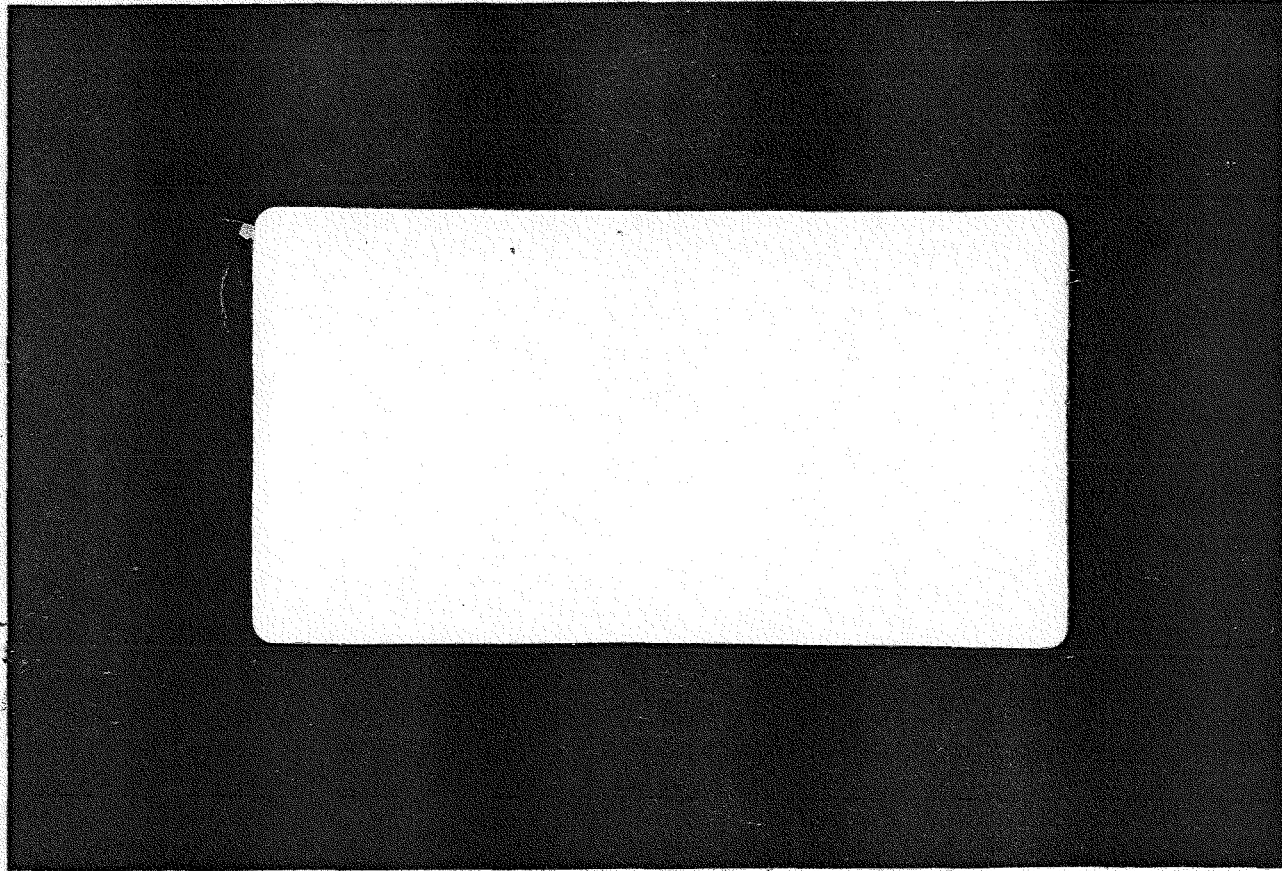
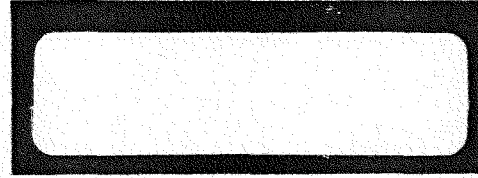
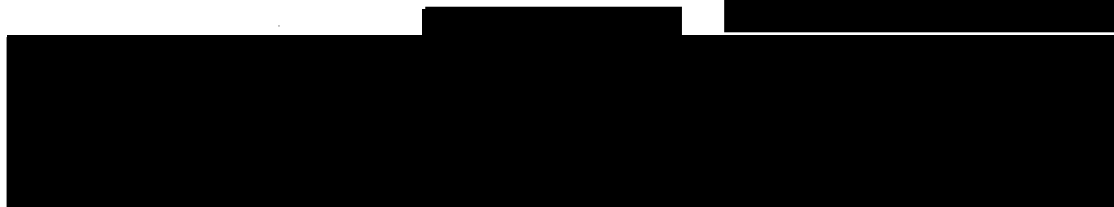
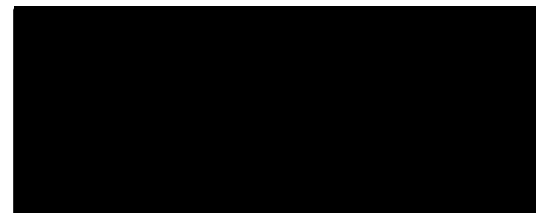


① I-1042 14. 219



Work Performed Under Contract DE-AC09-78ET-35900

ALLIED-GENERAL NUCLEAR SERVICES
P.O. BOX 847
BARNWELL, SC 29812



101
1-22-82
EC

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

AGNS--35900-2.5-142

DE82 006578

Distribution
Category UC-83

DISCLAIMER

This book was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

**STUDIES AND RESEARCH
CONCERNING BNFP**

MASTER

**MASS TRANSFER AND NEAR-REAL-TIME INVENTORY
IN PULSED COLUMNS**

**Dr. Anthony F. Cermak
James C. Neace
Richard G. Spaunburgh**

October 1981

**ALLIED-GENERAL NUCLEAR SERVICES
POST OFFICE BOX 847
BARNWELL, SOUTH CAROLINA 29812**

**PREPARED FOR THE
DEPARTMENT OF ENERGY
WASTE AND FUEL CYCLE TECHNOLOGY OFFICE
UNDER CONTRACT DE-AC09-78ET35900**

ACKNOWLEDGMENTS

The contributions of the AGNS Design Engineering, Operating, Analytical Services, Safeguards Technology, and Maintenance Departments are gratefully acknowledged.

ABSTRACT

Experimental studies were performed on pilot plant equipment, which was fully instrumented and interfaced to a computer, to determine near-real-time solutes inventory in pulsed columns. This work was done in support of in-process inventory safeguards programs at Allied-General Nuclear Services.

The uranium inventory in tested pulsed columns was determined both analytically and through the computer. Several different methods were used for the solute inventory determination in the column. The computer mass rate measurement technique and inventory determination was based on effluent stream concentration data, obtained both through chemical analysis in the laboratory and measurement with in-line instruments using flow rate data obtained in short-time intervals. Resultant inventory data from all the above methods are comparable. The computer technique can be applied for the solutes inventory determination in pulsed columns.

TABLE OF CONTENTS

	PAGE
ACKNOWLEDGMENTS	
ABSTRACT	
1.0 INTRODUCTION	1
2.0 SUMMARY	3
3.0 EXPERIMENTAL	5
3.1 Equipment Description	5
3.2 Experimental Procedure	13
4.0 RESULTS AND DISCUSSION	23
4.1 Mass-Transfer Tests	23
4.2 Variables	23
4.3 Uranium Concentration Profiles	28
4.4 Uranium Inventory in Pulsed Columns	28
5.0 CONCLUSIONS	101
6.0 REFERENCES	103
APPENDIX A - COMPUTER PRINTOUTS (Programs and Examples of Typical Results from Measurement Systems)	
APPENDIX B - COMPUTER PRINTOUTS (Column Holdup Program and Test Results)	

TABLE OF CONTENTS (CONTINUED)

PAGE

LIST OF TABLES

3-1	Planned Test Data	17
4-1	2A and 2B Columns Test Conditions and Data (Tests 2AM-1, 2AM-2, 2AM-3, 2AM-4, and 2AM-5)	33
4-2	3A and 3B Columns Test Conditions and Data (Tests 3AM-1, 3AM-2, 3AM-3, 3AM-4, and 3AM-5)	34
4-3	Concentration Profile Data (Test 2AM-1)	35
4-4	Concentration Profile Data (Test 2AM-2)	36
4-5	Concentration Profile Data (Test 2AM-3)	37
4-6	Concentration Profile Data (Test 2AM-4)	38
4-7	Concentration Profile Data (Test 2AM-5)	39
4-8	Concentration Profile Data (Test 3AM-1)	40
4-9	Concentration Profile Data (Test 3AM-2)	41
4-10	Concentration Profile Data (Test 3AM-3)	42
4-11	Concentration Profile Data (Test 3AM-4)	43
4-12	Concentration Profile Data (Test 3AM-5)	44
4-13	Flow Ratio and Uranium Concentration Experimental Data	45
4-14	Volume and Concentration Data (After Draining the Column)	46
4-15	Concentration, Flow Rate and Effluent Mass Rate Data (Test 2AM-2)	47
4-16	Concentration, Flow Rate and Effluent Mass Rate Data (Test 2AM-3)	48
4-17	Concentration, Flow Rate and Effluent Mass Rate Data (Test 2AM-4)	49
4-18	Concentration, Flow Rate and Effluent Mass Rate Data (Test 2AM-5)	50
4-19	Concentration, Flow Rate and Effluent Mass Rate Data (Test 3AM-1)	51
4-20	Concentration, Flow Rate and Effluent Mass Rate Data (Test 3AM-2)	52
4-21	Concentration, Flow Rate and Effluent Mass Rate Data (Test 3AM-3)	53
4-22	Concentration, Flow Rate and Effluent Mass Rate Data (Test 3AM-4)	54
4-23	Concentration, Mass Rate and Effluent Mass Rate Data (Test 3AM-5)	55
4-24	Tank Inventory Data (Tests 2AM-1 through 2AM-5)	56
4-25	Tank Inventory Data (Tests 3AM-1 through 3AM-5)	57
4-26	Column Uranium Inventory Data (Tests 2AM-1 through 2AM-5)	58
4-27	Column Uranium Inventory Data (Tests 3AM-1 through 3AM-5)	59

TABLE OF CONTENTS (CONTINUED)

PAGE

LIST OF FIGURES

3-1	Pilot Plant Flow Diagram and Instrumentation	19
3-2	Samplers Location at the 1A and 1BS Columns	21
3-3	Pilot Plant Instrument Data Acquisition System	22
4-1	The 2A Column Concentration Profiles for Test 2AM-1	60
4-2	The 2B Column Concentration Profiles for Test 2AM-1	61
4-3	The 2A Column Concentration Profiles for Test 2AM-2	62
4-4	The 2B Column Concentration Profiles for Test 2AM-2	63
4-5	The 2A Column Concentration Profiles for Test 2AM-3	64
4-6	The 2B Column Concentration Profiles for Test 2AM-3	65
4-7	The 2A Column Concentration Profiles for Test 2AM-4	66
4-8	The 2B Column Concentration Profiles for Test 2AM-4	67
4-9	The 2A Column Concentration Profiles for Test 2AM-5	68
4-10	The 2B Column Concentration Profiles for Test 2AM-5	69
4-11	The 3A Column Concentration Profiles for Test 3AM-1	70
4-12	The 3B Column Concentration Profiles for Test 3AM-1	71
4-13	The 3A Column Concentration Profiles for Test 3AM-2	72
4-14	The 3B Column Concentration Profiles for Test 3AM-2	73
4-15	The 3A Column Concentration Profiles for Test 3AM-3	74
4-16	The 3B Column Concentration Profiles for Test 3AM-3	75
4-17	The 3A Column Concentration Profiles for Test 3AM-4	76
4-18	The 3B Column Concentration Profiles for Test 3AM-4	77
4-19	The 3A Column Concentration Profiles for Test 3AM-5	78
4-20	The 3B Column Concentration Profiles for Test 3AM-5	79
4-21	Uranium Concentration in the 1A and 1BS Columns (Tests 2AM-1 through 2AM-5)	80
4-22	Uranium Concentration in the 1A and 1BS Columns (Tests 3AM-1 through 3AM-5)	81
4-23	Uranium Mass Rate Versus Time (Test 2AM-2)	82
4-24	Uranium Mass Rate Versus Time (Test 2AM-3)	83
4-25	Uranium Mass Rate Versus Time (Test 2AM-4)	84
4-26	Uranium Mass Rate Versus Time (Test 2AM-5)	85
4-27	Uranium Mass Rate Versus Time (Test 3AM-1)	86
4-28	Uranium Mass Rate Versus Time (Test 3AM-2)	87
4-29	Uranium Mass Rate Versus Time (Test 3AM-3)	88
4-30	Uranium Mass Rate Versus Time (Test 3AM-4)	89
4-31	Uranium Mass Rate Versus Time (Test 3AM-5)	90
4-32	Column Uranium Inventory Versus Time (Test 2AM-2)	91
4-33	Column Uranium Inventory Versus Time (Test 2AM-3)	92
4-34	Column Uranium Inventory Versus Time (Test 2AM-4)	93
4-35	Column Uranium Inventory Versus Time (Test 2AM-5)	94
4-36	Column Uranium Inventory Versus Time (Test 3AM-1)	95
4-37	Column Uranium Inventory Versus Time (Test 3AM-2)	96
4-38	Column Uranium Inventory Versus Time (Test 3AM-3)	97
4-39	Column Uranium Inventory Versus Time (Test 3AM-4)	98
4-40	Column Uranium Inventory Versus Time (Test 3AM-5)	99
4-41	Column Uranium Inventory $V_{(col.)} \cdot \frac{v_f}{v_{st}} \cdot C_{(U)f}$	100

1.0 INTRODUCTION

In recent years considerable interest has developed in advanced nuclear materials accounting systems for plutonium and enriched uranium in spent fuel reprocessing facilities subject to international inspection and inventory verification.

In support of this need, the Los Alamos National Laboratory (LANL), Allied-General Nuclear Services (AGNS), and other laboratories are developing advanced techniques for nuclear materials measurement.^(1,2) For example, researchers at the Ames Laboratory, Iowa State University, under the direction of Dr. L. E. Burkhart, have been developing theoretical models for pulsed column behavior which will predict solute profiles. This technique, when properly applied with signals coming from on-line process instruments interfaced to a computer can produce column inventories in near-real-time of sufficient accuracy to be used for safeguards purposes.

Work was initiated in 1979 at AGNS, under contract to the Department of Energy (DE-AC09-78ET-35900 Sub-Task 4.1), to carry out experimental studies on proposed coprocessing flowsheets in which a portion of the uranium is allowed to remain with the plutonium throughout the second and third plutonium purification cycles.⁽³⁾ This work was conducted in pilot scale pulsed columns using uranium only. These columns were equipped with samplers along the height of the column, from which samples could be obtained and solute profiles determined.

The work initiated in 1979 was further expanded in 1980 and 1981 to include solute profile, dispersed phase hold-up, and column uranium inventory studies on all Purex purification cycles under coprocessing conditions.^(4,5) The data from these studies were made available to LANL and Dr. Burkhart for comparison to the Burkhart model. An example of this comparison is given in Reference 1, Volume III, Appendix J. This program was continued and further expanded in FY 1981 in which the pilot plant equipment was fully instrumented and interfaced to the computer.

During operation of a Purex Facility, there customarily is a lag-time between the drawing of process samples and the time when chemical analyses for these samples are available. Thus, decisions involving parameter adjustment during a run must often be made without the benefit of complete analytical data. Also the manpower and logistical requirements for complete and frequent analytical coverage of an entire operating Purex plant can be a considerable drain on plant resources.

Since the year 1978, there has been an ongoing effort at AGNS to computerize the Separations Plant data collection system for in-process inventory (IPI).⁽⁶⁾ The results from this program have been utilized in related fields such as plant process control. The present study, though limited to the pilot plant, was able to draw upon some of the expertise generated by the IPI study and was supportive to other programs under Task 2 on advanced nuclear material control and accounting.

The program reported herein involved tests conducted in two pilot scale pulsed columns operating under the second and third plutonium cycle coprocessing conditions, in which a comparison was made of different techniques for in-column solute inventory determination. A computer was used for data acquisition and computation of the process data for purposes of process control and column inventories.

2.0 SUMMARY

Ten mass-transfer experimental runs were performed on the pilot plant two-inch diameter pulsed columns (with natural uranium) simulating coprocessing conditions ⁽⁷⁾ in the second (2A and 2B columns) and third plutonium process cycles (3A and 3B columns). The equipment was instrumented and interfaced to a computer.

The mass-transfer tests were designed to obtain the detailed uranium concentration profile, operational dispersed phase hold-up, and uranium inventory in tested columns as a function of the feed rate.

The main thrust of the experimental program was the determination of the uranium inventory in a pulsed column as carried out through:

- (a) Calculations from the experimental concentration profile and hold-up data.
- (b) Volume and concentration measurements at the end of each run.
- (c) Uranium mass rate measurements in feed and effluent streams in short-time intervals (performed analytically).
- (d) The uranium inventory in feed and receiving tanks at the end of each run.
- (e) Calculations by use of empirical equations.
- (f) Computer program based on mass rate measurements in feed and effluent streams determined through on-line instruments.

Uranium inventory data from all the above techniques are in good agreement. The obtained results indicate that the computerized mass rate measurement technique will be applicable for the solutes near-real-time inventory determination in large columns installed in the nuclear fuel reprocessing plant during startup and transient conditions and for short (up to several days) periods of continuous steady-state operation. In addition, it was determined that derived empirical equations, relating the ratio of the feed streams and solute concentration, can be used to determine column inventory under steady-state conditions. These techniques have applications in safeguards as well as for process control.

BLANK PAGE

3.0 EXPERIMENTAL

3.1 Equipment Description

The pilot scale experimental equipment, shown in Figure 3-1, consisted of two glass pulsed columns, two inches (50 millimeters) in diameter, and ancillary equipment such as tanks, pumps, and instruments required for the process control. All tanks and piping were made of stainless steel.

3.1.1 Columns

The 1A dual process column, used for extraction and scrubbing, had a working extraction (lower) section of 13.6 feet (4.15 meters) and scrubbing (upper) section of 8.8 feet (2.7 meters). The 1BS column, used for stripping, had a working section of 18.7 feet (5.7 meters). The 1A column operated with the organic phase continuous, and the 1BS column with the aqueous phase continuous. Both columns were provided with stainless steel nozzle plates of a thickness of 1/16 inch (1.6 millimeters), having 23% relative-free surface area and 1/8 inch (3.2 millimeters) orifice diameter. The nozzle plates were assembled on a central 1/4-inch-diameter (6-millimeter) stainless steel tie rod on a two-inch (50-millimeter) plate spacing. Each column was provided with a six-inch (150-millimeter) diameter top and bottom disengaging section. A bellows-type direct pulser was attached to the column bottom disengaging section. The interface in each column was controlled manually during tests to minimize the effect of the interface fluctuation on resultant data. Both columns were equipped with instruments (DT, WT) for measuring continuously the average liquid density within the column. The density was measured (separately) in each column working section (DT) and entire column (WT). The columns were provided with several samplers at different locations along their working section (Figure 3-2).

3.1.2 General Description of Ancillary Equipment

The 1AS, 1AF, and 1BS-X calibrated feed tanks were provided with a liquid level transmitter (LT), i.e., instrument for measuring continuously the liquid level in each tank during the experimental run, vent line, feed line, and a calibrated positive displacement pump (DP). Prior to test startup, the 1AX, and 1BS-X feed tanks were filled with the solution from the corresponding 1900-liter feed supply in the arrangement shown in Figure 3-1.

The 1AW, 1BS-P, and 1BS-W calibrated receiving tanks were equipped with a dip-tube densimeter (DT), liquid-level transmitter (LT), top liquid inlet, vent line, drain line, and a bottom sampler. In addition, both the 1BS-P and 1BS-W tanks were provided with an air sparger for mixing the liquid content, if required.

Uranium concentration in the 1AP, 1BS-P, and 1BS-W effluent stream was measured continuously by the calibrated X-Ray Fluorescence Analyzer (XRFA) in-line monitoring instrument. Density of the 1AP stream was measured by Mettler/Parr densimeter (DM). For comparison of different instrumentation, the 1BS-P effluent stream density was determined through Mettler/Parr (DM), Dynatrol density transmitter (DE), as well as dip-tube measurement (DT) in the 1BS-P density pot. Its acidity was determined by the on-line conductivity indicator and transmitter (CIT). The 1BS-W stream density was measured by the dip-tube densimeter (DT) in the 1BS-W density pot. During tests, the temperature of all feed streams as well as those of the 1AP and 1BS-P effluent streams was measured by use of an in-line temperature indicator (T).

At the end of each run, the solution in the 1BS-P and 1BS-W receiving tanks was transferred by vacuum into the corresponding 1900-liter final receiver shown in Figure 3-1.

3.1.3 Instrument Measurement Systems

3.1.3.1 Measurement of Tank Liquid Levels

Tank liquid level and tank density measurements were made by means of Taylor differential pressure instruments. The difference in pressure translates to the weight of the column of liquid which is displaced by the air forced into the lower tube. If the density of the liquid is known, the height of the column and thus the level of liquid in the tank can be calculated.

Tanks were calibrated by the incremental addition of weighed quantities of deionized water of known temperature and density. Liquid levels in the tanks, as a function of readout from Taylor instruments, were then calculated. Typically, three "passes" were made for each tank. Based upon these data, computer programs were prepared to interpolate tank contents (in liters) for any given Taylor differential pressure reading (in centimeters of water).

Preliminary testing indicated that tanks in the pilot plant were nonlinear. This was attributed to the relatively small size of these tanks compared to the size of the internal hardware they contain. The usual method for tank calibration by curve fitting, using regression analysis, did not appear desirable for these tanks. A search was therefore made for some other applicable method.

The LaGrange method of curvilinear interpolation,⁽⁸⁾ appeared to be a promising method for dealing with abrupt changes in tank internal geometry. By programming the computer to "look" at only a limited number of tank calibration data (a "window") at any one time, distant data points, containing possible irregularities, would not be factored into a given interpolation. By having the window "slide," the entire range of tank calibrations could be covered.

The computer program used to process the raw calibration data is shown as Appendix A-1. The X, Y pairs, i.e., the liquid level in centimeters [LL(cm)] and the corresponding volume in liters, respectively, are entered as data, starting at Step 295. A printout of this program, for the given data set, is shown as Appendix A-2. For convenience, the independent variable [LL(cm)] is normalized by the computer program to increments of 5 cm (see Column 1, Appendix A-2). This permits a direct comparison of the various passes so outliers can be rejected and averages can be made to obtain the final tank calibration. The "profile" of the tank is linear over the range of 45 cm to 90 cm and in this range 1 cm height of the tank is approximately equal to 6.33 liters (Column 3). This uniformity, however, does not exist at other locations on the tank. Two outliers (i.e., calibration errors) are shown at 95 cm and 100 cm, respectively. This was established by additional passes during which these data did not repeat themselves. On the other hand, the turbulence shown at the top and bottom of the tank profile did show up in later calibrations and is attributed to irregularities in tank internal geometry.

A program for curvilinear interpolation of calibration data is shown in Appendix A-3. In the example shown, the first 18 values of the middle column of Appendix A-2 (chosen to avoid use of the two outliers) are entered as data. To illustrate the use of this program, results for various interpolations are shown on the same page.

An equipment breakdown occurred before the calibrations could be completed. The digital balance that was being used for weighings became inoperative. Since repair or replacement was not forthcoming, an alternate procedure for calibration was devised.

With the aid of the computer, calibrations already completed were used to calibrate the remaining tanks. A computer program was prepared whereby a delivery tank of known calibration was used to calibrate a receiver tank by the dropout method. The program used is shown at the top of Appendix A-4. A printout produced by this program is shown at the bottom of Appendix A-4. Calibration data for the delivery tank were entered at lines 1000 and 1010 of the program. The resultant calibration data for the receiver tank (BP tank) are shown in the last two columns at the bottom of the page.

A volume history for a typical run is shown in Appendix A-5. The string of zeros under the heading of BW and BP represent the time required to fill these receiver tanks up to the tip of the bottom Taylor tube. Calculations are by the dropout method. The computer program which produced Appendix A-5 is not shown but is similar, in most respects, to that presented in Appendix B-1.

3.1.3.2 Tank and Column Density Measurements

The identical procedure, described for liquid level measurements, is used to obtain liquid densities. The only difference is that both tubes are immersed in the liquid. The specific gravity of an unknown liquid

may now be determined by comparing the pressure differential for the unknown liquid with that for water under the same conditions. In practice, the distance between the two tubes, determined by calibration with water, is used to make the calculations.

When both density and liquid level are to be determined in the same tank, the high-side tube is common so that only three tubes are required. During measurements, the tank is vented to allow the compressed air to escape. Since only pressure differences are read, changes in atmospheric air or other pressures within the tank have no bearing on the readout of the Taylor instrument.

In a similar manner, these instruments were used to determine the average density within the columns. They gave a good indication of the conditions which prevailed inside. Column upsets, or imminent column upsets, are easily detected in NRT plots such as Appendix A-6. In the given example, which represents a relatively smooth run, steady-state conditions in the A-Col may be detected by following the letter "T." Near the bottom of the plot, it can be seen that the drawing of samples from the column caused perturbances in the instrument readings. This is due to the fact that the instrument air line and sample line were common to each other and thus caused a temporary change in the differential pressure. The computer program which produced Appendix A-6 is not shown but is essentially the same, in most respects, as that presented in Appendix A-8.

3.1.3.3 On-Line Densimeter

The Mettler/Paar DMA-45 Digital Density Meter and a Dynatrol Model CL-10HY Density Cell were used for on-line density determinations. Each instrument is based upon the principle that a change occurs in the natural oscillation frequency of a hollow glass tube when it fills with liquids or gases of different densities. For this study, a continuous flow adapter (Mettler No. 5771) was installed on the DMA-45. The DMA-45 was made to do double duty, monitoring the BP stream directly and the AP stream indirectly by means of a DPR-412 unit which was plugged remotely into the DMA-45. Switching from one stream to the other was by computer. The output from each sensor to the computer was the period of oscillation. This was converted to density by the computer, using a mathematical formula. The Dynatrol instrument monitored the BP stream. A detailed description of this phase of the study has been reported elsewhere.⁽⁹⁾

3.1.3.4 Uranium Concentration by X-Ray Fluorescence Analysis (XRFA)

The principle of XRFA is based upon the accurate measurement of characteristic X-rays emitted from atoms after the atoms are bombarded by radiation. The bombardment radiation used in this study was the 122 keV gamma from a Co-57 source. The characteristic X-ray from uranium that was read was the $K_{\alpha 1}$. A computerized multichannel analyzer, used in conjunction with a Ge(Li) detector, made the measurements. Three XRFA units were used during this study, one each for the AP, the BW, and the

BP streams. A detailed description of this phase of the study has been reported elsewhere.⁽¹⁰⁾

A plot of XRFA data for one complete run is shown in Appendix A-7. The buildup of uranium in the product stream for each column can be seen in this plot, followed by a leveling off at steady-state conditions. These data offer a quick and convenient method for studying the progress of a run.

The computer program which produced Appendix A-7 is shown in Appendix A-8. The identical information, shown in the form of a graph in Appendix A-7, is presented in tabular form in Appendix A-9. (Note: Densimetric data for uranium, shown for comparison are not considered to be as accurate as the XRFA data, with regard to organic phase samples, since variations in %TBP introduce errors. For aqueous phase samples, the results by the two methods are considered to be comparable.)

3.1.3.5 Acid Determination by Conductivity Monitors

For acidity measurements, the Balsbaugh Laboratories, Inc., Series 1200 Electrodeless Conductivity Monitor, with the 1200-AT-C in-line cell attached, was used. The principle of operation is that toroidally wound coils are used to induce and sample electric currents in solution. The magnitude of these induced currents is proportional to the electrolytic conductivity, which in turn is a function of the hydrogen ion concentration. Automatic temperature compensation is provided by use of a thermistor temperature sensing element. The signal output is 4-20 mA DC. This is digitized and fed to the computer for processing. Additional details on this phase of the study have been reported elsewhere.⁽⁹⁾

3.1.4 Flow Rate Measurement

To simulate plant operational conditions, the feed flow rate was determined from liquid volume changes in each feed tank measured in short time intervals during the run. The liquid volume discharged from each calibrated feed tank during the measured time period was obtained by subtracting the measured liquid volume in the tank from the actual liquid volume at startup. During experimental runs, the liquid volume in each tank was determined through the continuous liquid level measurement (LT), by taking into account the liquid density of the feed solution measured in the laboratory (prior to runs). Calibrated positive displacement pumps, operating steadily, were used for feeding each column with the corresponding feed solution. Therefore, due to the pumps feed constancy, the average feed flow rate values, determined from the total liquid volume spent during the process time (total feed time), were used during analytical evaluation of the solute's feed mass rate and column inventory.

The intention was to determine also the flow rate of each effluent stream ending in a receiving tank (1AW, 1BS-P, and 1BS-W tanks) from the liquid volume measurement in each tank performed in short-term intervals as described above. Therefore, each receiving tank was provided with

instruments for measuring continuously the liquid level (LT) as well as liquid density (DT) in the tank. However, the liquid density and volume were not measured in receiving tanks during experimental runs. The flow rate of effluent streams, except that of the LAP stream, was determined from liquid volume changes corresponding to the standard liquid (water) and measured densities of the corresponding effluent stream. Flow measurements made from level changes over short-time intervals can be more accurate when the level change is large in comparison to density changes over the same interval.

The effluent stream flow rate, however, can be calculated considering the effect of the solutes concentration and temperature on solution density. It can be analytically proven that the liquid volume (or volume rate) change, due to a change in the solutes (U , HNO_3) concentration at room temperature of about 23 to 25°C, can be expressed as

$$\Delta V = V_{(R)} - V_{(s)} = V_{(s)} \cdot \left[\frac{0.486C_H + C_U}{11.8 - (0.486C_H - C_U)} \right] \quad \dots 1$$

and hence:

$$V_{(R)} = V_{(s)} \cdot \left[1 + \frac{0.486C_H + C_U}{11.8 - (0.486C_H + C_U)} \right] \quad \dots 2$$

The expression in brackets is affected little by temperature changes not exceeding about 35°C during the process. For example, by increasing the temperature approximately 10°C above the room temperature of 25°C, the above expression value increases only 0.03%. However, the effect of the temperature on the solvent volume cannot be neglected. The effect of both the solutes concentration and process temperature (up to 55 to 60°C) is described by the derived semi-empirical equation.

$$V(t) = V_{(s)} \cdot (1 + \alpha_s \Delta t) \left[1 + \frac{0.486 (1 + \alpha_H \Delta t) C_H + (1 + \alpha_U \Delta t) C_U}{11.8 - [0.486 (1 + \alpha_H \Delta t) C_H + (1 + \alpha_U \Delta t) C_U]} \right] \quad \dots 3$$

In these equations

$V_{(R)}$ = Solution volume (liters), or volume flow rate (liters/minute) at room temperature t_R

$V_{(s)}$ = Solvent volume (liters) or volume flow rate (liters/minute) at room temperature,

$V_{(t)}$ = Solvent volume (liters), or volume flow rate (liters/minute) at process temperature t_p not exceeding 60°C.

C_H = Nitric acid concentration (M)

C_U = Uranyl nitrate concentration (M)

α = Volume thermal expansion coefficient (1/deg)

Δt = $t_p - t_R$, temperature difference (°C)

All tests were performed at a room temperature of about 24°C. During analytical evaluation of experimental data, the flow rate of each effluent stream (the 1AW, 1AP, 1BS-P, and 1BS-W streams) was calculated from equation 2 by applying solutes (U, HNO₃) concentration determined through analyses in the laboratory. The 1AP effluent stream flow rates computed from equation 2 were used also during the uranium mass rate and column inventory evaluations by the computer program.

The flow rate history for a typical run is shown in Appendix A-10. In this example, the flow rates, obtained by the dropout method, are averaged over 16-minute periods. The average flow rate for the run is shown at the bottom of the page in the above Appendix A-10. The computer program is not given but is essentially the same, in most respects, as that presented in Appendix B-1.

3.1.5 Uranium Mass Rate Determination

At each measured time increment, the uranium mass rate in each stream was obtained as the product of the corresponding flow rate and concentration.

The uranium feed mass rate in the 1AF feed stream, entering the 1A column mid-section, was obtained from the known uranium feed concentration (analyzed prior to tests) and feed flow rate determined through volume measurements as described in Section 3.1.4.

The uranium mass rate in the 1AP, 1BS-P, and 1BS-W effluent streams was determined from the measured uranium concentration and calculated flow rate data. The effluent stream solutes (U, HNO₃) concentration was obtained (a) by analyzing the stream samples taken periodically in 15- to 30-minute intervals (all tests, except 1AM-1), and (b) from the XRFA on-line instrument, monitoring continuously the uranium concentration (only tests 3AM-3, 3AM-4, and 3AM-5). Each effluent stream flow rate was calculated from equation 2 using the above corresponding concentration data. Solute concentration in the 1AW effluent stream, leaving the 1A column bottom disengaging section, was determined analytically from samples drawn periodically from the 1AW line. With the same periodicity, the 1AW flow rate was calculated using the above solutes concentration data.

3.1.6 Computer System

A Digital Equipment Corporation (DEC) Decwriter III terminal was connected to the Material Accountability and Process Coordination System (MACS) as part of the AGNS Computerized Nuclear Material Control and Accounting System (CNMCAS) network (see Figure 3-3).⁽¹¹⁾ Instrument readings were automatically recorded on the RP04 disc each four minutes during a run. Concurrently, near-real-time (NRT) readout was provided at the terminal. The language used for all computer operations was BASIC-PLUS-2 (V 1.6).

3.1.7 Column Uranium Inventory

Of special interest for this study was the NRT determination of the column uranium inventory during the process. Ordinarily, this determination cannot be made during a run, but must await chemical analyses made after the run is finished. One of the goals of this study, therefore, was to see if this time lag could be avoided.

Partial success was achieved, as may be seen in Appendix A-11 which provides an NRT readout of A-Col uranium holdup. The top half of Appendix A-11 contains the NRT plot. (Note: This plot was actually made from recorded data but the procedure is the same, regardless of whether the data are "live" or recorded.) For comparison, the conventional plot for the same run, based upon data obtained by chemical analyses and post mortem flow rate determinations, is shown at the bottom of the page. Although there is still plenty of room for improvement, a start has been made in obtaining the NRT plot.

The computer program which printed out the top half is presented in Appendix B-1. During execution of this program, the various instruments are read by the computer and calculations made each four minutes. The flow rates from the tanks are computed by the dropout method. Among other subroutines, the program shown in Appendix B-1 uses the empirical equation for calculation of AP stream flow rates (line 602 of the program), the method for removal of densimetric noise (lines 555, 560, and 565 of the program), and curvilinear interpolation (starts line 20,000).

Based upon the calculated flow rates and on the uranium concentration in the AP stream as indicated by the XRFA instrument, the NRT plot at the top of Appendix A-11 was drawn by the computer. In much the same manner Appendix A-12 and Appendix A-13 were drawn representing NRT readout of holdup in the AB-Col (Columns A and B in series) and (by difference) the B-Col, respectively.

3.1.8 Acquisition and Run Status

A program, given in Appendix A-14, was prepared which prints out each four minutes, in NRT, an overall summary of the run then in progress. A typical example is given in Appendix A-15, where readings for a total of 24 instruments (counting the two temperature recorders) were scanned.

The printout of total volume, in mid-page of Appendix A-15 is an attempt to account for the entire liquid inventory in the system. A "Taylor volume," as used in this table, is defined as that volume of distilled water, at a temperature of 25°C, which would produce the given reading on the Taylor instrument. This is considered to be the most accurate volume reading possible, with the given instrumentation, since density measurements are not factored into Taylor volumes. The term "solution volume" as used, refers to the actual volumes of the various liquids after density adjustment. Under ideal conditions (i.e., after head pots and various other auxiliary vessels have reached near steady-state conditions), it was possible to detect a diversion of a few hundred milliliters (out of a total of approximately 1000 liters) in the system.

In the next part of this data summary is shown (left to right) the tank identity, liquid level in centimeters, volume in liters at 25°C, flow rate for the given period in liters per minute, cumulative flow rate, temperature of the BP stream, density, acidity, uranium content, and total uranium. Below this, similar information (where applicable) is listed for the lines and columns. Finally, the results for a summation of all the uranium in the system are given as a material balance.

