{\quad}{xx.x}$ kgs

NOTE: AT is from previous batch.

i) Before-Sample to After-Sample - Process Control

$C_9 = (W_{PC}$ for BS) - $(W_{PC}$ for AS) = $\frac{\quad}{xxx}$ kgs

j) After-Transfer to Before-Receipt - Accountability

$C_{10} = (W_A$ for AT) - W_A for BR) = $\frac{\quad}{xx.x}$ kgs

NOTE: AT is from previous batch.

k) Before-Sample to After-Sample - Accountability

$C_{11} = (W_A$ for BS) - $(W_A$ for AS) = $\frac{\quad}{xx.x}$ kgs

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3.3 U PRODUCT SAMPLE TANK

3.3.1 Measurement Parameter Calculation

a) Taylor Level

$$L_T = \left[(\text{LR-239 in \%}) \times (.97)\right] \times (2.54) = \underset{\text{xxx.xx}}{\underline{\qquad}} \text{ cm}$$

b) Ruska (primary)

$$L_{R1} = \text{direct read from LR-239-}R_1 = \underset{\text{xxx.xx}}{\underline{\qquad}} \text{ cm}$$

c) Ruska (backup)

$$L_{R2} = (\text{LR-239-}R_2 \text{ in cm}) = \underset{\text{xx.xx}}{\underline{\qquad}} \text{ cm}$$

d) Taylor Density

$$D_T = \left[\frac{(\text{DR-273 in \%}) \times .09 + 10}{10.1}\right] = \underset{\text{x.xxxx}}{\underline{\qquad}} \text{ g/ml}$$

e) Ruska Density

$$D_R = \frac{L_{R1} - L_{R2}}{25.65} = \underset{\text{x.xxxx}}{\underline{\qquad}} \text{ g/ml}$$

f) Lab Density at 25°C

D_L at 25°C = direct from lab results = $\underline{\hspace{2cm}}$ g/ml
x.xxxx

This quantity is the average of two reported lab densities.

g) Lab density at tank temperature

D_L at T = adjusted from lab results = $\underline{\hspace{2cm}}$ g/ml
x.xxxx

NOTE: Conversion formula presented in 3.1

h) Temperature

TJR = TJR-206-17 direct read = $\underline{\hspace{1.5cm}}$ °C
xx.x

i) Liquid level using backup Ruska

$$LL = \frac{L_{R2}}{D_L \text{ at tank temp}} + (25.65) = \underset{\text{xxx.xx}}{\underline{\hspace{2cm}}} \text{ cm}$$

or

$$LL = \frac{L_{R2}}{D_L \text{ at tank temp}}$$

and use the alternate calibration equation (See Section 3.1).

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3.3.2 Liquid Level - Process Control

a) For Before-Sample

LL_{PC} for BS = (L_{R_1} for BS)/D_T = ______cm
xxx.xx

or

LL_{PC} for BS = (L_{R_1} for BS)/(D_L at 25°C) = ______cm
xxx.xx

When analytical density available

b) For After-Sample

LL_{PC} for AS = (L_{R_1} for AS)/(D_L at 25°C) = ______cm
xxx.xx

c) For After-Transfer

LL_{PC} for AT = (L_{R_1} for AT)/(D_L at 25°C) = ______cm
xxx.xx

3.3.3 Liquid Level - Accountability

a) For Before-Sample

LL_A for BS = (L_{R_1} for BS)/(D_L at TJR-BS) = ______cm
xxx.xx

b) For After-Sample

LL_A for AS = (L_{R_1} for AS)/(D_L at TJR-BS) = ______cm
xxx.xx

c) For After-Transfer

LL_A for AT = (L_A for AT)/(D_L at TJR-AS) = ______cm
xxx.xx

3.3.4 Volume - Process Control

$$V_{PC} = 68.63 + 10.80859 \times LL_{PC} + 0.7543094 \times LL_{PC}^2 - 0.009221 \times LL_{PC}^3$$

IF $0 < LL_{PC} < 22.1$

$$V_{PC} = 2.613 + 18.63934 \times LL_{PC} + 0.36537 \times LL_{PC}^2 - 0.0015362 \times LL_{PC}^3$$

IF $22.1 \leq LL_{PC} < 92.5$

$$V_{PC} = 651.938 + 0.79564 \times LL_{PC} + 0.523177 \times LL_{PC}^2 - 0.001977 \times LL_{PC}^3$$

IF $92.5 \leq LL_{PC} < 154$

= ______ liters
xxxx.x

Use appropriate LL_{PC} for BS, AS, and AT to calculate V_{PC} for BS, AS, and AT.

3.3.5 Volume - Accountability

$$V_A = 68.63 + 10.80859 \times LL_A + 0.7543094 \times LL_A^2 - 0.009221 \times LL_A^3$$

IF $0 < LL_A < 22.1$

$$V_A = 2.613 + 18.63934 \times LL_A + 0.36537 \times LL_A^2 - 0.0015362 \times LL_A^3$$

IF $22.1 \leq LL_A < 92.5$

$$V_A = 651.938 + 0.79564 \times LL_A + 0.523177 \times LL_A^2 - 0.001977 \times LL_A^3$$

IF $92.5 \leq LL_A < 154$

= ______ liters
xxxx.x

Use appropriate LL_A for BS, AS, and AT to calculate V_A for BS, AS, and AT.

3.3.6 Solution Quantity - Process Control

a) For Before-Sample

W_{PC} for BS = (V_{PC} for BS) x (D_T for BS) =

______kgs
xxxx.x

Or when analytical results become available

W_{PC} for BS = (V_{PC} for BS) x (D_L at 25°C for this batch) =

______kgs
xxxx.x

b) For After-Sample

W_{PC} for AS = (V_{PC} for AS) x (D_L at 25°C for this batch) =

______kgs
xxxx.x

c) For After-Transfer

W_{PC} for AT = (V_{PC} for AT) x (D_L at 25°C for this batch) =

______kgs
xxxx.x

3.3.7 Solution Quantity - Accountability

a) For Before-Sample

W_A for BS = (V_A for BS) x (D_L for this batch at BS-TJR) =

______ kgs
xxxx.x

b) For After-Sample

W_A for AS = (V_A for AS) x (D_L for this batch at AS-TJR) =

______ kgs
xxxx.x

c) For After-Transfer

W_A for AT = (W_A for AT) x (D_L for this batch at AT-TJR) =

______ kgs
xxxx.x

3.3.8 U Concentrations

a) For Process Control

$$U_{PC} = \left[\frac{(D_L \text{ at } 25°C - 1.001 - (.032 \times \text{Acid Molarity})}{.318}\right]$$

$$\times\ 238.12 = \underset{xxx.xx}{\underline{\qquad}}\ g/l$$

b) For Accountability

U_A = direct from lab results = $\underset{xxx.xx}{\underline{\qquad}}$ mg/g

3.3.9 U Quantities

a) For Process Control

$M_{PC} = V_{PC} \times U_{PC} \times .001 = \underset{xxxx.x}{\underline{\qquad}}$ kg U

Calculate M_{PC} for BS, AS, and AT.

b) For Accountability

$M_A = W_A \times U_A = \underset{xxxx.x}{\underline{\qquad}}$ kg U

Calculate M_A for BS, AS, and AT.

3.3.10 U Quantities Transferred/Received

a) For PC quantities received

Q_{PC-R} = (M_{PC} from this batch BS) - (M_{PC} from previous batch AT) = ______ kg U
xxxx.x

b) For PC quantities sent

Q_{PC-S} = (M_{PC} from this batch BS) - (M_{PC} for this batch AT) = ______ kg U
xxxx.x

c) For A quantities received

Q_{A-R} = (M_A from this batch BS) - (M_A from previous batch AT) = ______ kg U
xxxx.x

d) For A quantities sent

Q_{A-S} = (M_A from this batch BS) - (M_A from this batch AT) = ______ kg U
xxxx.x

3.3.11 Solution Quantities Transferred/Received

a) For PC quantities received

S_{PC-R} = (W_{PC} from this batch BS) - (W_{PC} from previous batch AT) = ______ kgs Sol
xxxx.x

Note: W_{PC} for this batch BS may be calculated either of two ways from Section 3.2.6 (b)

b) For PC quantities transferred

S_{PC-S} = (W_{PC} from this batch BS) - (W_{PC} for this batch AT) = ______ kgs Sol
xxxx.x

Note: W_{PC} for this quantity is only calculated by the second method of Section 3.3.6 (b)

c) For A quantities received

S_{A-R} = (W_A for this batch BS) - (W_A from previous batch AT) = ______ kgs Sol
xxxx.x

d) For A quantities transferred

S_{A-S} = (W_A for this batch BS) - (W_A from this batch AT) = ______ kgs Sol
xxxx.x

3.3.12 Solution Volumes Transferred/Received

a) For PC quantities transferred

R_{PC-S} = (V_{PC} from this batch BS) - (V_{PC} from this batch AT) = $\underline{\hspace{2em}}$ liters
xxxx

b) For A quantities received

R_{A-R} = (V_A for this batch BS) - (V_A for previous batch AT) = $\underline{\hspace{2em}}$ liters
xxxx

c) For A quantities transferred

R_{A-S} = (V_A for this batch BS) - (V_A for this batch AT) = $\underline{\hspace{2em}}$ liters
xxxx

3.3.13 Measurement Control Calculations

a) Ruska (primary) to Taylor

$C_1 = (L_{R1}) - (L_T) = \underline{\hspace{2em}}$ cm
xx.xx

C_1 calculated for BS, AS and AT measurements.

b) Lab density at 25°C to After-Sample Ruska Density

$C_2 = (D_L \text{ at } 25°C) - (D_R) = \underline{}$ g/ml
x.xxxx

C_2 is calculated for AS only.

c) Lab density at 25°C to After-Sample Taylor

$C_3 = (D_L \text{ at } 25°C) - (D_T) = \underline{}$ g/ml
x.xxxx

C_3 is calculated for AS only.

d) Ruska density to Taylor density

$C_4 = (D_R) - (D_T) = \underline{}$ g/ml
x.xxxx

C_4 is calculated for BS and AS.

e) Lab density at tank temperature to Ruska density

$C_5 = (D_L \text{ at TJR}) - (D_R) = \underline{}$ g/ml
x.xxxx

C_5 is calculated for BS and AS.

f) Lab density at tank temperature to Taylor density

$C_6 = (D_L \text{ at TJR}) - (D_T) = \underline{}$ g/ml
x.xxxx

C_6 is calculated for BS and AS.

g) Before-Sample to After-Sample - Process Control

$C_7 = (W_{PC} \text{ for BS}) - (W_{PC} \text{ for AS}) = \underline{\quad\quad}$ kgs
xx.x

h) Before-Sample to After-Sample - Accountability

$C_8 = (W_A \text{ for BS}) - (W_A \text{ for AS}) = \underline{\quad\quad}$ kgs
xx.x

3.4 LIQUID WASTE (HWW SAMPLE TANK AND GPW CHECK TANK)

3.4.1 Measurement Parameter Calculations

a) Westinghouse Level

For HWW Sample Tank

$$L_W = [(\text{LR-419-W in \%}) \times (2.50)] = \underset{\text{xxx.x}}{\_\_\_\_\_} \text{ inches}$$

For GPW Check Tank

$$L_W = [(\text{LR-412-W in \%}) \times (1.00)] = \underset{\text{xx.x}}{\_\_\_\_} \text{ inches}$$

b) Taylor Level

For HWW Sample Tank

$$L_T = [(\text{LR-419 in \%}) \ (2.04)] = \underset{\text{xx.x}}{\_\_\_\_} \text{ inches}$$

For GWP Check Tank

$$L_T = [(\text{LR-412 in \%}) \ (.713)] = \underset{\text{xx.x}}{\_\_\_\_} \text{ inches}$$

c) Westinghouse Density

For HWW Sample Tank

$$D_W = \frac{[(\text{DR-430-W in \%}) \times (.50)]}{9.50} = \underset{\text{x.xxxx}}{\_\_\_\_\_\_} \text{ g/ml}$$

For GPW Check Tank

$$D_W = \frac{[(\text{DR-416-W in \%}) \times (.50)]}{9.86} = \underset{\text{x.xxxx}}{\_\_\_\_\_\_} \text{ g/ml}$$

d) Taylor Density

For HWW Sample Tank

$$D_T = \frac{[(\text{DR-430 in \%}) \times .9 + 10]}{9.50} = \underline{}\ \text{g/ml}$$

x.xxxx

For GPW Check Tank

$$D_T = \frac{[(\text{DR-416 in \%}) \times .9 + 10]}{9.86} = \underline{}\ \text{g/ml}$$

x.xxxx

e) Lab Density at 25°C

D_L at 25 = direct from lab result = ______ g/ml

x.xxxx

f) Temperature

For HWW Sample Tank

TJR = direct from TJR-414-5 = ____ °C

xx.x

For GPW Check Tank

TJR = direct from TJR-415-7 = ____ °C

xx.x

3.4.2 Calculation of Liquid Level, Solution Volume and Solution Weight

For HWW Sample Tank

$LL = L_W/D_W = \underline{\quad\quad}$ inches*
xxx.x

where L_W and D_W as defined for HWW Sample Tank above.

$V = 128.511103 + 20.966280 \times LL = \underline{\quad\quad}$ liters
xxxx.x

$W = V \times D_W = \underline{\quad\quad}$ kg*
xxxx.x

LL, V, and W are calculated for BS, AS, and AT.

For GPW Check Tank

$V = 5 \times LL$

IF $0 < LL < 2.4$

$V = -24.8559 + 15.2765415 \times LL$

IF $2.4 \leq LL$

where L_W and D_W as defined for GPW Check Tank above.

$V = 5 \times LL$

IF $0 < LL < 2.4$

$V = 24.8559 + 15.2765415 \times LL$

IF $2.4 \leq LL$

$W + V \times D_W = \underline{\quad\quad}$ kgs*
xxx.x

* For After-Transfer measurement, use After-Sample reading for D_W.

3.4.3 U Concentrations

U = direct from lab results ______ g/l
xx.xx

3.4.4 U Quantities

M = (V) x (U) = ______ grams
xxx.x

Calculate M for BS, AS and AT quantities.

3.4.5 U Quantities Transferred/Received

a) Quantity Received

Q_R = (M for BS this batch) - (M for AT last batch) =

______ grams.
xxx.x

b) Quantity Transferred

Q_S = (M for BS this batch) - (M for AT last batch) =

______ grams.
xxx.x

3.4.6 Solution Quantities Transferred/Received

a) Quantity Received

S_R = (W for BS this batch) - (W for AT last batch) =

______ kgs
xxxx.x

b) Quantity Transferred

S_R = (W for BS this batch) - (W for AT this batch) =

______ kgs
xxxx.x

3.4.7 Solution Volumes Transferred/Received

a) Quantity Received

R_R = (V for BS this batch) - (V for AT last batch) =

____ liters
xxxx

b) Quantity Transferred

R_S = (V for BS this batch) - (V for AT this batch) =

____ liters
xxxx

3.4.8 Measurement Control Calculations

a) Westinghouse to Taylor Level

$C_1 = (L_W) - (L_T) =$ ____ inches
xx.x

b) Taylor to Westinghouse Density

$C_2 = (D_W) - (D_T) =$ ______ g/ml
x.xxxx

C_2 is calculated for BS and AS data.

c) Westinghouse to Lab Density

$C_3 = (D_W) - (D_L \text{ at } 25°C) =$ ______ g/ml
x.xxxx

C_3 is calculated f

d) Before-Sample to After-Sample

C_4 = (W for BS) - (W for AS) = $\underset{xx.x}{\underline{\qquad}}$ kgs

3.5 MBA TRANSFER CALCULATIONS

The only MBA* transfer of concern is from the U Product Sample Tank to the Input Accountability Tank. The equations for this transfer comparison are as follows.

3.5.1 First Pass Comparison

This comparison uses available Before-Sample data in the Accountability tank and available After-Transfer data in the U Product Sample tank.

$MBAC_1$ = [W_{PC} for BS (In Acct Tk) - W_{PC} for AT of previous batch] - [S_{PC-S} for Product Tank]

Note: W_{PC} for BS is described in 3.2.6 (b) first method

W_{PC} for AT is described in 3.2.6 (d)

S_{PC-S} is described in 3.2.10 (b)

*MBA and MCA are used interchangeably in this specification.

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3.5.2 Second Pass Comparison

This comparison uses lab results in Accountability tank to make a refined comparison.

$MBAC_2$ = [S_{PC-R} for Acct Tk] - [S_{PC-S} for Product Tank]

Note: S_{PC-R} is described in 3.2.11 (a)

S_{PC-S} is described in 3.3.11 (b)

3.5.3 Third Pass Comparison

When all data are available a final comparison using Accountability calculations is made. This comparison is made on solution quantities and total U transferred.

$MBAC_3$ = [S_{A-R} for Acct Tk] - [S_{A-S} for Product Tank]

Note: S_{A-R} is described in 3.2.11 (c)

S_{A-S} is described in 3.3.11 (d)

and

$MBAC_4$ = [Q_{A-R} for Acct Tk] - [Q_{A-S} for Product Tank]

Note: Q_{A-R} is described in 3.2.10 (c)

Q_{A-S} is described in 3.3.10 (d)

SECTION IV

ACCOUNTING PROGRAMS

The two Accounting Program modules are the Lot/Inventory Definition Task and the Report Generation Task. The Lot/Inventory Definition Task creates new Lots and/or Inventory Periods, as defined by the operator. The Report Generation Task produces three types of reports: the Accounting Report, Summary Report, and Material Balance Report. Descriptions of these two tasks and details of the generated reports are described in the subsections that follow.

4.1 DEFINITIONS

Terms and definitions used in the accounting programs are listed in this section.

Measurement Point - a point at which material is generated or measured.

Report - a statement of the Material Balance at a particular measurement point.