There is room for improvement, but a start has been made. Information such as that shown in Appendix A-15 was used many times by operators during various runs to detect faulty run conditions in time for needed corrections to be made. Also the listings for tank liquid levels were consulted frequently by the operators before, during, and after a given run.

3.2 Experimental Procedure

The proposed experimental work on pilot-plant pulsed columns comprised ten mass-transfer tests with natural uranium shown in Table 3-1. The actual operating conditions are presented in Tables 4-1 and 4-2. The tests included (a) the uranium concentration profile measurement along the tested columns operating under steady-state process conditions, (b) actual dispersed phase holdup measurement at the end of each run, and (c) columns uranium inventory determination performed both analytically and by the computer.

3.2.1 Concentration Profile

The longitudinal uranium concentration profiles were determined by taking samples of both the continuous and dispersed phase at each sampler on the tested column (Figure 3-2) operating under steady-state conditions. Samples were analyzed for uranium and nitric acid concentration. Resultant analytical data were then used for calculation of the actual solute concentration at each sampling point. From these values, the solute concentration profiles were obtained.

The methods for chemical analyses are described in Appendix A in Reference 3. The model for calculation of the solute concentration profile, based on chemical analyses, is shown also in Reference 3.

Concentration profile data of the ten experimental runs with natural uranium simulating the second and third plutonium process cycles of BNFP, are summarized in Tables 4-3 through 4-12, as well as Figures 4-1 through 4-20. These data are discussed in Section 4.2.

3.2.2 Dispersed Phase Holdup

The actual dispersed holdup was determined through liquid volume measurements in the tested column at the end of each run. This technique comprises determination of the interface position in the disengaging section prior to shutdown, then separation (settling) of both liquid phases within the column after closing all feed and effluent lines, followed by turning off the pulser, and performing measurement of liquid volumes within the calibrated column. The dispersed phase holdup is then determined by dividing the measured volume of the dispersed phase by the total liquid volume of the column active section.^(4,5) Actual holdup data are shown in Tables 4-1 through 4-3.

3.2.3 Solute Inventory Determination in Pulsed Columns

The inventory of solutes (U, Pu, HNO_3 , etc.) in pulsed columns used in a nuclear fuel reprocessing plant is discussed in References 4 and 5. Empirically, the solute inventory in a column can be determined using the following methods:

- (a) Concentration profile and actual dispersed phase holdup measurements performed in the column operating under steady-state process conditions.
- (b) Volume and concentration measurement of each phase at the end of each run after draining the column.
- (c) Feed and effluent streams mass rate measurement performed in short-time intervals during the run.
- (d) Solutes inventory measurement in feed and receiving tanks.
- (e) Computer program based on the mass rate measurement technique in item (c).
- (f) Calculation from empirical equations,⁽⁴⁾ which is discussed in Section 5.3

3.2.3.1 Concentration Profile - Holdup Method

The method is comprehensively described in Reference 4. It requires determination of both the solute concentration profile and dispersed phase holdup within the column, as well as volume calibration of each column section. From the solute average concentration obtained from the concentration profile and the dispersed phase holdup value within the calibrated column section, the solute inventory in that section can be

determined. The total solute inventory is then given by the sum of all sectional (partial) inventories in the column. The uranium inventory in the 1A dual process column was determined by using holdup data calculated from the equation in Reference 5. The inventory in the 1BS stripping column was determined by using actual dispersed phase holdup data, measured at the end of each run.

3.2.3.2 Volume-Concentration Measurement Method

The technique is based on draining the column after reaching the operational steady-state, decanting and measuring both the volume and solute concentration in each liquid phase.⁽⁴⁾ The quantity of a solute in each phase is then given by the product of the corresponding liquid volume and solute concentration. The total solute inventory in the column is expressed as the sum of both the organic and aqueous solute quantities.

3.2.3.3 Mass Rate Measurement Method

A detailed description of the method is given in Reference 5. It is based on the flow and solute concentration measurement in feed and effluent streams performed in short-time intervals, starting from the moment when the feed solution (1AF) is first introduced into the 1A column. The general equation for the solute inventory in the equipment (column, vessel) has the form

$$\begin{aligned}\Delta M_{t(n)} &= \frac{\Delta t}{2} \cdot \sum_{i=1}^{(n)} (\Delta m_{i-1} + \Delta m_i) \\ &= \frac{\Delta t}{2} \cdot \left[\Delta m_{(0)} + \Delta m_{(n)} + 2 \sum_{i=1}^{(n-1)} \Delta m_i \right] \quad \dots 4\end{aligned}$$

where: ΔM = Solute inventory (grams)

$$\Delta m = v_f \cdot C_f - \Sigma(v_e \cdot C_e) = m_f - m_e$$

solute mass rate difference (grams/minute)

v = Flow rate (l/min)

C = Solute concentration (g/l)

f = Feed

e = Effluent

$$v_f \cdot C = m_f; \text{ solute feed mass rate (g/min)}$$

$$\Sigma(v_e \cdot C_e) = m_e; \text{ total solute effluent mass rate (g/min)}$$

Δt = Time interval (minute).

The above equation applies to the (a) single process column, (b) dual process column, (c) entire process cycle, and (d) entire plant equipment.

The total solute inventory in a column is determined by measuring the solute mass rate difference (Δm) in short-time intervals during operation, starting from time zero (t_0) when the feed solution is first introduced into the column. Theoretically, a zero mass rate difference ($\Delta m=0$) is obtained during measurements performed under operational steady-state conditions in the column, when the feed mass rate equals the effluent mass rate. If solute's removal (diversion) occurs in any tank, column or stream, the mass rate difference will be always higher than zero ($\Delta m>0$). From measured time and mass rate data, the quantity of the removed solute, the approximate "diversion" time, its duration, as well as its place could be detected by this method. This assumes all measurement systems are accurately calibrated with minimum systematic errors.

3.2.3.4 Tanks Solute Inventory Method

The total solute inventory in the columns and ancillary equipment, operating under steady-state conditions, can be determined by measuring and comparing the solute's quantity spent in the feed tank with that accumulated in all receivers during the same time period. In this case, the solute inventory can be calculated from the equation

$$\Delta M(t_i) = \Delta M_{F.Tk.}(t_i) - \Sigma \Delta M_{Rec.}(t_i) \quad \dots 5$$

where:

$\Delta M(t_i)$ = Solute inventory (grams) measured in time t_i (minutes)

$\Delta M_{F.tk}(t_i)$ = Solute quantity spent in the feed tank (grams) during time t_i (minutes)

$\Sigma \Delta M_{Rec.}(t_i)$ = Solute quantity accumulated in all receivers (grams) during time t_i (minutes)

3.2.3.5 Computer Method

The computer method is based on the mass rate measurement technique described in Section 3.2.3.3. Equation 4 in that section was used for uranium inventory computation in each column. The developed computer program is given in Appendix B-1.

The mass rate measurement technique, applied either analytically or by the computer, requires basically two things: (1) determination of the flow rate of each stream entering and leaving the column, and (2) measurement of the solute concentration in each stream, performed in short-time intervals during the process.

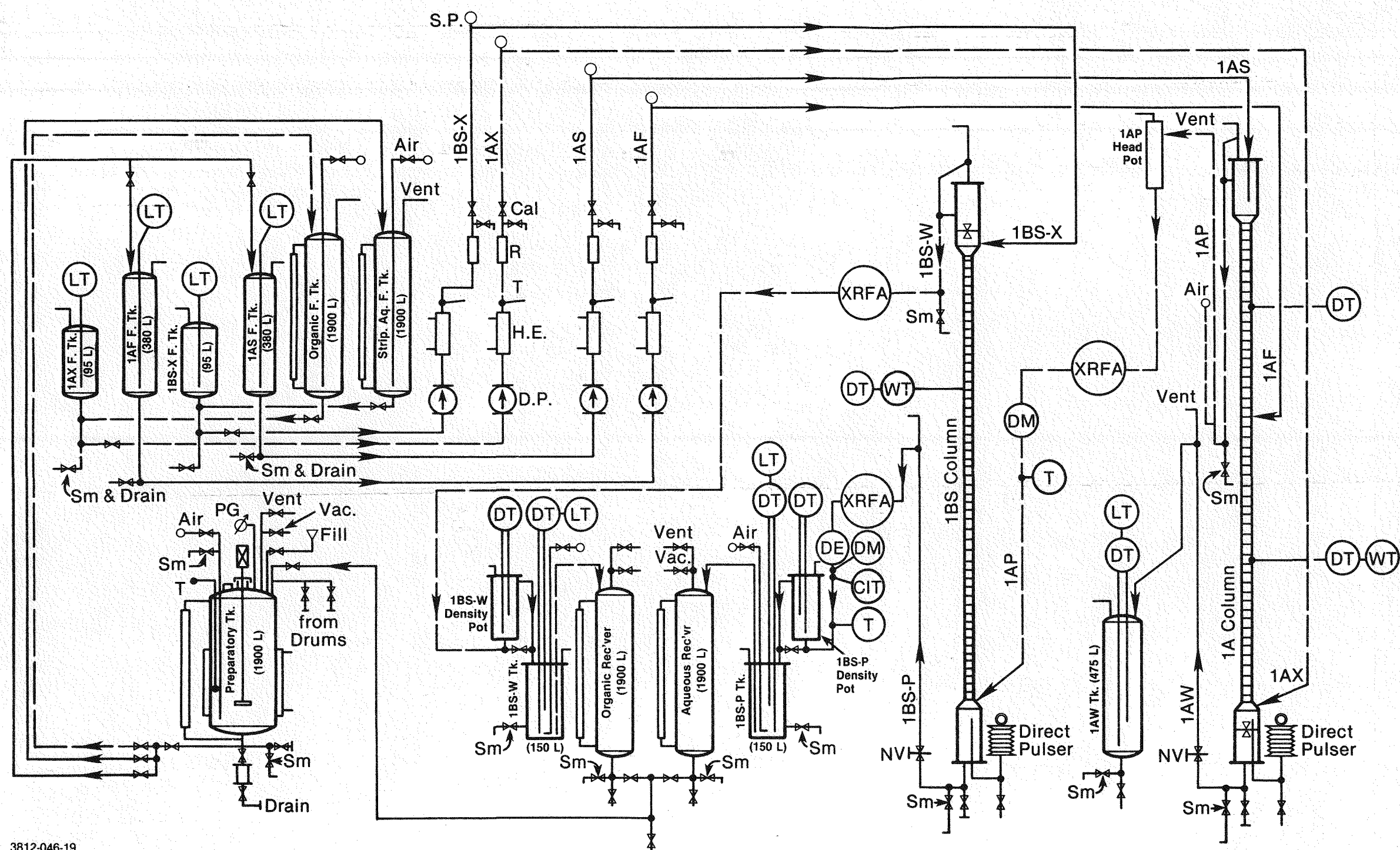
TABLE 3-1

PLANNED TEST DATA

Column:	Feed Stream:	Phase:*	Concentration:			Flow Rate: (ml/min)				
			U (g/l)	HNO ₃ (M)	Others:					
2A & 2B Columns:	Tests at room temperature:					2AM-1	2AM-2	2AM-3	2AM-4	2AM-5
2A Column (≡1A Column)	2AS	A	0.0	1.0	N/A	104	104	104	104	104
	2AF	A	26.0	3.0	N/A	750	550	550	350	350
	2AX	0	0.0	0.0	30% TBP	280	280	280	280	280
2B Column (≡1BS Column)	2BX	A	0.0	0.3	N/A	280	280	280	280	280
3A & 3B Columns:	Tests at room temperature:					3AM-1	3AM-2	3AM-3	3AM-4	3AM-5
3A Column (≡1A Column)	3AS	A	0.0	1.0	N/A	100	100	100	100	100
	3AF	A	40.0	3.3	N/A	550	450	450	350	350
	3AX	0	0.0	0.0	30% TBP	260	260	260	260	260
3B Column (≡1BS Column)	3BX	A	0.0	0.2	N/A	260	260	260	260	260

*A - aqueous; 0 - organic

BLANK PAGE



- Cal Flow Calibration
- CIT Conductivity Indicator and Transmitter
- DE Dynatrol Density
- DM Mettler Parr Densimeter
- D.P. Displacement Pump
- DT Liquid Density Transmitter
- H.E. Heat Exchanger
- LT Liquid Level Transmitter
- NV Needle Valve
- R Flowmeter
- Sm Sampling
- S. P. Surge Pot
- T Temperature Indicator
- WT Weight Recorder Transmitter
- XRFA Instrument for On-Line Uranium Concentration Measurement
- ⊗ Interface

3812-046-19

PILOT PLANT FLOW DIAGRAM
AND INSTRUMENTATION

FIGURE 3-1

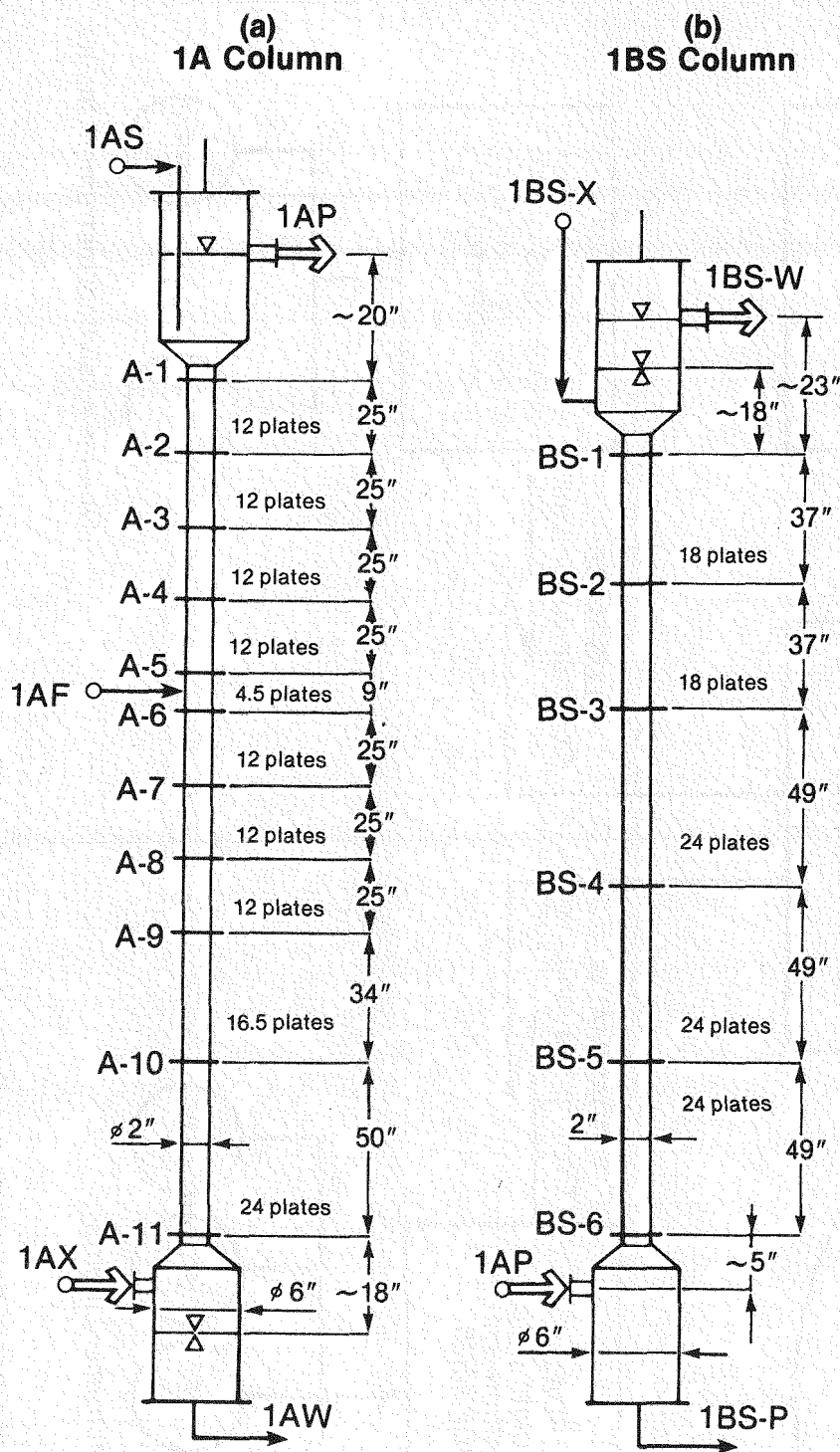
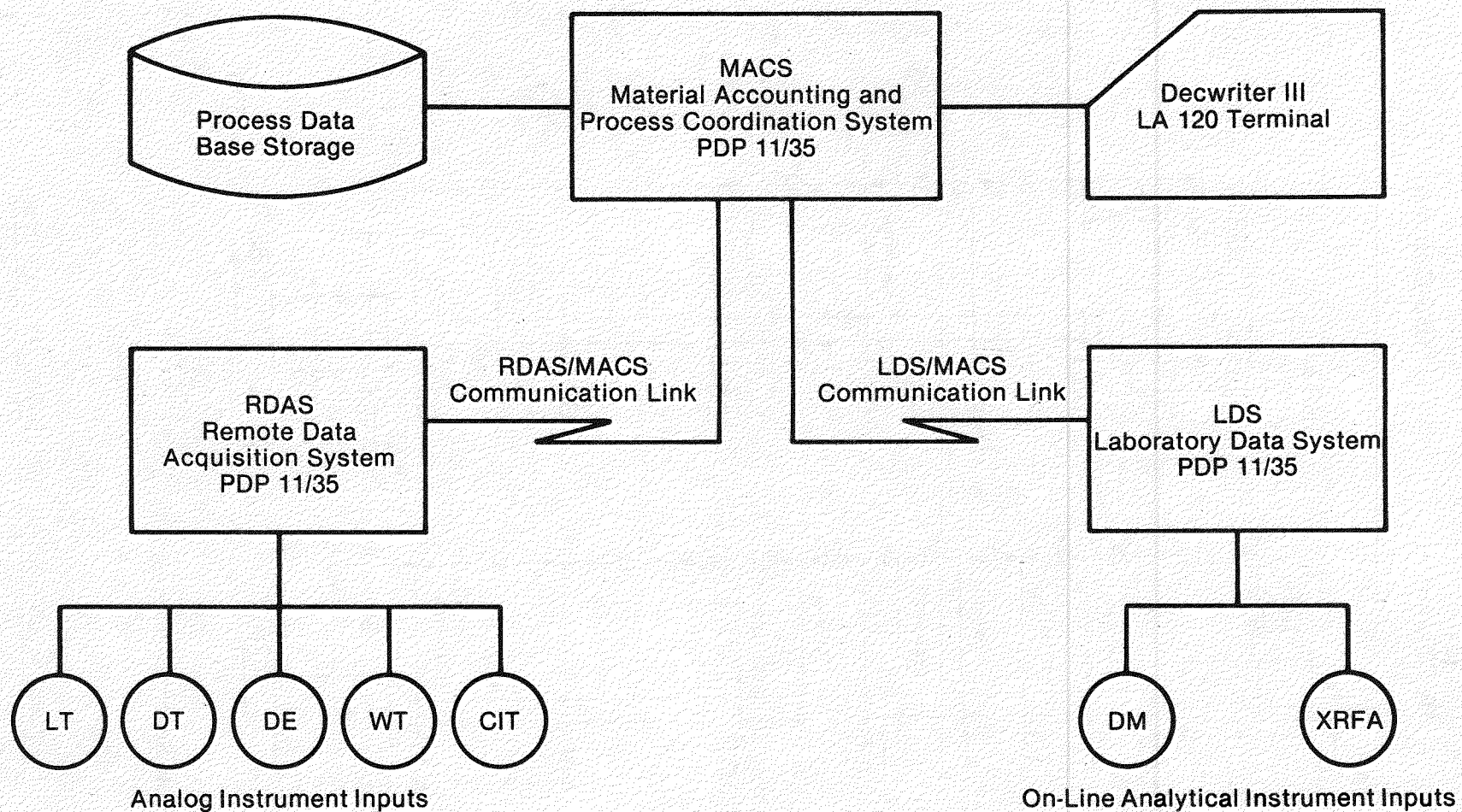


Plate Spacing: 2-inches

80-153-1

SAMPLERS LOCATION AT THE 1A AND 1BS COLUMNS

FIGURE 3-2



Note: For instrument symbol definition, see figure 3-1

3812-046-20

PILOT PLANT INSTRUMENT DATA ACQUISITION SYSTEM

FIGURE 3-3

4.0 RESULTS AND DISCUSSION

4.1 Mass-Transfer Tests

Flow and operating conditions of ten mass-transfer tests with natural uranium are presented in Tables 4-1 and 4-2. They include also the actual dispersed phase holdup values measured in each column during experimental runs. All tests were performed at a room temperature of about 24°C.

Uranium extraction in the 1A column was very efficient. In all tests, the 1AW raffinate contained <0.01 grams uranium per liter, except test 3AM-1, where the uranium content was about 4 grams per liter. (See effluent stream data in Tables 4-3 through 4-12). Scrubbing in the 1A column upper section and stripping in the 1BS column was as expected. Uranium concentration in the 1AP and 1BS-P product streams increased about linearly with an increase in the 1AF feed flow rate maintaining the other feed flow rates constant. It increased in about the same manner also with an increase in the 1AF feed concentration at a constant 1AF/1AX, and 1AF/1BS-X flow ratio, respectively. Compare data in Table 4-14 and Figures 4-21 and 4-22.

During tests, the 1A column and 1BS column operated about 10 to 13%, and 25 to 30% below the corresponding upper flooding curve,⁽⁴⁾ respectively. The operational steady-state in the 1A column was reached within 100 to 150 minutes after turning on the 1AF feed stream, or in about 1.2 to 1.4 exchanges of the organic phase volume within the column operating with the organic phase continuous. Both the 1A and 1BS columns operated under steady-state conditions in approximately 210 to 250 minutes, or after about 2.3 to 2.5 exchanges (with the organic phase) of the organic phase volume in the 1A column.

As shown in Table 3-1, it was planned to change only the 1AF feed flow rate by maintaining all other feed streams constant during experimental runs. Actual flow rates measured volumetrically during runs are presented in Tables 4-1 and 4-2. Comparison of data in the above tables indicates deviation in flow rates, although each flow rate was controlled by the calibrated diaphragm-type displacement pump. It demonstrated the expected technical difficulties in simulating or repeating the same runs. For example, during similar 2AM-2 and 2AM-3 tests, the flow rate deviation from the planned value was in the 1AS stream +1% and +34%, in the 1AF stream +12% and +2%, in the 1AX stream +10% and 14%, and in the 1BS-X stream +16% and +15%, respectively.

4.2 Variables

Essentially variables required for evaluation of the mass balance, mass-transfer process, and particularly the solute inventory in a column are the feed and effluent streams flow rate, and the solute concentration in each stream.

4.2.1 Feed Flow Rate

The flow rate of any feed stream can be determined through liquid volume measurements in the corresponding feed tank during a measured time interval. Assuming that liquid volume ΔV is spent in a feed tank during time interval Δt , then the average feed flow rate (in that time interval) will be

$$v = \frac{\Delta V}{\Delta t} \text{ (l/min), (l/hr)} \quad \dots 6$$

The accuracy of the flow rate value, as shown, depends on the accuracy in measuring both the liquid volume change in the tank (ΔV), and time interval (Δt). Generally, measuring the time interval is easier than measuring the liquid volume change within the tank. However, the longer the time interval, the more accurate is the Δt and ΔV reading.

The liquid volume measurement in a tank requires (a) a thorough calibration of the tank, (b) reliable liquid level reading, and (c) reliable liquid density measurement.

The accuracy in tank calibration is affected essentially by the design of the tank. For example, a simple cylindrical tank, with no internal piping, mixer, filling materials and complex baffles, is calibrated easier than tanks provided with those parts. The calibration of a tank is made by determining the relationship between the measured volume of the standard liquid (water of known density) and corresponding liquid level reading along the tank. The liquid level change in the tank is usually monitored by the calibrated dip-tube (air bubbler) instrument measuring continuously the pressure difference between the pressure within the dip-tube, when air is bubbling into the tank, and air pressure inside the tank. The measured liquid level is then

$$L_{St} = 1000 \frac{\Delta P}{\rho_{St}} \quad \dots 7$$

where:

L_{St} = Standard liquid level (cm)

ΔP = Pressure differential (kg/cm²)

ρ_{St} = Standard liquid density (grams/cm³)

The liquid level instrument indicates always the level corresponding to the standard liquid used during calibration. At different liquids than the standard liquid, the actual liquid level (L) and volume (V) will be different than indicated by the instrument (L_{St} , V_{St}), depending on the liquid density (ρ). The density (ρ) of each feed solution was determined (from samples) prior to startup of tests. The actual liquid level in the tank is then

$$L = L_{St} \frac{\rho_{St}}{\rho} = 1000 \frac{\Delta P}{\rho} \quad \dots 8$$

and the actual liquid volume with regard to the calibration curve, indicating the V-L relationship, is

$$V = V_{St} \cdot \frac{\rho_{St}}{\rho} \quad \dots 9$$

All feed tanks in the pilot plant are cylindrical, provided with one internal dip-tube. It was found through calibration that the calibration number representing the liquid level change per liquid unit volume changes little along the tank. The average value along both the IAS and IAF 380-liter feed tanks is about 0.35 cm/liter, and along the IAX and IBS-X 95-liter feed tanks is 1.27 cm/liter.

The small values of the calibration numbers affected considerably the accuracy in reading the liquid volume changes in each feed tank, especially when performed in short-time intervals and at low flow rates. For example, the liquid volume readings in eight-minute time intervals in each tank during 3AM-3 test are presented in Appendix B-2. Calculating the flow rate from the above periodic volume readings during the 284-minute operating time (from 8:30 a.m. to 1:14 p.m.), it can be shown that the measured volume flow rate of the IAS feed stream deviates about 25% from its average value of 0.106 liter per minute, whereas the IAF stream flow rate deviates only about 3.5% from the IAF average flow rate of 0.435 liters per minute (four times higher than that of the IAS stream). It can be shown also that the IAS and IAF flow rates calculated from volume readings in 16 to 24-minute time intervals in Appendix B-2, deviate about 9% and 3.0% from the above average flow rate values, respectively.

To obtain more reliable flow rate data, it is recommended to perform liquid volume readings in each feed tank periodically in at least 15-minute time intervals during the run.

4.2.2 Effluent Flow Rate

The liquid volume increase measured in set time intervals in a receiving tank cannot be used for the precise evaluation of the corresponding effluent stream flow rate. For example, consider a usual receiving tank provided, besides the filling, draining and vent lines, also with the liquid level monitoring instrument (LT) and densimeter (DT).

Assume liquid volume and density measurements in time interval

$$\Delta t_{1,2} = t_2 - t_1$$

The liquid level L_1 , Volume V_1 , and density ρ_1 were measured in time t_1 . The liquid level L_2 , volume V_2 , and density ρ_2 were measured in time t_2 .

The tank was calibrated with the standard liquid of a density of ρ_{St} , for which applies

$$V_{St1} \cdot \rho_{St} = V_1 \cdot \rho_1$$

and

$$V_{St2} \cdot \rho_{St} = V_2 \cdot \rho_2$$

Taking into account the mass (or weight) change equation

$$V_2 \cdot \rho_2 = V_1 \cdot \rho_1 + \Delta V_{1,2}^* \cdot \rho_2 \quad \dots 10$$

the volume increase measured in time interval $\Delta t_{1,2}$ in the tank will be

$$\begin{aligned} \Delta V_{1,2}^* &= V_2 - V_1 \cdot \frac{\rho_1}{\rho_2} \\ &= V_{St2} \cdot \frac{\rho_{St}}{\rho_2} - V_{St1} \cdot \frac{\rho_{St}}{\rho_2} \\ &= \Delta V_{St1,2} \cdot \frac{\rho_{St}}{\rho_2} \quad \dots 11 \end{aligned}$$

The measured volume increase ($\Delta V_{1,2}^*$) is different than the volume of the effluent stream ($\Delta V_{e1,2}$) entering the tank during time period $\Delta t_{1,2}$. The effluent stream density ($\rho_{e1,2}$) is affected by the solutes concentration within the stream. Its value is constant only when the column operates under steady-state conditions.

Considering the mass change equation

$$V_2 \cdot \rho_2 = V_1 \cdot \rho_1 + \Delta V_{e1,2} \cdot \rho_{e1,2} \quad \dots 12$$

the actual volume change is

$$\Delta V_{e1,2} = \Delta V_{St1,2} \cdot \frac{\rho_{St}}{\rho_{e1,2}} \quad \dots 13$$

The relationship between the actual effluent volume ($\Delta V_{e1,2}$) and measured liquid volume change ($\Delta V_{1,2}^*$) during time period $\Delta t_{1,2}$ is then

$$\Delta V_{e1,2} = \Delta V_{1,2}^* \cdot \frac{\rho_2}{\rho_{e1,2}} \quad \dots 14$$

As shown in this equation, the $\Delta V_{e1,2}$ determination requires, in addition to the liquid volume and density measurement in the tank, also the measurement of the effluent stream density ($\rho_{e1,2}$) in time interval $\Delta t_{1,2}$. Before reaching the operational steady-state within the column, the effluent stream density is not constant due to changes in the solute concentration. In this case, its approximate average value for short-time interval $\Delta t_{1,2}$ (e.g., up to ten minutes) can be estimated from the equation

$$\rho_{e1,2} \approx \frac{\rho_{e1} + \rho_{e2}}{2} \quad \dots 15$$

where ρ_{e1} and ρ_{e2} are effluent stream densities measured at the beginning and end of the time interval, respectively.

To measure continuously the above density required for $\Delta V_{e1,2}$ determination, the receiving tank has to be provided with a densimeter on the effluent line outside the tank. For illustration, see the arrangement of both the LBS-P and LBS-W receiving tanks in Figure 3-1. Knowing the $\Delta V_{e1,2}$ value, then the average effluent stream flow rate in time interval $\Delta t_{1,2}$ can be calculated from the equation

$$\begin{aligned} v_{e1,2} &= \frac{\Delta V_{e1,2}}{\Delta t_{1,2}} \\ &= \frac{\Delta V_{St1,2} \cdot \rho_{St}}{\Delta t_{1,2} \cdot \rho_{e1,2}} \end{aligned} \quad \dots 16$$

The flow rate value depends on the accuracy in reading the volume change ($\Delta V_{St1,2}$) in the tank, and in measuring the effluent stream density ($\rho_{e1,2}$) in short-time intervals, as well as on the tank calibration. For example, the flow rates of both the LBS-P ($\equiv$ BP) and LBS-W ($\equiv$ BW) effluent streams evaluated from volume readings in eight-minute intervals in Appendix B-2 (test 3AM-3) are about 6 to 12% lower than expected with regard to the solutes concentrations, see Appendix B-24. These lower flow rate values resulted basically from inaccurate volume and density measurements.

For satisfactory determination of the effluent streams flow rate through volume and density measurements, it is recommended to recalibrate:

- (a) Both the LBS-P and LBS-W receiving tanks in the Pilot-Plant
- (b) The liquid level measuring instrument (LT) at the LBS-P and LBS-W receiving tanks.
- (d) The effluent stream densimeter of both the LBS-P and LBS-W density pots.

The flow rate of each effluent stream containing uranium and nitric acid can be readily calculated by use of equation 1 in Section 3.1.4. The equation was applied, e.g., during analytical determination of the uranium inventory in test columns presented in this report. Its use is justified through the achieved satisfactory results. The equation shows the expected increase in solutes (U, HNO_3) concentration in the effluent stream.

The concentration profiles indicate that the uranium concentration in both the organic and aqueous phase within the 1A column at the 1AF feed inlet does increase with an increase in the 1AF stream flow rate at a constant flow of other streams, or with an increase in feed (1AF) to stripping stream (1AX) flow ratio, as expected. The uranium concentration in effluent streams from both columns is affected by the 2AF flow rate in the same manner. Resultant diagrams from experimental data in Table 4-13, describing the above effect, are shown in Figures 4-21 and 4-22. From comparison of data in the above table and

figures, it can be deduced that, at a given flow ratio, the higher the uranium concentration within the IAF feed stream, the higher will be the concentration in the product streams (IAP and IBS-P), as well as within the IA column around the IAF stream inlet.

4.3 Uranium Concentration Profiles

Uranium and nitric acid concentrations along the tested pulsed column were determined through sampling and calculations as described in Section 3.2.1 and Reference 3. Resultant profile data from the ten experimental runs are summarized in Tables 4-3 and 4-12, and are presented graphically in Figures 4-1 through 4-20. These data were used, in conjunction with the corresponding dispersed phase holdup values given in Tables 4-1 and 4-2, to calculate the column uranium inventory using the method noted in Reference 4.

4.4 Uranium Inventory in Pulsed Columns

The uranium inventory, i.e., its holdup within the pulsed column tested during each experimental run, was determined both analytically and by the computer.

The analytical methods used for uranium inventory determination in pulsed columns were as follows:

- (1) "Concentration Profile - Holdup Measurement" method
- (2) "Liquid Volume - Concentration Measurement" method
- (3) "Mass Rate Measurement" method
- (4) "Tanks Inventory" method
- (5) Calculation from empirical equations.

The computer method, based on the "Mass Rate Measurement" technique included:

- (a) Uranium inventory computation using laboratory analysis of U concentration in flow samples and average flow rate data.
- (b) Uranium inventory computation using average flow rate data and uranium concentration on effluent streams monitored by the corresponding XRFA instrument in four-minute time intervals.
- (c) Uranium inventory computation using both the flow rate and XRFA concentration readings in four-minute time intervals.

The analytical methods in items (1) through (4) were described in Sections 3.2.3.1 through 3.2.3.4, respectively.

Estimated data from concentration profiles in Figures 4-1 through 4-20 were used, in connection with the dispersed phase holdup values in

Tables 4-1 and 4-2, to determine the uranium inventory in tested columns through the "Concentration Profile - Holdup Measurement" method.

Experimental liquid volume and concentration data obtained from measurement after draining the columns, given in Table 4-14, were used for calculation of the uranium inventory in columns during each run, which is considered the most reliable method.

Flow rates, analytical concentration data, and effluent mass rate data on all tests (except test 2AM-1), determined in 15- to 30-minute time intervals, are summarized in Tables 4-15 through 4-23. The measured uranium mass rate versus time relationship is shown graphically in Figures 4-23 through 4-31. Those data were used for analytical determination of the uranium inventory in tested columns through the "Mass Rate Measurement" method. The determined relationship between the measured column uranium inventory and time is presented in Figures 4-32 through 4-40.

Uranium inventory data on the 1AF feed tank, the 1AW, 1BS-W and 1BS-P receiving tanks, and 1AP head pot at the end of the experimental run are shown in Tables 4-24 and 4-25. Those analytical data were used for determination of the total uranium inventory in both columns through the "Tanks Inventory" method. The uranium concentration in receiving tanks was determined analytically after completion of each test. Due to technical difficulties in measuring the actual liquid volume in the receiving tanks (densimeters did not operate), the liquid volume in each tank was calculated from the measured average feed flow rate and known total feed time of the corresponding stream. The volumes were then corrected by use of equation 2 in Section 3.1.3.6.

The uranium inventory in columns was also calculated from the empirical equations described in Reference 4. The calculated inventories correlate well with those determined experimentally through the above analytical methods, as shown in Tables 4-26, 4-27, and as shown graphically in Figure 4-41. Plotting resultant inventory data in the diagram in Figure 4-41 shows that the uranium inventory in the 1A dual process column, simulating the 2A and 3A columns performance in the plant, can be approximately calculated from the empirical equation:

$$M_{1A} \approx 0.84 V_{col} \cdot \left(\frac{v_f}{v_{St}} \cdot C_{(U)_f} - 30 \right) \quad \dots 17$$

$$\text{when } \frac{v_f}{v_{St}} \cdot C_{(U)_f} \geq 55 \text{ g U/l, and from the equation} \quad \dots 18$$

$$M_{1A} \approx 0.44 \cdot V_{col} \cdot \frac{v_f}{v_{St}} \cdot C_{(U)_f}$$

$$\text{when } \frac{v_f}{v_{St}} \cdot C_{(U)_f} < 55 \text{ g U/l.}$$

The uranium inventory in the 1BS stripping column, simulating the 2B and 3B plant columns performance, can be calculated from the empirical equation:

$$M_{1BS} = 0.45 V_{(col)} \cdot \frac{v_f}{v_{St}} \cdot C(U)_f \quad \dots 19$$

In these equations:

M = Uranium inventory in the column (grams),
 $V_{(col)}$ = Column total liquid volume (liters),
 v_f = Feed flow rate (liters/minute),
 v_{St} = Stripping stream flow rate (liters/minute),
 $C(U)_f$ = Uranium concentration in the feed stream (grams U/liter).

Equation 18 is identical to that developed for columns operating under HS column process conditions, with the exception of the $v_f/v_{St} \cdot C(U)_f$ range, which is about half of that of the HS Column.

The above equations apply only to the tested pilot plant columns. The column design (dimensions) will affect the coefficient value in these equations. (4) For example, analyzing experimental data from the cold uranium mini-run on the second and third plutonium cycles in the plant, (6) the equation for uranium inventory determination will be:

In the 2A Plant Column of a total liquid volume of 712 liters:

$$M_{2A} \approx 0.34 V_{(col)} \cdot \left(\frac{m_f}{v_{St}} - 30 \right) \quad \dots 20$$

or

$$M_{2A} \approx 242 \cdot \left(\frac{m_f}{v_{St}} - 30 \right) \quad \dots 21$$

In the 2B Plant Column of a total liquid volume of 425 liters:

$$M_{2B} \approx 0.58 \cdot V_{(col)} \cdot \frac{m_f}{v_{St}} \quad \dots 22$$

or

$$M_{2B} \approx 246.5 \frac{m_f}{v_{St}} \quad \dots 23$$

In the 3A Plant Column of a total liquid volume of 518 liters:

$$M_{3A} \approx 0.39 V_{(col)} \cdot \left(\frac{m_f}{v_{St}} - 30 \right) \quad \dots 24$$

or

$$M_{3A} \approx 202 \left(\frac{m_f}{v_{St}} - 30 \right) \quad \dots 25$$

In the 3B Plant Column of a total liquid volume of 468 liters:

$$M_{3B} \approx 0.265 V_{(col)} \cdot \frac{m_f}{v_{St}} \quad \dots 26$$

or

$$M_{3B} \approx 124 \cdot \frac{m_f}{v_{St}} \quad \dots 27$$

In the above equations:

- M = Column uranium inventory (grams U),
- m_f = $\Sigma v_f C(U)_f$; uranium feed mass rate (grams U/minute),
- v_f = Feed flow rate (liters/minute),
- v_{St} = Stripping stream flow rate (liters/minute),
- $C(U)_f$ = Uranium concentration in the feed stream (grams U/liter)

Validity of these equations may be reverified through subsequent mini-runs performed under about the same conditions in the plant. As indicated, the coefficient in equations 20, 22, 24, and 26 are different than those equations 17 through 19 due mainly to different column dimensions.

Experimental (analytical) data in Tables 4-15 through 4-23 were used also for computation of the uranium inventory in tested columns through the computer program, which resulted in inventories shown in Appendices B-4 through B-23, and Tables 4-26 and 4-27. The computer inventories from analytical data are quite comparable with those determined through analytical methods.

After satisfactory recalibration of the XRFA in-line instrument for effluent uranium concentration monitoring, the near-real-time uranium inventory in columns during the last three tests (3AM-3, 3AM-4, and 3AM-5) was determined by the computer program (see Appendix B-1) using the XRFA concentration data (Appendices B-24, B-25, and B-26, respectively) and flow rate data (Appendix B-3). Results are given in Table 4-27, and Appendices B-27 through B-32. They indicate a higher

deviation from the corresponding uranium inventory determined through the liquid volume and concentration measurements after draining the tested columns (considered the most reliable experimental method) than other inventories obtained from the average flow rate values. It was assumed that the above deviation is mainly due to the inaccuracy in reading the liquid volume changes in each tank in the noted short-time intervals.

To verify the above assumption, the uranium inventory in columns was computed during the 3AM-3, 3AM-4, and 3AM-5 tests also from XRFA concentration readings (Appendices B-24, B-25, and B-26, respectively) performed in four-minute time intervals by using the average flow rate values determined from data in Appendix B-3. Resultant inventory data are shown in Table 4-27, and in Appendices B-33 through B-36. They correlate well with the corresponding uranium inventory evaluated through the "Liquid Volume - Concentration Measurement" method as indicated in Table 4-27. In this case, the use of the average flow rate values is justified because all feeds to tested columns were controlled by steadily operating (calibrated) positive displacement pumps.

All ten tests evaluated in this report were performed smoothly as indicated through the corresponding weight and density recorder readings at each column. These readings obtained during the 3AM-3, 3AM-4, and 3AM-5 tests are presented in Appendices B-37, B-38, and B-39, respectively, as examples. The 1BS column density readings through the average column density recorder and weight recorder could not be done entirely during experimental runs due to the upper limit setpoint on the above instruments (1.02 and 1.04 grams/cm³, respectively). All readings on the 1A column indicate smoothness in the corresponding run performance, as well as the approximate time when the column started to operate under steady-state process conditions. From that time on, all readings remained about constant. Drawing concentration profile samples for the 1A column, which started about 12:10 to 12:20 p.m., resulted in discernible changes (drops) in density readings as shown in Appendices B-37 through B-39. Column density readings can follow any process upset within the column during operation. For example, an additional run made under similar conditions as that of the 2AM-1 test, with the exception of the pulse velocity which was about 13% higher, resulted in the 1A column flooding. Density readings are shown in Appendix B-40. The column was flooded twice, i.e., at 10:00 a.m. and 12:20 p.m. In both cases, reversal of phases occurred. The recovery from these upsets was slow when only the pulse frequency was reduced (of about 30%). Therefore, after each flooding, it was required to shut down also the 1AF feed stream for about 30 minutes.

Column density readings are indispensable for the process control in the pulsed column. They can be used effectively as an early warning system for undesirable process conditions which may be building up in plant column.

TABLE 4-1

2A AND 2B COLUMNS,
TEST CONDITIONS AND DATA
(Tests 2AM-1, 2AM-2, 2AM-3, 2AM-4 and 2AM-5)

Column:	Stream:	Phase:	Concentration:		Flow Rate : (ml/min)					
			U (g/l)	HNO ₃ (M)	Test 2AM-1	Test 2AM-2	Test 2AM-3	Test 2AM-4	Test 2AM-5	
2A Column (≡1A Column)	2AS	A	0.0	1.0	104	105	140	84	96	
	2AF	A	26.4	3.0	740	614	560	325	333	
	2AX (30% TBP)	0	0.0	0.0	275	307	317	298	282	
2B Column (≡1BS Column)	2BX	A	0.0	0.3	265	323	321	305	304	
2A Column	Pulse Frequency:		(c/min)		~ 84	86	85	85	85	
	Pulse Amplitude:		(cm)		~1.8	1.8	1.8	1.8	1.8	
	Dispersed Phase Holdup: (%)	Scrubbing			(13.0)	(13.9)	(13.9)	(13.0)	(13.3)	
		Extraction			(23.2)	(22.7)	(21.6)	(18.0)	(18.4)	
			Average (Scrubbing and Extraction)			~20.1	18.9	19.3	16.7	17.2
2B Column	Pulse Frequency:		(c/min)		~60	60	60	60	60	
	Pulse Amplitude:		(cm)		~1.9	1.9	1.9	1.9	1.9	
	Dispersed Phase Holdup:		(%)		~7.5	7.6	7.8	7.0	6.6	
2A and 2B Columns	Temperature:		(°C)		~24	24	24	24	24	

NOTE: Holdup data in parenthesis were calculated from the equation shown in the report
AGNS-35900-2.5-124, 1981 (Reference 5)

TABLE 4-2
TEST CONDITIONS AND DATA
3A and 3B Columns

(Tests: 3AM-1, 3AM-2, 3AM-3, 3AM-4, and 3AM-5)

Column:	Stream:	Phase:	Concentration:		Flow Rate: (ml/min)				
			U (g/l)	HNO ₃ (M)	Test 3AM-1	Test 3AM-2	Test 3AM-3	Test 3AM-4	Test 3AM-5
3A Column (≡1A Col.)	3AS	A	0.0	1.0	~ 100	107	106	106	105
	3AF	A	40.13	3.2	536	452	435	325	321
	3AX	O	0.0	0.0	258	260	262	260	265
3B Column (≡1BS Col.)	3BX	A	0.0	0.2	302	278	267	275	277
3A Column	Pulse Frequency: (c/min)				~ 85	84	84	85	85
	Pulse Amplitude: (cm)				1.7	1.7	1.7	1.7	1.7
	Dispersed Phase Holdup: (%)	Scrubbing		(11.5)	(11.2)	(11.2)	(11.6)	(11.6)	
		Extraction		(18.4)	(16.9)	(16.7)	(16.0)	(15.9)	
		Average (Scrubbing and Extraction)		~16.0	14.8	14.7	14.5	14.0	
3B Column	Pulse Frequency: (c/min)				61	60	60	62	62
	Pulse Amplitude: (cm)				1.9	1.9	1.9	1.9	1.9
	Dispersed Phase Holdup: (%)				~ 7.7	8.0	7.4	8.3	8.5
3A and 3B Column	Temperature: (°C)				~ 24	24	24	24	24

NOTE: Holdup data in parenthesis were calculated from the equation shown in the report AGNS-35900-2.5-124, 1981 (Reference 5).

TABLE 4-3

CONCENTRATION PROFILE DATA
(Test: 2AM-1)

2A Column: ($\equiv$ 1A Col.)					2B Column: ($\equiv$ 1BS Col.)				
Sample:	Aqueous:		Organic:		Sample:	Aqueous:		Organic:	
	U (g/l)	HNO ₃ (M)	U (g/l)	HNO ₃ (M)		U (g/l)	HNO ₃ (M)	U (g/l)	HNO ₃ (M)
End	(2AS)	(2AS)	(2AP)	(2AP)	End	(2BX)	(2BX)	(2BW)	(2BW)
Stream	0.0	1.0	~71.0	~0.115	Stream	0.0	0.30	~22.9	<10 ⁻³
A-1	~6.0	~1.0	72.4	0.115	B-1	~9.7	0.28	27.6	<10 ⁻³
A-2	-----	-----	-----	-----	B-2	22.7	0.29	40.4	<10 ⁻³
A-3	34.9	1.14	86.9	0.125	B-3	31.9	0.29	50.2	0.007
A-4	-----	-----	-----	-----	B-4	39.7	0.30	61.6	0.012
A-5	42.9	1.62	95.6	0.137	B-5	48.4	0.29	68.1	0.018
A-6	38.0	2.70	91.7	0.175	B-6	49.7	0.31	70.8	0.055
A-7	5.9	2.92	40.8	0.40	End	(2BP)	(2BP)	(2AP)	(2AP)
A-8	-----	-----	-----	-----	Stream	~49.8	~0.39	71.0	0.115
A-9	<0.01	2.87	<0.01	0.52					
A-10	-----	-----	-----	-----					
A-11	<0.01	2.75	<0.01	0.44					
End	(2AW)	(2AW)	(2AX)	(2AX)					
Stream	<0.01	2.71	0.0	0.0					

2AF →

TABLE 4-4

CONCENTRATION PROFILE DATA

(Test: 2AM-2)

2A Column: ($\equiv$ 1A Col.)					2B Column: ($\equiv$ 1BS Col.)				
Sample:	Aqueous:		Organic:		Sample:	Aqueous:		Organic:	
	U (g/l)	HNO ₃ (M)	U (g/l)	HNO ₃ (M)		U (g/l)	HNO (M)	U (g/l)	HNO ₃ (M)
End	(2AS)	(2AS)	(2AP)	(2AP)	End	(2BX)	(2BX)	(2BW)	(2BW)
Stream	0.0	1.0	~51.6	~0.115	Stream	0.0	0.3	~14.9	<10 ⁻³
A-1	---	---	53.8	0.115	B-1	~6.6	0.28	18.7	<10 ⁻³
A-2	-----	-----	-----	-----	B-2	15.4	0.29	27.5	0.01
A-3	~17.6	1.19	66.5	0.121	B-3	21.5	0.30	36.0	0.01
A-4	-----	-----	-----	-----	B-4	26.6	0.29	41.2	0.014
A-5	18.9	2.20	69.8	0.26	B-5	33.0	0.31	47.1	0.03
A-6	18.6	2.71	65.9	0.40	B-6	34.9	0.33	51.2	0.06
A-7	0.56	2.85	5.1	0.40	End	(2BP)	(2BP)	(2AP)	(2AP)
A-8	-----	-----	-----	-----	Stream	~35.4	~0.40	51.6	0.115
A-9	<0.01	2.82	<0.1	0.51					
A-10	-----	-----	-----	-----					
A-11	<0.01	2.73	<0.01	0.34					
End	(2AW)	(2AW)	(2AX)	(2AX)					
Stream	<0.01	2.69	0.0	0.0					

2AF

TABLE 4-5

CONCENTRATION PROFILE DATA

(Test: 2AM-3)

<u>2A</u> Column: ($\equiv$ 1A Col.)					<u>2B</u> Column: ($\equiv$ 1BS Col.)				
Sample:	Aqueous:		Organic:		Sample:	Aqueous:		Organic:	
	U (g/l)	HNO ₃ (M)	U (g/l)	HNO ₃ (M)		U (g/l)	HNO ₃ (M)	U (g/l)	HNO ₃ (M)
End	(2AS)	(2AS)	(2AP)	(2AP)	End	(2BX)	(2BX)	(2BW)	(2BW)
Stream	0.0	1.0	~46.0	~0.115	Stream	0.0	0.30	~15.6	<10 ⁻³
A-1	~8.9	~1.0	50.0	0.115	B-1	~7.9	~0.29	16.8	<10 ⁻³
A-2	-----	-----	-----	-----	B-2	14.9	0.29	28.6	<10 ⁻³
A-3	17.3	1.21	66.8	0.118	B-3	20.9	0.30	36.4	0.012
A-4	-----	-----	-----	-----	B-4	24.3	0.29	41.7	0.027
A-5	18.4	2.16	69.6	0.23	B-5	29.4	0.30	45.1	0.035
A-6	18.1	2.73	65.6	0.37	B-6	30.3	0.34	45.4	0.06
A-7	0.35	2.81	4.5	0.39	End	(2BP)	(2BP)	(2AP)	(2AP)
A-8	-----	-----	-----	-----	Stream	~30.5	~0.41	46.0	0.115
A-9	<0.01	2.80	<0.01	0.50					
A-10	-----	-----	-----	-----					
A-11	<0.01	2.77	<0.01	0.36					
End	(2AW)	(2AW)	(2AX)	(2AX)					
Stream	<0.01	2.74	0.0	0.0					

2AF

TABLE 4-6

CONCENTRATION PROFILE DATA
(Test: 2AM-4)

<u>2A</u> Column: (≡ 1A Col.)					<u>2B</u> Column: (≡ 1BS Col.)				
Sample:	Aqueous:		Organic:		Sample:	Aqueous:		Organic:	
	U (g/l)	HNO ₃ (M)	U (g/l)	HNO ₃ (M)		U (g/l)	HNO ₃ (M)	U (g/l)	HNO ₃ (M)
End	(2AS)	(2AS)	(2AP)	(2AP)	End	(2BX)	(2BX)	(2BW)	(2BW)
Stream	0.0	1.0	~28.5	~0.114	Stream	0.0	0.3	~8.9	<10 ⁻³
A-1	~5.4	1.0	30.6	0.115	B-1	~5.4	0.28	11.0	<10 ⁻³
A-2	-----	-----	-----	-----	B-2	10.3	0.29	16.8	<10 ⁻³
A-3	10.1	1.20	41.3	0.150	B-3	13.4	0.29	21.2	0.011
A-4	-----	-----	-----	-----	B-4	15.6	0.30	25.8	0.018
A-5	7.0	2.37	38.4	0.36	B-5	17.0	0.30	27.8	0.023
A-6	6.2	2.70	35.5	0.42	B-6	19.1	0.34	28.4	0.06
A-7	1.1	2.90	4.2	0.46	End	(2BP)	(2BP)	(2AP)	(2AP)
A-8	-----	-----	-----	-----	Stream	~19.2	~0.40	28.5	0.114
A-9	<0.01	2.84	<0.01	0.49					
A-10	-----	-----	-----	-----					
A-11	<0.01	2.60	<0.01	0.40					
End	(2AW)	(2AW)	(2AX)	(2AX)					
Stream	<0.01	2.54	0.0	0.0					

○ 2AF →

TABLE 4-7

CONCENTRATION PROFILE DATA

(Test: 2AM-5)

<u>2A Column: (≡ 1A Col.)</u>					<u>2B Column: (≡ 1BS Col.)</u>				
Sample:	Aqueous:		Organic:		Sample:	Aqueous:		Organic:	
	U (g/l)	HNO ₃ (M)	U (g/l)	HNO ₃ (M)		U (g/l)	HNO ₃ (M)	U (g/l)	HNO ₃ (M)
End Stream	(2AS) 0.0	(2AS) 1.0	(2AP) ~31.0	(2AP) ~0.115	End Stream	(2BX) 0.0	(2BX) 0.30	(2BW) ~10.4	(2BW) <10 ⁻³
A-1	~5.6	1.0	33.0	0.115	B-1	~5.3	0.29	10.6	<10 ⁻³
A-2	-----	-----	-----	-----	B-2	10.1	0.30	17.7	0.006
A-3	9.5	1.20	39.6	0.140	B-3	14.3	0.29	22.6	0.01
A-4	-----	-----	-----	-----	B-4	15.2	0.30	27.1	0.016
A-5	6.6	2.4	33.9	0.40	B-5	16.9	0.31	30.2	0.021
A-6	5.9	2.6	31.4	0.45	B-6	19.1	0.35	30.7	0.05
A-7	0.9	2.87	1.3	0.53	End Stream	(2BP) ~19.2	(2BP) ~0.40	(2AP) 31.0	(2AP) 0.115
A-8	-----	-----	-----	-----					
A-9	<0.01	2.85	<0.01	0.54					
A-10	-----	-----	-----	-----					
A-11	<0.01	2.58	<0.01	0.42					
End Stream	(2AW) ~<0.01	(2AW) ~2.43	(2AX) 0.0	(2AX) 0.0					

2AF →

TABLE 4-8

CONCENTRATION PROFILE DATA
(Test: 3AM-1)

<u>3A Column:</u> ($\equiv$ 1A Col.)					<u>3B Column:</u> ($\equiv$ 1BS Col.)				
Sample:	Aqueous:		Organic:		Sample:	Aqueous:		Organic:	
	U (g/l)	HNO ₃ (M)	U (g/l)	HNO ₃ (M)		U (g/l)	HNO ₃ (M)	U (g/l)	HNO ₃ (M)
End	(3AS)	(3AS)	(3AP)	(3AP)	End	(3BX)	(3BX)	(3BW)	(3BW)
Stream	0.0	1.0	~71.5	0.114	Stream	0.0	0.2	~6.8	<10 ⁻³
A-1	~9.4	1.0	72.1	0.114	B-1	~5.1	0.19	9.0	<10 ⁻³
A-2	-----	-----	-----	-----	B-2	9.9	0.19	14.5	0.007
A-3	39.4	1.30	80.8	0.12	B-3	15.2	0.19	20.5	0.010
A-4	-----	-----	-----	-----	B-4	24.4	0.20	34.8	0.017
A-5	49.5	2.0	98.2	0.19	B-5	38.6	0.20	51.0	0.020
A-6	47.6	2.82	97.8	0.25	B-6	54.9	0.22	70.7	0.060
A-7	48.3	2.95	98.3	0.27	End	(3BP)	(3BP)	(3AP)	(3AP)
A-8	-----	-----	-----	-----	Stream	~55.4	~0.28	71.5	0.114
A-9	40.1	2.93	85.8	0.35					
A-10	-----	-----	-----	-----					
A-11	6.6	2.87	10.7	0.34					
End	(3AW)	(3AW)	(3AX)	(3AX)					
Stream	~4.0	~2.80	0.0	0.0					

TABLE 4-9

CONCENTRATION PROFILE DATA

(Test: 3AM-2)

3A Column: ($\equiv$ 1A Col.)					3B Column: ($\equiv$ 1BS Col.)				
Sample:	Aqueous:		Organic:		Sample:	Aqueous:		Organic:	
	U (g/l)	HNO ₃ (M)	U (g/l)	HNO ₃ (M)		U (g/l)	HNO ₃ (M)	U (g/l)	HNO ₃ (M)
End	(3AS)	(3AS)	(3AP)	(3AP)	End	(3BX)	(3BX)	(3BW)	(3BW)
Stream	0.0	1.0	~67.9	~0.09	Stream	0.0	0.2	~12.6	<10 ⁻³
A-1	~8.1	1.0	69.6	0.10	B-1	~7.0	0.19	14.1	<10 ⁻³
A-2	-----	-----	-----	-----	B-2	12.7	0.19	19.8	0.008
A-3	30.6	1.21	84.9	0.12	B-3	21.4	0.20	29.6	0.012
A-4	-----	-----	-----	-----	B-4	30.7	0.19	41.0	0.013
A-5	36.3	2.20	92.1	0.23	B-5	41.5	0.20	52.2	0.016
A-6	34.7	2.80	93.4	0.27	B-6	51.9	0.22	67.1	0.029
A-7	33.3	2.95	89.2	0.27	End	(3BP)	(3BP)	(3AP)	(3AP)
A-8	-----	-----	-----	-----	Stream	~52.4	~0.25	67.9	0.09
A-9	12.1	2.91	43.2	0.38					
A-10	-----	-----	-----	-----					
A-11	<0.01	2.80	<0.01	0.36					
End	(3AW)	(3AW)	(3AX)	(3AX)					
Stream	<0.01	2.74	0.0	0.0					

TABLE 4-10

CONCENTRATION PROFILE DATA

(Test: 3AM-3)

3A Column: ($\equiv$ 1A Col.)					3B Column: ($\equiv$ 1BS Col.)				
Sample:	Aqueous:		Organic:		Sample:	Aqueous:		Organic:	
	U (g/l)	HNO ₃ (M)	U (g/l)	HNO ₃ (M)		U (g/l)	HNO ₃ (M)	U (g/l)	HNO ₃ (M)
End	(3AS)	(3AS)	(3AP)	(3AP)	End	(3BX)	(3BX)	(3BW)	(3BW)
Stream	0.0	1.0	~64.7	0.10	Stream	0.0	0.20	~12.7	<10 ⁻³
A-1	~4.7	1.0	66.1	0.10	B-1	~6.1	0.19	14.7	0.004
A-2	-----	-----	-----	-----	B-2	13.3	0.20	20.1	0.009
A-3	29.8	1.18	74.4	0.12	B-3	19.7	0.20	31.3	0.011
A-4	-----	-----	-----	-----	B-4	31.3	0.20	40.9	0.013
A-5	35.4	2.24	77.6	0.24	B-5	40.2	0.20	51.5	0.013
A-6	34.3	2.83	77.0	0.27	B-6	51.3	0.23	64.1	0.040
A-7	27.4	2.91	71.2	0.30	End	(3BP)	(3BP)	(3AP)	(3AP)
A-8	-----	-----	-----	-----	Stream	~51.9	~0.26	64.7	0.01
A-9	4.3	2.90	26.1	0.37					
A-10	-----	-----	-----	-----					
A-11	<0.01	2.79	<0.01	0.34					
End	(3AW)	(3AW)	(3AX)	(3AX)					
Stream	<0.01	~2.70	0.0	0.0					

2AF →

TABLE 4-11

CONCENTRATION PROFILE DATA

(Test: 3AM-4)

3A Column: ($\equiv$ 1A Col.)					3B Column: ($\equiv$ 1BS Col.)				
Sample:	Aqueous:		Organic:		Sample:	Aqueous:		Organic:	
	U (g/l)	HNO ₃ (M)	U (g/l)	HNO ₃ (M)		U (g/l)	HNO ₃ (M)	U (g/l)	HNO ₃ (M)
End	(3AS)	(3AS)	(3AP)	(3AP)	End	(3BX)	(3BX)	(3BW)	(3BW)
Stream	0.0	1.0	~49.1	~0.10	Stream	0.0	0.20	~7.3	<10 ⁻³
A-1	~4.0	1.0	50.6	0.10	B-1	~4.9	0.19	8.5	<10 ⁻³
A-2	-----	-----	-----	-----	B-2	6.7	0.20	11.6	0.004
A-3	29.3	1.11	60.6	0.12	B-3	11.0	0.19	14.9	0.010
A-4	-----	-----	-----	-----	B-4	16.9	0.20	24.8	0.016
A-5	33.6	1.97	63.2	0.18	B-5	27.5	0.20	35.6	0.020
A-6	34.2	2.80	61.9	0.24	B-6	39.4	0.22	48.6	0.042
A-7	19.1	2.91	52.7	0.29	End	(3BP)	(3BP)	(3AP)	(3AP)
A-8	-----	-----	-----	-----	Stream	~39.9	~0.25	49.1	0.01
A-9	0.6	2.93	4.5	0.38					
A-10	-----	-----	-----	-----					
A-11	<0.01	2.80	<0.01	<0.33					
End	(3AW)	(3AW)	(3AX)	(3AX)					
Stream	<0.01	~2.72	0.0	0.0					

2AF

TABLE 4-12

CONCENTRATION PROFILE DATA
(Test: 3AM-5)

<u>3A Column:</u> ($\equiv$ 1A Col.)					<u>3B Column:</u> ($\equiv$ 1BS Col.)				
Sample:	Aqueous:		Organic:		Sample:	Aqueous:		Organic:	
	U (g/l)	HNO ₃ (M)	U (g/l)	HNO ₃ (M)		U (g/l)	HNO ₃ (M)	U (g/l)	HNO ₃ (M)
End Stream	(3AS) 0.0	(3AS) 1.0	(3AP) ~47.5	(3AP) ~0.10	End Stream	(3BX) 0.0	(3BX) 0.20	(3BW) ~7.6	(3BW) <10 ⁻³
A-1	~5.0	1.0	49.1	0.11	B-1	~5.0	0.20	8.6	<10 ⁻³
A-2	-----	-----	-----	-----	B-2	6.1	0.19	10.7	0.010
A-3	32.3	1.12	60.4	0.11	B-3	11.1	0.19	16.9	0.010
A-4	-----	-----	-----	-----	B-4	16.6	0.20	25.4	0.013
A-5	36.0	1.99	61.6	0.20	B-5	27.8	0.20	36.1	0.017
A-6	35.2	2.82	61.1	0.24	B-6	37.9	0.23	46.8	0.040
A-7	20.3	2.93	49.8	0.30	End Stream	(3BP) ~38.7	(3BP) ~0.26	(3AP) 47.5	(3AP) 0.10
A-8	-----	-----	-----	-----					
A-9	0.3	2.95	3.4	0.41					
A-10	-----	-----	-----	-----					
A-11	<0.01	2.82	<0.01	<0.35					
End Stream	(3AW) <0.01	(3AW) ~2.71	(3AX) 0.0	(3AX) 0.0					

o 2AF →

TABLE 4-13

FLOW RATIO AND URANIUM CONCENTRATION EXPERIMENTAL DATA

Test:	Flow Ratio:		Uranium Concentration: (gU/l)				
	1A Column:	1BS Column:	1A Column:		1BS Column:		
			At 1AF Inlet:				
	1AF/1AX	1AF/1BS-X	Org.	Aq.	1AP stream	1BS-P stream	1BS-W stream
2AM-1	2.69	2.79	95.6 91.7	42.9 38.0	71.0	49.8	22.9
2AM-2	2.0	1.90	69.8 65.9	18.9 18.6	51.6	35.4	14.9
2AM-3	1.77	1.75	69.6 65.6	18.4 18.1	46.0	30.5	15.6
2AM-4	1.09	1.07	38.4 35.5	7.0 6.2	28.5	19.2	8.9
2AM-5	1.18	1.10	33.9 31.4	6.6 5.9	31.0	19.2	10.4
3AM-1	2.08	1.78	98.2 97.8	49.5 47.6	71.5	55.4	6.8
3AM-2	1.74	1.63	92.1 93.4	36.3 34.7	67.9	52.4	12.6
3AM-3	1.66	1.63	77.6 77.0	35.4 34.3	64.7	51.9	12.7
3AM-4	1.25	1.18	63.2 61.9	33.6 34.2	49.1	39.9	7.3
3AM-5	1.21	1.16	61.6 61.1	36.0 35.2	47.5	38.7	7.6

TABLE 4-14

VOLUME AND CONCENTRATION MEASUREMENT DATA
(after draining the column)

Test:	Column:	Organic Phase:		Aqueous Phase:		Uranium Inventory in Column: (grams <u>U</u>)
		Volume (ℓ)	U (gU/ℓ)	Volume (ℓ)	U (gU/ℓ)	
2AM-1	2A (≡1A)	~20.5	49.2	10.1	3.5	~1045
	2B (≡1BS)	3.6	57.2	27.0	31.4	1055
2AM-2	2A	~19.9	32.7	10.7	2.9	680
	2B	3.5	36.3	27.1	21.0	695
2AM-3	2A	~19.5	32.6	11.1	2.6	665
	2B	3.8	35.9	26.8	19.0	645
2AM-4	2A	~22.0	16.6	8.6	1.2	375
	2B	3.9	13.7	26.7	14.3	435
2AM-5	2A	~22.2	17.2	8.4	1.3	395
	2B	3.2	13.5	27.4	13.2	405
3AM-1	3A	~24.9	53.9	5.7	12.8	1415
	3B	3.3	14.5	27.3	30.7	885
3AM-2	3A	~23.8	40.2	6.8	6.6	1000
	3B	3.4	23.0	27.2	31.3	930
3AM-3	3A	~23.6	38.2	7.0	6.2	945
	3B	3.5	24.6	27.1	30.4	910
3AM-4	3A	~24.1	26.8	6.5	5.9	685
	3B	3.4	13.6	27.2	23.2	680
3AM-5	3A	~24.3	25.4	6.3	5.3	650
	3B	3.5	13.0	27.1	22.9	665

TABLE 4-15

CONCENTRATION, FLOW RATE, AND EFFLUENT MASS RATE DATA

(Test 2AM-2)

Sampling Time: (min)	2A Column ($\equiv$ 1A Col.)					2B Column ($\equiv$ 1BS Col.)						
	U Conc. (g/l)		Flow Rate (l/min)		Effluent Mass Rate: (gU/min)	U Conc. (g/l)		Flow Rate (l/min)		Effluent Mass Rate: (gU/min)		
	2AP stream	2AW stream	2AP stream	2AW stream		2BW stream	2BP stream	2BW stream	2BP stream	2BW	2BP	Total:
15	<0.01	<0.01	~0.307	~0.715	~0.0	<0.01	<0.01	0.307	0.323	0.0	0.0	0.0
30	9.2	<0.01	0.308	0.715	2.83	<0.01	<0.01	0.307	0.323	0.0	0.0	0.0
45	30.9	<0.01	0.311	0.715	9.60	<0.01	1.0	0.307	0.323	0.0	~0.32	0.32
60	45.8	<0.01	0.313	0.715	14.34	<0.01	6.2	0.307	0.324	0.0	2.0	2.0
75	49.8	<0.01	0.314	0.715	15.64	0.9	10.9	0.307	0.324	0.27	3.53	3.8
90						3.8	14.8	0.307	0.325	1.17	4.81	5.98
120	51.7	<0.01	0.314	0.715	16.23	9.1	24.7	0.308	0.326	2.8	8.05	10.85
150	51.8	<0.01	0.314	0.715	16.26	11.8	29.3	0.310	0.326	3.66	9.55	13.21
180												
210	51.4	<0.01	0.314	0.715	16.14	14.9	35.5	0.310	0.327	4.62	11.6	16.22

TABLE 4-16

CONCENTRATION, FLOW RATE, AND EFFLUENT MASS RATE DATA

(Test 2AM-3)

Sampling Time: (min)	2A Column ($\equiv$ 1A Col.)					2B Column ($\equiv$ 1B Col.)						
	U Conc. (g/l)		Flow Rate (l/min)		Effluent Mass Rate: (gU/min)	U Conc. (g/l)		Flow Rate (l/min)		Effluent Mass Rate: (gU/min)		
	2AP stream	2AW stream	2AP stream	2AW stream		2BW stream	2BP stream	2BW stream	2BP stream	2BW	2BP	Total:
15	~1.0	~0.7	~0.317	~0.697	~0.8	~0.0	~1.0	~0.317	~0.321	~0.0	~0.32	~0.3
30	0.7	0.7	0.317	0.697	0.71	0.0	1.6	0.317	0.321	0.0	0.51	0.5
45	19.4	<0.01	0.319	0.697	6.2	0.0	2.2	0.317	0.321	0.0	0.71	0.7
60	42.0	<0.01	0.321	0.697	13.4	0.0	2.2	0.317	0.321	0.0	0.71	0.7
75	44.3	<0.01	0.322	0.697	14.3	1.0	7.7	0.317	0.321	0.32	2.48	2.8
90	45.5	<0.01	0.322	0.697	14.7	2.3	11.4	0.317	0.322	0.73	3.67	4.4
120	46.0	<0.01	0.322	0.697	14.8	6.5	20.3	0.317	0.322	2.06	6.54	8.6
150	45.5	<0.01	0.322	0.697	14.7	12.6	25.5	0.318	0.323	4.0	8.25	12.2
180	45.6	<0.01	0.322	0.697	14.7	15.0	29.0	0.319	0.323	4.78	9.37	14.1
210						15.6	30.3	0.319	0.323	4.97	9.79	14.8
240						15.6	30.5	0.319	0.323	4.97	9.85	14.8

TABLE 4-17

CONCENTRATION, FLOW RATE, AND EFFLUENT MASS RATE DATA

(Test 2AM-4)

Sampling Time: (min)	2A Column ($\equiv$ 1A Col.)					2B Column ($\equiv$ 1BS Col.)						
	U Conc. (g/l)		Flow Rate (l/min)		Effluent Mass Rate: (gU/min)	U Conc. (g/l)		Flow Rate (l/min)		Effluent Mass Rate: (gU/min)		
	2AP stream	2AW stream	2AP stream	2AW stream		2BW stream	2BP stream	2BW stream	2BP stream	2BW	2BP	Total:
15	<0.01	<0.01	~0.298	~0.410	~0.0	<0.01	<0.01	~0.298	~0.305	0.0	0.0	0.0
30	6.1	<0.01	0.299	0.410	1.83	<0.01	<0.01	0.298	0.305	0.0	0.0	0.0
45	16.9	<0.01	0.300	0.410	5.07	<0.01	0.3	0.298	0.305	0.0	~0.1	0.1
60	23.3	<0.01	0.301	0.410	7.0	<0.01	1.8	0.298	0.305	0.0	0.55	0.55
75	27.8	<0.01	0.301	0.410	8.37							
90	28.5	<0.01	0.301	0.410	8.58	1.3	5.6	0.298	0.306	0.39	1.71	2.1
120	28.5	<0.01	0.301	0.410	8.58	5.6	10.2	0.298	0.306	1.67	3.12	4.79
150						8.2	15.1	0.299	0.307	2.45	4.64	7.09
180						8.0	17.1	0.299	0.307	2.39	5.25	7.64
210						8.9	19.2	0.299	0.307	2.66	5.9	8.56
240						9.1	18.7	0.299	0.307	2.72	5.74	8.46

TABLE 4-18

CONCENTRATION, FLOW RATE, AND EFFLUENT MASS RATE DATA

(Test 2AM-5)

Sampling Time: (min)	2A Column ($\equiv$ 1A Col.)					2B Column ($\equiv$ 1BS Col.)						
	U Conc. (g/l)		Flow Rate (l/min)		Effluent Mass Rate: (gU/min)	U Conc. (g/l)		Flow Rate (l/min)		Effluent Mass Rate: (gU/min)		
	2AP stream	2AW stream	2AP stream	2AW stream		2BW stream	2BP stream	2BW stream	2BP stream	2BW	2BP	Total:
20	~0.1	~0.01	~0.282	~0.430	~0.03	~0.0	~0.0	~0.282	~0.304	~0.0	~0.0	~0.0
35	4.4	<0.01	0.282	0.430	1.2	0.0	0.0	0.282	0.304	0.0	0.2	0.0
50	20.9	<0.01	0.284	0.430	5.9	0.1	2.9	0.282	0.304	0.03	0.88	0.9
65	27.6	<0.01	0.285	0.430	7.9	1.0	4.4	0.282	0.304	0.28	1.34	1.6
95	31.8	<0.01	0.285	0.430	9.0	4.4	8.5	0.282	0.305	1.24	2.59	3.8
125	30.0	<0.01	0.285	0.430	8.6	5.6	14.7	0.282	0.305	1.58	4.48	6.1
155	31.8	<0.01	0.285	0.430	9.0	7.9	16.2	0.283	0.305	2.24	4.94	7.2
185	30.3	<0.01	0.285	0.430	8.6	9.8	17.9	0.283	0.305	2.77	5.46	8.3
215	30.6	<0.01	0.285	0.430	8.7	10.9	18.8	0.283	0.305	3.09	5.74	8.8
245	30.8	<0.01	0.285	0.430	8.8	10.8	19.0	0.283	0.305	3.06	5.80	8.8