Material Transfer - a sequence of operations taken from the following group.

a. Measure the heel quantity
b. Fill the vessel
c. Measure the material
d. Sample the material
e. Measure material again
f. Transfer the material
g. Measure the heel quantity

Batch - an identifiable unit of material for measurement and accounting purposes

Lot - a number assigned to a group of one or more batches

Inventory Period - a number assigned to a group of one or more lots; it may be open ended. Example: "Lot number 12 and all following lots-to-date constitute the current Inventory Period."

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4.2 LOT/INVENTORY DEFINITION TASK

This task creates new Lots and/or Inventory Periods, as defined by the operator.

The user initiates the task by typing "LO" for Lot definition or "IP" for Inventory Period definition. The task response is described in the following text.

4.2.1 <u>Dialogue in Response to "LO"</u>

Question #1:	ENTER MEASUREMENT POINT NUMBER (NN)
Operator Input:	NN
where	NN = a valid measurement point number
Error:	If other than a legal measurement point number is entered, Question #1 is repeated.
Question #2:	ENTER BATCH NUMBERS (LL, HH)
Operator Input:	LL, HH
where	LL = low batch number for lot being defined
	HH = high batch number for lot being defined (optional)
Error:	Program responds "ERROR RE-ENTER" if a batch number is entered which duplicates a batch in an existing lot.

Next Question: LOT NUMBER m INCLUDES BATCHES LL-HH

where m = next available contiguous lot number

LL-HH = batch numbers that have just been correctly entered by the user.

Next Question: End of dialogue.

4.2.2 Dialogue in Response to "IP"

Question #1: ENTER MEASUREMENT POINT NUMBER (NN)

Operator Input: NN

where NN = a valid measurement point number

Error: Question #1 is repeated if other than a legal measurement point number is entered.

Question #2: ENTER LOT NUMBERS (LL, HH)

Operator Input: LL, HH

where LL = low lot number for the Inventory Period being defined

HH = high lot number for the Inventory Period being defined (optional)

Error: Program responds "ERROR RE-ENTER" if a lot number is entered which duplicates a lot in an existing Inventory Period.

Next Question: INVENTORY PERIOD NUMBER m
INCLUDES LOTS LL-HH

where m = next available contiguous Inventory Period number

LL-HH = batch numbers that have just been correctly entered by the user.

Next Question: End of dialogue.

4.2.3 Lot/Inventory Definition Task Function

When the Lot/Inventory Definition task is activated, the task requests the measurement point as described in Section 4.2 and waits for the user's response.

After the user enters a correct measurement point, the Lot Definition task (LO) searches through the Lot Index File for that measurement point. (The format of the Lot Index File is shown in Figure 7-3, Section VII.) The task checks the batch numbers LL, HH entered by the user against those already in the file. If there is no duplication, a new entry is made at the end of the Lot Index File with the user-defined batch numbers.

The Inventory Period Definition function, IP, is the same as LO, except the user-entered lot numbers make up a new entry in the Inventory Period Index File. (See Figure 7-2, Section VII.)

4.3 REPORT GENERATION TASK

The Report Generation Task produces three types of reports: The Accounting Report, Summary Report, and Material Balance Report. Sample reports are shown in Figures 4-1 and 4-2. The Summary Report format (not shown) is similar to the Accounting Report. A detailed description is provided in Section 4.3.3.

The Report Generation Task is activated by typing "RP" for Report Generation. The program responds with a request for the type of report to be generated: Accounting, Summary, or Material Balance. After supplying the report type, the program requests the measurement point number when applicable.

4.3.1 Report Formulation

Four primary measurement points are used to demonstrate accounting and material balance routines. Output data is based on preliminary results as well as final results, because the turn-around time for obtaining analytical results of samples can be lengthy. The use of less accurate preliminary results, however, does offer a means of reporting status as near real-time as possible. Each reported quantity is coded as preliminary (P) or final (F), and each summary total is segregated by (P) or (F) status to advise the user accordingly.

Other items reported include:

1. "Received from" and "transfer to" points

   The points from which the material was received and the points to which the material was transferred are reported. Batches recycled back into process are excluded from input/output material balances, and must be segregated. Therefore all line items are segregated by "from" and "to" points.

2. Quantitative data

   Liters of solution, kilograms of solution, and grams of uranium are reported on all reports, even though liters or kilograms of solution do not enter into material balance determinations.

3. Sample log numbers

   This information is for reference purposes.

4. Uranium concentration

   The uranium concentration as mg. U/g is used for overchecking and evaluation needs.

5. The time of year applicable to the measurements used.

6. Beginning inventory, total receipts, total removals, and ending balance.

The Report Generation Task locates data for the reports as follows:

- Refers to the Lot Index File to find appropriate batch numbers(s) (Figure 7-3, in Section VII.)

- Refers to the Batch Index File to find the relative location of data in the Raw Data File and in the Analytical Data File (Figures 7-4, 7-5, 7-6, in Section VII).
- Uses the selected data to formulate the report.

4.3.2 Accounting Report Description

The Accounting Report is a detailed report for each measurement point, which lists all the individual batches and lots. A detailed format is shown in Figure 4-1. Column headings and contents are described in the text that follows.

1. LOT NO. - This heading identifies the lot number, and subdivides the report into lot groupings.

2. BATCH NO. - A unique number assigned to a batch. Batch numbers are assigned consecutively for a measurement point.

3. AS MEASUREMENT DATE - The date indicates when the after-sample measurement was made.

4. LOG NO. - This is the log number assigned by the analytical laboratory.

5. CODE - There are two types of calculations made. One is the preliminary (P), which is based on density and acidity level; and the second is final (F), which is based on the reported uranium concentrations. Whenever

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NMC - ACCOUNTING
INPUT/OUTPUT REPORT FOR MEASUREMENT POINT 2-003
DATE OF REPORT--1/19/78

LOT NO.	BATCH NO.	MANUAL CHANGE	DATE	LOG NO.	CODE*	BATCH NO.	REC. FROM	U-CONC MG-U/G	QUANTITY RECVD. LITERS	QUANTITY RECVD. Kg SOL	QUANTITY RECVD. U-CONTENT	QUANTITY TRANSFERRED LITERS	QUANTITY TRANSFERRED Kg SOL	QUANTITY TRANSFERRED U-CONTENT	DEST.
Beginning Inventory									XX	XX	XX				
1	1		1-10-78	35606	F		2-001	235.89	10	15	12	8	13	10	2-005
1	2	C	1-11-78	35510	F		2-001	236.81	12	18	14	10	15	12	2-005
1	3		1-12-78	35514	F		2-001	237	8	12	10	10	15	12	2-006
1	4		1-12-78	35518	F		2-002	240	12	18	14	10	15	12	2-005
Lot Totals					F				42	63	50	38	58	46	
2	5		1-13-78	35620	F		2-001	239.00	16	24	12	12	18	8	2-005
2	5		1-14-78	35624	P		2-001	241.30	20	30	15	15	23	11	2-005
2	7		1-15-78	35628	P		2-001	227.62	14	21	10	0	0	0	
Lot Totals									50	75	37	27	41	19	
Cummulative Totals					F		2-001		46	69	48	40	61	42	2-005
Lots - 1 thru 2					F		2-002		12	18	14	10	15	12	2-006
			Sub Total						58	87	62	50	76	54	
					P		2-001		34	51	25	15	23	11	2-005
			Grand Total						92	138	87	65	99	65	
			Ending Balance									27	39	22	

*Preliminary (P) or Final (F) Code

FIGURE 4-1. TYPICAL NMC ACCOUNTING REPORT a report is requested, the program goes to the final uranium concentrations first to make the calculations. If the final data are available, they are used and coded as (F) on the report. If not, then, the preliminary data are used and coded (P) on the report.

6. RECEIVED FROM - This is the measurement point from which the material was received and the batch number for the quantity transferred. It is used to provide a ready means for comparing quantities transferred and received between two points.

7. U CONC. Mg-U/g - This is the uranium concentration calculated for the preliminary results or the results from the analytical determinations for the final values.

8. QUANTITY RECEIVED - Three quantities are reported consisting of the liters and kilograms of solution, and kilograms of uranium. Values are reported to the nearest tenth of a liter or kilogram.

9. QUANTITY TRANSFERRED - The three quantities transferred from the reporting point are recorded to the nearest tenth of a unit.

10. DESTINATION - This is the measurement point to which the material was transferred. It is also coded with an (R) when material is recycled.

11. BATCH LISTING - Below the lot heading, each batch number and all detail, Items 2 through 10, are recorded.

12. LOT TOTALS - The quantities received and transferred are summed for all the batches in the lot. These totals are subdivided into the "received from" points for quantity received and "destination" points for quantity transferred and by (P) or (F) codes.

13. CUMULATIVE TOTALS

Subtotals - This section consists of the summations of the lot totals by subtotals for preliminary and final results and by each "received from" measurement point and "destination" point.

Grand Total - This is the total of all receipts and removals for all the batches listed on the report.

14. BEGINNING BALANCE - This balance is the Ending Balance from the previous lot not requested on the report. Each time a report is requested, the lot numbers are provided. The program then calculates the previous Ending Balance and enters this quantity in Beginning Balance for the report being generated. This Beginning Balance is not always the same unless it is based on all final results. Each time, it may be different depending on the status of the preliminary values used. For this reason, the status code (P) or (F) is shown for the Beginning Balance to advise the user accordingly.

15. ENDING BALANCE - The Ending Balance is the difference between the Beginning Inventory plus receipts, less the quantity transferred.

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4.3.3 Summary Report

The Summary Report is a report for each measurement point similar to the Accounting Report, except that the Summary Report shows lot totals without individual batch details. Other sections not required are:

1. Batch Number
2. After-Sample Measurement Date
3. Sample Log Number
4. Uranium Concentration - Mg U/g

The Beginning Balance in a Summary Report is the same as for the corresponding point in the Accounting Report. The lot totals are provided in the same manner, based on "received from" points and "destination" points for receipts and transfers respectively. The appropriate (P) or (F) code is shown for each line entry.

The only difference is that the individual batches are not listed or shown on the Summary Report. All of the lots on record for the inventory interval are reported unless otherwise specified.

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4.3.4 Material Balance Report

The Material Balance Report (MBR) is primarily a consolidated report of the Accounting Reports for the four measurement points. However, the Material Balance Report does not include the quantities recycled (rerouted back into the process from output points) in the output totals when calculating the Ending Balance.

The Material Balance Report is formulated as follows:

1. A beginning balance is entered from inventory reports by NMC via the terminal, and stored in the program for use as needed.

2. The input accountability point (2-003) derives the quantities as calculated and summarized from the Summary Reports for the quantity received. These received subtotals provided in the Summary Reports are the same used in the MBR.

3. The output points also derive the quantities as obtained in the summary reports. Since some of the batches at output points are of a recycled (R) category, these are not output quantities for the MBR. The (R) batches are included in the detail section of the report, and are shown as (R) in the CODE column. The totals recorded in the MBR section, however, do not have these (R) quantities included.

The detail format for the Materials Balance Report is provided in Figure 4-2. Column headings and contents are described in the text that follows.

1. REPORT PERIOD - is operator selectable in two different ways as follows:
    1) Beginning and ending date
    2) Beginning and ending inventory period number
2. DATE OF REPORT - is the time of year the report was prepared.
3. FROM and TO - are the points from which the material was received as input, and the destination points for the output. Reports are summarized for each "To" and "From" within an input or output point.

4. CODE - is the standard (P) and (F) for preliminary or final, and (R) for recycle. Each of the "To" and "From" points are also subdivided for this status. All totals and details are always coded by (P), (F), or (R) to advise the user accordingly.

5. DETAIL - this column shows the volumes and quantities.

6. MBR - this column shows volumes and quantities as totals of the detail columns.

7. BEGINNING INVENTORY - is the starting quantity for the MBR interval.

8. INPUT - in this section, the lots and batches are included within the report. Since lots and batches are sequentially numbered, only inclusive numbers need be shown (for example, Lot 1, Batch 20 through Lot 4, Batch 66). The total input is the summation of all the "From" points and (P) and (F) status. If any (P) status are shown, then the total is (P).

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NUCLEAR MATERIAL ACCOUNTING
MATERIAL BALANCE REPORT FOR PERIOD _____

DATE OF REPORT __________

			DETAIL			MBR		
	FROM/TO	CODE	LITERS	Kg.SOL.	Kg U	LITERS	Kg.SOL.	Kg U
BEGINNING INVENTORY								XX.XXX
INPUT								
2-003 ACCT TANK								
LOTS 1-1 THRU 6-62	XX	P	XXX.X	XXX.X	XX.XXX			
	XX	RP	XXX.X	XXX.X	XX.XXX			
2-003 TOTAL FOR MBA			XXX.X	XXX.X	XX.XXX	XXX.X	XXX.X	XX.XXX
OUTPUT								
2-009 PROD SAMPLE TANK								
LOTS 1-3 THRU 4-25	XX	P	XXX.X	XXX.X	XX.XXX			
2-009 TOTAL FOR MBA			XXX.X	XXX.X	XX.XXX	XXX.X	XXX.X	XX.XXX
2-023 HWW SAMPLE TANK								
LOTS 1-1 THRU 1-3	XX	F	XXX.X	XXX.X	XX.XXX			
2-023 TOTAL FOR MBA			XXX.X	XXX.X	XX.XXX	XXX.X	XXX.X	XX.XXX
2-028 GPW CHECK TANK								
LOTS 1-2 THRU 2-4	XX	RF	XXX.X	XXX.X	XX.XXX			
2-028 TOTAL FOR MBA			XXX.X	XXX.X	XX.XXX	XXX.X	XXX.X	XX.XXX
ENDING BALANCE								XX.XXX

FIGURE 4-2. TYPICAL MATERIALS BALANCE REPORT

9. OUTPUT - This is the same as described in the input for lots and batches. An additional category is shown, which is the "R" for recycle. The total for the MBR, however, does not have the recycle included in it.

10. The ending balance is the difference between the beginning inventory plus the input, less the output.

SECTION V

MEASUREMENT CONTROL PROGRAM

5.1 PROGRAM DESCRIPTION

The Measurement Control Program provides for various checks and comparisons of measurement data to control measurement anomalies prior to acceptance into the base file, for trend and error analysis of stored measurement data, and for propagation of errors into limits of error for material balance calculation. The various checks and comparisons used to ensure reliable data are an integral part of the measurement sequence. These are specifically included in the discussions of measurement sequences. They are presented here for continuity of measurement control discussions. The methods, procedures, and output formats for the trend and error analysis programs are specifically discussed below.

Software development for propagation of errors into limits of error will not be included in the Uranium Input/Output (U I/O) Demonstration Program.

5.1.1 <u>Controlling Measurement Anomalies</u>

Comparisons of measurement data are made to maintain measurement anomalies at a minimum. These comparisons are made at the time of data generation using available measurement data. This allows timely application of these comparisons and associated limits. Notification of indicated problems is provided to initiate supervisor corrective action and ensure proper measurement data are recorded.

The comparisions are applied to minimize measurement anomalies. These comparisons are made at the time of data generation using available measurement data. This allows timely application of these comparisons and associated limits. Notification of indicated problems is provided to initiate supervisory corrective action and ensure proper measurement data are recorded.

The comparisions applied to control measurement anomalies are discussed below. Methods to assign control limits are also presented and levels of action to respond to indicated problems are outlined.

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5.1.2 Specific Comparisions Within an Individual Measurement

Specific instrument comparisions can be made using the data collected for an individual measurement. Timely evaluation of these data and notification to supervision when problems are indicated can indicate instrument or measurement problems. Investigation and corrective actions provide the control of measurement anomalies within individual measurements.

5.1.2.1 Redundant Instrument Comparisions

Specific instrument comparisions are made at the time of measurement where two or more instruments are installed in parallel and are reading the same differential pressure (whether level or density indications). These comparisons are used to flag potential instrument problems. In these cases, the second instrument is considered backup to the primary and comparision is made to the primary.

Example: Ruska and Taylor instruments in parallel reading pressure differential indicating liquid level. The Ruska instrument is considered primary and the Taylor is considered backup.

This comparision consists of:

$$|(\text{Ruska liquid level}) - (\text{Taylor liquid level})| \le \text{control limit}$$

where liquid levels are the calculated liquid levels from the raw instrument readings. It should also be noted that the control limits are specific to the instrument application. They may change from measurement point to measurement point.

5.1.2.2 <u>Process Density to Lab Density Comparisons</u>

Process density to lab density (at 25°C) comparisions are made to provide timely assurances that tank solution is mixed and that both instrument and associated purge lines are functioning satisfactorily. The calculated density from the primary density instruments are compared to the laboratory density result (at 25°C).

Process density is calculated as follows:

$$\text{Process Density} = \frac{(\text{differential pressure across density probes in in. } H_2O^*)}{(\text{probe separation in inches})}$$

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*NOTE: The differential pressure across the density probes may be obtained in two ways depending on instrument hookups. A differential pressure transmitter installed across the two density probes measures the differential pressure directly. A second method uses Ruska instruments to measure differential pressure from the in-tank reference to the high pressure density probe (the same as level measurement) and to measure differential pressure from the in-tank reference probe to the low pressure density probe. The difference between these two measurements is the differential pressure across the density probes.

Process density is now compared to lab density (at 25°C) as follows:

$$|(\text{process density})-(\text{lab density})| \leq \text{control limit}$$

5.1.2.3 <u>Process Density to Process Density</u>

When process density is measured by the second method (Section 5.2.1.2) using Ruska instruments, Taylor determined density from direct measurement of differential pressure across the density probes is also available.

Comparison of these two determinations of density provides an additional check on instrument performance.

The comparison between the two densities is as follows:

$$|(\text{Taylor density}) - (\text{Ruska density})| \leq \text{control limits}$$

5.1.3 Comparisons Between Measurements

During the routine measurement sequences, a number of "remeasurement" situations occur, where a specific quantity of solution is remeasured at a later time and comparison of the two quantities can be made. These may take the form of "Before-Sample" to "After-Sample" measurement comparisons and "After-Transfer" to "Before-Receipt" measurement comparisons (referred to as repeat measurements), or between tank transfer comparisons (referred to as redundant measurements).