TABLE 4-19

CONCENTRATION, FLOW RATE, AND EFFLUENT MASS RATE DATA

(Test 3AM-1)

Sampling Time: (min)	3A Column ($\equiv$ 1A Col.)					3B Column ($\equiv$ 1BS Col.)						
	U Conc. (g/l)		Flow Rate (l/min)		Effluent Mass Rate: (gU/min)	U Conc. (g/l)		Flow Rate (l/min)		Effluent Mass Rate: (gU/min)		
	3AP stream	3AW stream	3AP stream	3AW stream		3BW stream	3BP stream	3BW stream	3BP stream	3BW	3BP	Total:
15	<0.01	<0.01	~0.258	~0.628	0.0	<0.01	<0.01	~0.258	~0.302	0.0	0.0	0.0
30	<0.01	<0.01	0.258	0.628	0.0	<0.01	<0.01	0.258	0.302	0.0	0.0	0.0
45	20.1	<0.01	0.261	0.628	5.22	<0.01	<0.01	0.258	0.302	0.0	0.0	0.0
60	49.1	<0.01	0.263	0.628	12.91	<0.01	3.02	0.258	0.302	0.0	0.91	0.91
75	65.5	<0.01	0.265	0.628	17.35	<0.01	8.5	0.258	0.305	0.0	2.6	2.6
90	69.0	0.9	0.266	0.628	18.92	<0.01	16.0	0.258	0.306	0.0	4.9	4.9
120						<0.01	28.2	0.258	0.308	0.0	8.7	8.7
150	71.6	3.9	0.266	0.630	21.5	2.6	40.5	0.258	0.309	0.67	12.51	13.18
180	72.9	3.3	0.266	0.630	21.47	5.6	49.7	0.259	0.310	1.45	15.4	16.85
210	71.0	4.2	0.266	0.630	21.53	5.6	52.9	0.259	0.310	1.45	16.4	17.85
240	70.3	4.0	0.266	0.630	21.22	6.8	55.7	0.259	0.310	1.76	17.27	19.03

TABLE 4-20

CONCENTRATION, FLOW RATE, AND EFFLUENT MASS RATE DATA

(Test 3AM-2)

Sampling Time: (min)	3A Column ($\equiv$ 1A Col.)					3B Column ($\equiv$ 1BS Col.)						
	U Conc. (g/l)		Flow Rate (l/min)		Effluent Mass Rate: (gU/min)	U Conc. (g/l)		Flow Rate (l/min)		Effluent Mass Rate: (gU/min)		
	3AP stream	3AW stream	3AP stream	3AW stream		3BW stream	3BP stream	3BW stream	3BP stream	3BW	3BP	Total:
15	<0.01	<0.01	~0.260	~0.550	~0.0	<0.01	<0.01	~0.260	~0.278	~0.0	~0.0	0.0
30	1.5	<0.01	0.260	0.550	0.39	<0.01	<0.01	0.260	0.278	0.0	0.0	0.0
45	29.7	<0.01	0.264	0.550	7.84	<0.01	<0.01	0.260	0.278	0.0	0.0	0.0
60	52.6	<0.01	0.266	0.550	14.0	<0.01	2.6	0.260	0.278	0.0	0.72	0.72
75	59.5	<0.01	0.266	0.550	15.83	1.8	5.6	0.260	0.279	0.47	1.56	2.0
90	61.8	<0.01	0.266	0.550	16.44	3.2	11.5	0.260	0.279	0.80	3.21	4.01
120	64.8	<0.01	0.267	0.550	17.30	5.8	25.8	0.260	0.281	1.50	7.25	8.75
150	67.4	<0.01	0.267	0.550	18.0	6.5	39.6	0.260	0.282	1.70	11.17	12.87
180	68.4	<0.01	0.267	0.550	18.26	10.2	46.2	0.261	0.283	2.66	13.07	15.73
210	67.9	<0.01	0.267	0.550	18.13	12.5	49.6	0.261	0.283	3.26	14.04	17.30
240						12.6	52.4	0.261	0.283	3.30	14.83	18.13

TABLE 4-21

CONCENTRATION, FLOW RATE, AND EFFLUENT MASS RATE DATA

(Test 3AM-3)

Sampling Time: (min)	3A Column ($\equiv$ 1A Col.)					3B Column ($\equiv$ 1BS Col.)						
	U Conc. (g/l)		Flow Rate (l/min)		Effluent Mass Rate: (gU/min)	U Conc. (g/l)		Flow Rate (l/min)		Effluent Mass Rate: (gU/min)		
	3AP stream	3AW stream	3AP stream	3AW stream		3BW stream	3BP stream	3BW stream	3BP stream	3BW	3BP	Total:
15	<0.01	<0.01	~0.262	~0.537	~0.0	<0.01	<0.01	~0.262	~0.267	~0.0	~0.0	0.0
30	2.3	<0.01	0.262	0.537	0.60	<0.01	<0.01	0.262	0.267	0.0	0.0	0.0
45	25.1	<0.01	0.265	0.537	6.65	<0.01	2.8	0.262	0.267	0.0	0.75	0.75
60	55.5	<0.01	0.268	0.537	14.87	<0.01	5.9	0.262	0.268	0.0	1.60	1.60
75	59.1	<0.01	0.269	0.537	15.90	<0.01	11.3	0.262	0.268	0.0	3.03	3.03
90	60.5	<0.01	0.269	0.537	16.27	1.3	20.8	0.262	0.269	0.34	5.60	5.94
120	63.4	<0.01	0.269	0.537	17.06	5.6	32.9	0.263	0.270	1.47	8.88	10.35
150	64.7	<0.01	0.269	0.537	17.40	8.5	42.6	0.263	0.271	2.24	11.55	13.79
180	64.4	<0.01	0.269	0.537	17.32	11.5	47.8	0.263	0.272	3.02	13.0	16.02
210	64.4	<0.01	0.269	0.537	17.32	12.1	50.3	0.263	0.272	3.20	13.70	16.90
240	65.5	<0.01	0.269	0.537	17.62	12.7	51.9	0.263	0.272	3.37	14.12	17.49

TABLE 4-22

CONCENTRATION, FLOW RATE, AND EFFLUENT MASS RATE DATA

(Test 3AM-4)

Sampling Time: (min)	3A Column ($\equiv$ 1A Col.)					3B Column ($\equiv$ 1BS Col.)						
	U Conc. (g/l)		Flow Rate (l/min)		Effluent Mass Rate: (gU/min)	U Conc. (g/l)		Flow Rate (l/min)		Effluent Mass Rate: (gU/min)		
	3AP stream	3AW stream	3AP stream	3AW stream		3BW stream	3BP stream	3BW stream	3BP stream	3BW	3BP	Total:
15	<0.01	<0.01	~0.260	~0.428	~0.0	<0.01	<0.01	~0.260	~0.275	~0.0	~0.0	0.0
30	1.3	<0.01	0.260	0.428	0.34	<0.01	<0.01	0.260	0.275	0.0	0.0	0.0
45	11.9	<0.01	0.262	0.428	3.10	<0.01	0.3	0.260	0.275	0.0	0.08	0.08
60	35.1	<0.01	0.264	0.428	9.27	<0.01	1.9	0.260	0.275	0.0	0.52	0.52
75	46.5	<0.01	0.265	0.428	12.32	<0.01	3.8	0.260	0.275	0.0	1.05	1.05
90	48.5	<0.01	0.266	0.428	12.90	1.2	6.2	0.260	0.276	0.31	1.71	2.02
120	49.0	<0.01	0.266	0.428	13.03	2.1	22.0	0.260	0.277	0.55	6.09	6.64
150	49.1	<0.01	0.266	0.428	13.06	6.2	31.1	0.261	0.278	1.62	8.65	10.27
180	49.0	<0.01	0.266	0.428	13.03	6.8	35.7	0.261	0.279	1.77	9.96	11.73
210						7.2	39.2	0.261	0.279	1.88	10.94	12.82
240						7.3	39.9	0.261	0.279	1.90	11.13	13.03

TABLE 4-23

CONCENTRATION, FLOW RATE, AND EFFLUENT MASS RATE DATA

(Test 3AM-5)

Sampling Time: (min)	3A Column ($\equiv$ 1A Col.)					3B Column ($\equiv$ 1BS Col.)						
	U Conc. (g/l)		Flow Rate (l/min)		Effluent Mass Rate: (gU/min)	U Conc. (g/l)		Flow Rate (l/min)		Effluent Mass Rate: (gU/min)		
	3AP stream	3AW stream	3AP stream	3AW stream		3BW stream	3BP stream	3BW stream	3BP stream	3BW	3BP	Total:
15	<0.01	<0.01	~0.265	~0.420	~0.0	<0.01	<0.01	~0.265	~0.277	~0.0	~0.0	0.0
30	1.3	<0.01	0.265	0.420	0.35	<0.01	<0.01	0.265	0.277	0.0	0.0	0.0
45	20.3	<0.01	0.268	0.420	5.44	<0.01	<0.01	0.265	0.277	0.0	0.0	0.0
60	40.4	<0.01	0.270	0.420	10.90	<0.01	1.9	0.265	0.277	0.0	0.53	0.53
75	44.8	<0.01	0.270	0.420	12.10	<0.01	9.0	0.265	0.278	0.0	2.50	2.50
90	45.6	<0.01	0.271	0.420	12.36	<0.01	15.0	0.265	0.278	0.0	4.17	4.17
120	47.0	<0.01	0.271	0.420	12.74							
150	47.5	<0.01	0.271	0.420	12.87	5.6	34.1	0.266	0.280	1.49	9.55	11.04
180	47.4	<0.01	0.271	0.420	12.85	7.6	38.0	0.266	0.281	2.02	10.68	12.70
210	47.8	<0.01	0.271	0.420	12.95	7.6	38.7	0.266	0.281	2.02	10.87	12.89
240												

TABLE 4-24

TANK INVENTORY DATA

(Tests 2AM-1 Through 2AM-5)

Test:	Tank:	U (gU/l)	Flow Rate: (l/min)	Total Feed Time: (min)	Total Liquid Volume: (l)	Corrected Total Liquid Volume: (l)	U Fed (+) or Accumulated (-) in the Tank: (grams U)	U Inventory in 1A & 1BS Columns: (grams U)
2AM-1	1AF Tk.	~26.4	0.740	~270	199.8	---	~5275 (+)	~2120
	1BS-W Tk.	14.6	0.275	275	76.63	77.03	1125 (-)	
	1BS-P Tk.	22.3	0.265	275	72.88	73.46	1638 (-)	
	1AP Head Pot	71.0	---	---	~5.50	---	~391 (-)	
2AM-2	1AF Tk.	~26.4	0.614	~265	162.71	---	~4296 (+)	1415
	1BS-W Tk.	9.0	0.307	280	85.96	86.23	776 (-)	
	1BS-P Tk.	19.7	0.323	280	90.44	91.10	1795 (-)	
	1AP Head Pot	51.6	---	---	~6.0	---	~310 (-)	
2AM-3	1AF Tk.	~26.4	0.560	~270	151.2	---	~3992 (+)	1275
	1BS-W Tk.	8.8	0.317	285	90.35	90.63	798 (-)	
	1BS-P Tk.	17.7	0.321	285	91.49	92.07	1630 (-)	
	1AP Head Pot	46.0	---	---	~6.30	---	~290 (-)	
2AM-4	1AF Tk.	~26.4	0.32	~265	86.13	---	~2274 (+)	800
	1BS-W Tk.	4.1	0.298	270	80.46	80.59	330 (-)	
	1BS-P Tk.	11.8	0.305	270	82.35	82.75	976 (-)	
	1AP Head Pot	28.5	---	---	~6.0	---	~171 (-)	
2AM-5	1AF Tk.	~26.4	0.333	~280	93.24	---	~2462 (+)	815
	1BS-W Tk.	4.8	0.282	295	83.19	83.33	400 (-)	
	1BS-P Tk.	11.9	0.304	295	89.68	90.06	1072 (-)	
	1A Head Pot	31.0	---	---	~5.65	---	~175 (-)	

TABLE 4-25

TANK INVENTORY DATA

(Tests 3AM-1 Through 3AM-5)

Test:	Tank:	U (gU/l)	Flow Rate: (l/min)	Total Feed Time: (min)	Total Liquid Volume: (l)	Corrected Total Liquid Volume: (l)	U Fed (+) or Accumulated (-) in the Tank: (grams U)	U Inventory in 1A & 1BS Columns: (grams U)
3AM-1	1AF Tk.	~40.13	0.536	~300	160.8	---	~6453 (+)	2290
	1BS-W Tk.	3.0	0.258	324	83.59	84.02	252 (-)	
	1BS-P Tk.	32.9	0.302	324	97.85	99.80	3283 (-)	
	1AP Head Pot	71.5	---	---	6.3	---	450 (-)	
	1AW Tk.	~1.0	~0.601	~300	180.3	180.3	~180 (-)	
3AM-2	1AF Tk.	~40.13	0.452	~280	126.56	---	~5079 (+)	2020
	1BS-W Tk.	6.2	0.260	295	76.70	77.10	478 (-)	
	1BS-P Tk.	26.3	0.277	295	81.70	82.40	2167 (-)	
	1AP Head Pot	67.9	---	---	~6.1	---	~415 (-)	
3AM-3	1AF Tk.	~40.13	0.435	~300	130.5	---	~5237 (+)	1870
	1BS-W Tk.	7.0	0.262	310	81.22	81.75	572 (-)	
	1BS-P Tk.	31.3	0.267	310	82.77	83.57	2616 (-)	
	1AP Head Pot	64.7	---	---	~2.8	---	~180 (-)	
3AM-4	1AF Tk.	~40.13	0.325	~288	93.6	---	~3756 (+)	1340
	1BS-W Tk.	3.6	0.260	310	80.6	80.9	291 (-)	
	1BS-P Tk.	21.8	0.270	310	85.25	86.64	1889 (-)	
	1AP Head Pot	49.1	---	---	~4.8	---	~235 (-)	
3AM-5	1AF Tk.	~40.13	0.321	~290	93.09	---	~3736 (+)	1305
	1BS-W Tk.	4.0	0.265	310	82.15	82.55	330 (-)	
	1BS-P Tk.	22.7	0.277	310	85.87	86.57	1965 (-)	
	1A Head Pot	47.5	---	---	~2.9	---	~138 (-)	

TABLE 4-26

COLUMN URANIUM INVENTORY DATA

(Tests 2AM-1 Through 2AM-5)

Test:	Column:	$V_{col} \cdot \frac{V_f}{V_{st}} \cdot C(u)_f$ (gU)	Uranium Inventory in Columns: (grams U)						
			Analytical:					By Computer:	
			From Conc. Profile and Liquids Holdup Data:	From Liquids Volume and Concentration Measurement:	From Mass Rate Measurement:	From Tanks Inventory:	From Equation: (calculated)	Computerized Mass Rate Measurement Technique Using Analytical Concen- tration Data	Computerized Mass Rate Measure. Technique Using XRFA Instrument Conc. Data:
2AM-1	1A	2174	~ 990	1045	---	---	(1070)	---	-----
	1BS	2328	1030	1055	---	---	(1045)	---	-----
	1A & 1BS	---	2020	2100	---	2120	(2115)	---	-----
2AM-2	1A	1615	685	680	705	---	(710)	~715	-----
	1BS	1535	735	695	725	---	(690)	760	-----
	1A & 1BS	---	1420	1375	1430	1420	(1420)	1475	-----
2AM-3	1A	1427	645	655	680	---	(630)	710	-----
	1BS	1420	660	645	615	---	(640)	665	-----
	1A & 1BS	---	1305	1310	1295	1275	(1270)	1375	-----
2AM-4	1A	880	410	375	380	---	(390)	385	-----
	1BS	866	420	435	440	---	(390)	455	-----
	1A & 1BS	---	830	810	820	800	(780)	840	-----
2AM-5	1A	954	390	395	415	---	(420)	420	-----
	1BS	896	420	405	390	---	(400)	355; 415	-----
	1A & 1BS	---	810	800	805	815	(820)	775; 835	-----

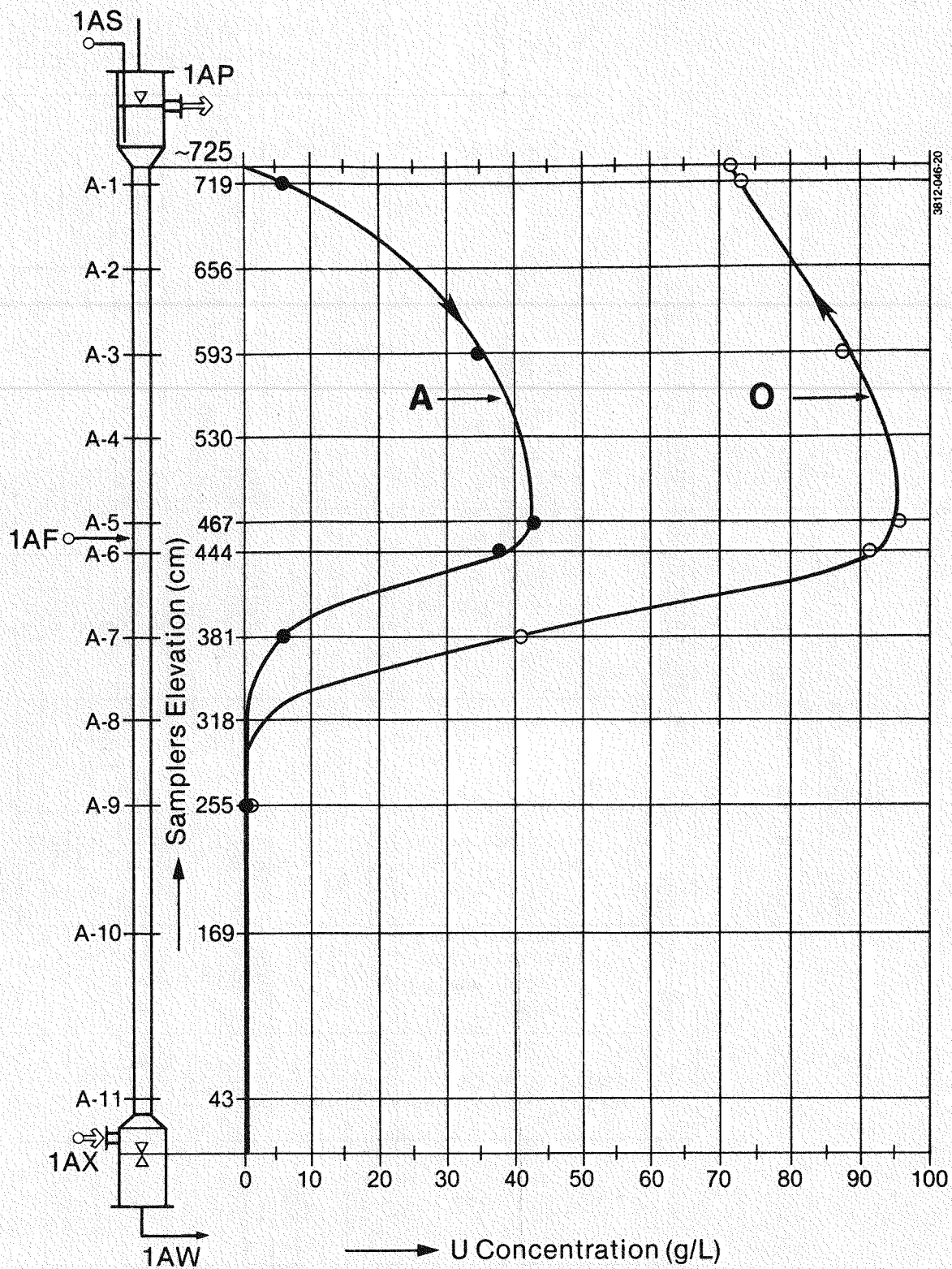
TABLE 4-27

COLUMN URANIUM INVENTORY DATA

(Tests 3AM-1 Through 3AM-5)

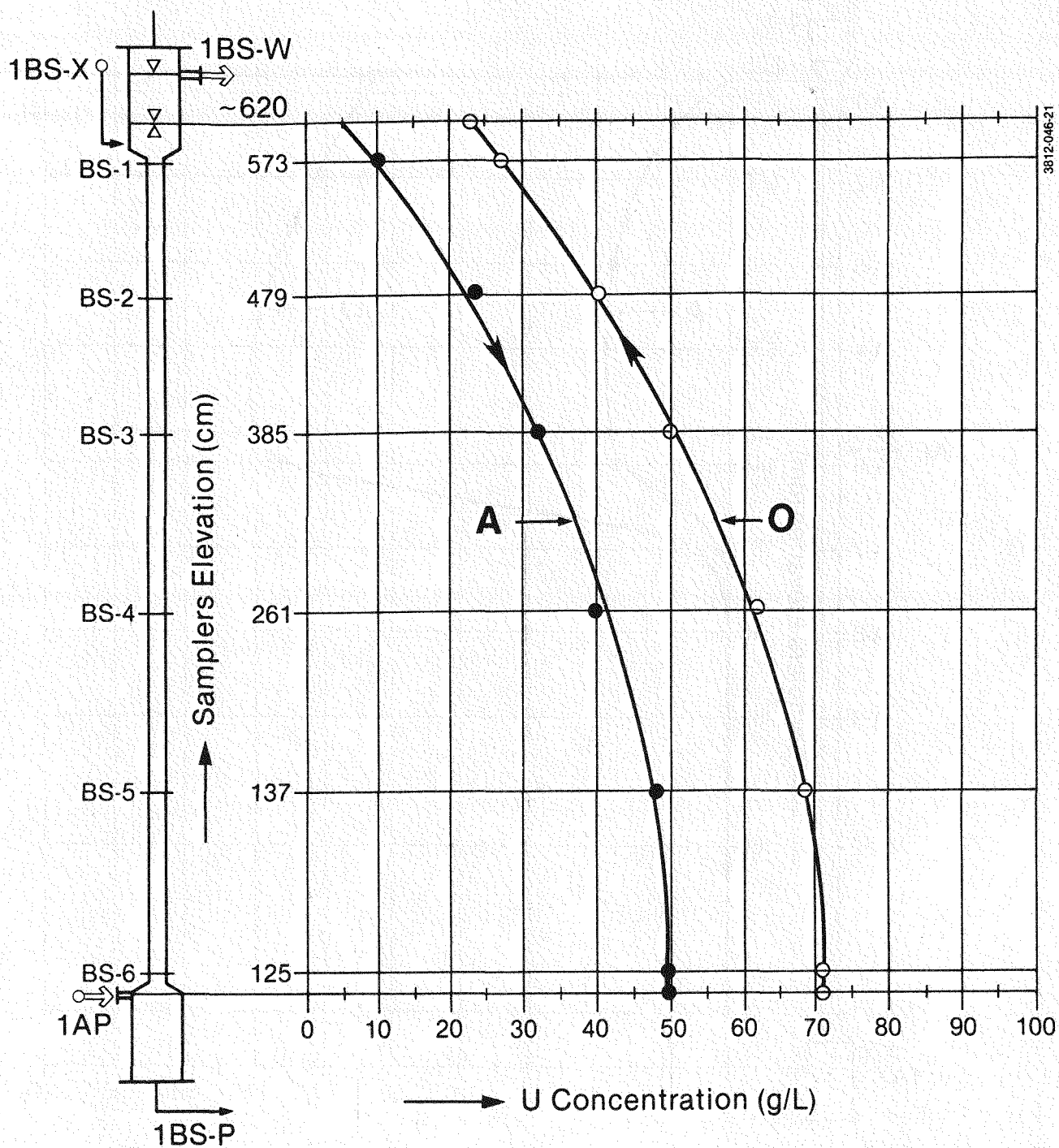
			Uranium Inventory in Columns: (grams U)						
Test:	Column:	$V_f \frac{C(u)_f}{V_{col.} V_{st}}$ (gU)	Analytical:					By Computer:	
			From Conc. Profile and Liquids Holdup Data:	From Liquids Volume and Concentration Measurement:	From Mass Rate Measurement:	From Tanks Inventory:	From Equation: (calculated)	Computerized Mass Rate Measurement Technique Using Analytical Concen- tration Data	Computerized Mass Rate Measure. Technique Using XRFA Instrument Conc. Data:
3AM-1	1A	2550	~1440	1415	1335	---	(1370)	~1330	-----
	1BS	1927	910	885	900	---	(870)	885	-----
	1A & 1BS	---	2350	2300	2235	2290	(2240)	2215	-----
3AM-2	1A	2135	1090	1000	985	---	(1020)	1000	-----
	1BS	2000	940	930	920	---	(900)	885	-----
	1A & 1BS	---	2030	1930	1905	2020	(1920)	1885	-----
3AM-3	1A	2040	960	945	900	---	(940)	920	~ 925; 800*
	1BS	2000	930	910	925	---	(900)	850; 880	--- 980*
	1A & 1BS	---	1890	1855	1825	1870	(1840)	1770; 1800	--- 1780*
3AM-4	1A	1535	735	685	700	---	(675)	705	710; 605*
	1BS	1453	665	680	670	---	(655)	675	650; 870*
	1A & 1BS	---	1400	1365	1370	1340	(1330)	1380	1360; 1475*
3AM-5	1A	1487	715	650	640	---	(655)	655	650; 615*
	1BS	1422	655	665	660	---	(665)	665	--- 585*
	1A & 1BS	---	1370	1315	1300	1305	(1320)	1320	--- 1200*

NOTE: Data marked with asterisk (*) were obtained from XRFA concentration and flow rate readings in four-minute time intervals.



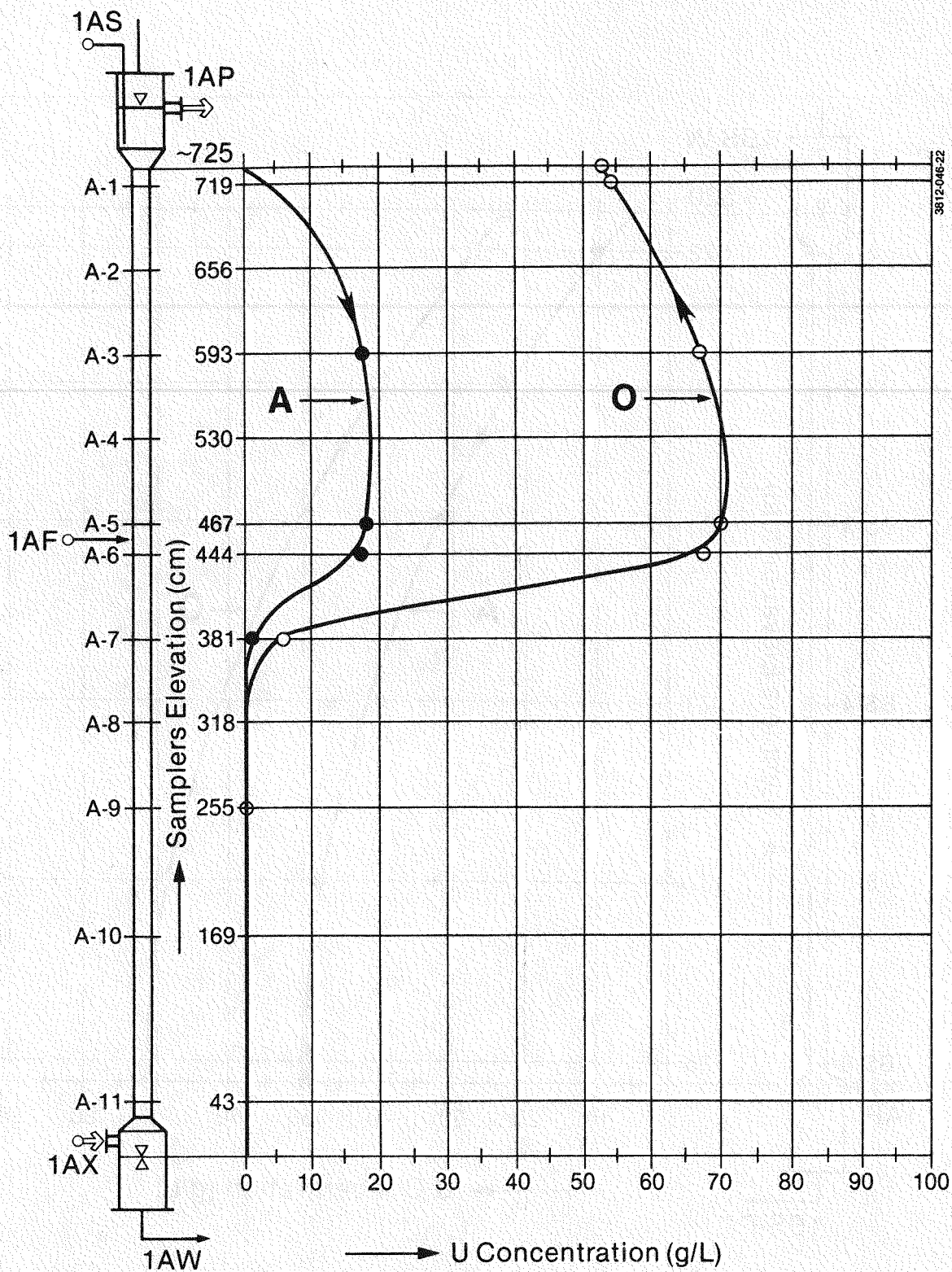
THE 2A COLUMN CONCENTRATION PROFILES FOR TEST 2AM-1

FIGURE 4-1



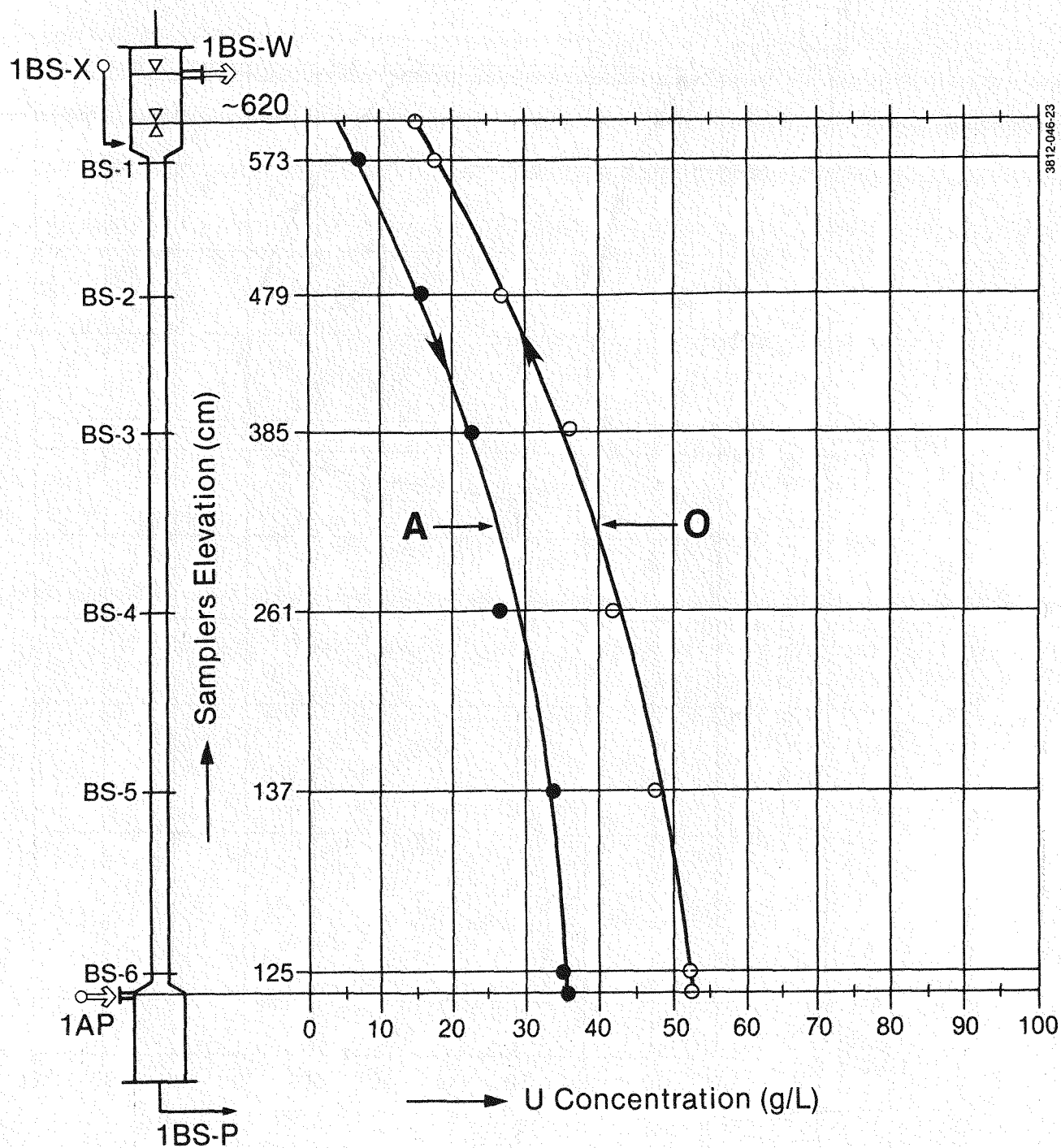
THE 2B COLUMN CONCENTRATION PROFILES FOR TEST 2AM-1

FIGURE 4-2



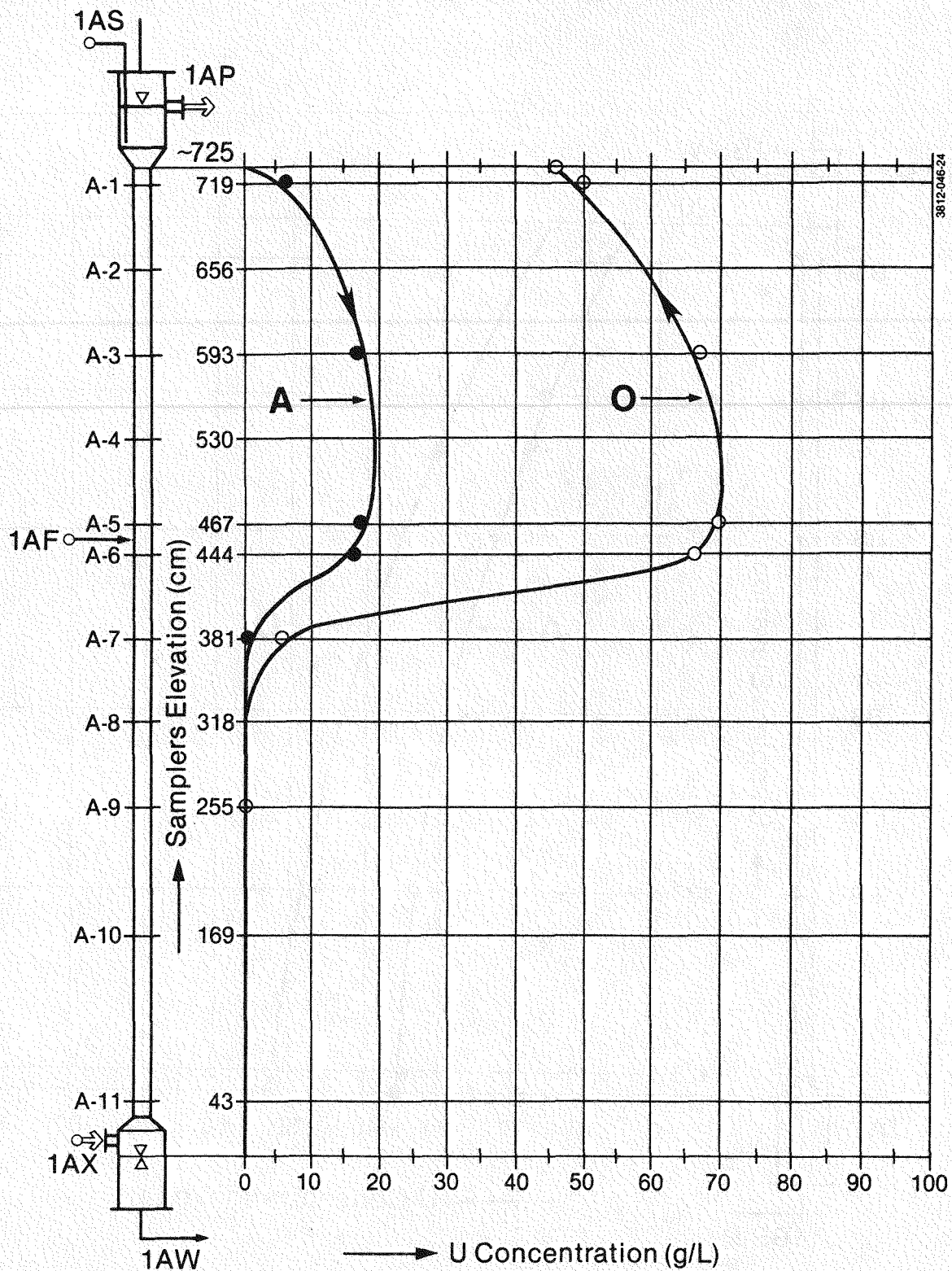
THE 2A COLUMN CONCENTRATION PROFILES FOR TEST 2AM-2

FIGURE 4-3



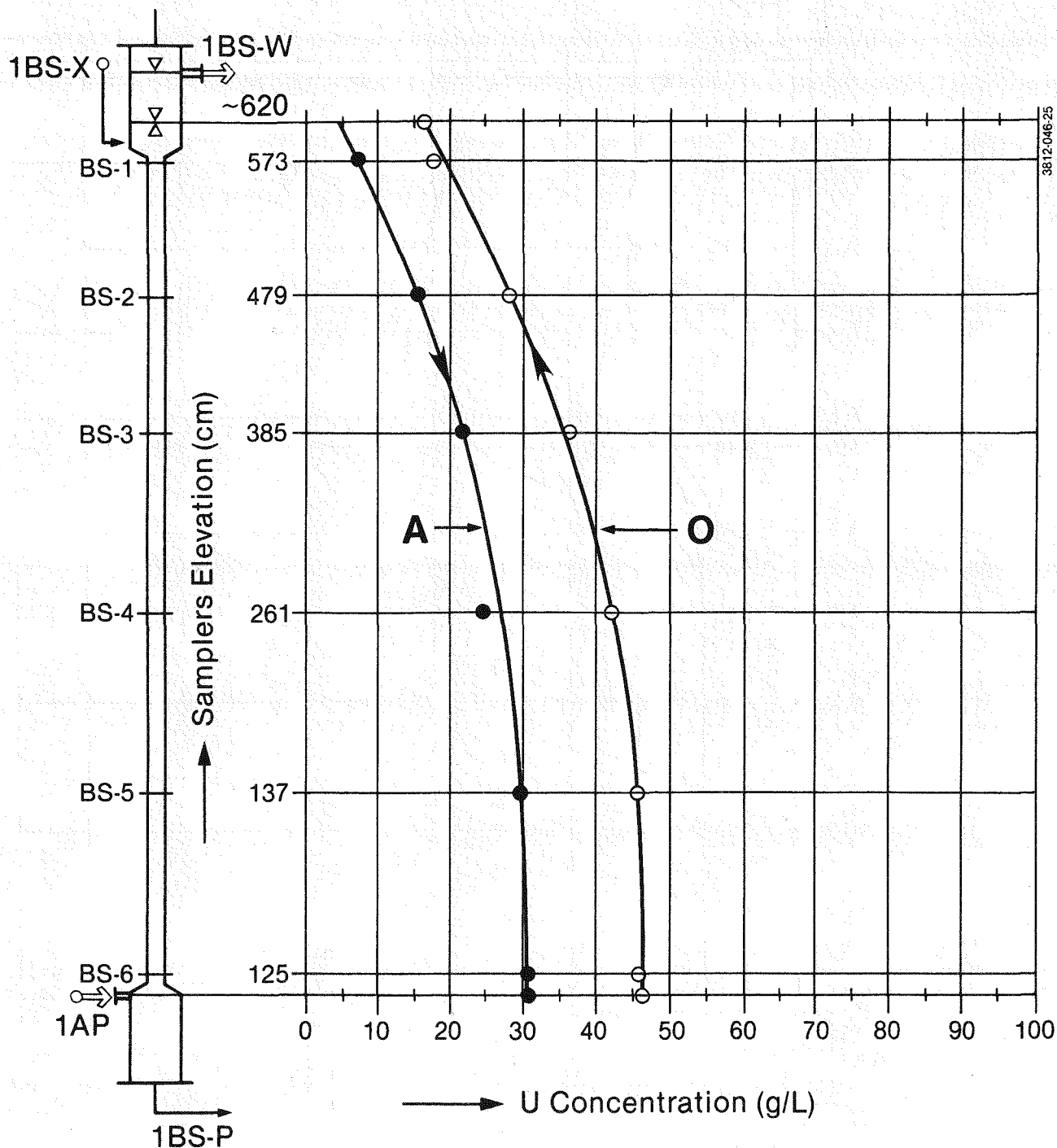
THE 2B COLUMN CONCENTRATION PROFILES FOR TEST 2AM-2

FIGURE 4-4



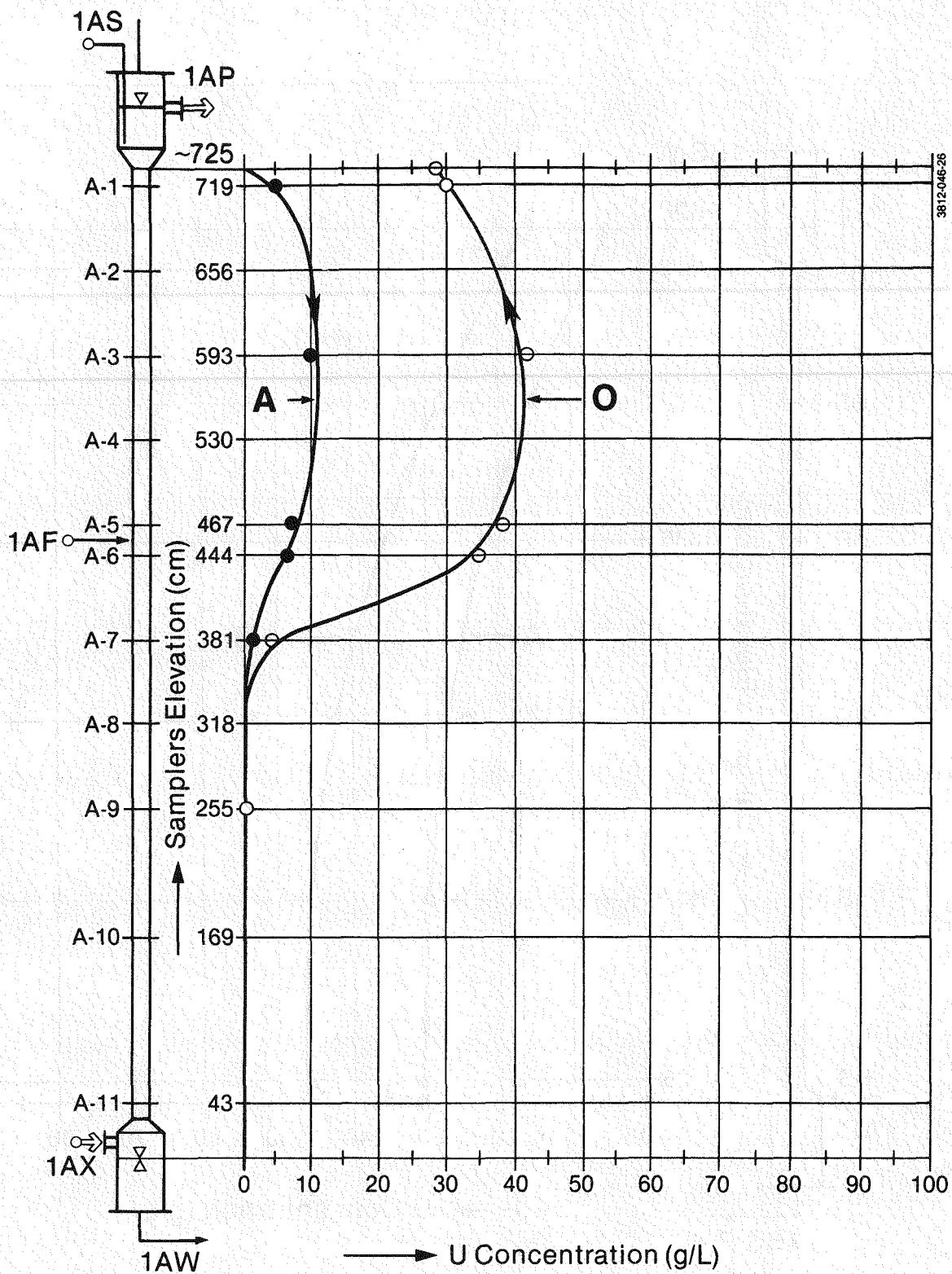
THE 2A COLUMN CONCENTRATION PROFILES FOR TEST 2AM-3

FIGURE 4-5



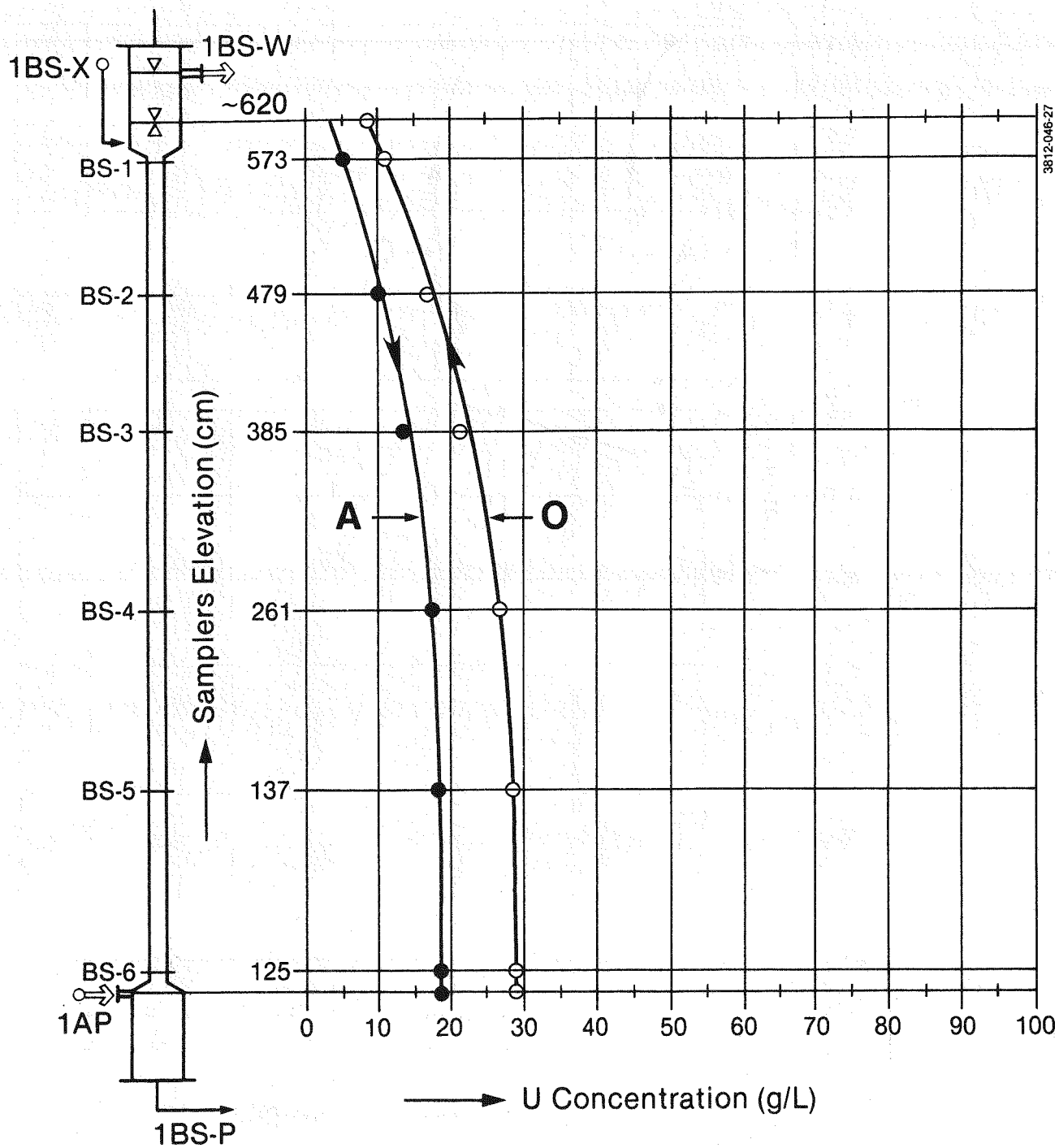
THE 2B COLUMN CONCENTRATION PROFILES FOR TEST 2AM-3

FIGURE 4-6



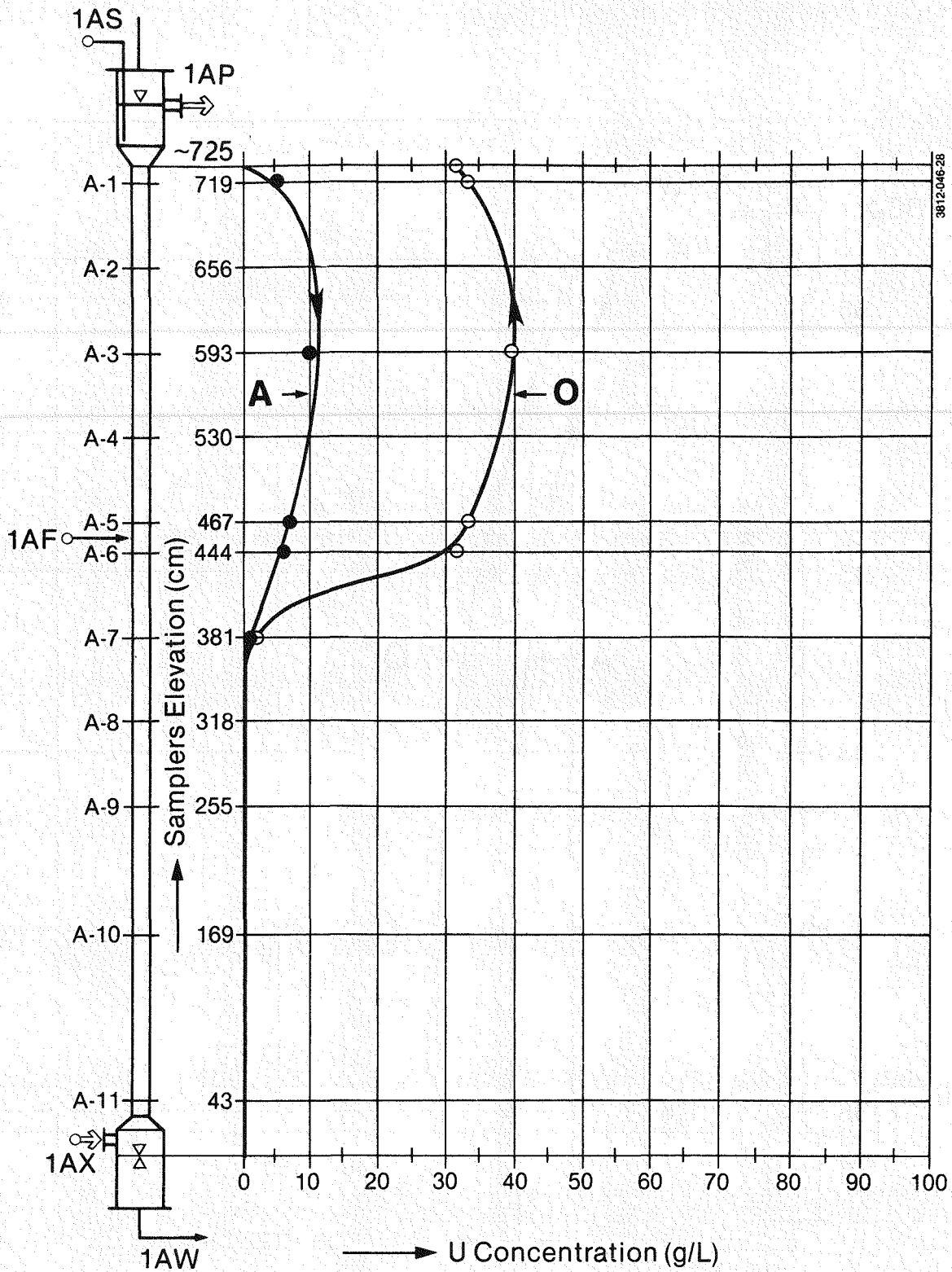
THE 2A COLUMN CONCENTRATION PROFILES FOR TEST 2AM-4

FIGURE 4-7



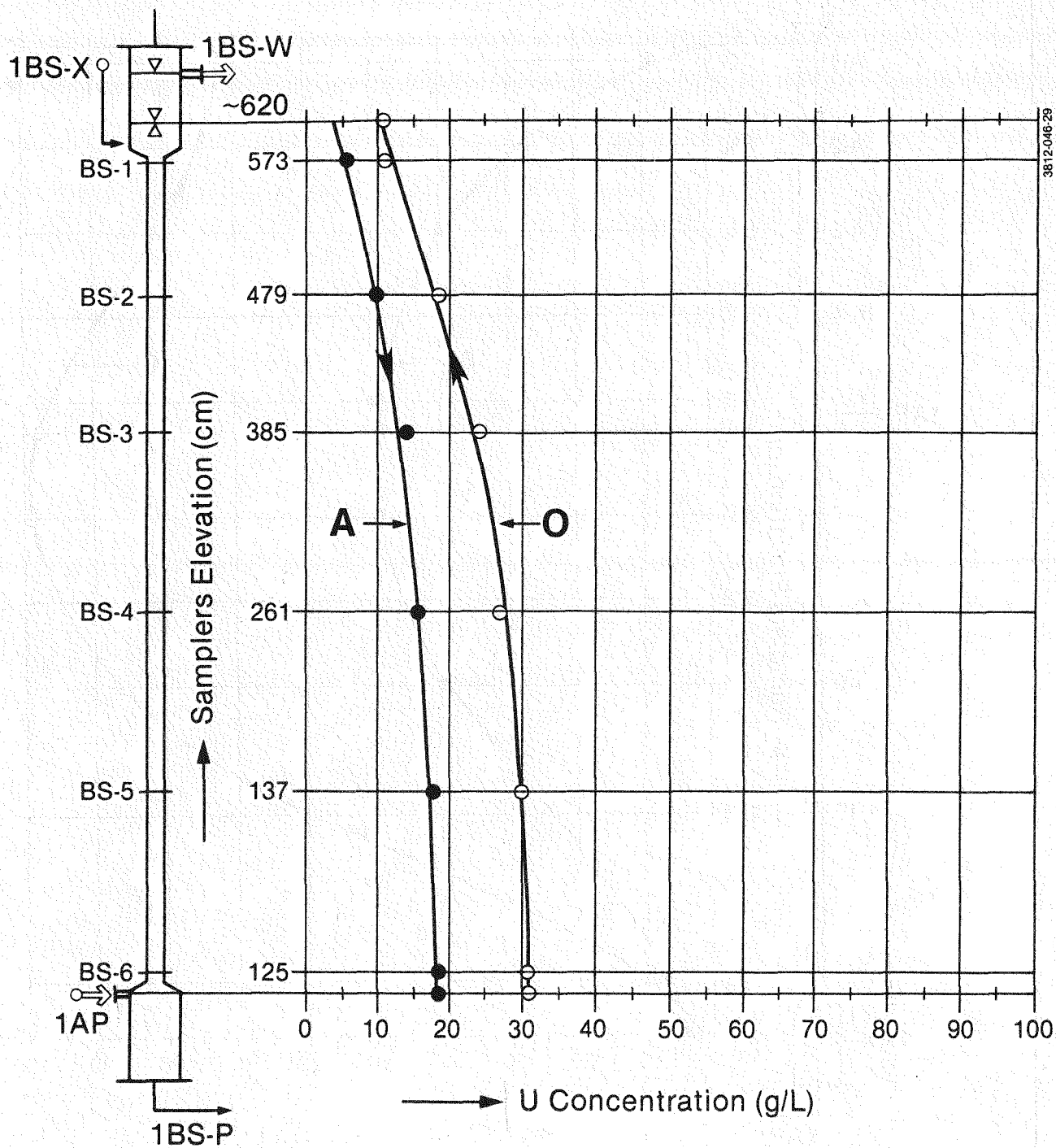
THE 2B COLUMN CONCENTRATION PROFILES FOR TEST 2AM-4

FIGURE 4-8



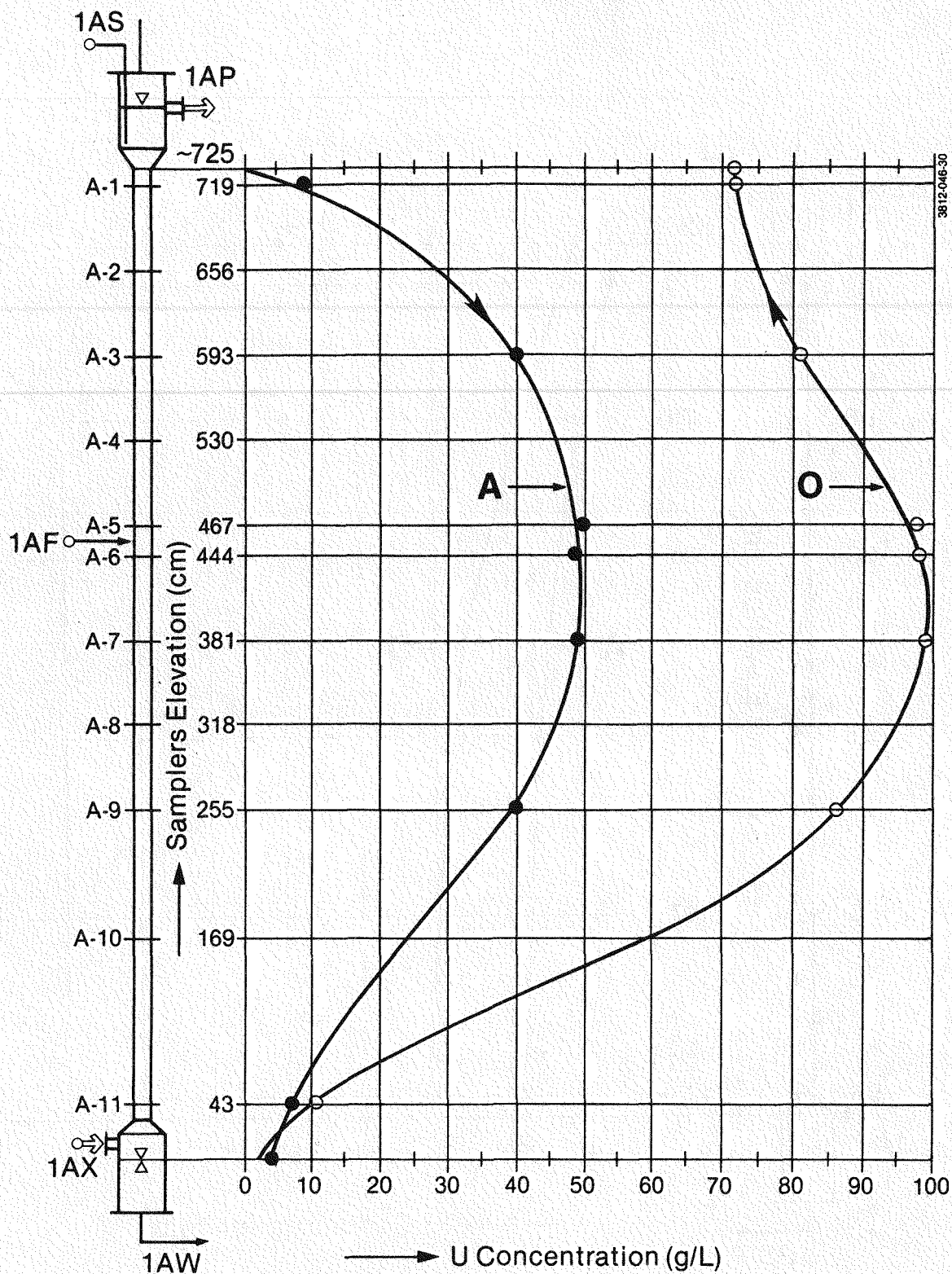
THE 2A COLUMN CONCENTRATION PROFILES FOR TEST 2AM-5

FIGURE 4-9



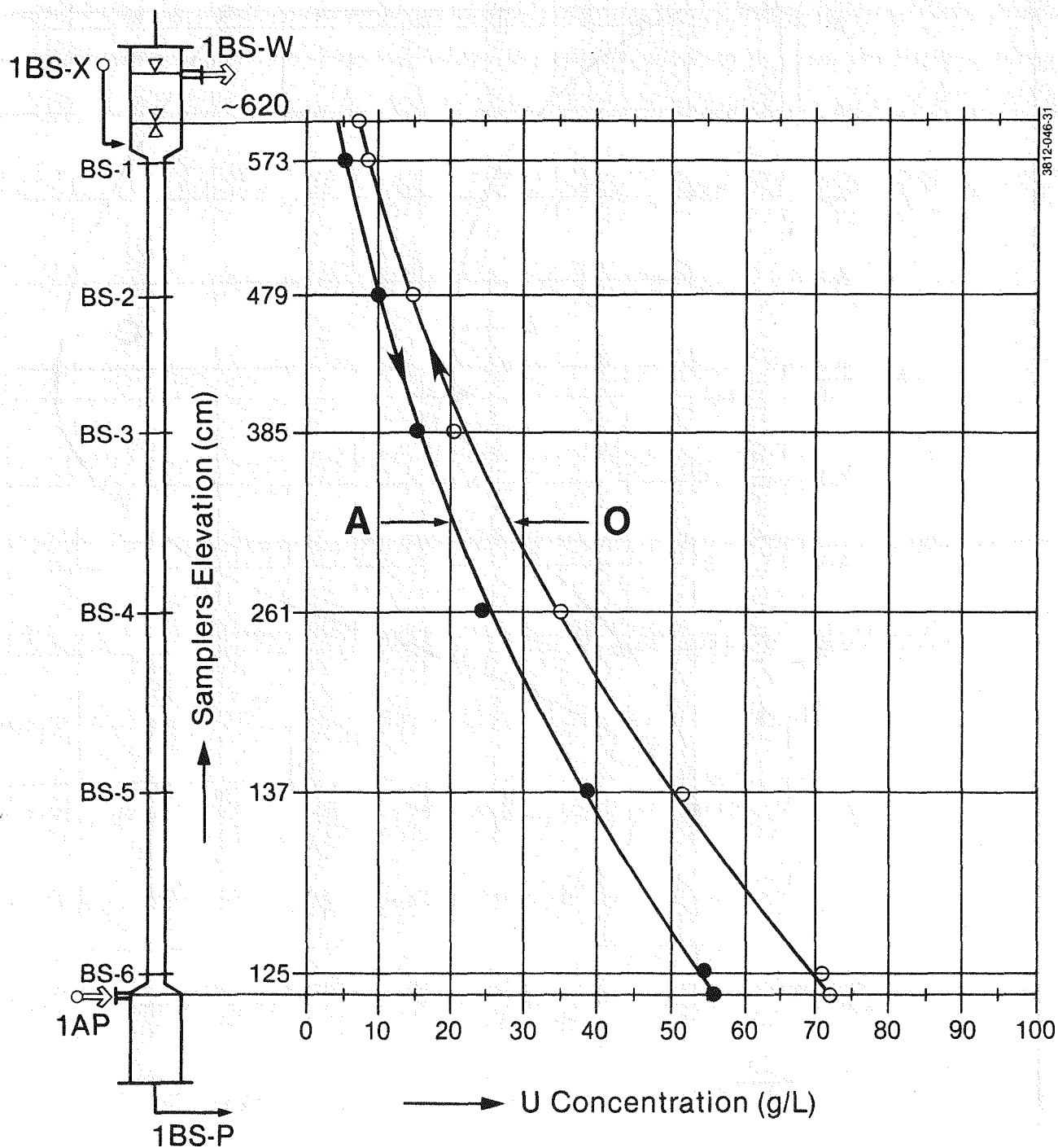
THE 2B COLUMN CONCENTRATION PROFILES FOR TEST 2AM-5

FIGURE 4-10



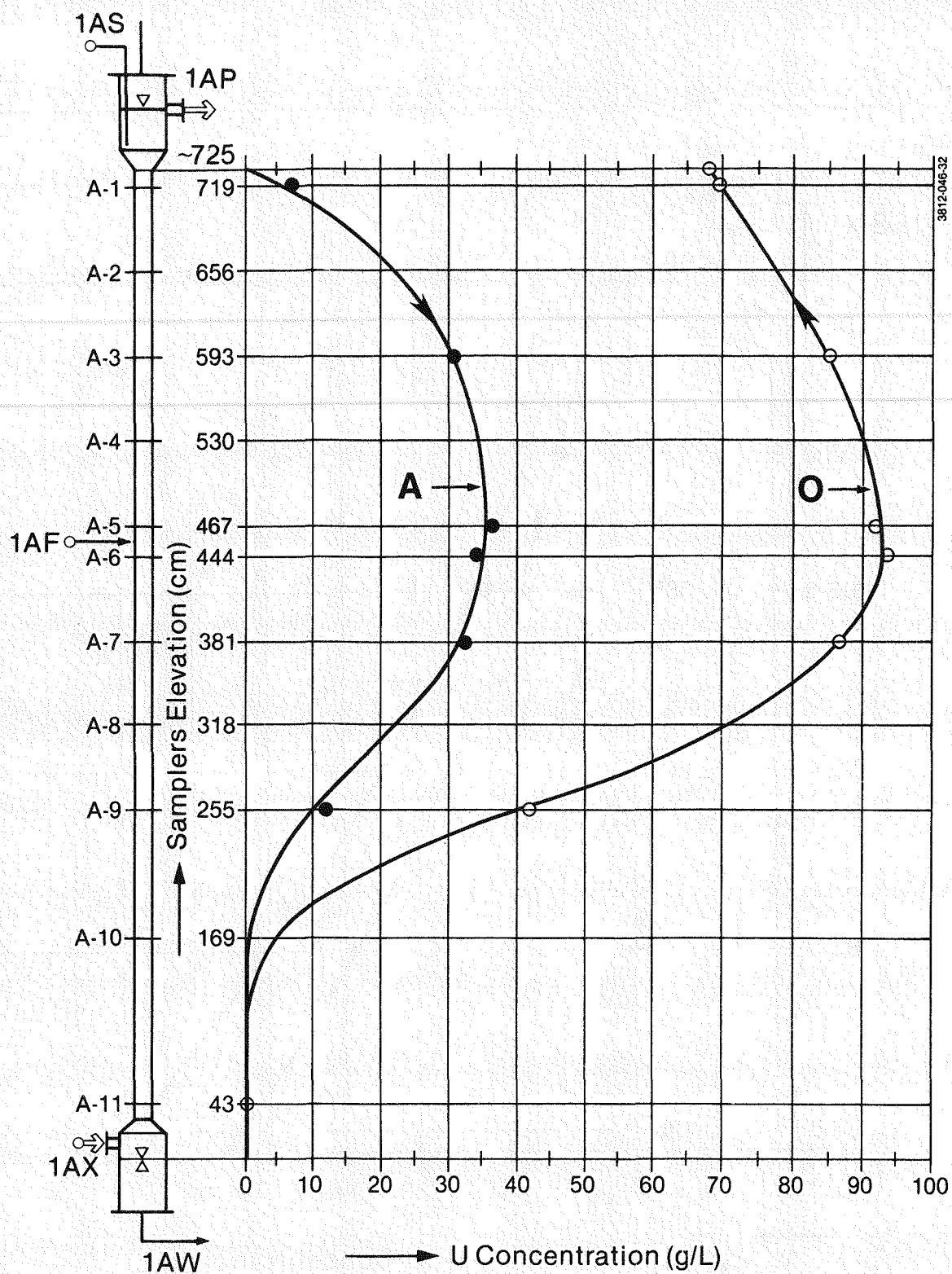
THE 3A COLUMN CONCENTRATION PROFILES FOR TEST 3AM-1

FIGURE 4-11



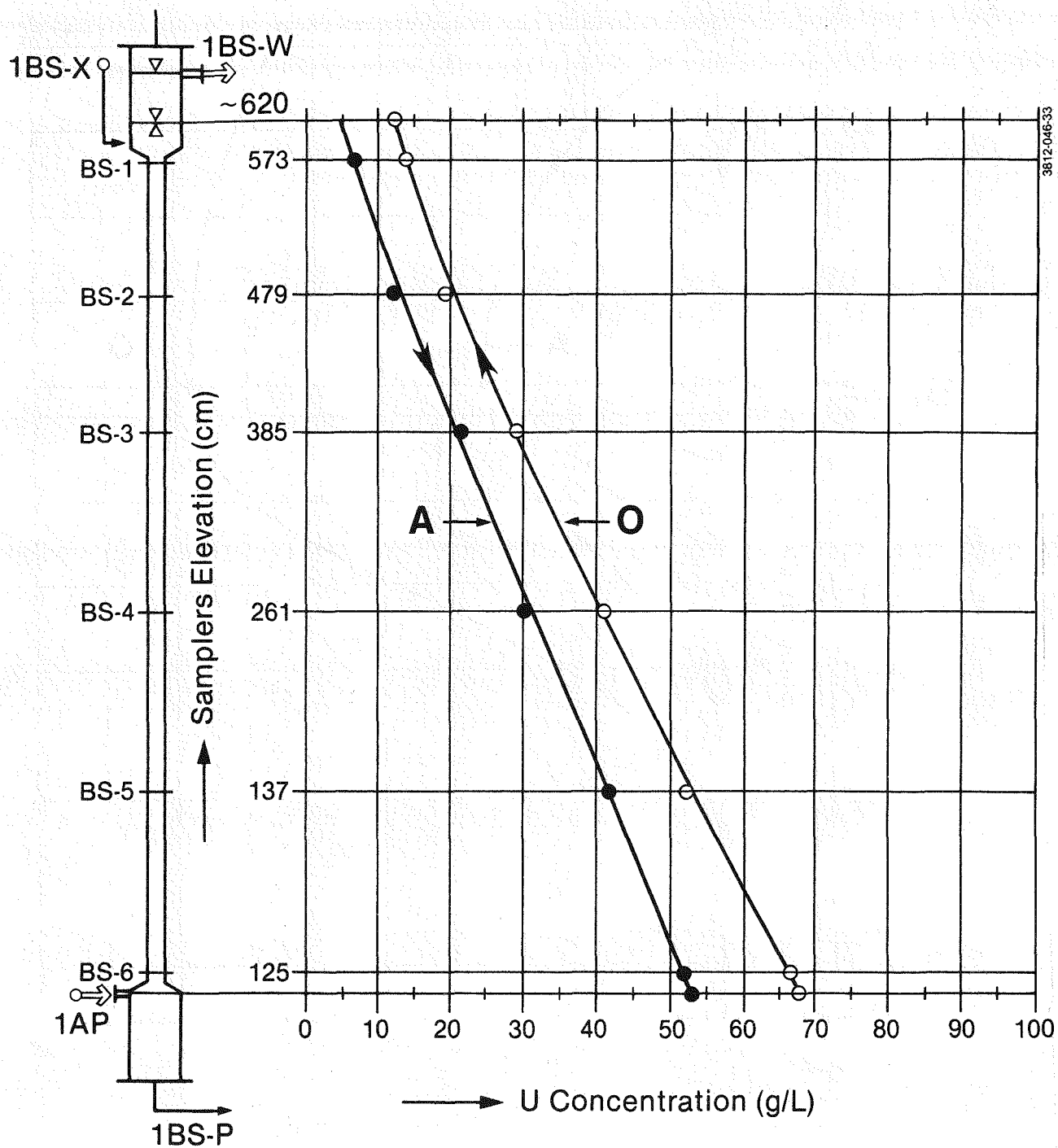