Timely application of these comparisons and supervisory review of indicated problems serves to further control measurement anomalies or indicate operational problems which may invalidate measurement problems.

5.1.3.1 Mass of Solution Comparisons - Repeat Measurements

Repeat measurements are provided in "Before-Sample" to "After-Sample" data and "After-Transfer" to "Before-Receipt" data when it is available. The mass of solution is calculated from data associated with each individual measurement. These repeat measurements and associated repeat determinations of solution quantities form the basis of solution comparisons to evaluate measurement system performance.

Comparison of repeat measurements of solution masses involves the following calculations:

(1) Calculation of process density from process instrument data:

$$D = \text{process density} = \frac{\text{(differential pressure in in. } H_2O}{\text{probe separation}}$$

NOTE: In the case of comparison of heel measurements, (AT to BR) solution level may be below density probes and AS measurement of density from previous batch is used for both calculations.

(2) Calculation of "true" liquid level from primary liquid level measurement data:

$$L = \text{liquid level} = \frac{\text{(liquid level differential pressure)}}{\text{process density}}$$

NOTE: Liquid level differential pressure is usually in inches of water.

(3) Calculation of solution mass:

$$M - \text{mass (kg sol)} = \left[a_0 + a_1(L) + a_2(L)^2 + a_3(L)^3 \ldots\right]\left[D\right]$$

where a_0, a_1, a_2, ..., are coefficients of vessel calibration equations.

The comparison of the initial measurement (M_1) and the remeasurement (M_2) is as follows:

$M_1 - M_2 \leq$ control limits.

5.1.3.2 Mass of Solution Comparisons - Redundant Measurements

Redundant measurements are provided when a batch of solution is transferred from one tank to another. Quantities sent are calculated from measurement data of the sending tank. Quantities received are independently measured and calculated in the receiving tank. These redundant measurements and comparisons allow timely review and indication of potential problems with transfer mechanisms/procedures or individual measurement performance.

For the U I/O program, this comparison is only applied in the U Product Sample Tank to Input Accountability Tank Transfer sequence. The specific calculations used in this comparison are provided in the measurement description for the Solution Quantities Transferred/Received (Section 3.2.11).

5.1.4 Establishing Control Limits

For each type of measurement comparison, a specific control limit is established at the 0.05 and 0.01 levels of significance. These control limits are based on historical comparison data when available (or are assigned by NMC when data are not available). Data for each comparison are summarized over an inventory period (or a period determined by NMC). By their nature, the comparison data are paired. The differences between the pairs are subjected to statistical analysis to calculate random error variance. This random error variance is the basis for calculation of the specific control limit.

The random error variance estimate for the paired data are calculated by the following formula:

$$s^2 = \frac{n \sum_{i=1}^{n} \left(d_i \right)^2 - \left(\sum_{i=1}^{n} d_i \right)^2}{n(n-1)}$$

where: d_i = difference between original and repeat or replicate measurement i.

n = number of measurements.

$$\bar{d} = \sum_{i=1}^{n} d_i/n$$

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s = standard deviation for the difference between measurements.

$s/\sqrt{2}$ = standard deviation for an individual measurement.

Alternately, the variance may be calculated on a relative basis as follows:

$$\hat{\gamma}^2 = \frac{n \sum_{i=1}^{n} \left(d_{ri}\right)^2 - \left(\sum_{i=1}^{n} d_{ri}\right)^2}{n(n-1)}$$

where: d_{ri} = relative difference between original (O) and replicate (R) measure i.

$$d_{ri} = \frac{O_i - R_i}{(O_i + R_i)/2}$$

n = number of measurements.

$\hat{\gamma}$ = coefficient of variation for the difference between two measurements.

$\bar{d}_r = \sum_{i=1}^{n} d_{ri}/n$

$\hat{\gamma}/\sqrt{2}$ = coefficient of variation for an individual measurement.

After calculation of the applicable s or $\hat{\gamma}$, a confidence interval of $\bar{d} \pm 3s$ (or $\bar{d}_r \pm 3\hat{\gamma}$) is established. A comparison of each d_i or d_{ri} is made to the appropriate interval. Any d_i or d_{ri} that exceeds the limit is "flagged." If any "flags" are encountered, the appropriate statistics are recalculated excluding the "flagged" value and the interval recalculated. Remaining d_i or d_{ri} quantities are compared. This iterative process is applied until all remaining d_i or d_{ri} fall within the confidence interval.

Control limits are then set at 0.05 and 0.01 levels of significance corresponding to 2 and 3 times the final calculated standard deviation or coefficient of variation. This calculation is applied to historical data for each of the measurement comparisons detailed above at the end of an inventory period. The resulting control limits are used during the subsequent period for measurement comparisons. Specific control limits and calculation parameters are identified in Section 5.2.5.

5.1.5 Response Levels of Action

The above calculated control limits are applied to measurement data as they are generated to effect timely review and indication of potential problems. This allows supervisory review and timely corrective action when required to control measurement anomalies.

Specific applications of the various measurement comparisons detailed above are included in discussions of measurement sequences, when control limits at the 0.05 and 0.01 levels of significance alarm and corrective action may be indicated. The specific responses to alarms are detailed in measurement sequences. They are specific for each type of comparison. The level of response depend on the importance of the measurement to NMC calculations. For example, an instrument comparison between a Ruska and a Taylor that is outside the established control limit may result in a calibration request for the Taylor. However, a before and after-sample measurement comparison that is outside the control limit would require a remeasurement or other corrective action.

For each measurement comparison, the difference (d_i or d_{ri}) is calculated and compared to the applicable control limit.

1. If d_i or $d_{ri} \leq$ control limit at 0.05 level of significance, data are acceptable and stored in appropriate file.

2. If d_i or $d_{ri} >$ control limit at 0.05 level of significance but $\leq$ control limit at 0.01 level of significance, data are acceptable for storage into the appropriate file. However, the measurement is flagged and a message is printed to the NMC office and to the Operations output terminal.

3. If consecutive d_i or d_{ri} exceed control limits of 0.05 level of significance; or

4. If d_i or d_{ri} exceed control limits at the 0.01 level of significance, the measurement data are not acceptable for use in the materials control and accounting program. A message is printed to the NMC office and to the Operations output terminal. These out of control situations may require immediate corrective action depending on importance to NMC measurements.

The specific options for supervisor response and corrective action are detailed in measurement sequences. The level of response is dependent upon the type of comparison and the importance of the measurement with respect to NMC calculations. In general, three levels of response can be identified for measurement comparison:

1. The first level corresponds to data being acceptable. No action is required and measurement sequences continue.

2. At the second level of response, a problem is indicated. The problem, in relation to importance in nuclear material control calculations, is of a minor nature. It does not directly impact measurement performance but warrants attention in future comparisons. This level of response provides notification to the NMC office and to Operations similar to the following:

   MESSAGE FOR TANK ___ BATCH_____ DATE_____ TIME_____
   __(Type of Comparison)____ IS MARGINAL.

   The message is followed by the instrument or calculation discrepancy to be investegated. Further operator response is not required. The measurement sequences continue.

3. The third level of response results when a problem that impacts nuclear material control has been detected. Notification is provided to the NMC office and to Operations as follows:

MESSAGE FOR TANK_____ BATCH_____ DATE_____ TIME_____

__(Type of Comparison)___ COMPARISON IS OUT-OF-LIMITS.

The message is followed by the instrument or calculation discrepancy to be investigated.

The message to Operations includes blank space for the supervisor to document his finding and report corrective action to NMC. He must investigate and resolve the discrepancy in the comparison prior to restarting the sequence. Restart requires supervisor initials and nonprinting code. The measurement sequences may not proceed until resolution of the out of control comparison is accomplished by remeasurement, resample, etc.

5.1.6 Measurement Control Summary Output Reports

Summary reports of measurement control activities are required on a routine basis to (1) allow assessment of measurement performance, (2) establish control limits for the measurement comparisons, and (3) generate applicable random error estimates for application to limits of error calculations. Each of the output summaries programs include protection codes to allow access by NMC only. Each of the programs allows summaries to be generated by (1) date or series of dates, (2) batch numbers or series of batch numbers, (3) lot numbers, or (4) entire summary of inventory period. The output is structured to allow batchwise listings in the summary or allow summary totals only.

These output summaries repeat the measurement control comparisons performed during solution measurement. This must be accomplished to establish control limits. Most of the summaries also recalculate the same comparisons and additional comparisons using additional measurement data not available at the initial measurement. This allows review and evaluation of measurement performance and estimates of random error components.

5.2 MEASUREMENT CONTROL PROGRAM DETAIL

The Measurement Control Program routines compare measurements which are printed in a report (Figures 5-1, 5-2, and 5-3) on user request. The measurements compared are made by different instruments or replicate measurements by the same instrument. The user may request measurement comparisons for (1) a single Batch, (2) a group of Batches, or (3) a specific date(s).

There are six types of measurement comparisons performed.

Instrument Comparisons - Compare two or more instruments which are reading the same pressure.

Liquid Level Comparisons - Level versus density probe. Liquid level may be computed from the level probe or from the density probe in a tank.

Mass of Solution Comparisons - Replicate pressure readings from the same tank at two different times in the process are used to compute mass of solution.

Process Density to Lab Density Comparisons - Density may be calculated from either tank sensors or a sample in the Lab.

<u>Process Density to Process Density Comparisons</u> - Process density may be computed from differential pressure between level and density probes, or between level probe and reference and density probe and reference.

<u>Mass of Solution Transferred to Mass of Solution Received Comparisons</u> - When an MBA transfer occurs, the mass of solution for an input Batch may be compared to the mass of the corresponding product Batch.

5.2.1 User Communication Syntax for Measurement Comparisons

In order to initiate the Measurement Control Program, the user must LOG into account 1,50 and then type "RUN MEACON" on the terminal. The following dialog presents the user communication syntax for enabling the comparison routines.

QUESTION #1: REPORT TYPES ARE: LV = LEVEL
DN = DENSITY
RP = REPLICATE
PI = PRODUCT TO INPUT
UC = U CONCENTRATION
CARRIAGE RETURN = END OF REPORTS
ENTER REPORT TYPE?

RESPONSE: User enters one of the five valid codes listed above or a <CR> to end program.

QUESTION #2: (For LV, DN, or RP reports only)

ENTER TANK ID OR 'ALL'?

RESPONSE: User enters the five-digit measurement point ID of the tank for which comparisons are desired or the 'ALL' command if comparisons are desired on all tanks.

QUESTION #3: ENTER BEGINNING BATCH NUMBER?

RESPONSE: User enters Batch number of the first Batch for which comparisons are desired (must be a valid Batch number).

QUESTION #4: ENTER ENDING BATCH NUMBER?

RESPONSE: User enters Batch number of the last Batch for which comparisons are desired (must be a valid Batch number).

QUESTION #5: ENTER EXTREME VALUE?

RESPONSE: User enters the extreme value of the comparison being made. If the calculated comparison is greater than this value, the comparison will be excluded from the comparison summary.

The program now cycles back to QUESTION #1.

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(NAME OF TANK) TANK DENSITY COMPARISONS
SUMMARY REPORT
FOR (Range of Report)

Batch No.	Before-Sample						After-Sample			
	Rus To Tay	Lab at T To Rus	Lab at T To Tay	Lab Den. at 25	Lab Den. To Tay	Lab at 25 to Rus	Lab at 25 To Tay	Lab at T To Rus	Lab at T To Tay	Rus To Tay

The following items are printed under these headings.

C_3 for BS	C_4 for BS	C_5 for BS	D_L at 25	D_L at T	C_1 for AS	C_2 for AS	C_4 for AS	C_5 for AS	C_3 for AS
x.xxxx	x.xxxx	x.xxxx	x.xxxx	x.xxxx	x.xxxx	x.xxxx	x.xxxx	x.xxxx	x.xxxx

Summary statistics are provided for each of the comparisons.

N =	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
Avg diff=	x.xxxx	x.xxxx	x.xxxx	x.xxxx	x.xxxx	x.xxxx	x.xxxx	x.xxxx
S_{diff} =	x xxxx	x.xxxx	x.xxxx	x.xxxx	x.xxxx	x.xxxx	x.xxxx	x.xxxx

FIGURE 5-1. DENSITY COMPARISONS
(TYPICAL REPORT)

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(NAME OF TANK) TANK REPEAT MEASUREMENTS
SUMMARY REPORT
FOR (Range of Report)

Batch No.	Process Control				Accountability			
	AT to BR		BS to AS		AT to BR		BS to AS	
	Kg Sol	AT-BR	Kg Sol	BS-AS	Kg Sol	BS-AS	Kg Sol	BS-AS

The following items are printed under these headings.

W_{PC} at AT	C_1	W_{PC} at BS	C_2	W_A at AT	C_3	W_A at BS	C_4
xxxx.x	xx.x	xxxx.x	xx.x	xxxx.x	xx.x	xxxx.x	xx.x

Summary statistics are provided for each of the comparisons.

N =	xxx	xxx	N =	xxx	xxx
Avg diff =	xx.x	xx.x	Avg diff =	xx.x	xx.x
S_{diff} =	xx.xx	xx.xx	S_{diff} =	xx.xx	xx.xx

FIGURE 5-2. REPEAT MEASUREMENTS

(TYPICAL REPORT)

(NAME OF TANK) TANK LEVEL COMPARISONS
SUMMARY REPORT
FOR (Range of Report)

Batch No.	Before Receipt			Before Sample			After Sample			After Transfer		
	Ruska Level cm.	Rus(1)-Tay cm.	TJR-TI °C	Ruska Level cm.	Rus(1)-Tay cm.	TJR-TI °C	Ruska Level cm.	Rus(1)-Tay cm.	TJR-TI °C	Ruska Level cm.	Rus(1)-Tay cm.	TJR-TI °C

The following items are printed (BR = Before Receipt, BS = Before-Sample, AS = After-Sample, AT = After-Transfer)

$BR-L_{R1}$	$BR-C_1$	$BR-C_2$	$BS-L_{R1}$	$BS-C_1$	$BS-C_2$	$AS-L_{R1}$	$AS-C_1$	$AS-C_2$	$AT-L_{R1}$	$AT-C_1$	$AT-C_2$
xxx.xx	xx.xx	xx.xx	xxx.xx	xx.xx	xx.xx	xxx.xx	xx.xx	xx.xx	xxx.xx	xx.xx	xx.xx

Summaries are provided for Before Sample and After Transfer Data Only.

Summaries:

N =	xxx	xxx	N =	xx	xx
Avg diff =	xx.xx	xx.xx	Avg diff =	xx.xx	xx.xx
S_{diff} =	xx.xx	xx.xx	S_{diff} =	xx.xx	xx.xx

FIGURE 5-3. LEVEL COMPARISONS
(TYPICAL REPORT)

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Response to #3 - DN

Question: PROCESS OR PROCESS/LAB

Response: PR for process density/process density comparisons

PL for process density/lab density comparisons

NEXT QUESTION: END OF DIALOGUE

5.2.2 Measurement Program Operation

The measurement program calculates the requested information with reference to the Raw Data File and Analytical Data File. Standard deviation S is calculated according to the formula:

$$S = \sqrt{\frac{n \sum_{i=1}^{n} d_i^2 - \sum_{i=1}^{n} d_i^2}{n(n-1)}}$$

where: n = number of measurements

d_i is calcuated according to the type of comparisons being made.

5.2.2.1 Instrument to Instrument Comparison

This comparison consists of:

$$d_i = \frac{P_1 - P_2}{P_1}$$

where: P_1 = net pressure differential of primary pressure measurement.

P_2 = net pressure differential of secondary pressure measurement.

for P_1 and P_2 see the following references:

INPUT TANK	Section 3.2.13 (a)(c)
PRODUCT TANK	Section 3.3.13 (a)
GPW TANK	Section 3.4.8 (a)(b)
HWW TANK	Section 3.4.8 (a)(b)

5.2.2.2 Liquid Level Comparisons

$$d_i = \left| LL - (DL + K) \right|$$

$$LL = \frac{(P_1)\ K}{P_1 - P_2}$$

$$DL = \frac{P_2\ K}{(P_1 - P_2)}$$

where: LL, DL = liquid level using bottom level probe and density probe, respectively.

P_1, P_2 = differential pressure between reference probe and the level and density probes, respectively.

K = probe separation.

For details of LL, DL, P_1, P_2, and K see the following references:

INPUT TANK	Section 3.2.3 (d)(e)
PRODUCT TANK	Section 3.3.2, 3.3.1 (i)

5.2.2.3 Mass of Solution Comparisons

$$d_i = M_1 - M_2$$

$$M_1 = \left[a_0 + a_1\left(\frac{P_1}{D_1}\right) + a_2\left(\frac{P_1}{D_1}\right)^2 + a_3\left(\frac{P_1}{D_1}\right)^3\right]\left[D_1\right]$$

$$M_2 = \left[\acute{a}_0 + \acute{a}_1\left(\frac{P_2}{D_2}\right) + \acute{a}_2\left(\frac{P_2}{D_2}\right)^2 + \acute{a}_3\left(\frac{P_2}{D_2}\right)^3\right]\left[D_2\right]$$

$$M_1 - M_2 = a_1(P_1 - P_2) + a_2\left(\frac{P_1^2}{D_1} - \frac{P_2^2}{D_2}\right) + a_3\left(\frac{P_1^3}{D_1^2} - \frac{P_2^3}{D_2^2}\right)$$

where:

M_1 = mass of solution for first measurement.

M_2 = mass of solution for second measurement.

a_0, a_1, a_2, a_3 = coefficients from vessel calibration equation.

P_1, P_2 = net pressure reading for the first and second measurements, respectively (i.e., adjusted for zero reading).

D_1, D_2 = lab density at 25°C connected to the corresponding density at tank temperature for the first and second measurements, respectively.

For details see the following references:

INPUT TANK - Section 3.2.7, 3.1, 3.2.13 (j) (k)

PRODUCT TANK - Section 3.3.7, 3.1, 3.3.13 (h)

WASTE TANKS - Section 3.4.2, 3.4.8 (d)

5.2.2.4 Process Density to Lab Density

Lab density at 25°C is connected to corresponding density at tank temperature according to the equations given in Section 2.5. The process density is compared to lab density as follows:

$$d_i = \left(\frac{D_T - PD}{D_T}\right) 100$$

where: D_T = lab density at tank temperature

PD - process density

Process density is calculated as follows:

$$(1)\quad P\,D = \frac{P_1 - P_2}{K}$$

where: PD = process density

P_1 = pressure reading-level to reference probe.

P_2 = pressure reading-density to reference probe.

K = probe separation

or

$$(2)\quad P\,D = \frac{P_3}{K}$$

where: P_3 = pressure reading between level and density probes.

K = probe separation.

For details see the following references:

INPUT TANK - Section 3.2.13 f, g

PRODUCT TANK - Section 3.3.13 e, f

5.2.2.5 Process Density to Process Density Calculation

$$d_i = \left| PD_1 - PD_2 \right|$$

$$PD_1 = \frac{P_1}{K}$$

$$PD_2 = \frac{(P_2 - P_3)}{K}$$

where: PD_1, PD_2 = process desnity from Taylor and Ruska, respectively.

P_1, P_2, P_3 = differential pressure reading from the three instruments

K = probe separation

For details see the following references:

INPUT TANK - Section 3.2.13 e

PRODUCT TANK - Section 3.3.13 d

WASTE TANKS - Section 3.4.8 b

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5.2.2.6 Mass of Solution Transferred to Mass of Solution Received

$$d_i = m_1 - m_2$$

The mass (m_1) of solution transferred and the mass (m_2) of solution received are calculated as follows:

$$m_1 = \left[a_0 + a_1\left(\frac{P_1}{D_1}\right) + a_2\left(\frac{P_1}{D_1}\right)^2 + a_3\left(\frac{P_1}{D_1}\right)^3\right]\left[D_1\right]$$

$$m_2 = \left[a_0{}^1 + a_1{}^1\left(\frac{P_2}{D_2}\right) + a_2{}^1\left(\frac{P_2}{D_2}\right)^2 + a_3{}^1\left(\frac{P_2}{D_2}\right)^3\right]\left[D_2\right]$$

where: m_1 + m_2 are the respective kgs solution

$a_0, a_1, a_2, a_3,$

$a_0{}^1, a_1{}^1, a_2{}^1, a_3{}^1$ = the respective volume calibration coefficients

P_1, P_2 = the respective net pressure readings

D_1, D_2 = the respective lab densities converted to densities at tank temperature

For details see the following references:

INPUT TANK - Section 3.2.11 c

PRODUCT TANK - Section 3.3.11 d

SECTION VI
MISCELLANEOUS PROGRAMS

6.1 LDS DRIVER/FILE UPDATE PROGRAM

The LDS Driver/File Update Program is the interface between the CNMCAS systems and the Lab Data system. All communications with the LDS is passed through this program. It retains enough information from each CNMCAS/LDS transaction to update the Data Base with the anlytical results when completed by the lab and marks that Data Base entry final.

Required parameters passed to this program are:

1) Vessel ID number
2) Batch number
3) Message to LDS operator

Return parameters from LDS are:

1) Vessel ID number
2) Batch number
3) Sampling complete indicator
4) Density and acid results

or

1) Vessel ID number
2) Batch number
3) Final results indicator
4) Number of data bytes to follow
5) Analytical results

When the LDS Driver receives a response from the LDS, it decodes the response to determine if it is a sample-complete message or Analytical Batch results. If it is a sample-complete message, the driver passes the Density and Acid results back to the calling program, and enters the Batch and vessel ID into the file update routines queue.

If the response is the Analytical Batch result, the program (1) checks the entry in the file update queue, (2) accesses the analytical data file assigned to that vessel, and (3) enters the analytical results received from LDS. It now accesses the Batch Index file for that vessel, and marks it final.

6.2 RTP DRIVER PROGRAM

The RTP Driver Program is used to interface the CNMCAS programs to the RTP system. It is a queue-driven program, which means that requests for data from the RTP system are logged into a queue and serviced in an orderly fashion to insure data integrity. It services requests on a first-come-first-serve basis. This program is always in execution, but is not using CPU time unless there are active requests for data from the RTP system.

Parameter passed to this program are:

1) Number of transducers to read
2) Transducer ID #1
3) Transducer ID #n
4) The address of a data buffer to put the transducer readings

The RTP driver communicates with the RTP system as if it were a terminal. It puts the terminal in binary mode and sends the request for transducer reads one at a time, waiting for the response before making the next request. When it has retrieved all of the readings that a user has requested, it puts them into the user's data buffer and signals that user that the transaction is complete. It then examines the input queue for any pending requests. If there are more requests, it will service the next one. When the queue is empty, the Driver suspends itself waiting for more activity.

Program Down Load

The RTP Driver Program is built and permanently stored in the CNMCAS system, and is down loaded to the RTP system on command from the RTP system.

6.3 DATA BASE MAINTENANCE PROGRAM

The Data Base Maintenance Program is used to (1) create new Data Bases, and (2) move portions of Data Bases to magnetic tape when their size gets too large. The program is activated by a systems manager, when he wishes to perform one or more of the above functions. He communicates with the program via a system terminal, with dialogue in the form of questions and answers.

When the program is activated when the following message is written to the terminal:

ENTER FUNCTION >

The operator now enters one of the following functions:

FUNCTION NAME	DESCRIPTION
CREATE	This function is used to create a new measurement point Data Base. The program responds with: ENTER MEASUREMENT POINT ID> XX-XXX The operator now enters XX-XXX, identifying the measurement point the new data base is to apply to. The program responds with: ENTER DATA TYPES> R,A,M,E

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FUNCTION NAME	DESCRIPTION
	The operator now enters all of the data types contained in the Data Base. R = RAW A = ANALYTICAL M = MANUAL E = EXPANSION If there are any errors in the above answers, the program recycles and asks that question again.

When all questions have been answered correctly, the program builds the Data Base as defined.

FUNCTION NAME	DESCRIPTION
SAVE	This function is used to save portions of the Data Base System on magnetic tape for historical purposes. The program responds with: ENTER OPTIONS> Data Base name or all The operator enters the unique Data Base name that he wishes to save, or the word ALL if he wants to save the entire Data Base System.

FUNCTION NAME	DESCRIPTION
	The program now responds with: ENTER TYPE> IP,n-m or > DA,DD-MMM-YY/DD-MM-YY If IP is entered, the program saves the inventory periods n through m of the defined Data Base(s). If DA is entered, the program saves the defined Data Base(s) beginning at DD-MMM-YY through DD-MMM-YY batch entry dates. If any errors are detected during entry of the above parameters, the program recycles back to the point of error and allows correction. Having successfully entered all parameters, the program responds with: MOUNT TAPE AND ENTER DRIVE ID> mto: The operator now must mount a clean magnetic tape on a tape drive and enter the drive ID. The program moves all data defined to magnetic tape, and upon completion, performs a read/verify operation or all data that was saved.

FUNCTION NAME	DESCRIPTION
	After the verify function is complete, the program asks the operator if he would like to delete all saved data from the disk. If the answer is yes, the program deletes all saved data and updates the files. Otherwise, it prompts the ENTER FUNCTION again.
NULL	Entry of this function causes the program to terminate.

At the completion of a function execution, the program always recycles to the enter function point.

6.4 DATA BASE EDIT PROGRAM

The Data Base Edit Program is used to edit the master data base, which is the primary source of historical data for the CNMCAS system. The program uses a double-password technique, with a timer running between the two passwords for safeguard. This means that in order to activate the program, the operator must correctly enter the second password within a specified period of time.

The Edit program allows only the quantity of solution in the Raw Data File to be changed. Whenever this entry is changed it is marked with a code indicating it.

The operator communicates with the Edit program through a system terminal. Unique commands will be defined during detail design.

SECTION VII

DATA BASE SYSTEM

7.1 DESCRIPTION

The Data Base for CNMCAS is composed of a collection of files linked together in a hierarchical structure. (See Figure 7-1). Each measurement point has one of these Data Bases. The collection of all measurement point Data Bases is called the Data Base System.

A detailed layout of each file in a data base is shown in Figures 7-2 through 7-6.

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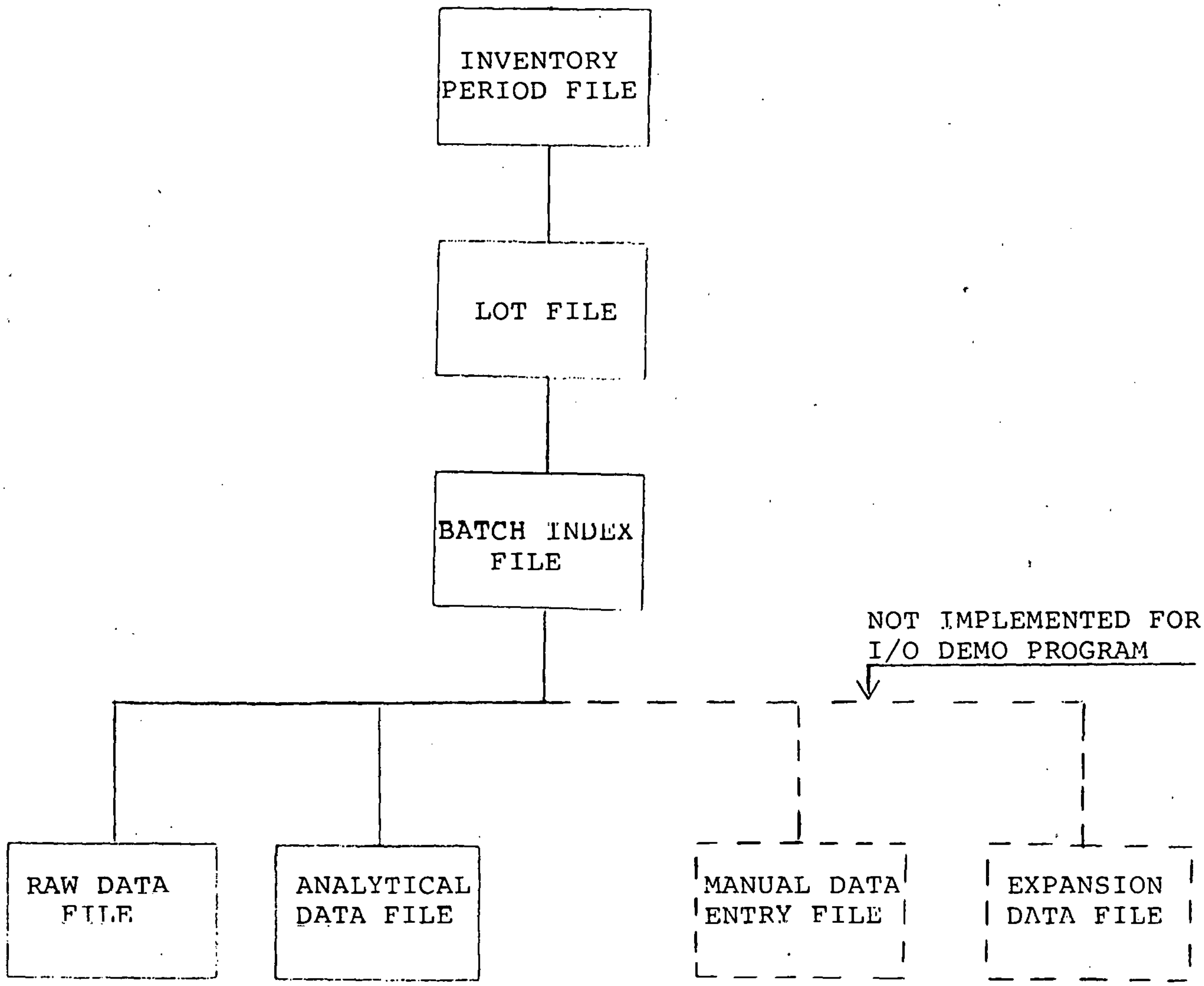

MAXIMUM SIZE - APPROX 941 BLOCKS

% OF RP04 - APPROX .54%

FIGURE 7-1. MEASUREMENT POINT DATA BASE

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7.2 INVENTORY PERIOD INDEX FILE

The Inventory Period Index File is used to associate an inventory period with a collection of lots. This file is managed by the Accounting program. Each entry is created by an operator when he wishes to create an inventory period. Lot numbers for an inventory period need not exist at the time an inventory period is created.

The estimated size of this file for a six-month collection of historical data is approximately 14 disk blocks. Each disk block contains up to 41 entries or inventory periods. There is no maximum size limitation.

Each disk block within the file is structured exactly alike. That is, each contains a ten-word header, followed by up to 41 six-word entries. Since the lot and inventory period numbers are contained in one 16-bit computer word, the maximum value of each is $65536_{(10)}$. This merely means that when the numbers reach that point, the numbers roll over and start with zero again.

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INVENTORY PERIOD INDEX FILE

TOTAL NUMBER OF ENTRIES	HEADER 10 WORDS
ENTRY SIZE	
FILE NAME OF LOT INDEX FILE	
INVENTORY PERIOD NUMBER FIRST LOT NUMBER LAST LOT NUMBER BEGIN INVENTORY QTY KgU P/F	ENTRY 6 WORDS
INVENTORY PERIOD NUMBER FIRST LOT NUMBER LAST LOT NUMBER BEGIN INVENTORY QTY KgU P/F	
≈	
INVENTORY PERIOD NUMBER FIRST LOT NUMBER LAST LOT NUMBER BEGIN INVENTORY QTY KgU P/F	

ENTRIES/BLOCK - 41
SIX MONTH SIZE - 14 BLOCK

FIGURE 7-2. INVENTORY PERIOD INDEX FILE

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7.3 LOT INDEX FILE

The Lot Index File associates a collection of Batches with a Lot number. This file, like the Inventory Period file, is managed by the Accounting program. When the operator wishes to create a Lot, he does it through the Create Lot function in the Accounting program. All limitations correspond to the Inventory Period Index File.

Figure 7-3 shows a detailed layout of the Lot Index File.

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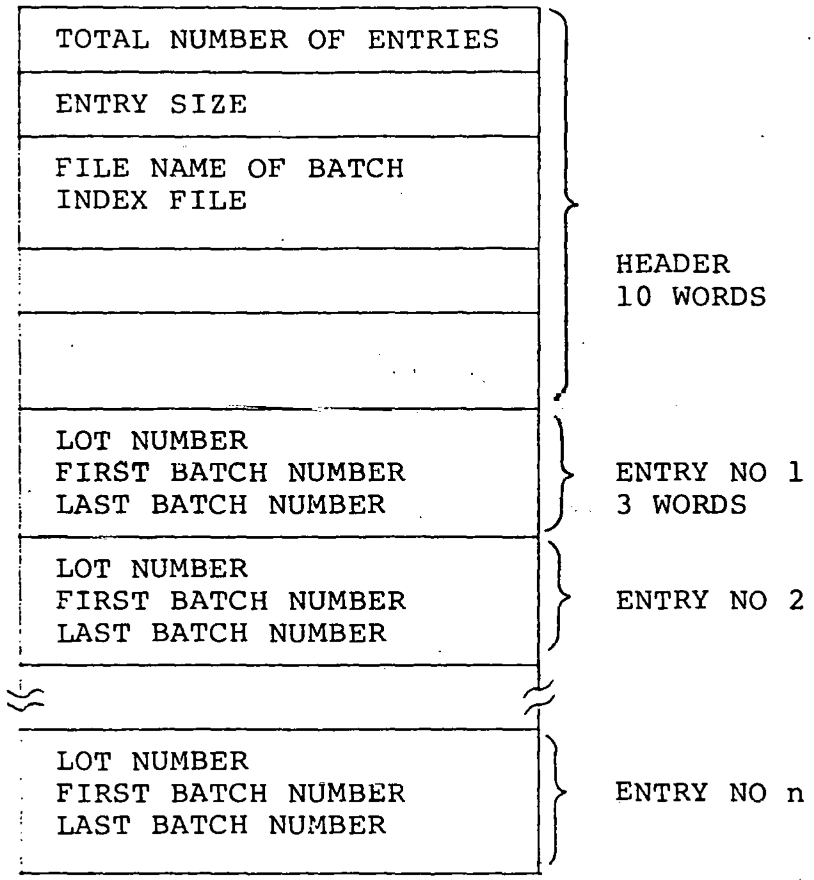

ENTRIES/BLOCK - 82
SIX MONTH SIZE - 14 BLOCKS

FIGURE 7-3. LOT INDEX FILE

7.4 BATCH INDEX FILE

The Batch Index File is the primary file used to record information about a Batch measurement. This file contains such things as the total number of batches currently in the Data Base, identification of the measurement point, and file names of all lower level files. These files are managed by the measurement programs. For every measurement program there is one Batch Index File. Figure 7-4 shows a detailed layout of the Batch Index File.

Each disk block is composed of a 32-word header and up to 7 entries of 32 words each.

This file can identify up to (4) four lower levels or files. There must be at least one lower level file per data base. The Data Base Type Code entry identifies the structure of the lower level files.

HEADER RECORD 32 WORDS

TOTAL NUMBER OF ENTRIES	
FILE TYPE CODE	ENTRY SIZE
MEASUREMENT POINT ID	
RAW DATA FILE NAME	
ANALYTICAL DATA FILE NAME	
MANUAL DATA ENTRY FILE NAME	
EXPANSION DATA FILE NAME	

BATCH ENTRY 32 WORDS

NUMBER OF ENTRIES THIS BLOCK	
BATCH NUMBER	
CREATION DATE/TIME	
RECYCLE	P/F
SOURCE OF SOLUTION	
DESTINATION OF SOLUTION	
REL BLK NO IN RAW DATA FILE	
REL BLK NO IN ANAL DATA FILE	
REL BLK NO IN MAN DATA FILE	
REL BLK NO IN EXP DATA FILE	

ENTRIES/BLOCK - 7
SIX MONTH SIZE - 103 BLOCKS

FIGURE 7-4. BATCH INDEX FILE

7.5 RAW DATA FILE

The Raw Data File is used to store raw data taken during the execution of a measurement program. The data is normally that data acquired from the RTP system. Each entry in the file contains the information about one batch.