THE 3B COLUMN CONCENTRATION PROFILES FOR TEST 3AM-1

FIGURE 4-12



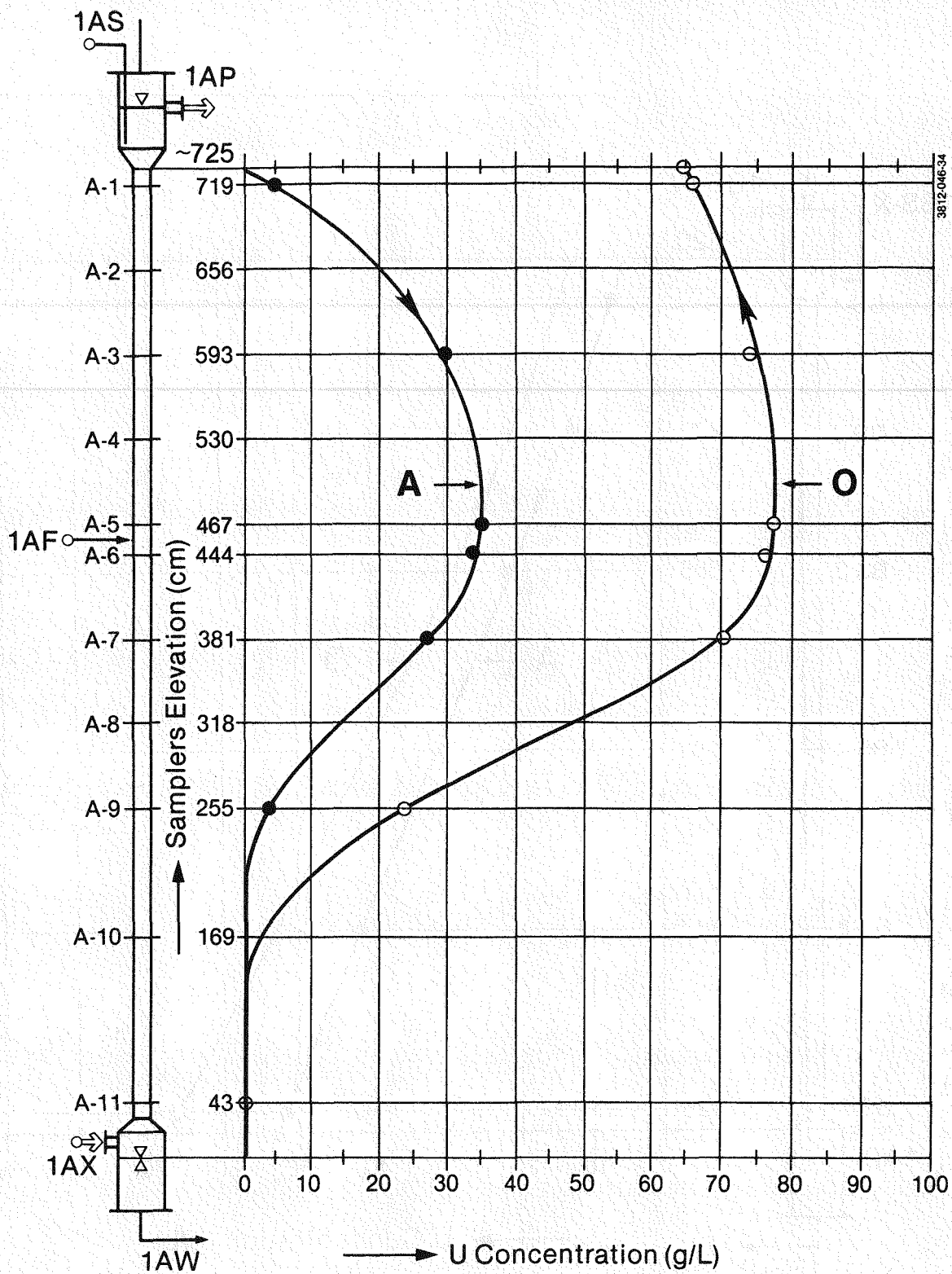
THE 3A COLUMN CONCENTRATION PROFILES FOR TEST 3AM-2

FIGURE 4-13



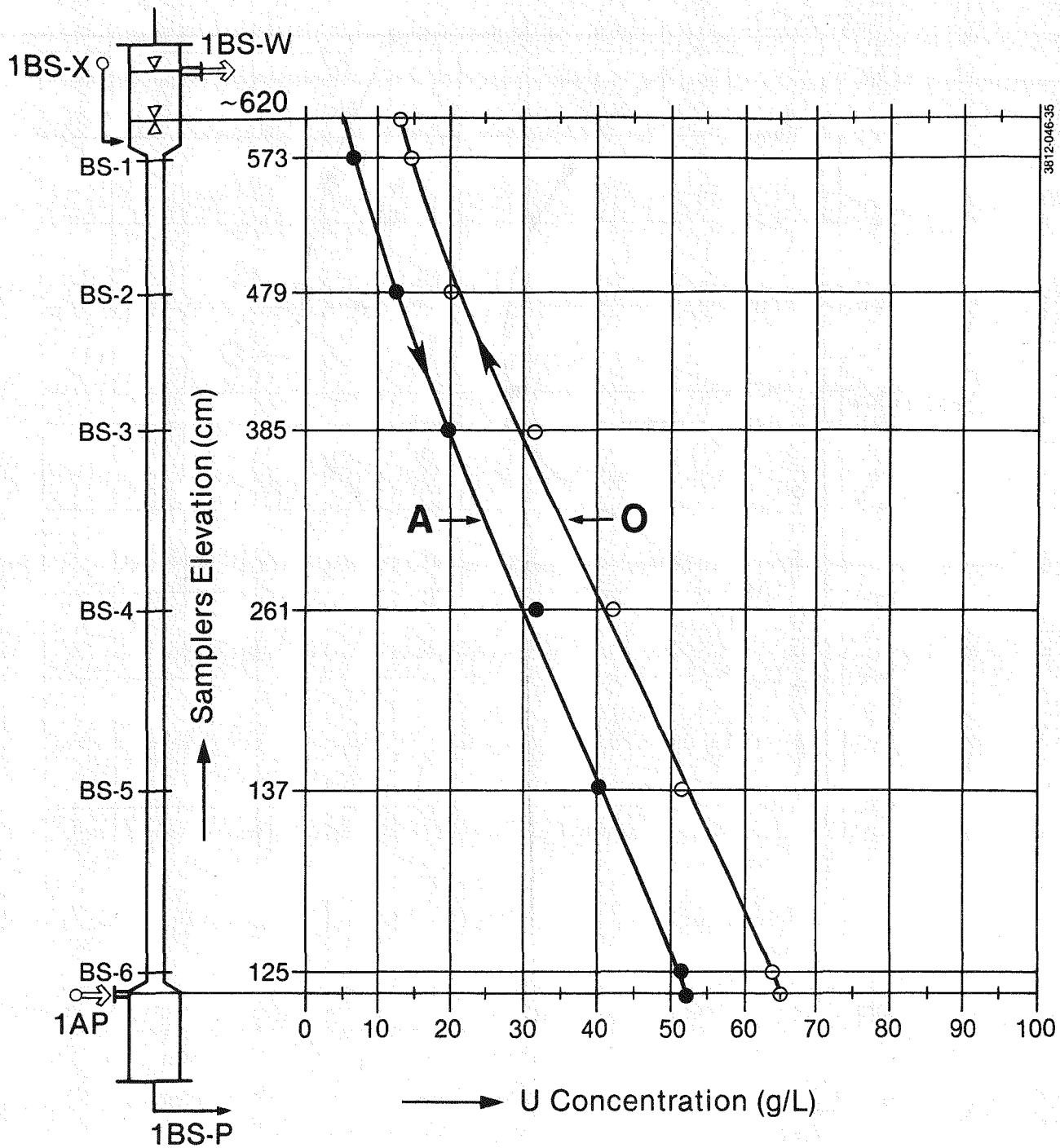
THE 3B COLUMN CONCENTRATION PROFILES FOR TEST 3AM-2

FIGURE 4-14



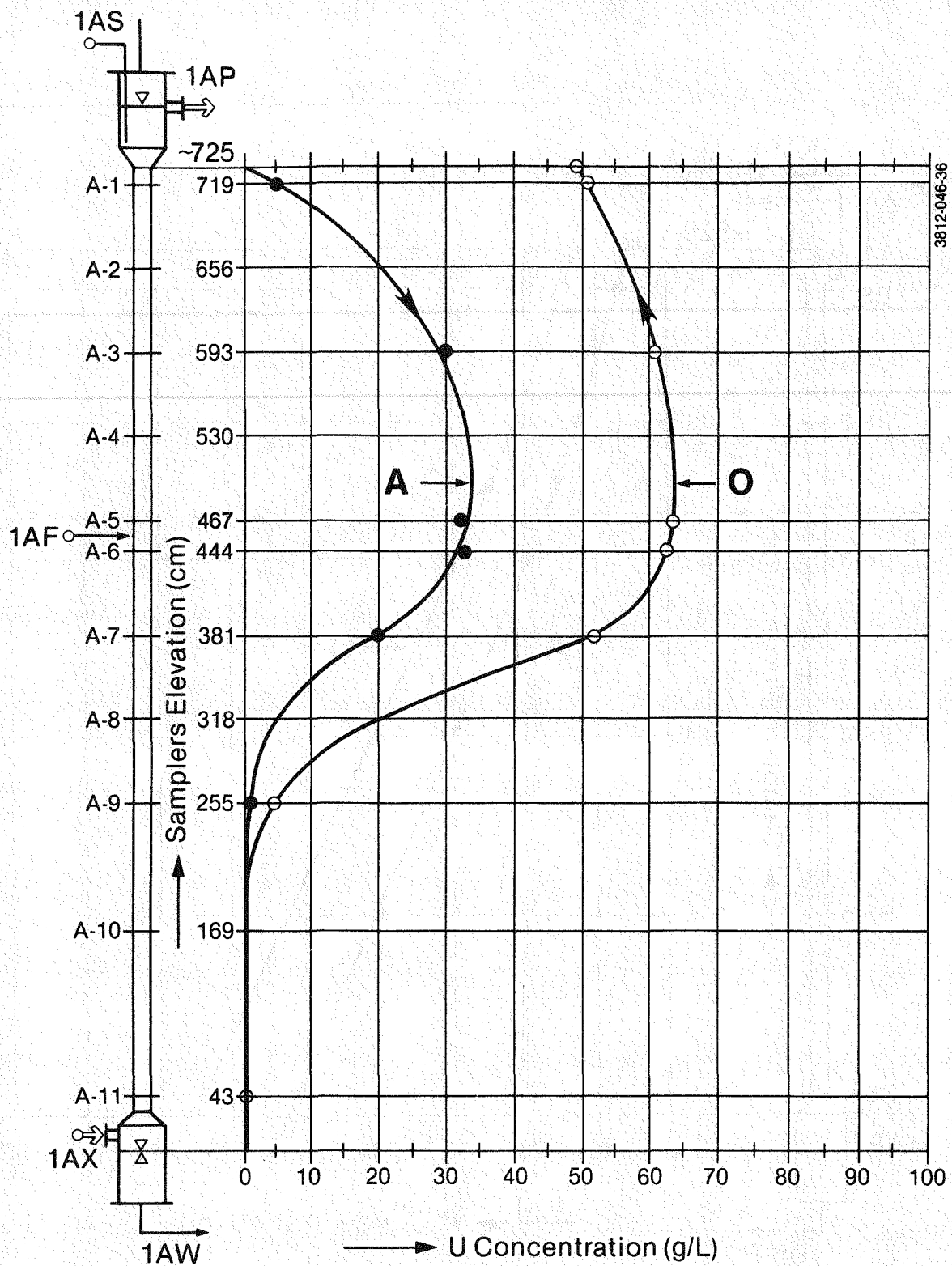
THE 3A COLUMN CONCENTRATION PROFILES FOR TEST 3AM-3

FIGURE 4-15



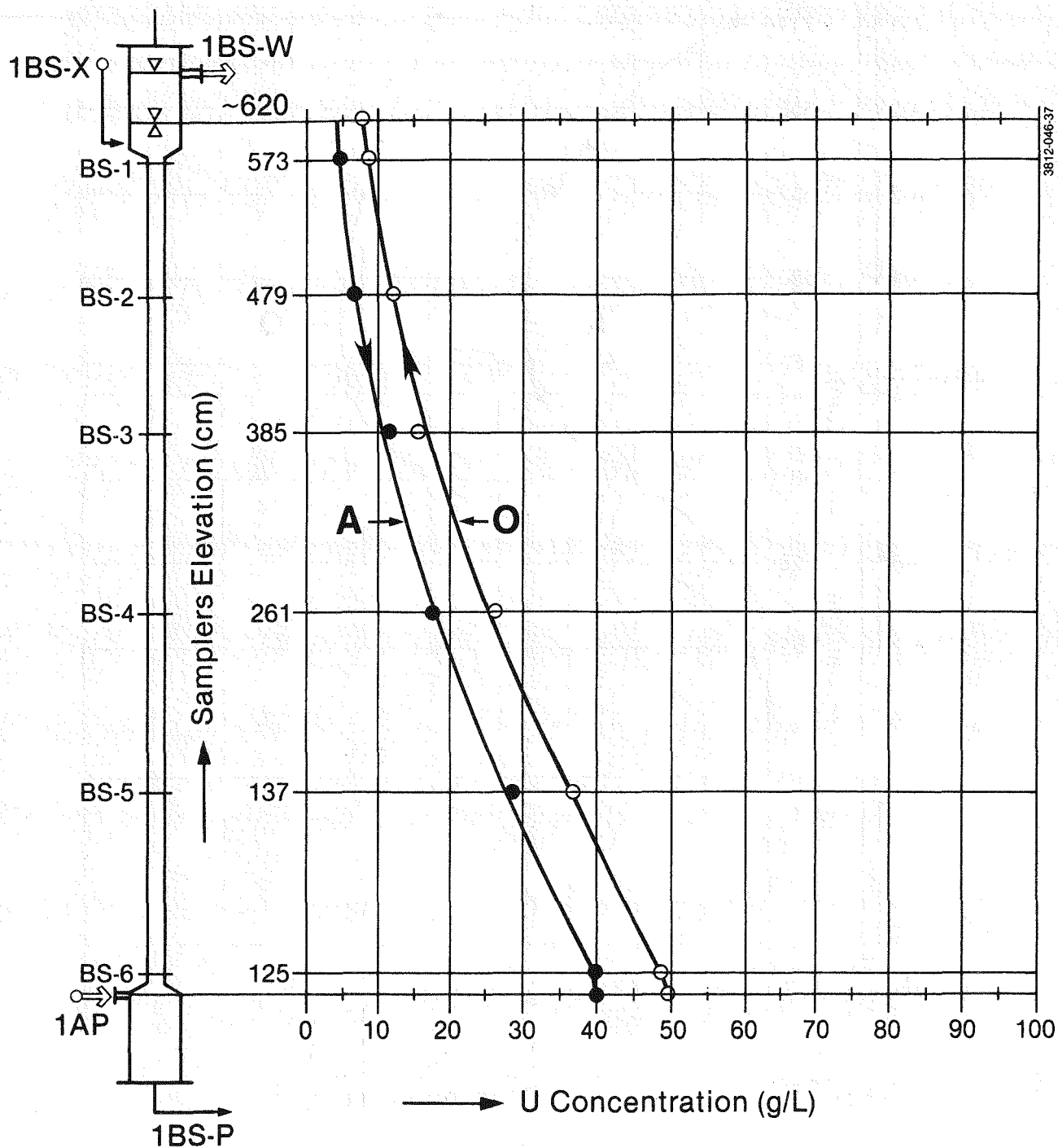
THE 3B COLUMN CONCENTRATION PROFILES FOR TEST 3AM-3

FIGURE 4-16



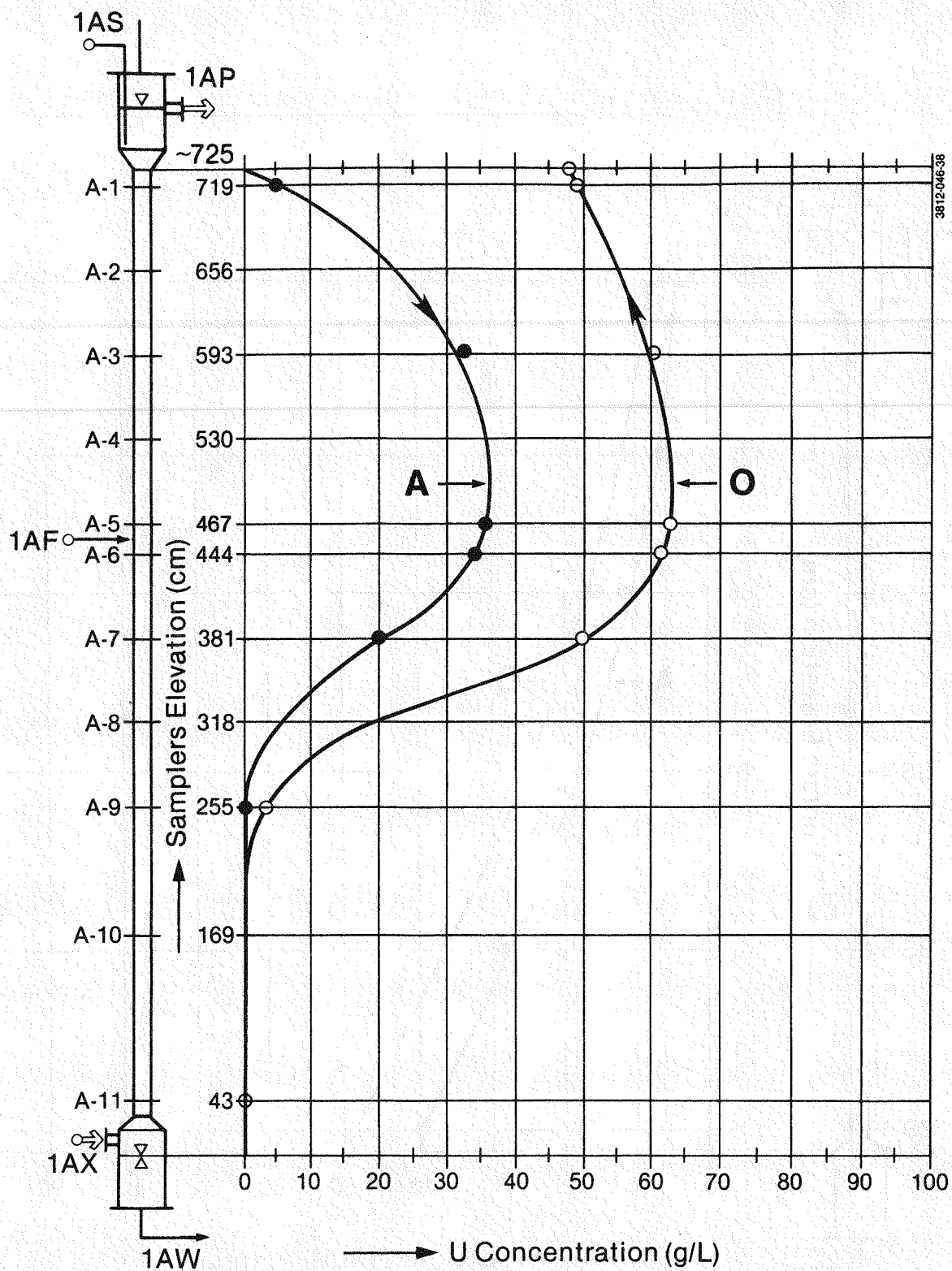
THE 3A COLUMN CONCENTRATION PROFILES FOR TEST 3AM-4

FIGURE 4-17



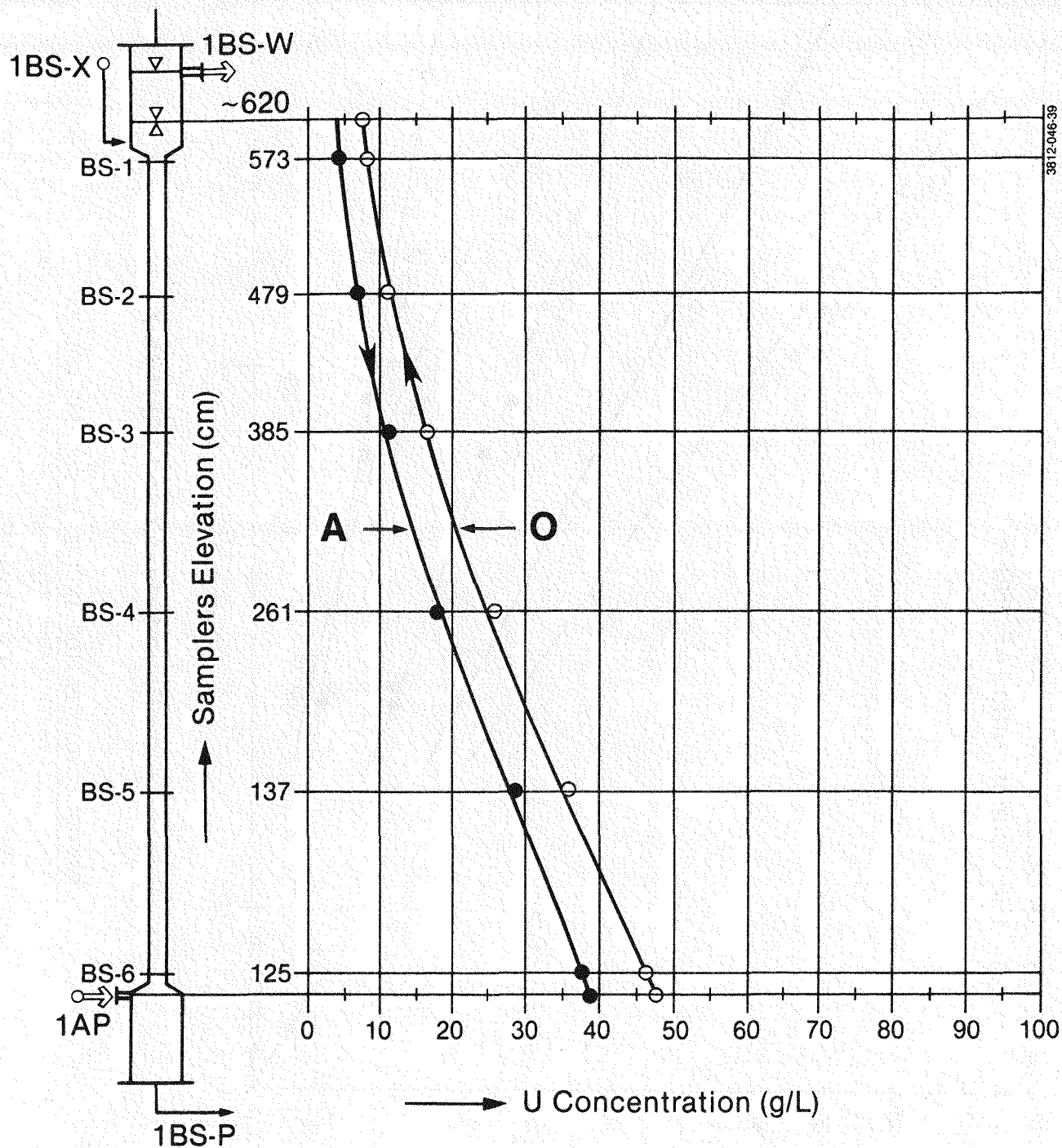
THE 3B COLUMN CONCENTRATION PROFILES FOR TEST 3AM-4

FIGURE 4-18



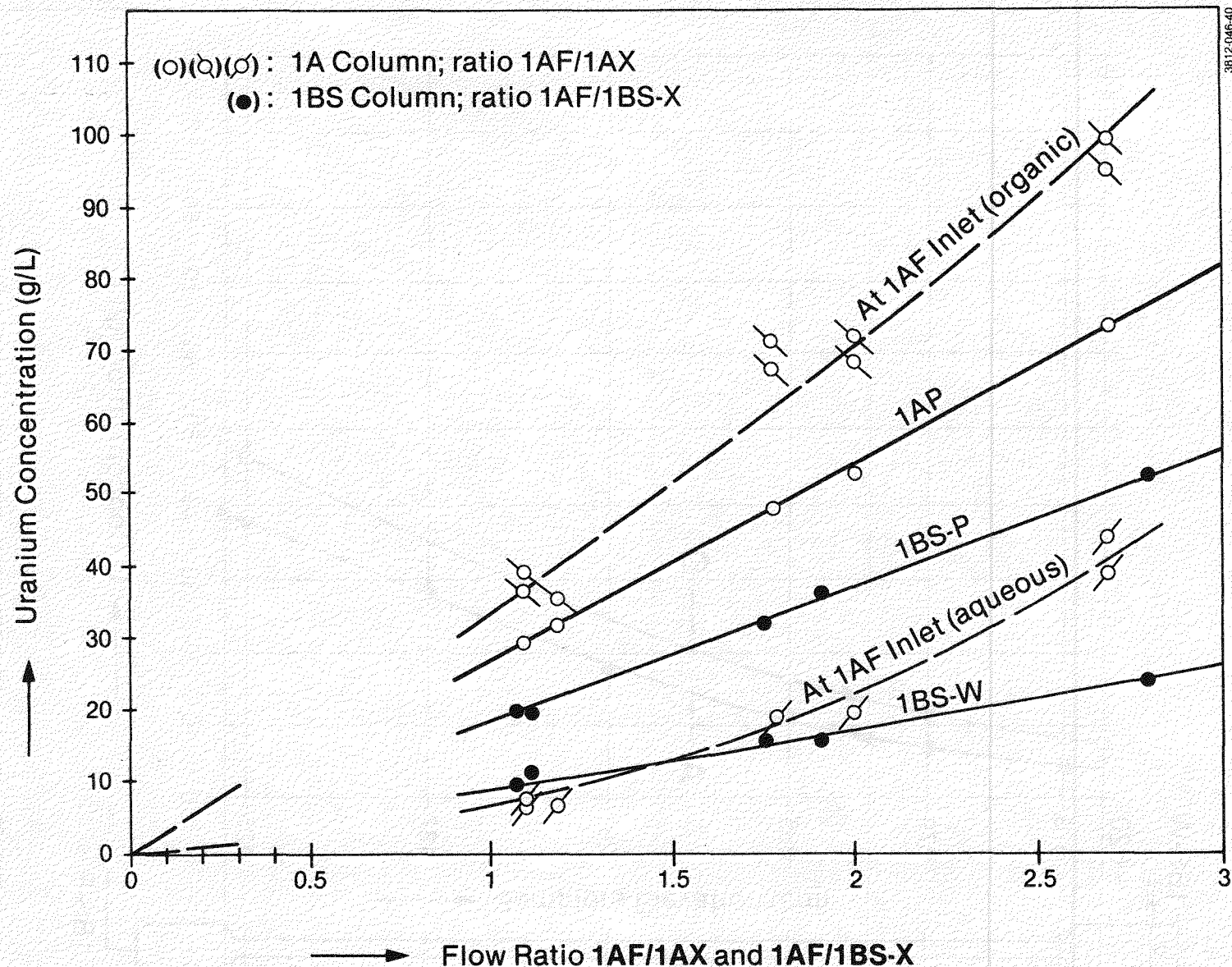
THE 3A COLUMN CONCENTRATION PROFILES FOR TEST 3AM-5

FIGURE 4-19



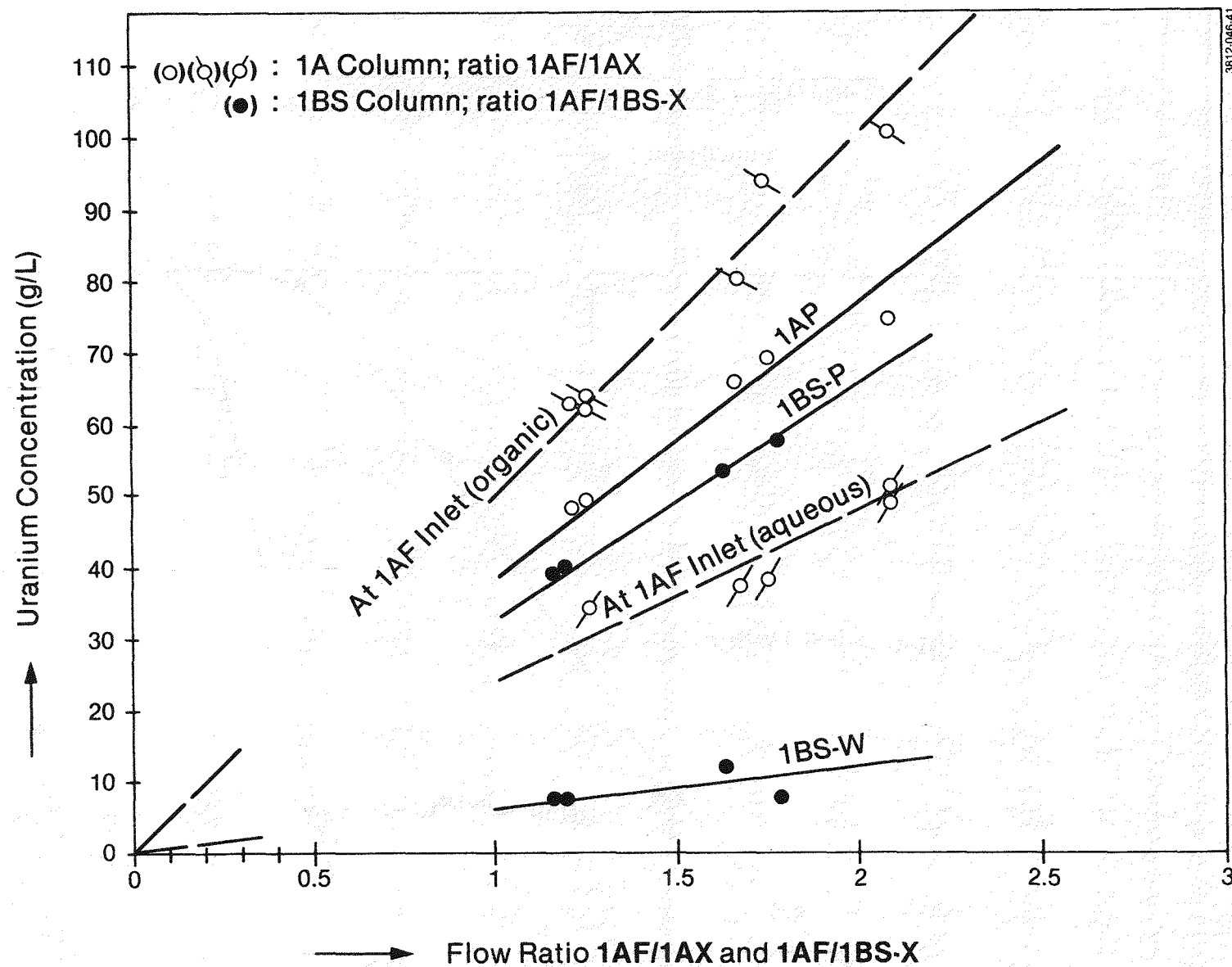
THE 3B COLUMN CONCENTRATION PROFILES FOR TEST 3AM-5

FIGURE 4-20



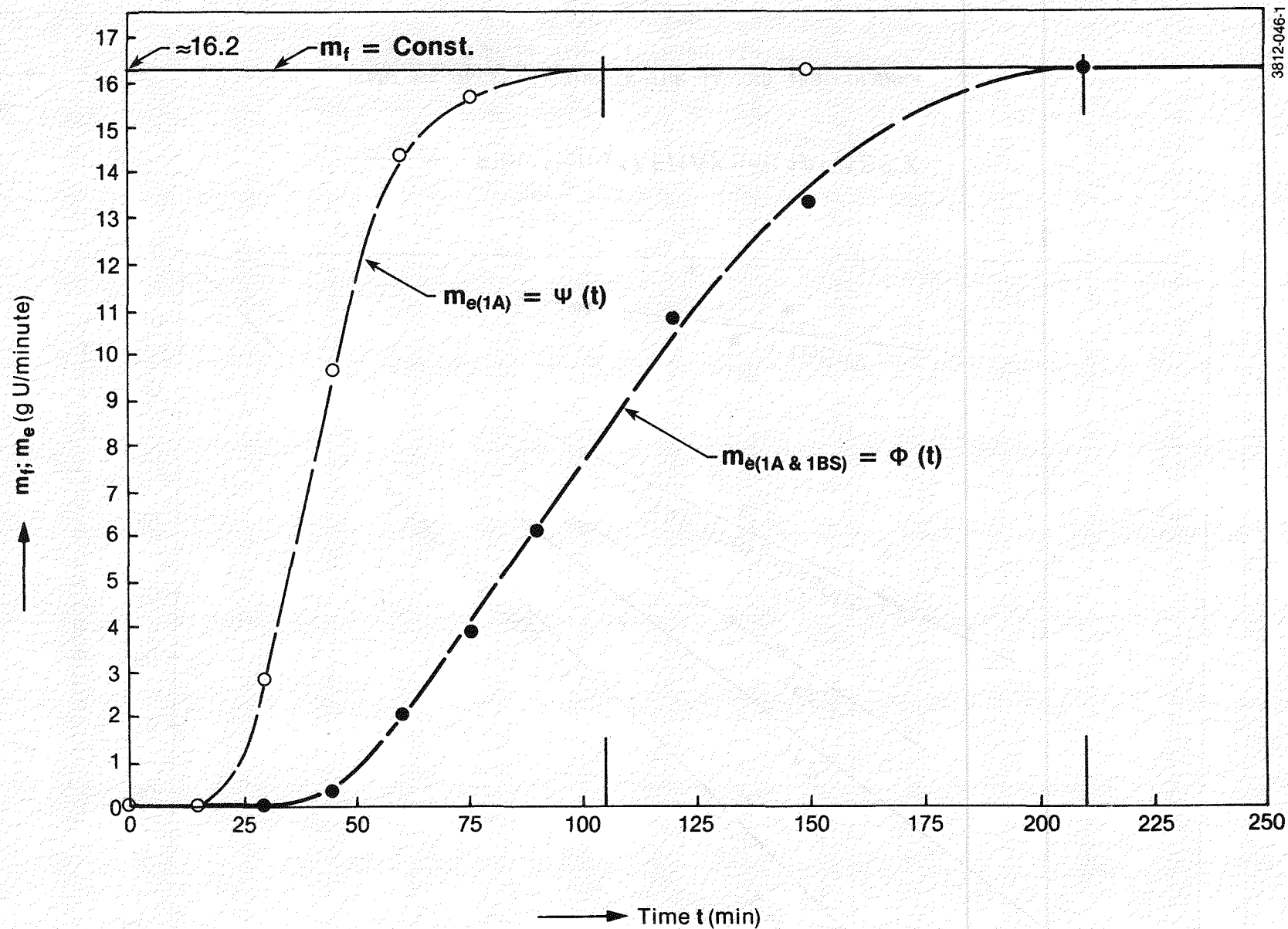
URANIUM CONCENTRATION IN THE 1A AND 1BS COLUMNS
(Tests 2AM-1 through 2AM-5)

FIGURE 4-21



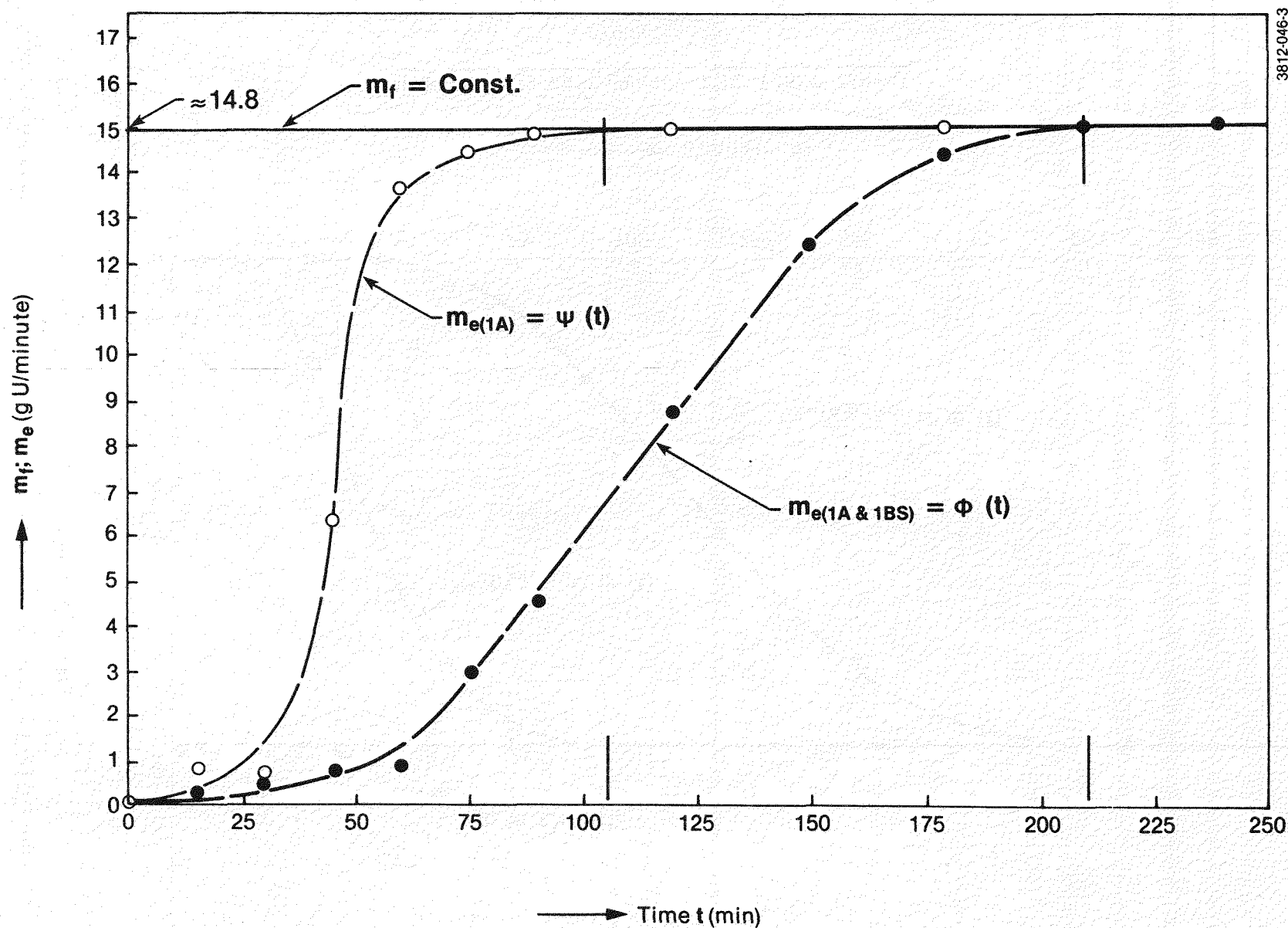
URANIUM CONCENTRATION IN THE 1A AND 1BS COLUMNS
(Tests 3AM-1 through 3AM-5)