Each entry contains six elements, and each element contains four items. (See Figure 7-5.) These items are in the order that the measurement programs acquire them. Any item not required by a given measurement program is left null, indicating it is not used. This structure allows the applications program to access and use the raw data, treating all raw data measurement data the same.

All data stored in the Raw Data File is single-precision, floating-point with the exception of the Time/Date and Batch number.

BATCH NUMBER		
TIME/DATE	BR	
TIME/DATE	BS	
TIME/DATE	AS	
TIME/DATE	AT	
LEVEL READING	BR	
LEVEL READING	BS	
LEVEL READING	AS	
LEVEL READING	AT	
DENSITY READING		
DENSITY READING		
DENSITY READING		
DENSITY READING		
TEMPERATURE READING		
TEMPERATURE READING		
TEMPERATURE READING		
TEMPERATURE READING		
QUANTITY OF SOLUTION		C
QUANTITY OF SOLUTION		C
QUANTITY OF SOLUTION		C
QUANTITY OF SOLUTION		C

BATCH ENTRY
128 WORDS

ENTRIES/BLOCK - 2
SIX-MONTH SIZE - 540 BLOCKS

C = ENTRY HAS BEEN MANUALLY CHANGED

FIGURE 7-5. RAW DATA FILE

7.6 ANALYTICAL DATA FILE

The Analytical Data File is used to store the analytical data received from the LDS. It is managed by the measurement programs. The LDS Driver program accesses this file in a background mode to complete the insertion of analytical data to the file. The detailed layout of each entry in this file is shown in Figure 7-6.

BATCH NUMBER		
LAB SAMPLE LOG NUMBER		
DENSITY		
TEMP		
ACID		
U CONCENTRATION #1	PRIMARY	M
U CONCENTRATION #2	PRIMARY	M
U CONCENTRATION #1	BACKUP	M
U CONCENTRATION #2	BACKUP	M
U ISOTOPIC RESULTS #1		
U ISOTOPIC RESULTS #2		
U ISOTOPIC RESULTS #3		
U ISOTOPIC RESULTS #4		
ENTRY TIME/DATE		

BATCH ENTRY
64 WORDS

ENTRIES/BLOCK - 4
SIX MONTH SIZE - 270 BLOCKS
M = METHOD USED = U-VI
U-VP
U-F
U-MSID

FIGURE 7-6. ANALYTICAL DATA FILE

SECTION VIII

PROJECT IMPLEMENTATION PLAN

Implementation of the I/O Demo Program and RTP System will require approximately 18 calendar weeks, as seen on the Implementation Schedule, Figure 8-1.

In order to achieve this schedule, it will require the project to be staffed with up to 7 people during this period.

We believe this is a realistic schedule based on the systems as we know them at the present time.

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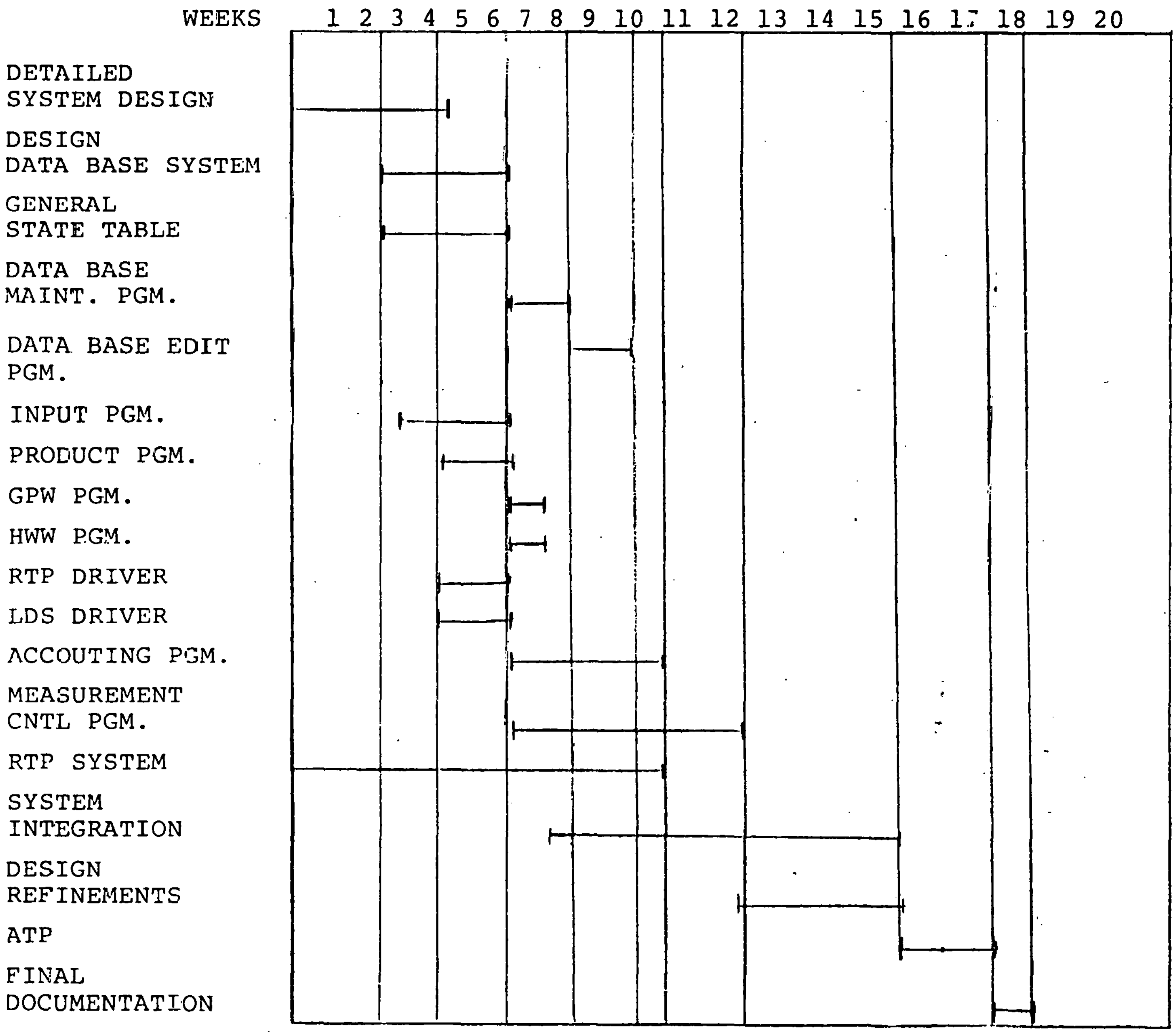

FIGURE 8-1. IMPLEMENTATION SCHEDULE

SECTION IX

DELIVERABLE ITEMS

Scientific Systems Services, Inc. intends to supply the following items with the Uranium Input/Output Demonstration Software:

- Program Source Listings
- Source Code on Disc
- Object/Load Modules on Disc
- Program Documentation (flow diagrams, write-ups)
- Operational Instruction Manual
- Acceptance Test Procedure (ATP)

All of the above items will be delivered at the conclusion of the software effort except for the Acceptance Test Procedure. It will be written and submitted to AGNS for approval sometime before completion of the project. After AGNS has ratified the ATP procedure, an ATP demonstration will be scheduled and performed at the end of the checkout phase.

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REPORT NO. AGNS-1040-2.2-9

COMPUTERIZED NUCLEAR MATERIALS CONTROL AND ACCOUNTING SYSTEM DEVELOPMENT EVALUATION REPORT -1978

APPENDIX D

RTP DATA ACQUISITION SYSTEM SOFTWARE SPECIFICATIONS

Prepared by:
Scientific Systems Services

October 1978

Allied-General Nuclear Services
Post Office Box 847
Barnwell, South Carolina 29812

CONTROL-SPEC ®

FOR THE

DATA ACQUISITION SYSTEM (RTP) PROGRAM

Prepared for: Allied-General Nuclear Services
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Barnwell, South Carolina 29812

Prepared by: Scientific Systems Services, Inc.
1135 John Rodes Boulevard
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Melbourne, Florida 32901

Date: October 12, 1978

Document: 1155-101B

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DEFINITIONS

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DEFINITIONS

Point (N): A number N, $0 \le N \le 1023$ uniquely specifying an analog input channel of the WRAIS

Sample (S_N): A sample (Raw Data) Input from point N

A 16-bit 2s complement number:

$-16384 \le S < 16384$

Reading (R_N) : A raw data reading of point N. Defined

as $R_N = \sum_{i=1}^{SC_N} Si/SC_N$

where: SC is the sample count.

R is a 16 bit 2's complement number: $-16384 \le R < 16384$

(For single sample readings, SC=1 and $R_N \equiv S_N$

Raw Voltage Reading (RV_N): Raw Voltage Reading of point N. A floating point number representing a reading of point N in millivolts.

Calculated as: (R_N) X (Gain Table Entry for point N)

Calibrated Voltage Reading (CV_N): Calibrated Voltage Reading of point N.

Calculated as: $CV_N = LIF\ (RV_N, LITP_{GAIN_N})$

Linear Interpolation function LIF $(X, LITP_x)$: Linear Interpolation function of X and pointer. X is a floating point number. $LITP_x$ point to four consecutive floating point numbers: $X_1, Y_1, X_2, Y_2 =$

$$\frac{X - X_1}{X_2 - X_1}\left(Y_2 - Y_1\right) + Y_1$$

Piecewise-Linear Interpolation function: $PLIF(X, PLIT_x) = LIF(X, LITP_{x_i})$

where: $LITP_{x_i}$ points to four consecutive values: $x_i, y_i, x_{i+1}, y_{i+1}$

such that: $x_i \leq X < X_{i+1}$

SECTION I

INTRODUCTION

This CONTROL-SPEC® is written in response to Allied-General Nuclear Services purchase order #A7-5106-00. It provides a complete definition of the Data Acquisition System (RTP) program.

The software described is intended to run on a DEC PDP 11/04 computer system, with Computer Products, Inc.'s Wide Range Analog Input System. All software will be written in DEC assembly language, using the Computerized Nuclear Materials Control and Accounting System (CNMCAS) hardware.

This CONTROL-SPEC® includes the following sections. Section II provides a functional description of the software.

Section III provides a detailed description of the data base.

Section IV provides a description of the deliverable items.

SECTION II

FUNCTIONAL DESCRIPTION

2.1 OVERVIEW

The RTP system is a stand-alone system that constantly monitors up to 1024 transducers connected to it through one or more wide range multiplexers. It is essentially a table driven system in that a set of tables describes all of the transducers, their physical characteristics, and sampling rates.

As the system executes, raw data is stored in memory as a function of the scan mode assigned to each transducer. When the CNMCAS system requests information about a unique transducer, the software retrieves that data from memory, converts it to engineering units, and then sends it to the requestor.

A block diagram of the RTP system hardware is shown in Figure 2-1.

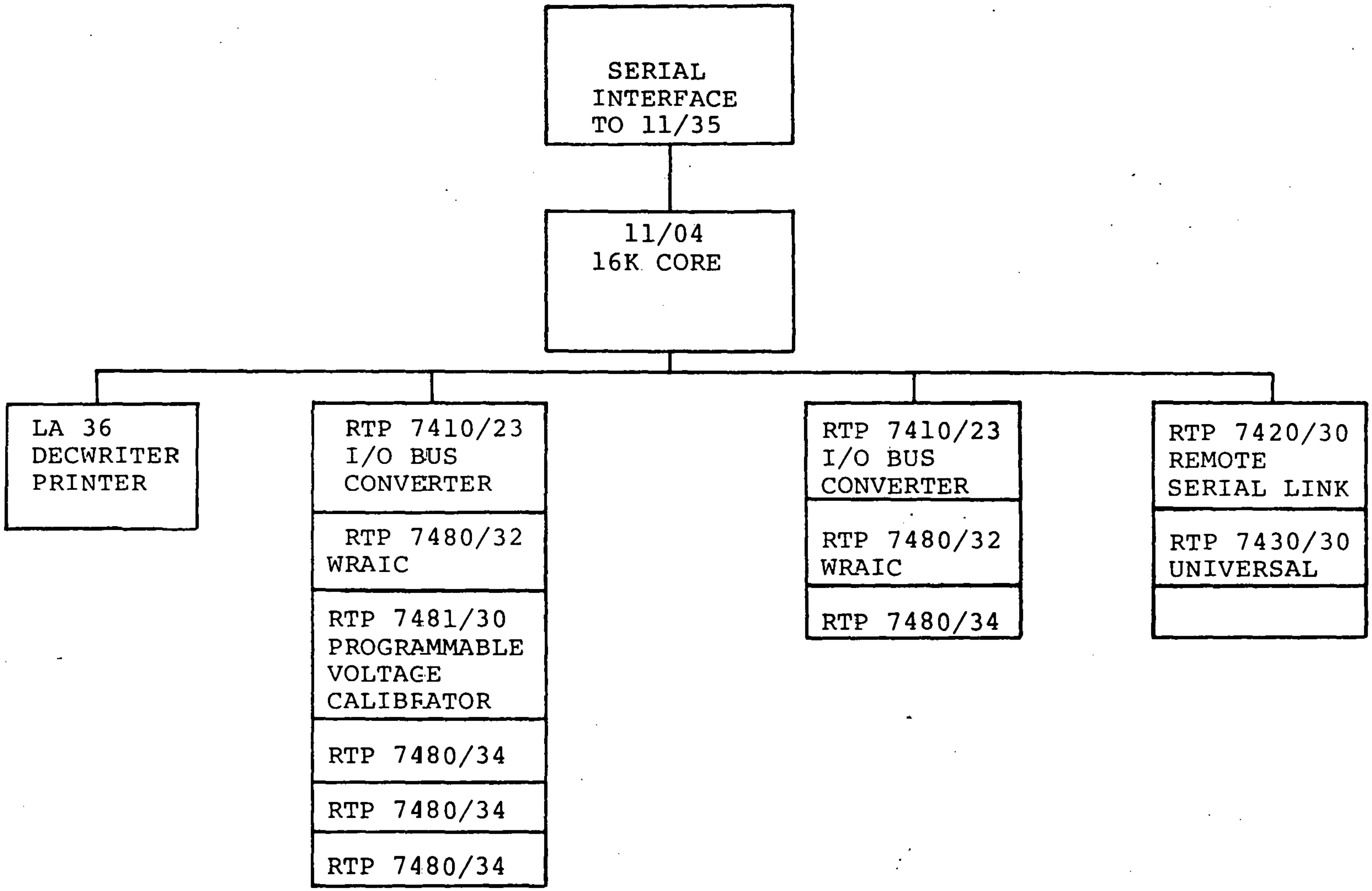

FIGURE 2-1. RTP SYSTEM HARDWARE

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2.2 SYSTEM SOFTWARE LOADING

The RTP software is stored on disc in the CNMCAS system, and downloaded to the RTP system via the serial link. A small bootstrap loader, resident in the 11/04, is activated through the console emulator. The Download program retrieves the load module file from the CNMCAS system disc and sends it to the RTP system. The protocol for sending the load module will be defined in detail during implementation of the RTP system software.

2.3 DATA ACQUISITION

The RTP system will continuously input raw data samples from the Wide Range Analog Input System (WRAIS). Processing of previously read samples may occur while another sample is being taken. Also, samples from different WRAIS controllers may be taken simultaneously.

Each point (see Appendix Definitions) in the system belongs to a unique scan mode, and the subset of points being sampled is defined by the current scan mode.

There are three scan modes which are described in the paragraphs that follow.

Scan Mode 1

Scan Mode 1 is the background scan mode. Samples of points in this mode are continuously input unless a higher scan mode is invoked. The raw data reading (R) of a point in this mode is equivalent to the raw data sample(s).

Scan Modes 2 and 3

Scan modes higher than 1 are invoked periodically, as defined by the priority scan frequency parameter(PSF). This is a value expressed in minutes. Each of these scan modes has a scan interval parameter (SI) expressed in seconds, and a scan time offset (STO) expressed in seconds.

The scan time interval (SI) defines the length of time that the system will continuously input samples of points in that scan mode. A running accumulation of samples, a count of samples (SC), and the highest and lowest sample values are kept for each point in the scan mode.

At the end of the interval SI, the raw data readings (R_N) are computed for each point N in the scan mode as:

$$R_N = \sum_{i=1}^{SC_N} S_i / SC_N$$

For points in Scan Mode 2, the five latest N values of R_N will be held internally for conversion and transmission to CNMCAS on demand.

For points in Scan Mode 3, the three latest values of R_N will be held.

The scan time offset (STO) defines the relative time within the PSF that the scan mode will be invoked.

Figure 2-2 shows the operation of the RTP subsystem on the basis of some typical scan mode parameter values.

Figure 2-3 shows the typical number of samples per reading, on the basis of the number of points in a high level scan mode versus the scan interval (SI) parameter for that mode.

PSF = 4 Minutes

Scan Mode 2: SI = 20 seconds
STO = 0 seconds

Scan Mode 3: SI = 10 seconds
STO = 120 seconds

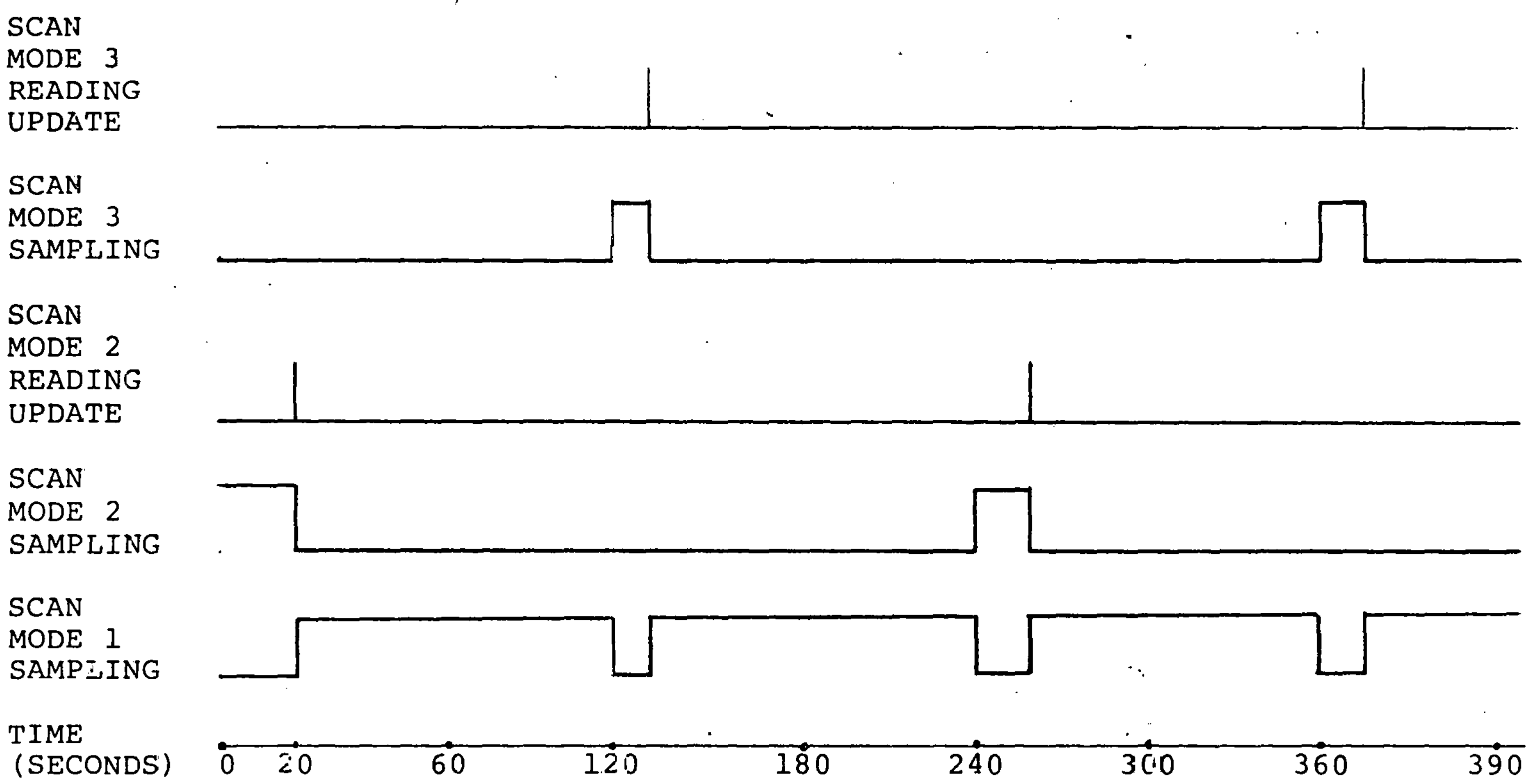

FIGURE 2-2. RTP DATA ACQUISITION FUNCTION WITH TYPICAL SCAN PARAMETERS

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SAMPLES/READING AT 40 SAMPLES/SECOND SCAN INTERVAL
VERSUS NUMBER OF POINTS IN SCAN

NUMBER OF POINTS IN SCAN

SI CAN NTERVAL N SECONDS	5	10	20	30	40	50	60	70	80	90	100
5	40	20	10	6	5	4					
10	80	40	20	13	10	8	6	5	5	4	4
20	160	80	40	26	20	16	13	11	10	8	8
30	240	120	60	40	30	24	20	17	15	13	12

FIGURE 2-3. TYPICAL SAMPLES PER READING

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2.4 DATA CONVERSION

Conversion of raw data readings to engineering units (measurements) takes place when:

1. CNMCAS requests a measurement
2. An alarm limit is being checked

Two classes of transducers may be connected to RTP points: standard instruments and thermocouples.

2.4.1 <u>Conversion of Standard Instrument Readings</u>

Standard instruments are those whose conversion from voltage to engineering units is a linear function or piecewise-linear function. Taylor, Ruska, and Westinghouse pressure transducers and pressure differential transducers fall into this class. Standard instrument samples are input from the RTP as a 15-bit binary number or as a 5-digit Binary Coded Decimal (BCD) number plus sign (21 bits).

The conversion of a reading (R) of point N, connected to a standard instrument into a measurement M, is defined as:

$$M_N = LIF\ (CV_N, LITP_N)\ \text{or}\ PLIF\ (CV_N, PLITP_N)$$

where

$LITP_N$ or $PLITP_N$ is the pointer to the linear or piecewise-linear interpolation table (PLIT) entry associated with point N. (See Definition Appendix for definitions of the LIF and PLIF functions.)

2.4.2 Conversion of Thermocouple Class Readings

Thermocouple class measurements are expressed in degrees Celsius. The range of these measurements is from $0^{o}C$ to $132^{o}C$. They are converted from millivolts using the piecewise-linear interpolation function (PLIF), with a maximum of 16 interpolation points.

Before the conversion from voltage to degrees Celsius can take place, a correction for thermocouple-to-copper junction error is made. This is done by first computing the temperature of the unithermal reference plate (T_{UTR}) in which the junctions occur. (See Section 2.5.) The degrees Celsius reading is converted to millivolts, and this correction is added to the calibrated voltage reading of the thermocouple point.

Symbolically, a temperature measurement, M, of a thermocouple point N in degrees Celsius is:

$$M_N = PLIF(PLIF(T_{UTR}, PLIT_{UTR}) + CV_N, PLIT_N)$$

2.5 UTR PLATE TEMPERATURE COMPUTATION

Each UTR plate has two analog inputs attached to RTP points, D1 and D2. (Refer to CPI document PM 070-052/53B for detailed description of hardware.)

Points D1 and D2 are placed in Scan Mode 1 so that their readings are always current.

A UTR Temperature T_{UTR} is defined as:

$$T_{UTR} = K_1 \left(\frac{CV_{D2}}{CV_{D1}} - K_2 \right) + K_3$$

where

K_1 and K_2 are constants associated with this particular UTR plate, and K_3 is a temperature correction constant.

2.6 AUTOMATIC VOLTAGE CALIBRATION

If a WRAIS includes a programmable voltage calibrator (PVC), raw voltage readings of points are converted to calibrated voltage readings before being converted to measurement (engineering units).

There are 13 consecutive entries in the Linear Interpolation Table (LIT), one for each gain value. Conversion of a raw voltage reading of point n, R_N, into a calibrated voltage reading CV_N is defined as:

$$CV_N = LIF(RV_N, LITP_{GAIN_N})$$

If a WRAIS does not have a PVC:

$$CV_N = RV_N$$

<u>Calibration Data Update Task</u>

Each programmable voltage calibrator has eight analog inputs attached to eight RTP points. These points are not contained in any of the scanning modes.

Periodically, normal scanning is suspended and 26 readings are taken, two for each of the 13 gains (one each at 0.0V and one each at 40% or 80% of full scale). These readings are converted to millivolts held as the Y-values of the calibration entries in the LIT.

The frequency of execution of this task is specified by the Calibration Task Frequency parameter (CTF) in minutes.

2.7 ALARM LIMITS CHECKING AND REPORTING

The Alarm Limits Checking task examines each point in the system. If a point has associated alarm limits, the latest reading is converted to a measurement in engineering units. This measurement is compared to the point's associated alarm limits. If the measurement falls outside these limits, a single line is output to the LA36 printer as follows:

DATE TIME POINT LOW LIMIT HIGH LIMIT MEASUREMENT

where

POINT is the transducer point number (0-1023)

LOW LIMIT, HIGH LIMIT, MEASUREMENT } are expressed in engineering units as an F-format number:

XXX.XXX

where

X is a decimal number with a decimal point.

This task is executed periodically and its frequency is specified by the Alarm Task Frequency parameter, A, expressed in minutes. Alarm limit reporting can be disabled and enabled.

2.8 CNMCAS - RTP COMMUNICATIONS

The purpose of CNMCAS - RTP communications is to allow CNMCAS to obtain the most recent readings on any specified transducer.

The RTP system is always ready to accept a request for information, except when it is in the process of transferring information due to a previous request.

A request for a reading comes from CNMCAS on a 3-word command specifying a function code, a transducer point number, and an instrument type. (See Figure 2-4.)

RTP responds with a 13-word buffer specifying the number of readings, success code, transducer point number, and the requested readings. (See Figure 2-5.) Each reading is a 32-bit, single-precision, floating-point number representing the value of the reading in engineering units associated with that transducer. If multiple readings are requested, they are transmitted in reverse chronological order (for example, the most recent and then the next most recent). An example of CNMCAS - RTP communications is presented in Figure 2-6.

RTP DATA REQUEST FORMAT

WORD 0 (16 Bits)	FUNCTION CODE	
	1 = send most recent reading of a point.	
	2 = send last 2 readings of a point.	
	3 = send last 3 readings of a point.	
	4 = send last 4 readings of a point.	
	5 = send last 5 readings of a point.	
	6 = send all readings outside of alarm limits.	
WORD 1 (16 Bits)	TRANSDUCER POINT NUMBER	
WORD 2 (16 Bits)	INSTRUMENT TYPE	
	0 = Analog	
	1 = Ruska	

FIGURE 2-4. RTP DATA REQUEST FORMAT

RTP RESPONSE FORMAT

WORD 0	(16 Bits)	NUMBER OF GOOD DATA VALUES RETURNED
WORD 1	(16 Bits)	SUCCESS CODE
		Equal to requested function code implies successful
		7 = have sent all points outside alarm limits
		-1 = illegal function code requested
		-2 = illegal transducer point number requested
WORD 2	(16 Bits)	TRANSDUCER POINT NUMBER
WORD 3	(16 Bits)	FLOATING-POINT VALUE (most significant half)
WORD 4	(16 Bits)	FLOATING-POINT VALUE (least significant half)
WORD 5	(16 Bits)	FLOATING-POINT VALUE (most significant half)
WORD 6	(16 Bits)	FLOATING-POINT VALUE (least significant half)
WORD 7	(16 Bits)	FLOATING-POINT VALUE (most significant half)
WORD 8	(16 Bits)	FLOATING-POINT VALUE (least significant half)
WORD 9	(16 Bits)	FLOATING-POINT VALUE (most significant half)
WORD 10	(16 Bits)	FLOATING-POINT VALUE (least significant half)
WORD 11	(16 Bits)	FLOATING-POINT VALUE (most significant half)
WORD 12	(16 Bits)	FLOATING-POINT VALUE (least significant half)

FIGURE 2-5. RTP RESPONSE FORMAT

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EXAMPLE OF CNMCAS-RTP COMMUNICATIONS

CNMCAS Sends:			RTP Sends:		
WORD 0:	2	Request two most recent readings of transducer number 9	WORD 0:	1	Number of good data values
WORD 1:	9		WORD 1:	1	Success code:OK
WORD 2:	0		WORD 2:	9	Transducer number 9
			WORD 3:	XX	Floating-point data value (WORDS 3–4)
			WORD 4:	XX	
			WORD 5:	XX	Floating-point data value (WORDS 5–6)
			WORD 6:	XX	
			WORD 7:	YY	Floating-point representation of 999.99 (WORDS 7–8)
			WORD 8:	YY	
			WORD 9:	YY	
			WORD 10:	YY	
			WORD 11:	YY	
			WORD 12:	YY	

END OF DIALOGUE

ORD 0:	3	Request 3 most recent readings of transducer number 150C	WORD 0:		Number of good data values
ORD 1:	1500		WORD 1:	-2	Success code: Illegal transducer number
ORD 2:	0		WORD 2:	1500	Transducer number 1500
			WORD 5:	YY	Floating-point representation of 999.99 (WORDS 5–6)
			WORD 6:	YY	
			WORD 7:	YY	
			WORD 8:	YY	
			WORD 9:	YY	
			WORD 10:	YY	
			WORD 11:	YY	
			WORD 12:	YY	

END OF DIALOGUE

FIGURE 2-6. EXAMPLE OF CNMCAS-RTP COMMUNICATIONS

2.9 POWER FAIL/RESTORE PROCEDURES

The power fail software logic operates in the following manner. When power is restored after a power failure, the system will reinitialize itself and continue to operate as defined. This obviates down-loading the program from CNMCAS after a power failure affecting the RTP subsystem only.

Reinitialization includes all historical readings of points in scan priorities 2 and 3.

SECTION III

CNMCAS RTP DATA BASE STRUCTURE

The data base is designed to be independent of the software logic, easily changed and expandable.

The data base is divided into two sections (Figure 3-1). The first section contains table pointers and parameter values, which are accessed as an absolute offset from the data base start. The second section contains the tabular information as shown in Figures 3-2 through 3-6. Each table is individually expandable, and contains a variable number of entries. Additional tables and parameters are easily added.

Figure 3-1 shows the general structure of the data base and Figures 3-2 through 3-6 define the entry and data formats of all tables.

CNMCAS AGNS RTP SYSTEM DATA BASE STRUCTURE

(All Table pointers are byte address offsets from the data base start.)

OFFSET	MNEMONIC	
0	GNTP	GNT (Gain Table Pointer)
2	UTRTP	UTRT (Unithermal Ref. Table Pointer)
4	PDTP	PDT (Point Definition Table Pointer)
6	P2TP	P2T (Priority 2 Table Pointer)
10	P3TP	P3T (Priority 3 Table Pointer)
12	LITP	LIT (Linear Interp. Table Pointer
14	PLITP	LIT (Non-Linear Interp. Table Pointer
16	ALTP	ALT (Alarm Table Pointer
20	PSF	Priority Scan Frequency (Seconds)
22	SI2	Priority 2 Scan Time Interval (Seconds)
24	STO2	Priority 2 Time Offset (Seconds)
26	SI3	Priority 3 Time interval (Seconds)
30	STO3	Priority 3 Time Offset (Seconds)
32	MAXP	Largest Point Number
34	ATF	Alarm Task Frequency (Minutes)
36	CTF	Calibrator Task Frequency (Minutes)
40	TOY	Time and Date
		Gain Table
		UTR Table
		PDT Table
		. . .

FIGURE 3-1. CNMCAS AGNS RTP SYSTEM DATA BASE STRUCTURE

GNT: Gain Table

26 words as 13 floating-point numbers, one for each gain range representing a constant which when multiplied by a raw datum gives a reading in millivolts.

UTRT: Unithermal Reference Table

8 words/entry

16 entries maximum

Word 1	PDT Pointer to D_1	
Word 2	PDT Pointer to D_2	
Words 3 & 4	$K_1 = 5500./(R_A-R_C)$	F. P. Number
Words 5 & 6	$K_2 = R_C/100.$	F. P. Number
Word 7	PLIT Pointer (°C→mv)	F. P. Number
Word 8	Unused	

where: R_A and R_C are constants associated with each UTR plate, K_3 =-.045 °C

and temperature of the UTR plate in °C is:

$$T_{UTR} = K_1(CV_{D2}/CV_{D1} - K_2) + K_3$$

FIGURE 3-2. GNT AND UTRT TABLES

PDT: TRANSDUCER POINT DEFINITION TABLE

4 words per entry

Maximum 1024 entries

Position in table implies

WRAIS channel and address

WORD 1

15	14–3	2–0
	INTERPOLATION TABLE ENTRY NO.	SCAN MODE

Bit 15:
- 0 → Bits 3-14 specify entry no. into LIT
- 1 → Bits 3-14 specify entry no. into PLLIT

SCAN MODE:
- 0=null entry
- 1=P1
- 2=P2
- 3=P3
- 4=Calibration

WORD 2

15–6	5–4	3–0
ALT (alarm table) Entry No.	CLASS	TYPE

CLASS:
- 00 Standard Instrument TYPE=instrument type
- 01 TYPE K Thermocouple TYPE=UTRT entry no.
- 10 Calibration Point TYPE=Calibration Scale: 0-7

WORD 3

LAST SAMPLE (RAW DATA)

WORD 4

15–6	5–4	3–0
P1T or P2T Entry No.		GAIN

GAIN: Represents actual Gain Code for WRAIS command and pointer into GNT

FIGURE 3-3. TRANSDUCER POINT DEFINITION TABLE

P2T: PRIORITY 2 TABLE -10 WORDS/ENTRY

P3T: PRIORITY 3 TABLE - 8 WORDS/ENTRY

WORD 1 WORD 2	DOUBLE PRECISION INTEGER SUM OF SAMPLES (S)	
WORD 3	SAMPLE COUNT (SC)	
WORD 4	LO SAMPLE	
WORD 5	HI SAMPLE	
WORD 6	MOST RECENT READING (Σ S/SC)	
WORD 7	2ND MOST RECENT READING	
WORD 8	3RD MOST RECENT READING	
WORD 9	4TH MOST RECENT READING	P2T Only
WORD 10	5TH MOST RECENT READING	P2T Only

FIGURE 3-4. P2T AND P3T TABLES

LIT: LINEAR INTERPOLATION TABLE

8 Words/entry as 2 pairs of floating point numbers

Words 1 + 2: Point 1(X_1) value (millivolts)
Words 3 + 4: Point 1(Y_1) value (EGUs)
Words 5 + 6: Point 2(X_2) value (millivolts)
Words 7 + 8: Point 2(Y_2) value (EGUs)

The first 13 entries of the LIT are calibration correction functions for automatic voltage correction. The Y values are computed by the Calibration task.