FIGURE 4-22



URANIUM MASS RATE VERSUS TIME (TEST 2AM-2)

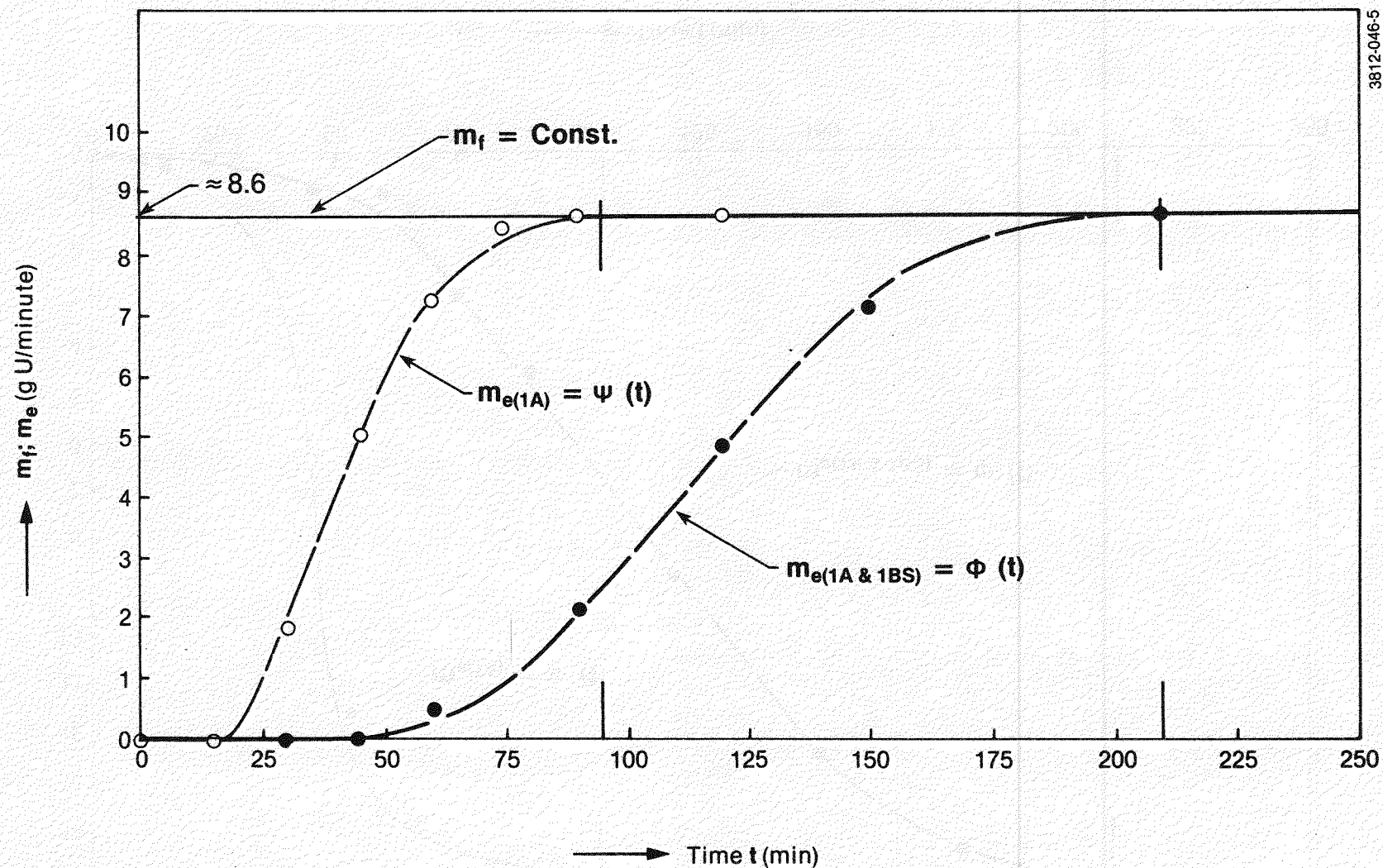
FIGURE 4-23



3812-046-3

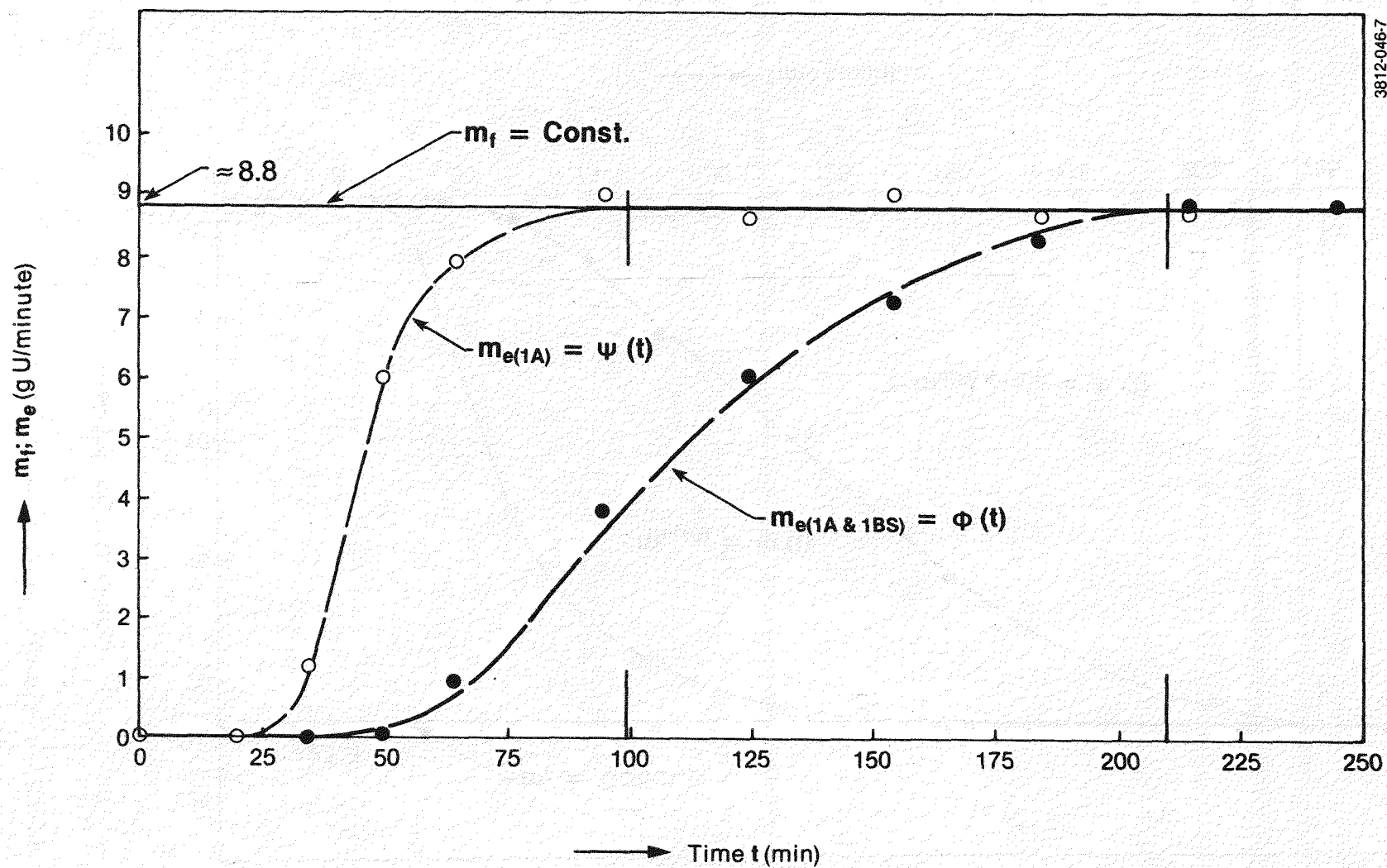
URANIUM MASS RATE VERSUS TIME (TEST 2AM-3)

FIGURE 4-24



URANIUM MASS RATE VERSUS TIME (TEST 2AM-4)

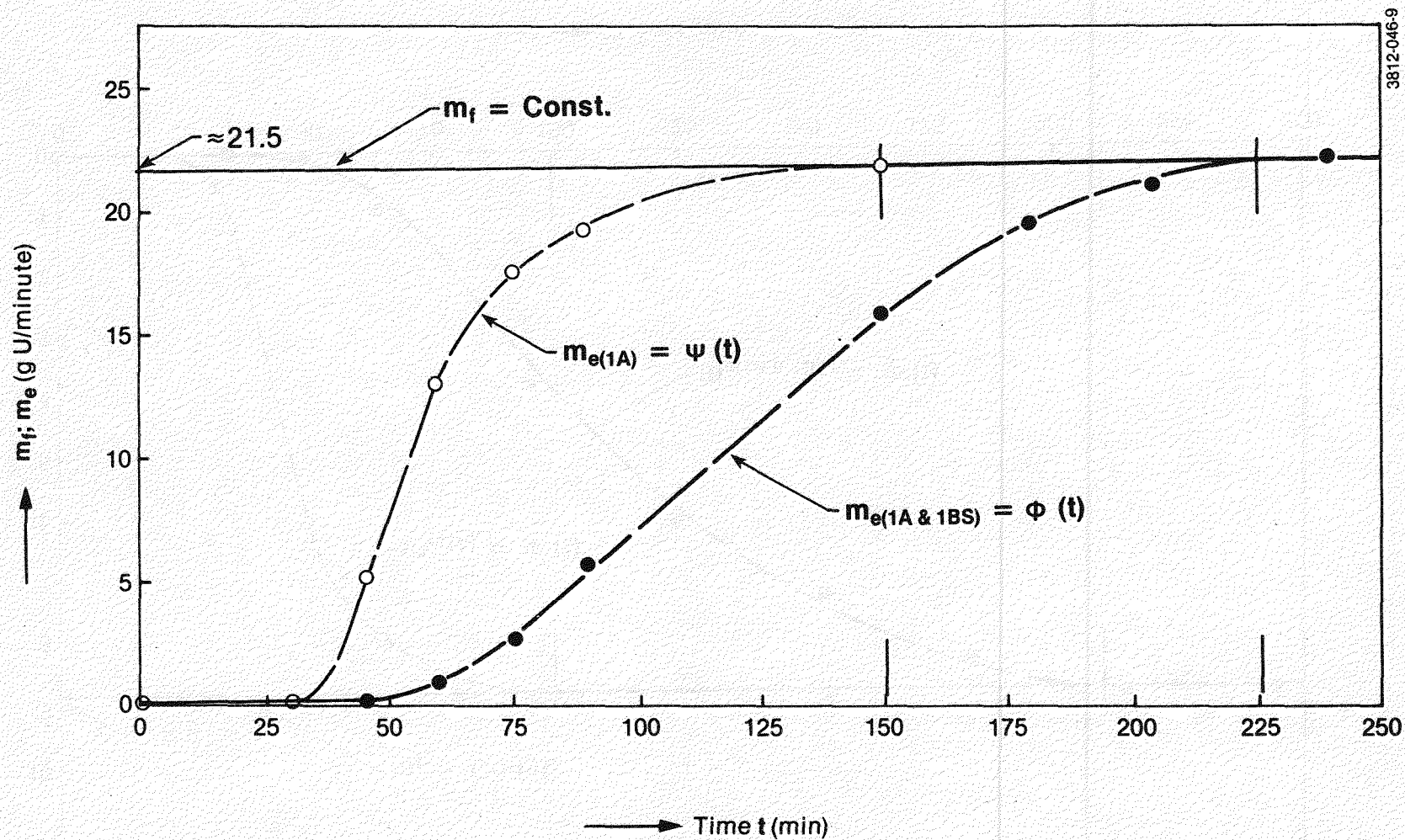
FIGURE 4-25



URANIUM MASS RATE VERSUS TIME (TEST 2AM-5)

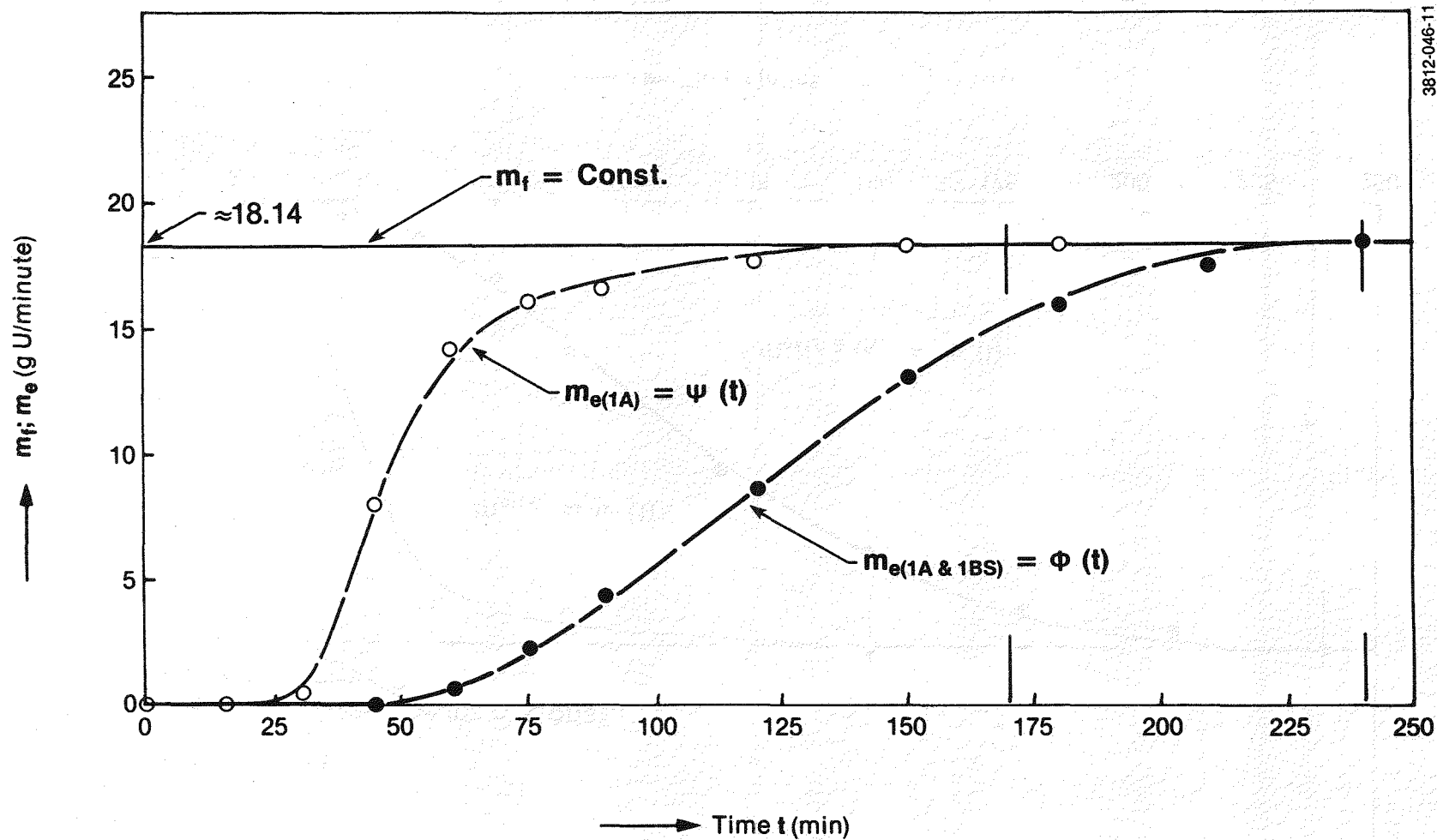
FIGURE 4-26

3812-046-7



URANIUM MASS RATE VERSUS TIME (TEST 3AM-1)

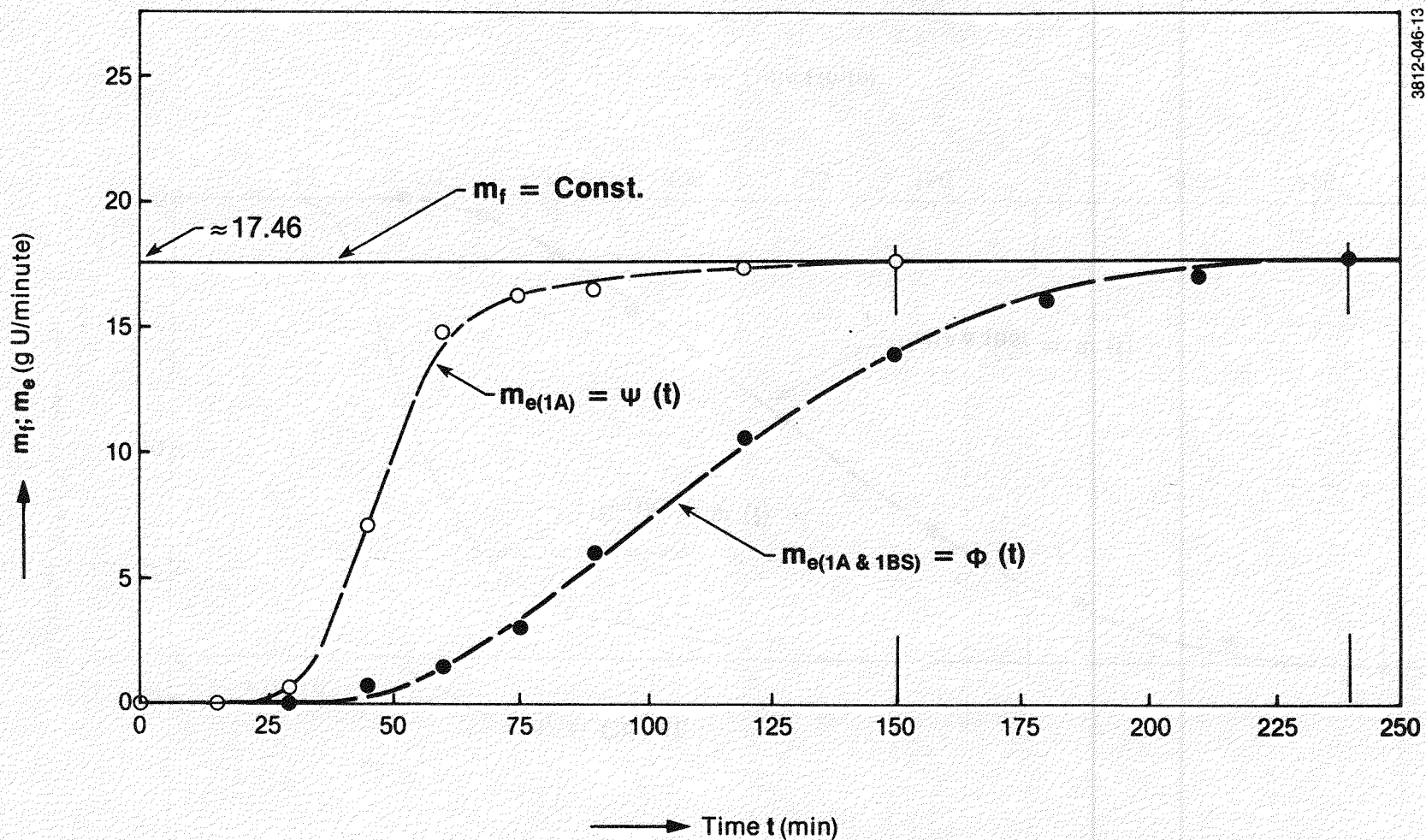
FIGURE 4-27



URANIUM MASS RATE VERSUS TIME (TEST 3AM-2)

FIGURE 4-28

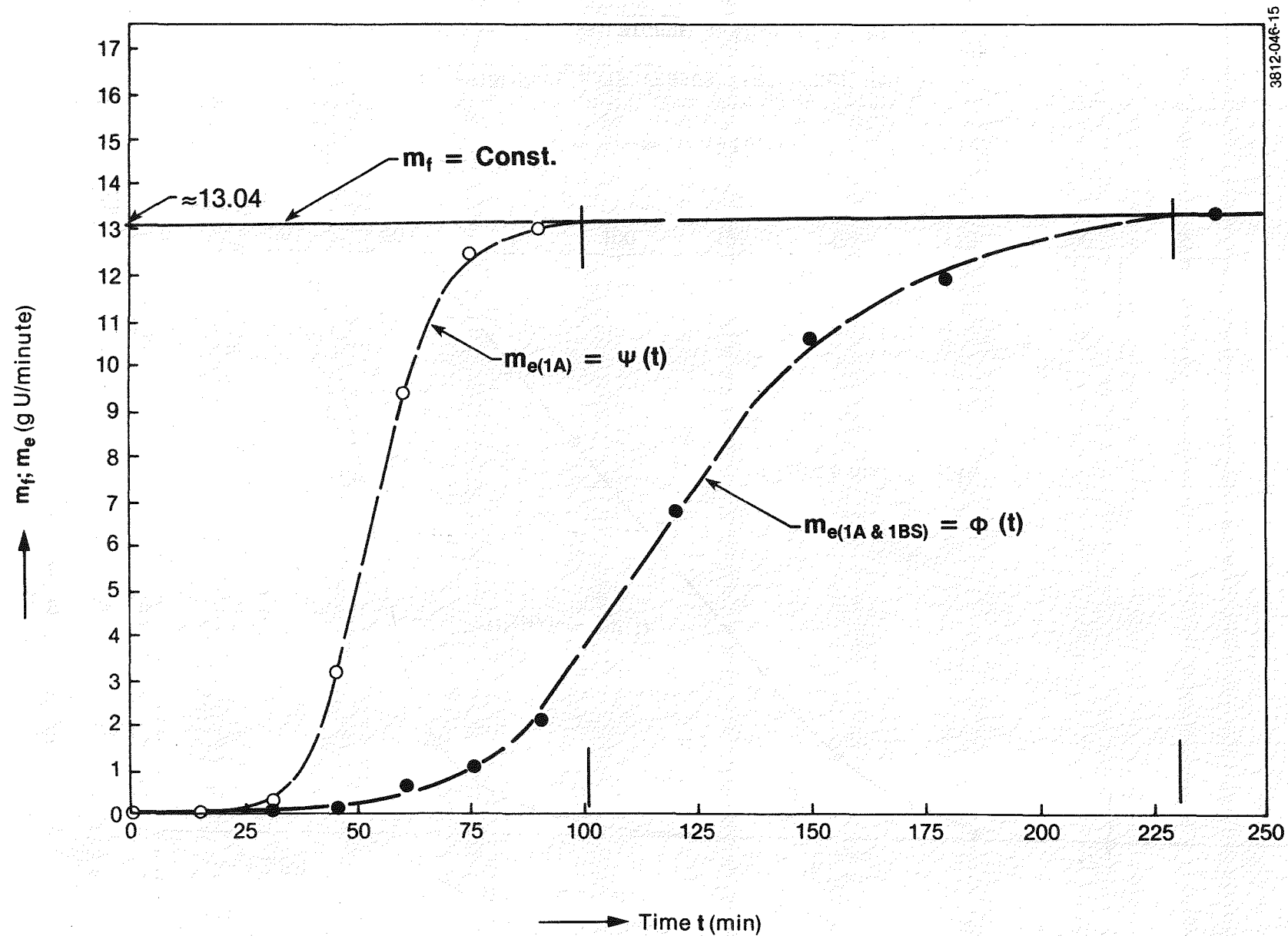
3812-046-11



3812-046-13

URANIUM MASS RATE VERSUS TIME (TEST 3AM-3)

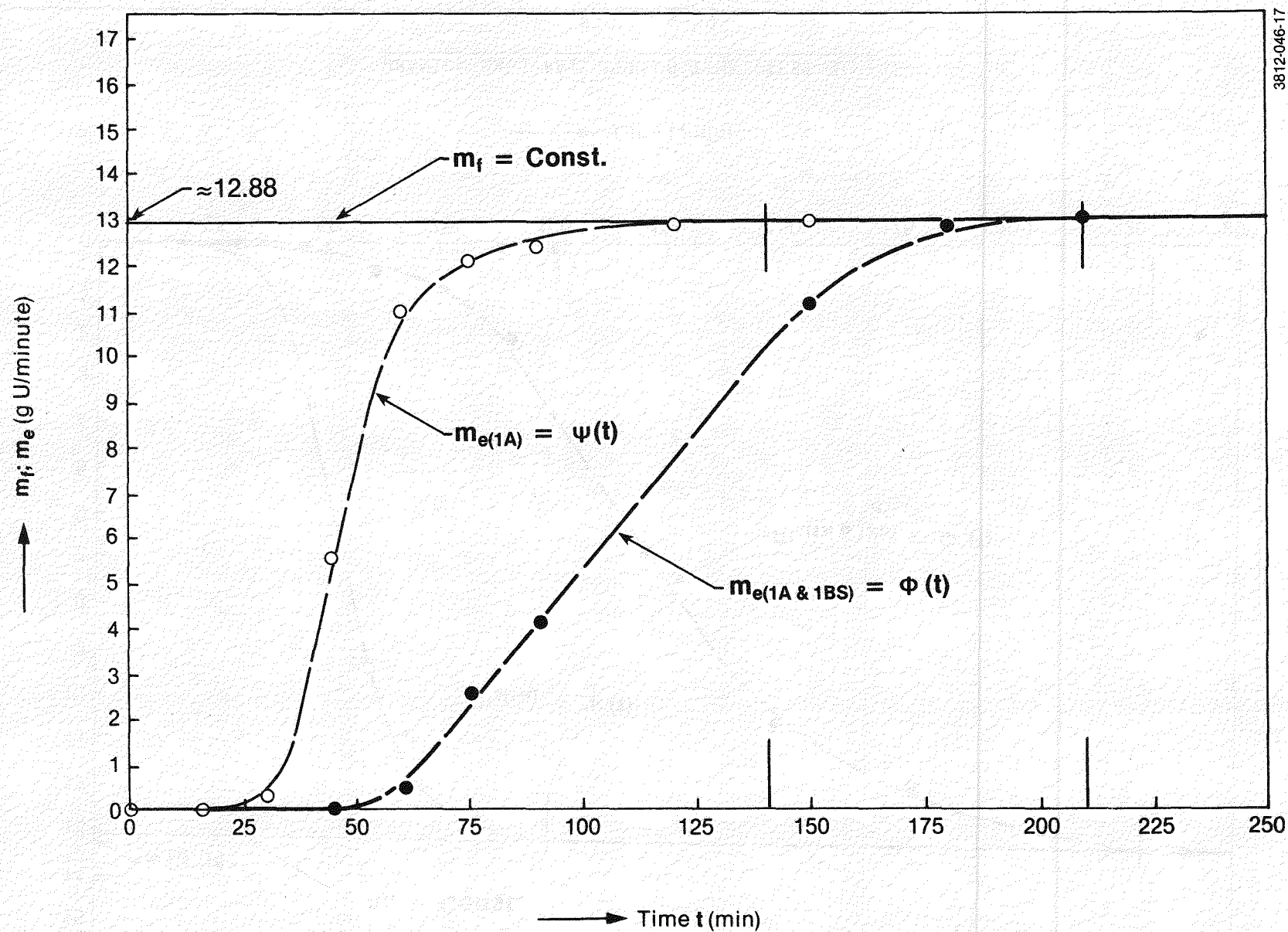
FIGURE 4-29



URANIUM MASS RATE VERSUS TIME (TEST 3AM-4)

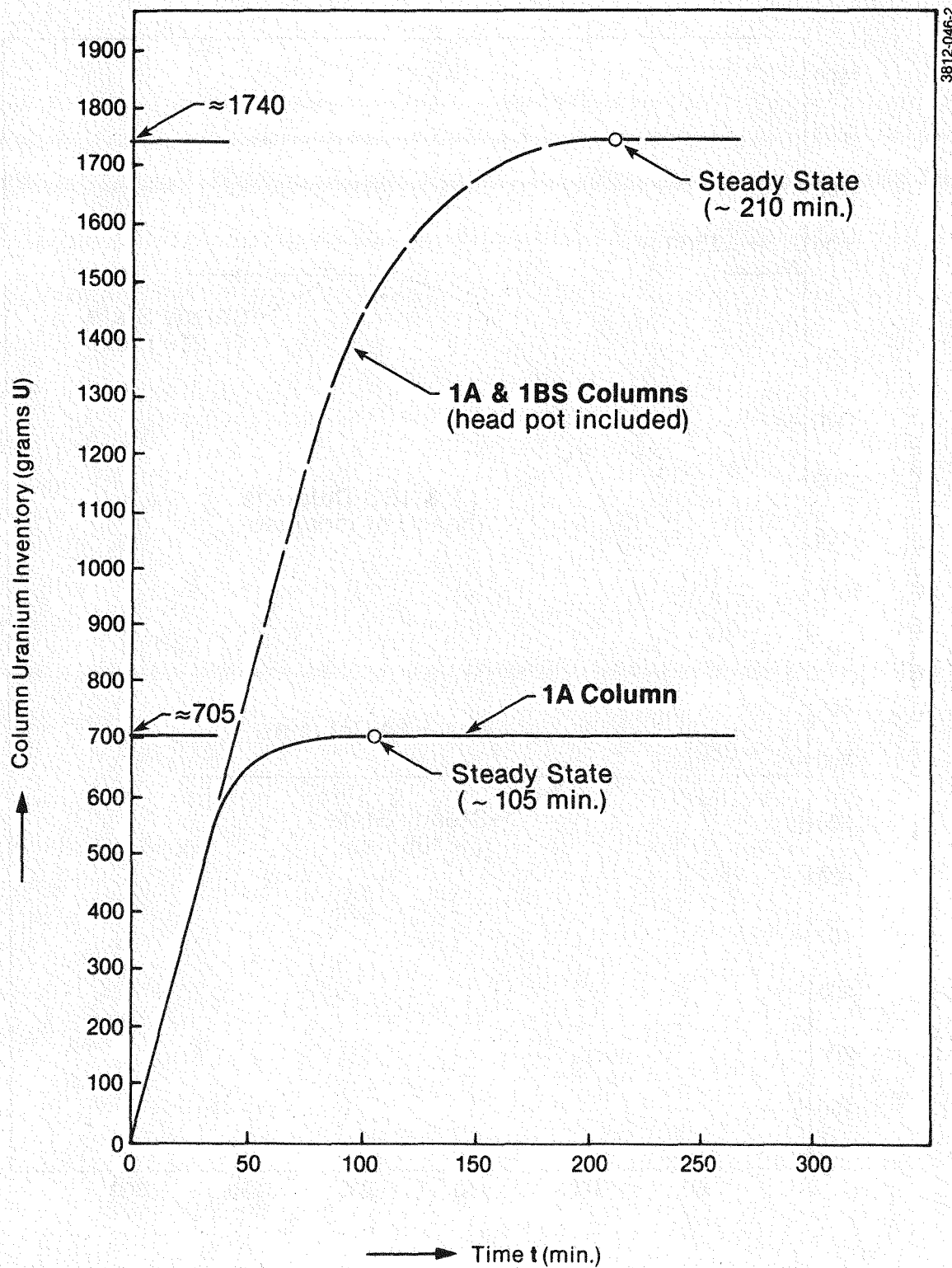
FIGURE 4-30

3812-046-15



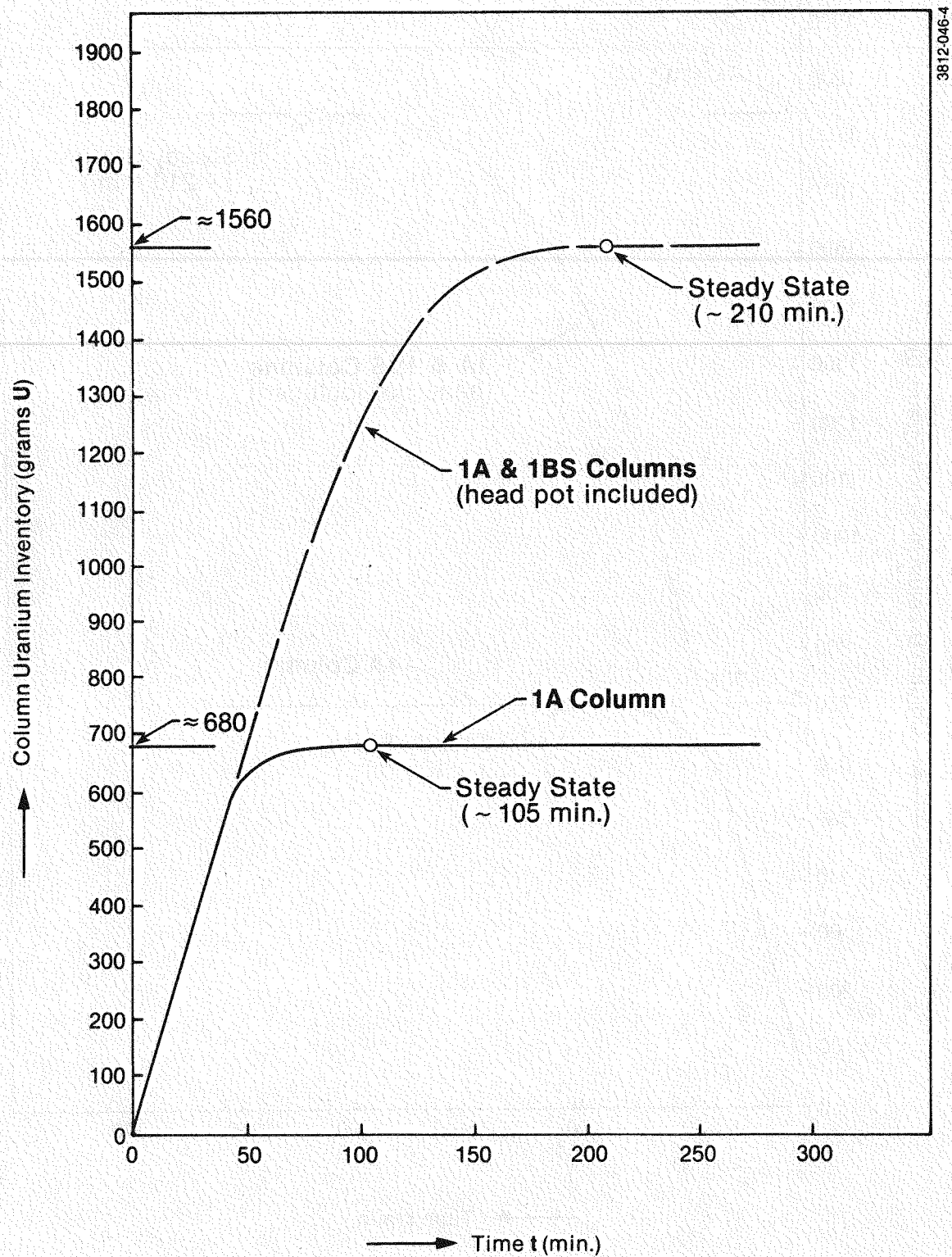
URANIUM MASS RATE VERSUS TIME (TEST 3AM-5)