	X_1	Y_1	X_2	Y_2
Entry 1	0.0	Gain 1 Reading @0.0	8192.	Gain 1 Reading @8192 mv
2	0.0	Gain 2 Reading @0.0	2048.	Gain 2 Reading @2048 mv
3	0.0	Gain 3 Reading @0.0	2048.	Gain 3 Reading @2048 mv
4	0.0	Gain 4 Reading @0.0	512.	Gain 4 Reading @ 512 mv
5	0.0	Gain 5 Reading @0.0	512.	Gain 5 Reading @ 512 mv
6	0.0	Gain 6 Reading @0.0	128.	Gain 6 Reading @ 128 mv
7	0.0	Gain 7 Reading @0.0	128.	Gain 7 Reading @ 128 mv
8	0.0	Gain 8 Reading @0.0	32.	Gain 8 Reading @ 32 mv
9	0.0	Gain 9 Reading @0.0	32.	Gain 9 Reading @ 32 mv
10	0.0	Gain 10 Reading @0.0	8.	Gain 10 Reading @ 8 mv
11	0.0	Gain 11 Reading @0.0	8.	Gain 11 Reading @ 8 mv
12	0.0	Gain 12 Reading @ 0.0	2.	Gain 12 Reading @ 2 mv
13	0.0	Gain 13 Reading @ 0.0	2.	Gain 13 Reading @ 2 mv

FIGURE 3-5. LINEAR INTERPOLATION TABLE

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PLIT: PIECEWISE-LINEAR INTERPOLATION TABLE

2n Words/entry as M-1 pairs of floating point numbers as per LIT, giving a variable number of linear interpolation pairs, maximum. M=16

ALT: ALARM TABLE

4 Words/entry as 2 floating point values

Words 1 + 2: Low Alarm Value

Words 3 + 4: High Alarm Value

FIGURE 3-6. PLIT AND ALT TABLES

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SECTION IV

DELIVERABLE ITEMS

Scientific Systems Services, Inc. intends to supply the following items with the RTP system software:

- Program Source Listings
- Source Code on Disc
- Object/Load Modules on Disc
- Program Documentation (flow diagrams, write-ups)
- Operational Instruction Manual
- Acceptance Test Procedure (ATP)

All of the above items will be delivered at the conclusion of the software effort except for the Acceptance Test Procedure. It will be written and submitted to AGNS for approval sometime before completion of the project. After AGNS has ratified the ATP procedure, an ATP demonstration will be scheduled and performed at the end of the checkout phase.

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COMPUTERIZED NUCLEAR MATERIALS CONTROL AND ACCOUNTING SYSTEM DEVELOPMENT EVALUATION REPORT - 1978

APPENDIX E

CNMCAS DEVELOPMENT SOFTWARE - FY 1978

Donald Reed
Scientific Systems Services

October 1978

Allied-General Nuclear Services
Post Office Box 847
Barnwell, South Carolina 29812

Appendix E contains listings of the programs and modules developed for the Uranium Input/Output Demonstration Program and RTP system during FY 1978. The listings are presented in the attached tables as follows:

- Table E-1, Measurement Programs and Modules
- Table E-2, Accounting Programs and Modules
- Table E-3, Measurement Control Programs and Modules
- Table E-4, RTP System Programs and Modules
- Table E-5, Miscellaneous Programs.

Information presented in the tables includes program/module name, identifier, and purpose.

TABLE E-1

MEASUREMENT PROGRAMS AND MODULES

	Name	ID	Purpose
1.	Accountability Tank Measurement Program	P02003	Control the measurement process for the Accountability Tank.
2.	Uranium Product Sample Tank Measurement Program	P02009	Control the measurement process for the Uranium Product Sample Tank.
3.	HWW Sample Tank Measurement Program	P02023	Control the measurement process for the HWW Sample Tank.
4.	GPW Check Tank Measurement Program	P02028	Control the measurement process for the GPW Check Tank.
5.	Calculation Module	CALI	Make instrument and solution comparisons, convert RTP readings, calculate liquid level, volume, and solution quantities, initialize batch parameters, mark marginal indicators, and calculate quantities transferred/received for the Accountability and Uranium Product Sample tanks.
6.	Calculation Module	CALW	Make instrument and solution comparisons, convert RTP readings, calculate liquid level, volume, solution quantities transferred/received, initialize batch parameters, and mark marginal indicators for the HWW Sample and GPW Check Tanks.
7.	Initialize Module	INIT	Increment batch number, put time and date into temporary data area, and zero remaining sections of temporary data area.
8.	LDS Module	LDS	Communicate with LDS system to request a lab sample and return results for the Accountability and Uranium Product Sample Tank.
9.	LDS Module	LDSW	Communicate with LDS system to request a lab sample and return results for the HWW Sample and GPW Check Tanks.
10.	Message Module	NONE	Print message to operator and NMC office.

TABLE E-1 (CONTINUED)

MEASUREMENT PROGRAMS AND MODULES

Name	ID	Purpose
11. OP Initials Module	OPI	Get operator's initials and save in temporary data area.
12. Option Module	OPT	Gets one of either two or three options from operator.
13. Password Module	PAS	Gets supervisor's password and checks for validity.
14. Response Module	RES	Get either a YES or NO response from operator.
15. RTP Module	RTP	Communicate with RTP system to get readings of RTP.
16. Ruska Module	RUS	Get numerical data from operator for Ruska zero value.
17. Status Module	STAT	Update STATUS File.
18. Start Module	STRT	Set temporary data area to ones IF the state Pointer is zero. Executed ONLY ONCE to get program started. Removed from task due to memory limitations.
19. Summary Module	SUM	Print batch summary to operator and NMC office and record batch data in data base.
20. Transfer Module	TRN	Determines if transfer was made from Uranium Product Sample Tank to Accountability.
21. Vessel Module	VES	Get Vessel ID of source and destination vessels and check for validity.

TABLE E-2

ACCOUNTING PROGRAMS AND MODULES

Name	ID	Purpose
1. Accounting Main Program	ACCPGI	To define new lot or inventory period, or generate an Accounting, Summary, or Material Balance Report.
2. Lot Definition Subprogram	ACCLOT	To define a new lot.
3. Inventory Definition Subprogram	ACCINV	To define a new inventory period.
4. Accounting Summary Report Subprogram	ACCASR	To provide an Accounting or Summary Report.
5. Material Balance Report Subprogram	ACCMBR	To provide the Material Balance Report.
6. Measurement Point True Subprogram	ACCMPT	To ask the operator for the measurement point and check that it exists.

TABLE E-3

MEASUREMENT CONTROL PROGRAMS AND MODULES

	Name	ID	Purpose
1.	Measurement Control Program	MEACON	Controls execution of Measurement Control Subprograms.
2.	Level Report	LEVEL	Calculates and prints Level Measurement Control Report.
3.	Density Report	DNSTY	Calculates and prints Density Measurement Control Report.
4.	Replicate Report	REPLC	Calculates and prints Replicate Measurement Control Report.
5.	Product-to-Input Report	PRDIN	Calculates and prints Product-to-Input Measurement Control Report.
6.	Uranium Concentration Report	UCONC	Calculates and prints Uranium Concentration Measurement Control Report.

TABLE E-4

RTP SYSTEM PROGRAMS AND MODULES

	Name	ID	Purpose
1.	Initialization Procedures		The 3SX-11 System Initialization Routine contains the entry point required to start system operation. This routine performs the following initialization functions:
2.	SCHED Task	SCHED	Controls execution of other tasks. Controls execution of functions driven by time table. Reinitializes start after a power failure.
3.	Operator Task	OPR	Program allows the operator to enter system time, activate alarm edit, request dumps and ask for help.
4.	Subroutine Help	HELP	Outputs information to system console to assist operator in communications with RTP system.
5.	Calibration Dump	CDUMP	Dumps the calibration values found in (CPDT) Calibration Point Definition Table.
6.	Ruska Dump	RDUMP	Dumps Ruska points to system console.
7.	Dump Data Base	DDB	Dumps the data base with the following information for each wide range channel: channel number, scan mode, gain, range, raw value percent, and engineering units.
8.	Print Data Line	PDLINE	Prints data line.
9.	Print Dump Header	PHEAD	Prints dump header.
10.	Clear Data Buffer	CLRBUF	Clears Data Buffer.
11.	Collect Task	COLECT	Collects data from the Computer Products RTP equipment.
12.	DDLAY	DDLAY	Determines if a multiplexer has failed to respond in the prescribed time limit.

TABLE E-4 (CONTINUED)

RTP SYSTEM PROGRAMS AND MODULES

Name	ID	Purpose
13. CALPT	CALPT	Inputs raw values from the programmable voltage calibrator and stores them in the CPDT table.
14. Ruscol Task	RUSCOL	Collects data from Ruska devices.
15. HILOW	HILOW	Replace the high and low Ruska sample values with the last sample if appropriate.
16. AVARGE	AVARGE	"Ripples" the storage of the last 5 readings. Calculate most recent reading by dividing accumulation by sample count. Clear accumulation and sample count.
17. Alarm Checking Program	ALARM	Task examines each point in the system. If the point has associated alarm limits, the latest reading is converted to engineering units.
18. Calibrate Task	CALIBR	Calibrate calibration point.
19. CNMCAS Communications Task	COMME	To process requests from the CNMCAS link for data.
20. FLR	FLR	Fetch all readings for a point, convert them to engineering units in floating point format and return them to the caller.
21. MOVE	MOVE	Transfer data from one data buffer to another.
22. Entry address Locator to any table	ADDFND	Program will find any word location in any table.
23. Alarm Edit	AEDIT	This subroutine will enable or disable a single channel, blanket enable or disable all channels, or to force an alarm heading.

TABLE E-4 (CONTINUED)

RTP SYSTEM PROGRAMS AND MODULES

Name	ID	Purpose
24. ASCII Decimal to Binary Conversion	ATOB	Converts ASCII data in contiguous memory locations to an absolute binary value in one 16-bit word. ATOB stops converting as soon as it encounters a non-numeric character.
25. Average Point	AVRGE	To average either scan mode or point readings.
26. BCD-To-Binary	BCDB	Converts a BCD number to a positive binary integer.
27. Binary To ASCII Decimal Conversion	BTOA	Converts a single 16-bit binary value into five decimal ASCII characters.
28. CHECK	CHECK	Checks if input device is clear and will wait until clear if device is busy.
29. Clear History	CHIST	Clears P2T and P3T tables; also clears Ruska P2T tables.
30. CPIDI1	CPIDI1	Data interrupt routine for CPI F480 AIS system on parallel link (F410/23).
31. Julian Date	DAYMON	Converts Julian days to months and days.
32. Floating Point to ASCII	FP2A	Converts fixed point to binary to decimal ASCII
33. Gain Value	GAINVL	Finds the gain value associated with a point number.
34. High-Low Sample Routine	HILOW	Compares the last sample with the high and low values accumulated and replaces them if appropriate.
35. INPUT	INPUT	Requests data from CPI channel.
36. Interpolation Table Entry Point	ITEP	Program finds the interpolation table entry point number and determines whether the LIT or PLIT table is to be accessed.

TABLE E-4 (CONTINUED)

RTP SYSTEM PROGRAMS AND MODULES

Name	ID	Purpose
37. Linear Interpolation Function	LIF	Determines Y on a set curve with the following equation: Y = (X-X1)/(X2-X1)* (Y2-y1) + Y1
38. Measure	MEASUR	Calculates measurement for all instrument types.
39. Mcnth-Day to Julian Date	MONDAY	Converts the month-day date to the Julian date
40. Multiply-Divide	MUDIV	Contains Multiply and Divide subroutines plus Utility Multiply and Divide Routines.
41. Utility Divide	UDIVIDE	Utility Divide Routine designed for positive integers only.
42. Utility Multiply	UMULT	Utility Multiply Routine designed for positive integers.
43. Multiply	MULT	General Purpose Multiply Routine for fixed point number.
44. Divide	DIVIDE	General Purpose Divide routine for fixed point numbers.
45. Piecewise Linear Interpolation Function	PLIF	Determines the measurement through the Piecewise Linear Interpolation Table.
46. Point Device Locator	PNTDEV	Determine device number from point number.
47. Programmable Voltage Calibrator Device Routine	PVCDEV	Determines device number from point number, checks for PVC on device, and returns the calibrated voltage.
48. RRPT and RORPT	RRPT	Read all Ruska points. The caller passes a buffer address where RRPT places 8 words of data for the values received.
49. RRPT and RORPT	RORPT	Reads a Ruska point. A valid channel (#2512-2515) is supplied by the caller to indicate the two CPI cards to input from. The Ruska values are inputed and converted to a fixed point value. Data is passed back to the caller.

TABLE E-4 (CONTINUED)

RTP SYSTEM PROGRAMS AND MODULES

Name	ID	Purpose
50. Request Time-Date	RTD	Request time and date from operator. Subroutine updates system clock and time table.
51. Small Integer Multiply	SMUL	Performs a short integer multiply.
52. Target Update	TARGET	Updates time tables when necessary.
53. Time Check	TEMCHK	Adjusts the time for 60 seconds/minute, 60 minutes/hour, 24 hours/day, and 365 days/year, except leap years 366 days/year.
54. Fixed-To-Floating-Subroutine	TOFLT	To convert a fixed point number to floating point.
55. Ruska-Input	W2SOF	Converts data stream to serial link format.
56. Short Fixed Point Divide	SDIV	Performs a short, fixed point division.

TABLE E-5

MISCELLANEOUS PROGRAMS

	Name	ID	Purpose
1.	Data Base Maintenance Program	DBMPGI	To create new data bases or save and delete portions of one or all data bases.
2.	Data Base Creation Subprogram	DBMCRE	To create a new measurement point data base.
3.	Data Base Save Subprogram	DBMSAV	To save a portion of one or all data bases and delete that portion if required.
4.	Data Base Edit Program	DBEPGM	To edit the measurement point data bases that are the primary source of historical data for CNMCAS.
5.	Status Program	STATUS	Prints current status of all Vessel Measurement Programs.
6.	Automatic LOGIN Program	BEGIN	Automatic LOGIN for all Vessel Measurement Programs.
7.	Display Program	DISPLY	Updates (at predetermined intervals) current status of Vessel Measurement Programs and current flow rate on the color video.
8.	Offset and Sigma Change Program	SIGCNG	Program for allowing change off the offsets and sigmas used for making instrument comparisons. Requires password.
9.	HA Feed Tank Flow Rate Program	HAFTFR	Calculates the current flow rate approximately every 30 minutes.
10.	Uranium In-Process Inventory Program	UPI	Calculates the current Uranium In-Process Inventory.

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APPENDIX F

LDS-CNMCAS INTERFACE PROGRAM

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G. D. Workman

October 1978

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Post Office Box 847
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LDS-CNMCAS INTERFACE PRGRAM

The Laboratory Data System - Computerized Nuclear Materials Control and Accounting System (LDS - CNMCAS) interface program allows the two computers to communicate, i.e., pass messages and data as required. On the LDS side, the interface program currently allows the Production Department to authorize sampling and analysis of the following vessels:

Sample Identification	Sample Point Number	Measurement Point Number
Accountability Tank	N001	02003
Uranium Product Sample Tank	N003	02009
HWW Sample Tank	N018	02023
GPW Check Tank	N034	02028

The CNMCAS computer is considered as a terminal to the LDS; and the interface program (see Figure 1) runs in a continuous keyboard wait state, except when triggered by another LDS program or the CNMCAS.

The CNMCAS computer passes the following information to the LDS:

(1) Function code (1 to authorize, 2 to cancel a request) as a binary integer.

(2) Measurement point number consisting of the material balance area (MBA) and the measurement point as a RADIX-50 value.

(3) Batch sequence number as a binary integer.

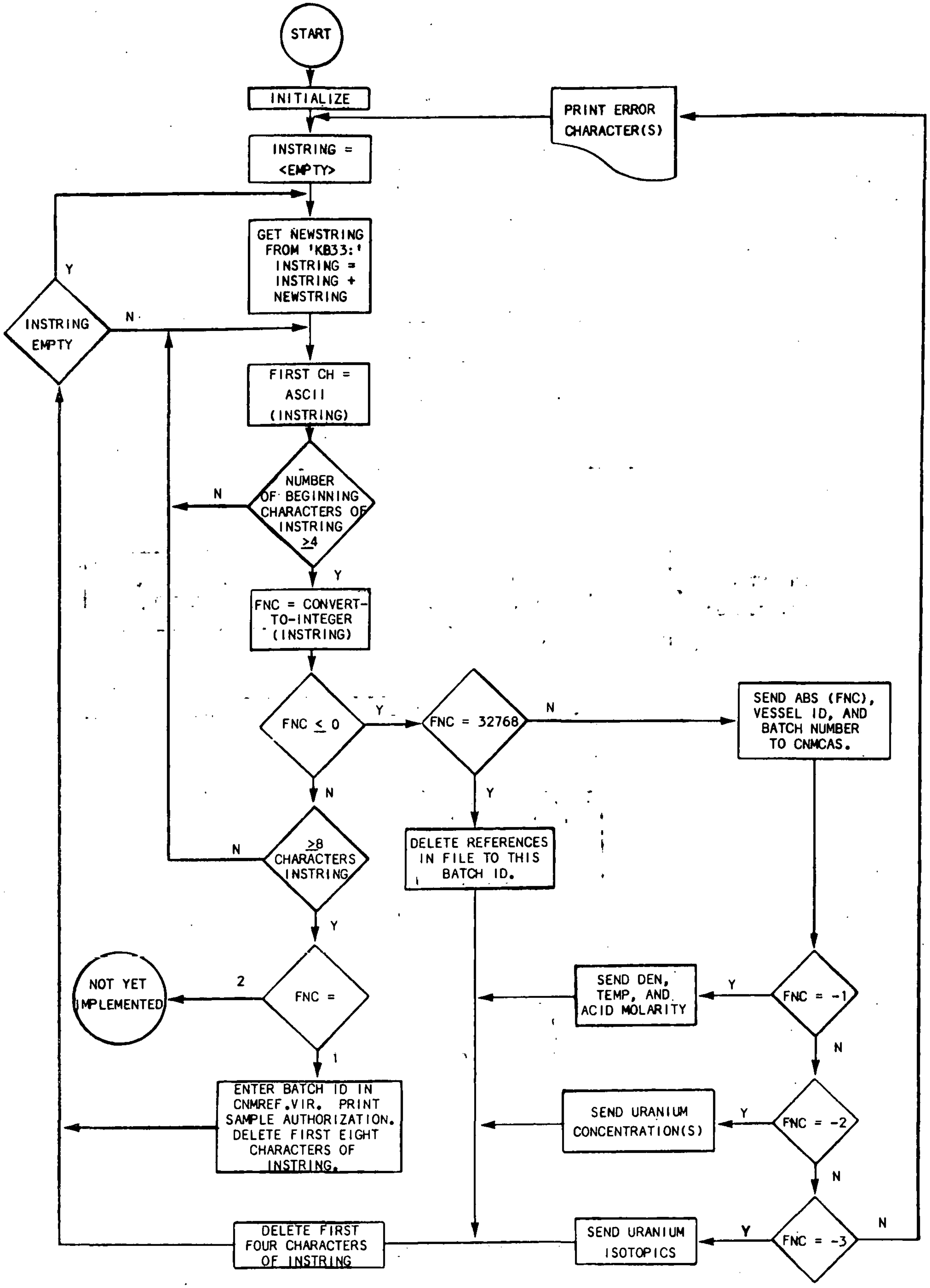
This information is written to a temporary file (CNMREF.VIR).

The LDS returns a function code (indicating the type of analytical results to follow), a corresponding measurement point number, a batch sequence number, an analytical sample log number, and the analytical results. Function code 1 precedes the temperature, density, and acidity results. Function code 2 precedes the uranium concentrations and the analytical method used. Function code 3 precedes any isotopic results; if there are none, no such record is sent.

When an authorization is received by the interface program, the LDS prints a message to the sampling area (AVOS) and the analytical sample receiving station, initiating the actual sampling. After sampling is completed, the sample is logged in using the SLOG program at an LDS remote terminal. The LDS SLOG Program also writes the analytical log number to the CNMREF.VIR file (see Figure 2).

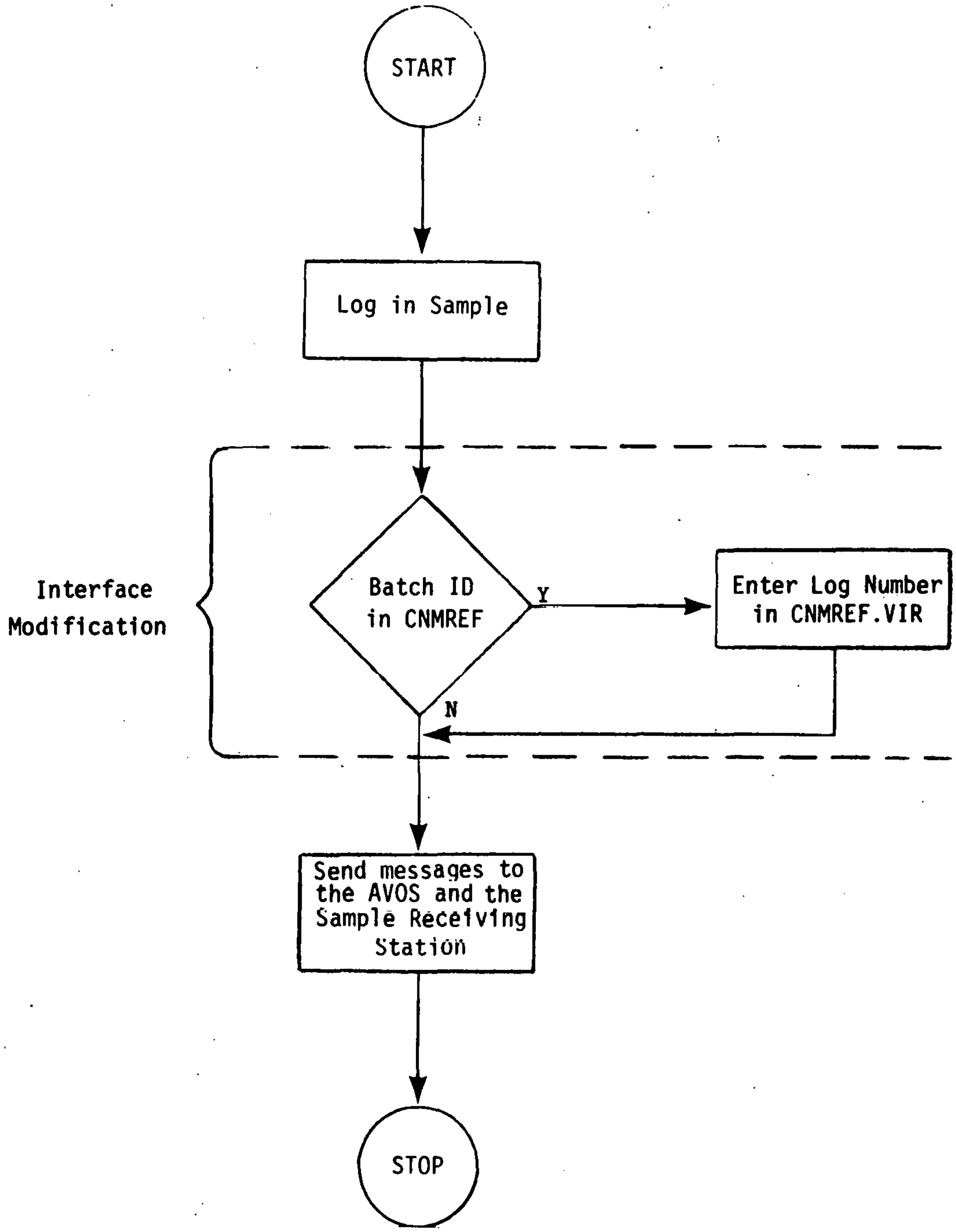
At this point the samples are analyzed and the data are entered into the LDS via a laboratory instrument interface or a remote terminal. The programs that calculate the analytical results were modified to write the results to the CNMREF.VIR file (see Figures 3 and 4). The acid method program also triggers the interface program to send function code 1 results. For the GPW check tank and HWW sample tank, the uranium method programs trigger the interface program to send function code 2 results.

The LDS APPROVAL Program, which is used to give final approval of results for a sample, triggers the sending of function code 2 for the uranium product sample tank and function codes 2 and 3 for the accountability tank (see Figure 5). The APPROVAL Program also clears the temporary file for that particular batch.



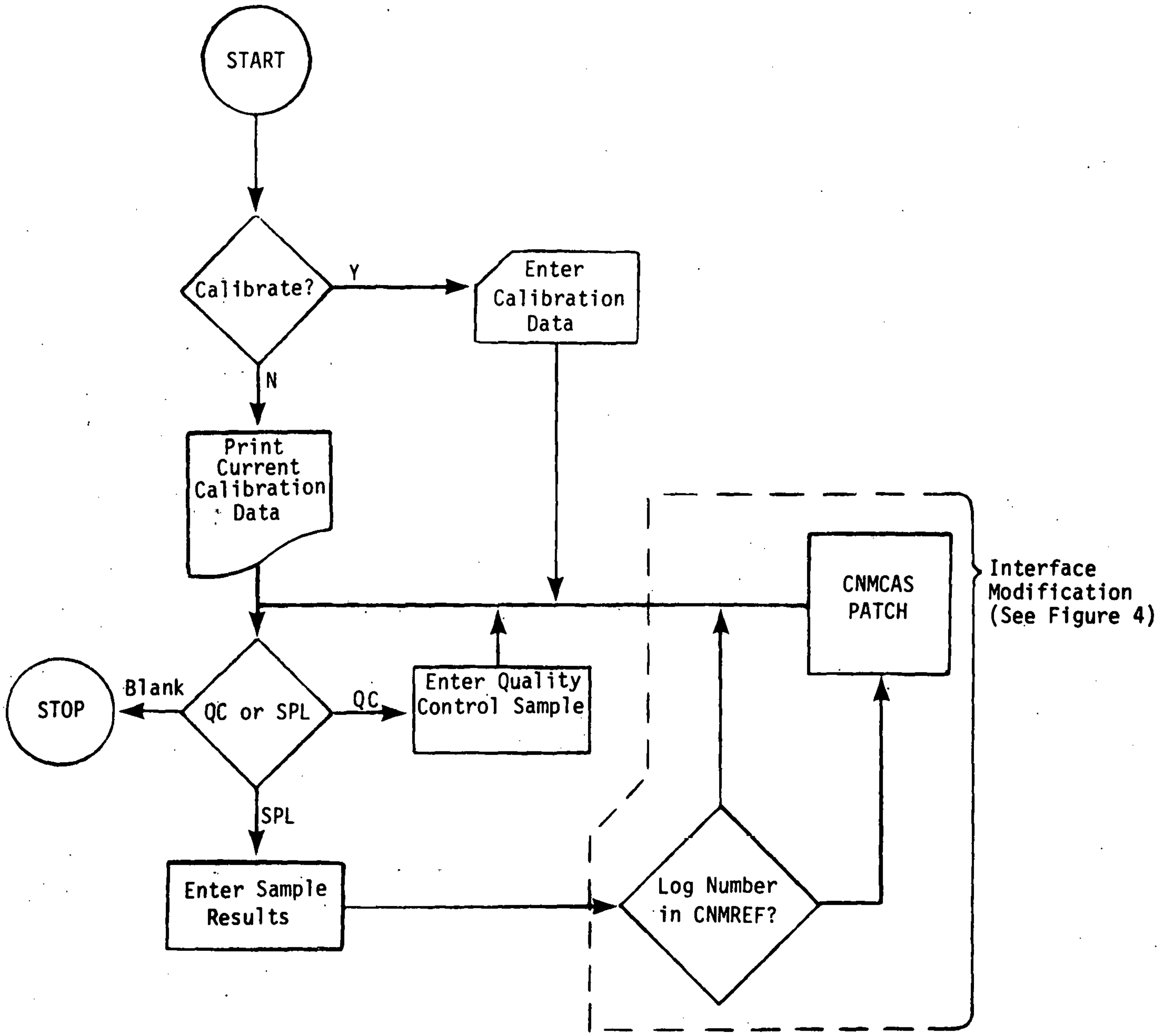
LDS-CNMCAS INTERFACE PROGRAM

FIGURE F-1



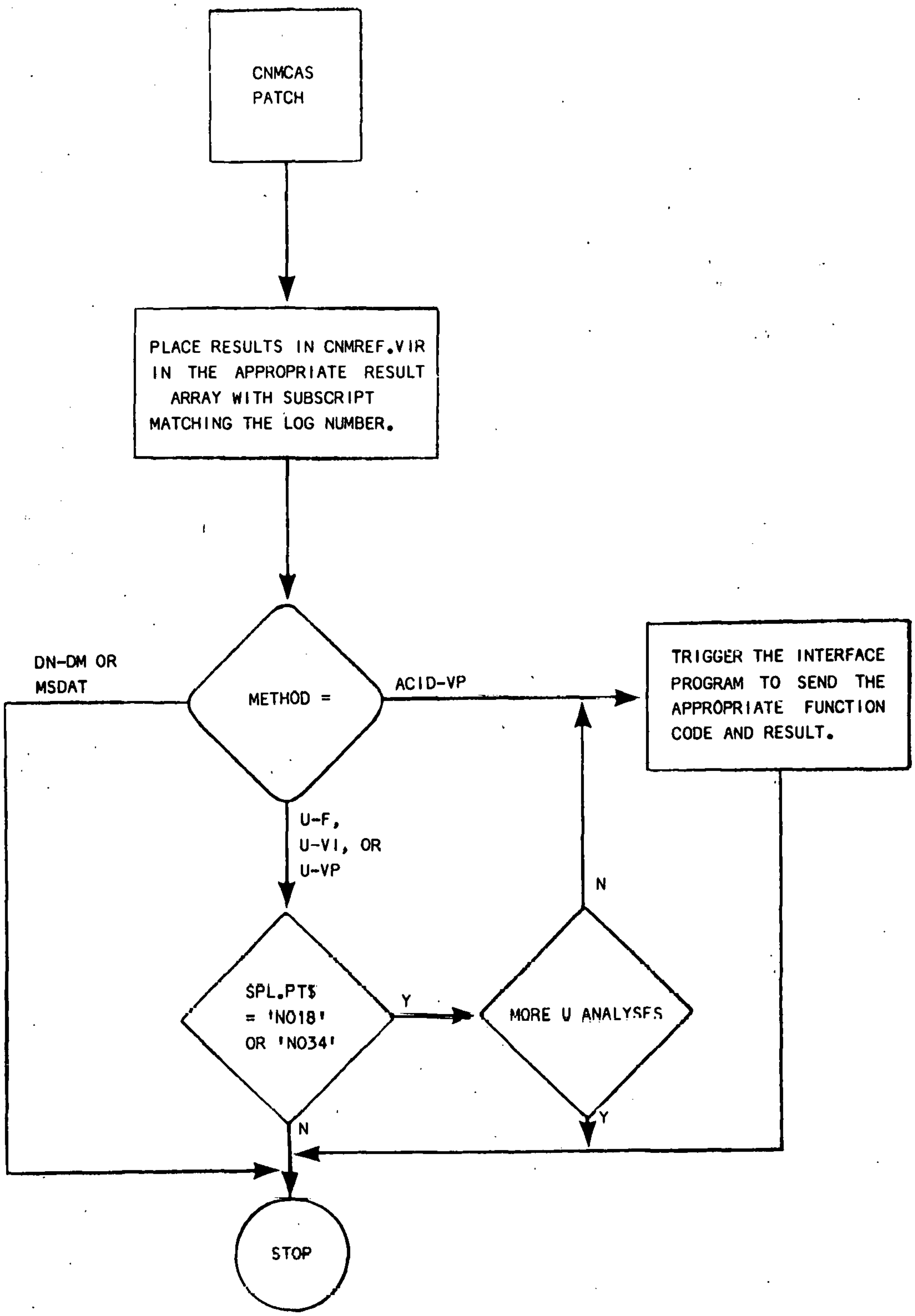
ANALYTICAL SAMPLE LOG IN PROGRAM

FIGURE F-2



ANALYTICAL METHODS PROGRAM INDICATING CNMCAS MODIFICATIONS

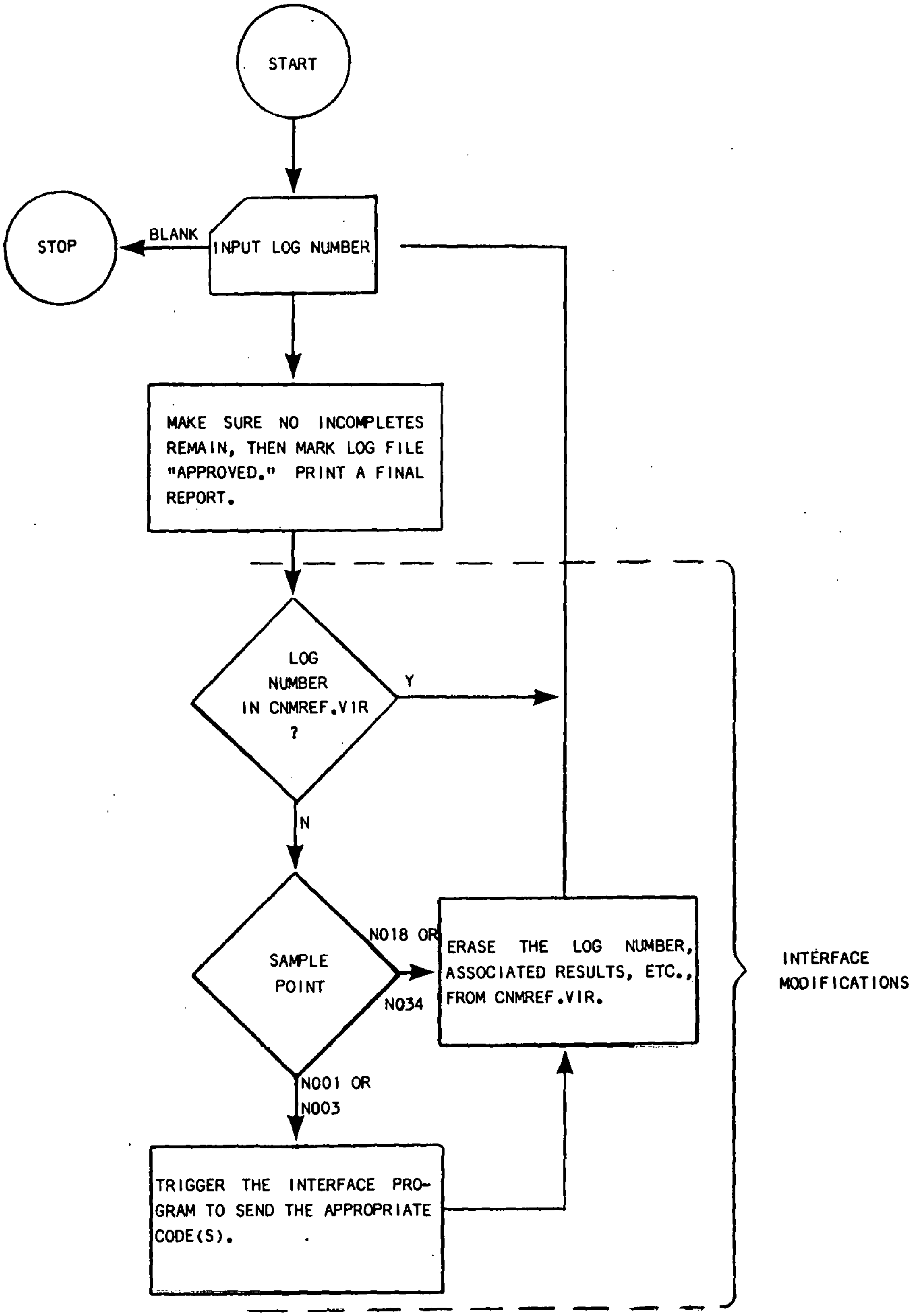
FIGURE F-3



NOTE: THE ◇ IS NOT A DECISION BLOCK. THE PATHS OUT OF IT INDICATE THE DIFFERENT TASKS THE VARIOUS METHODS PROGRAMS HAVE TO IMPLEMENT.

MODIFICATIONS MADE TO ANALYTICAL METHODS PROGRAMS

FIGURE F-4



ANALYTICAL RESULTS APPROVAL PROGRAM

FIGURE F-5

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