FIGURE 4-31



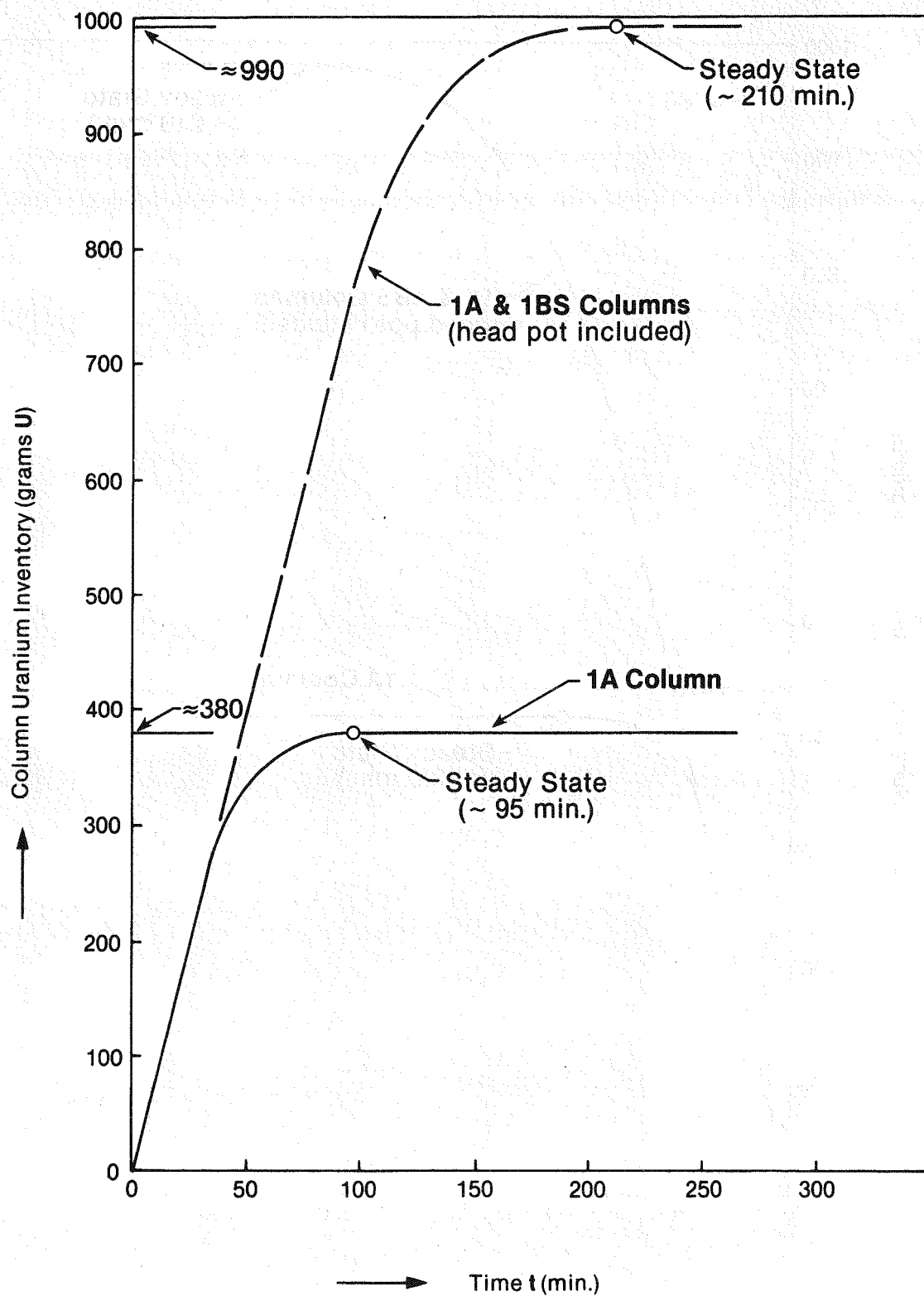
COLUMN URANIUM INVENTORY VERSUS TIME (TEST 2AM-2)

FIGURE 4-32



COLUMN URANIUM INVENTORY VERSUS TIME (TEST 2AM-3)

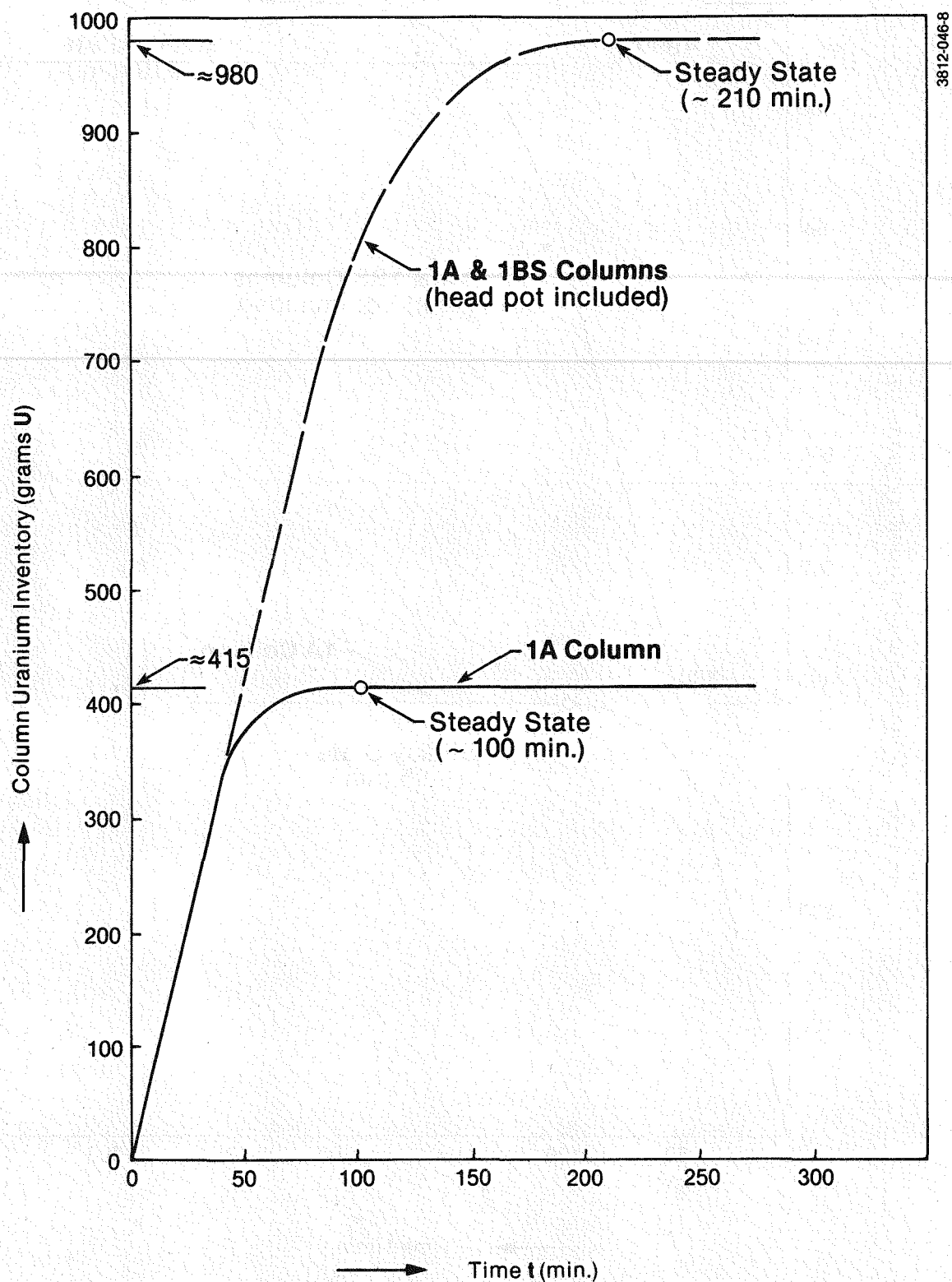
FIGURE 4-33



3812-046-6

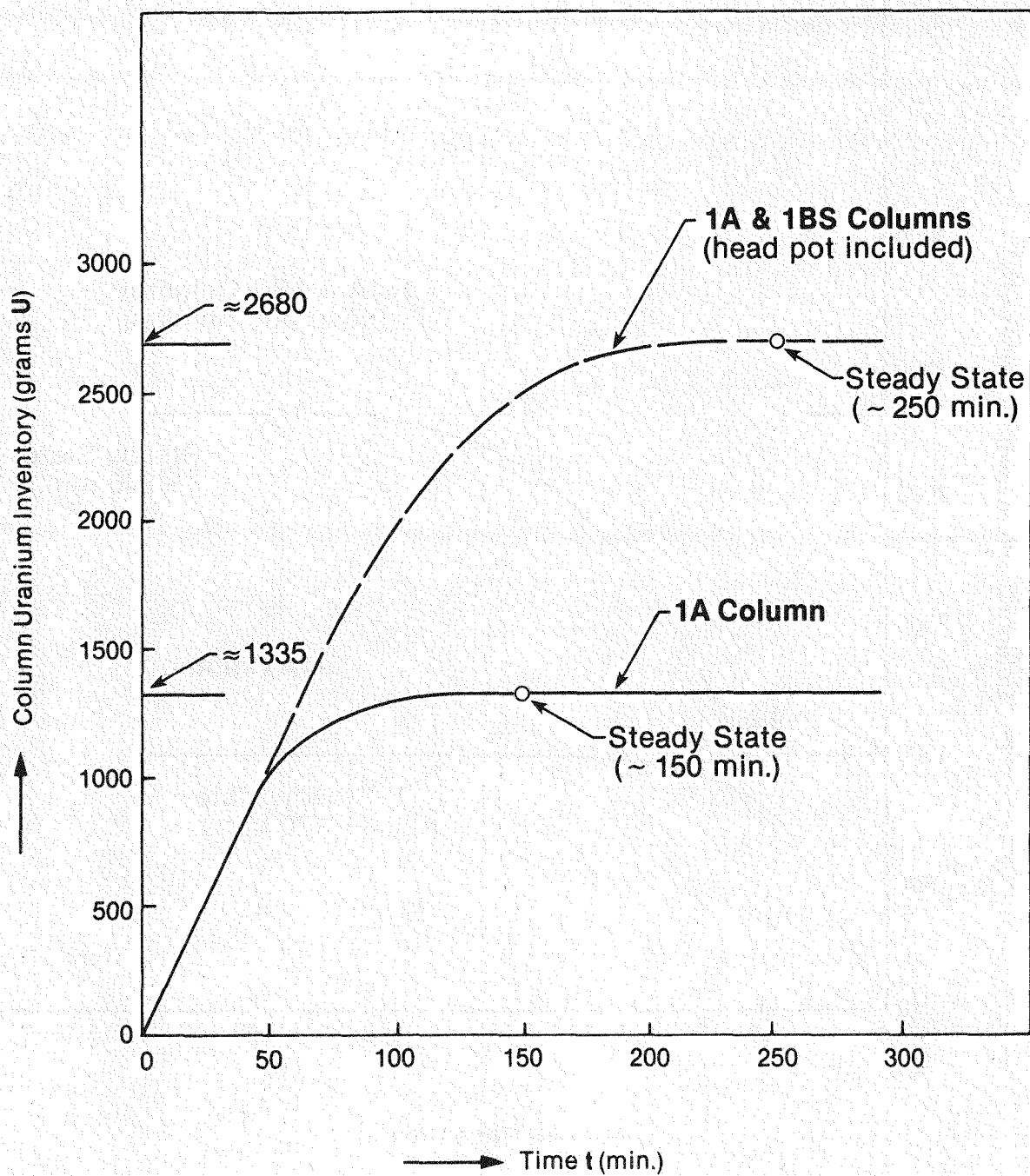
COLUMN URANIUM INVENTORY VERSUS TIME (TEST 2AM-4)

FIGURE 4-34



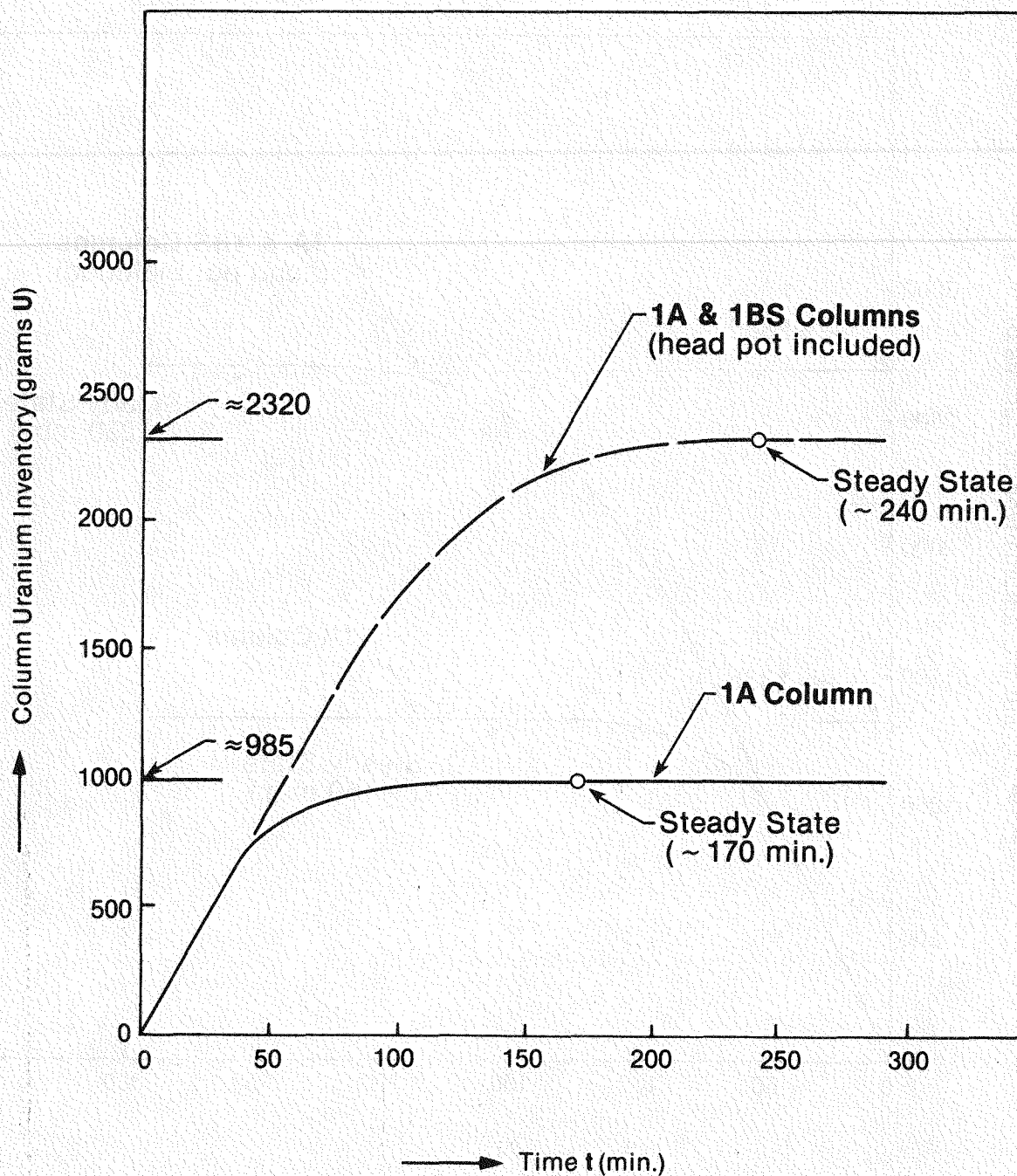
COLUMN URANIUM INVENTORY VERSUS TIME (TEST 2AM-5)

FIGURE 4-35



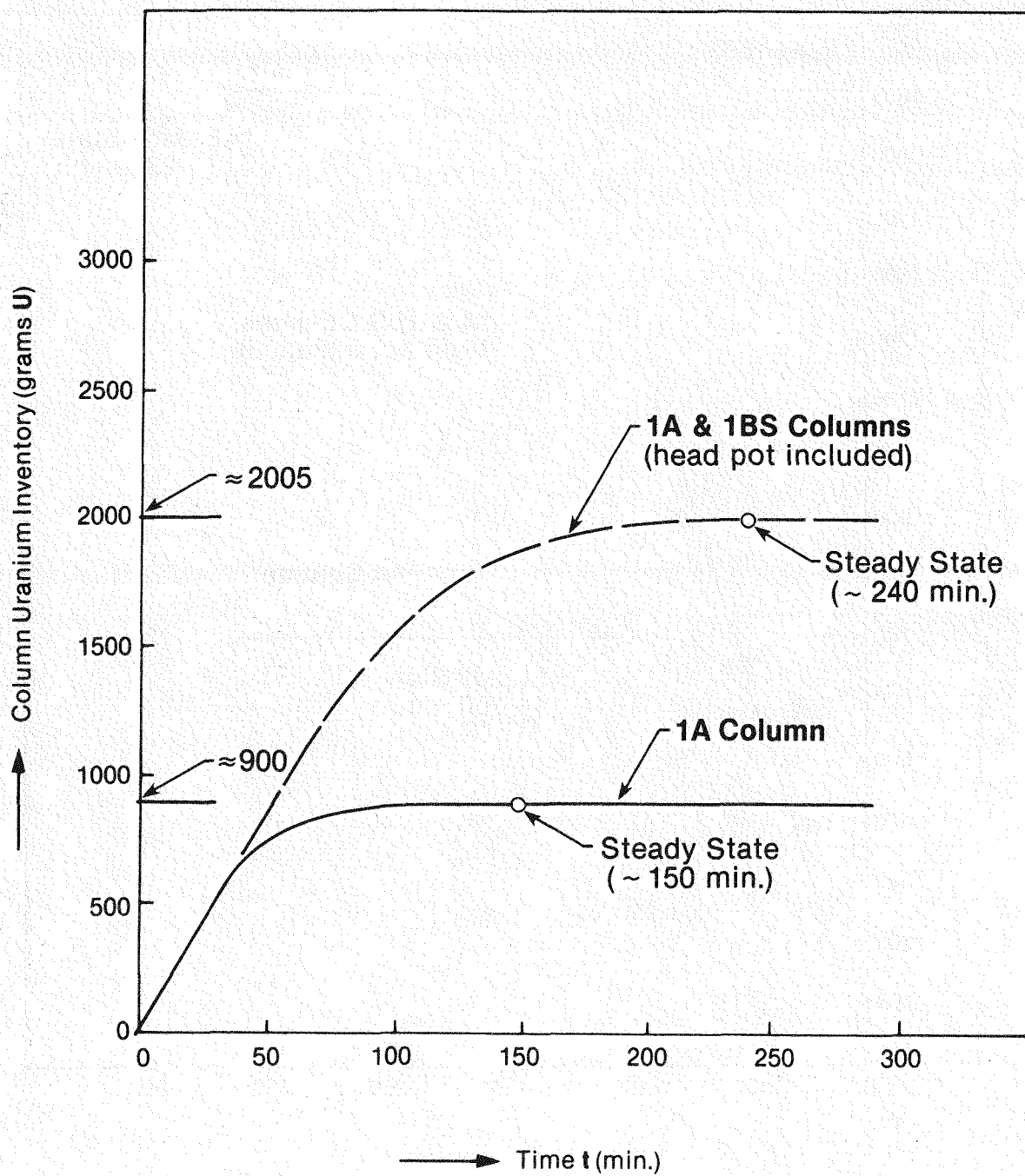
COLUMN URANIUM INVENTORY VERSUS TIME (TEST 3AM-1)

FIGURE 4-36



COLUMN URANIUM INVENTORY VERSUS TIME (TEST 3AM-2)

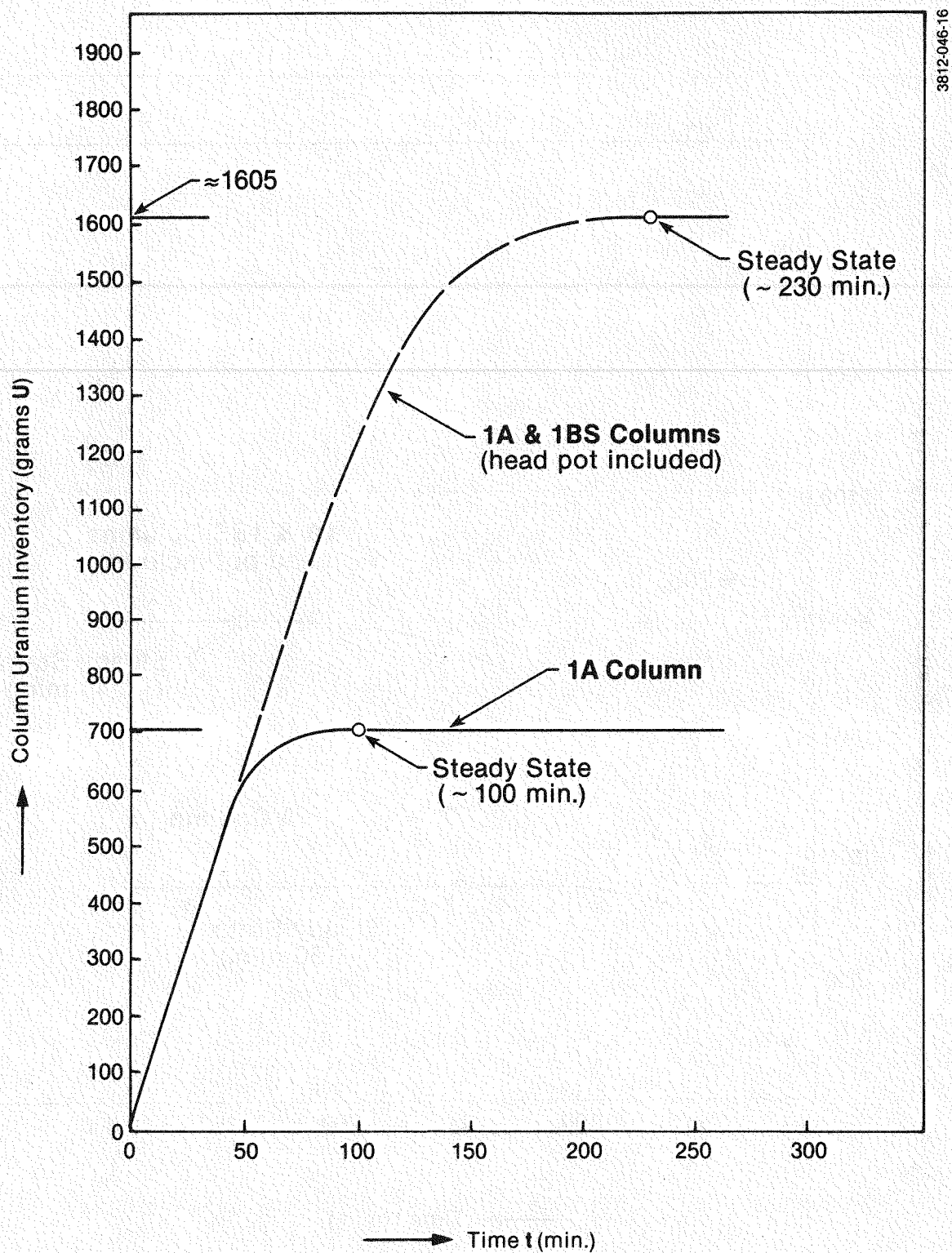
FIGURE 4-37



3812-046-14

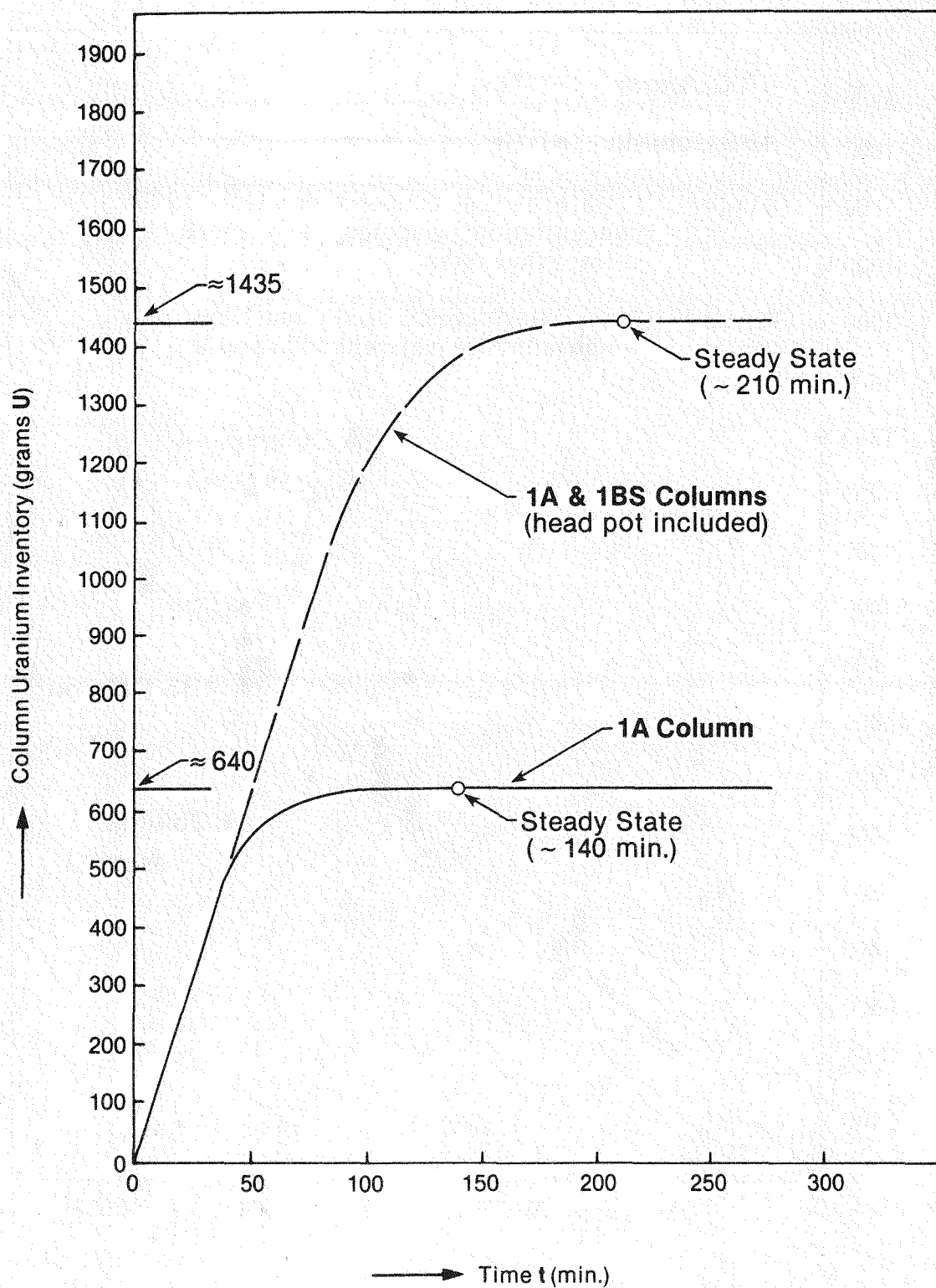
COLUMN URANIUM INVENTORY VERSUS TIME (TEST 3AM-3)

FIGURE 4-38



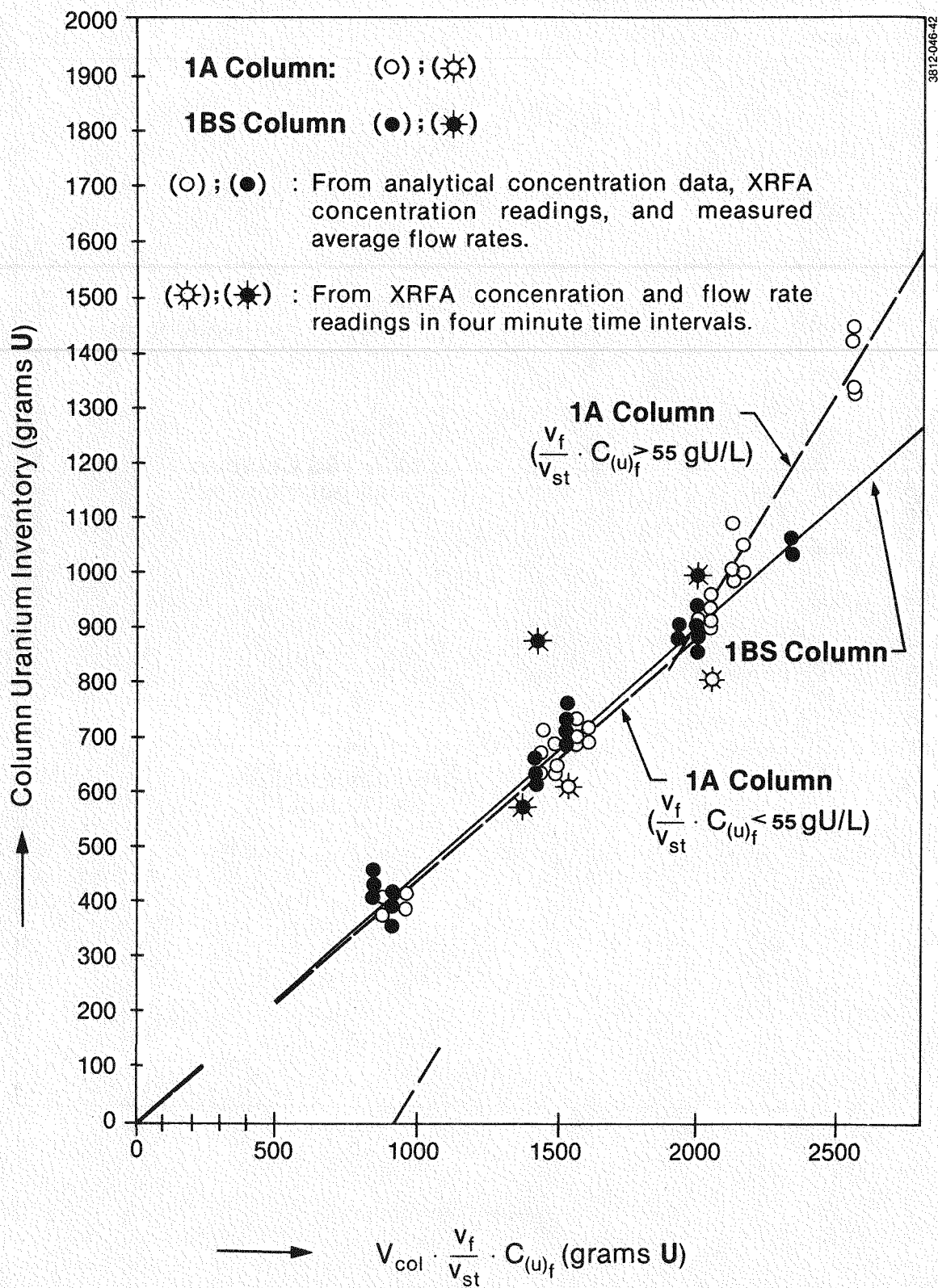
COLUMN URANIUM INVENTORY VERSUS TIME (TEST 3AM-4)

FIGURE 4-39



COLUMN URANIUM INVENTORY VERSUS TIME (TEST 3AM-5)

FIGURE 4-40



COLUMN URANIUM INVENTORY

FIGURE 4-41

5.0 CONCLUSIONS

Several different methods were developed and applied to determine the solute inventory in pulsed columns as follows:

- (1) Concentration Profile - Hold-up Measurement Method is usable for analytical evaluation of the solute inventory only when the tested column operates under steady-state conditions. The column has to be provided with several (at least five) samplers for both phases along its working section. The method is reliable; however, it is analytically laborious and time-consuming due to the large numbers of samples which must be processed. In this study concentration profiles were determined primarily to benchmark a computer program being developed specifically for pulsed columns.^(1,2) When the program is complete, it will have the potential for determining the column inventory, given the appropriate input data such as the column physical parameters and operating conditions.
- (2) Volume Concentration Measurement Method - Although considered the most reliable, it can be used for solutes inventory determination in a column only at the end of the run, by discharging the column liquid content into calibrated vessels where the above measurements are performed. The method is suitable for laboratory pilot scale, and full scale columns, when operated using "cold" feed. The technique is particularly useful for verifying column inventories determined by other methods such as empirical equations and computer methods.
- (3) Mass Rate Measurement Method determines the near-real-time solute inventory in a column during the startup and transient conditions when the measurement points are interfaced to a computer. It requires periodic measurements of both the flow rate and solute concentrations in each feed and effluent process stream. The method is useful for process control and safeguard applications to identify inventory changes. However, measurements made on flow rates and solute concentrations are subject to systematic (bias) errors. Therefore, when this method is applied over extended periods of time (several weeks or months), these errors may accumulate and lead to sizable errors in the column inventory.
- (4) Tanks Inventory Measurement Method - Based on the mass rate measurement technique in Item (3), it can be used for the near-real-time solute inventory determination in equipment (separate columns, entire process cycle, several cycles) when it is provided with adequate feed and receiving tanks, where the continuous volume and concentration change can be readily measured. The equipment solute inventory, at a given measured time t , is obtained by subtracting the total solute mass (weight) accumulated in receiving tanks from that spent in feed tanks during the time t . In the pilot plant equipment, the quantity of uranium spent in the LAF feed tank and that accumulated in the LAW, LBS-P, and LBS-W receiving tanks was

measured only at the end of each test included in this report. The analytical method is suitable for use in plant equipment, which is provided with calibrated and well instrumented feed and receiving tanks.

- (5) Empirical equations were developed for determination of the total uranium inventory within the column, when the column operates under steady-state conditions. This method requires the knowledge of the column volume, solute mass feed rate and flow rate of the stripping stream.

All of the above methods gave comparable results.

6.0 REFERENCES

- (1) Hakkila, E. A., et al, Materials Management in an Internationally Safeguarded Fuels Reprocessing Plant, Los Alamos Scientific Laboratory, LA-8042 (April 1980).
- (2) Cobb, D. D., and Ostenak, C. A., Dynamic Materials Accounting for Solvent Extraction System, Los Alamos Scientific Laboratory, LA-UR-3221 (1979).
- (3) Cermak, A. F., Neace, J. C., and Spaunburgh, R. G., Coprocessing Tests with Uranium on the Electropulse Column and Pilot-Scale Pulse Columns Simulating the Second and Third Plutonium Process Cycles, Allied-General Nuclear Services, AGNS-35900-4.1-20 (November 1979).
- (4) Cermak, A. F., Pilot-Scale Pulsed Columns, Column Profile and Holdup Studies, Allied-General Nuclear Services, AGNS-35900-3.1-111 (November 1980).
- (5) Cermak, A. F., Pilot-Scale Pulsed Columns, Aqueous Continuous Dual Process and Holdup Studies, Allied-General Nuclear Services, AGNS-35900-2.5-124 (April 1981).
- (6) Ehinger, M. H. and Kight, H., CNMCAS In-Process Inventory and Process Monitoring Programs Application for International Safeguards, Allied-General Nuclear Services, AGNS-35900-2.3-151 (November 1981).
- (7) Hall, J. C., Evaluation of Alternatives for Processing Uranium Based LWR Fuels, Allied-General Nuclear Services, AGNS-1040-3.1-15 (May 1978).
- (8) Pool, L. and Borchers, M., Some Common Basic Programs, p 83, Osborne Press (1978).
- (9) Shiley, J. E., Jordan, L. G., and Huff, G. A., On-Line Density Measurement, Allied-General Nuclear Services, AGNS-35900-2.4-135 (July 1981).
- (10) Henderson, B. C., et al, Energy Dispersive X-Ray Fluorescence Analysis for On-Line Uranium Concentration Measurement, Allied-General Nuclear Services, AGNS-35900-CONF-145 (September 1981).
- (11) Ellis, J. H., et al, CNMCAS Expansion and Development Evaluation Report, Allied-General Nuclear Services, AGNS-35900-2.3-86 (November 1980).

APPENDIX A

COMPUTER PRINTOUTS

(Programs and Examples of Typical Results from Measurement Systems)

APPENDIX A-1

PIP TI:=TKPRO.B2S

5 REM: This program prints a volume profile of a tank, given calibration data. Internal hardware may be located by
constrictions in the profile. The program is interactive except for DATA and the DIM statement.

```

10 PRINT "TANK PROFILE"
20 DIM X(60),Y(60),B(330)
30 INPUT "NUMBER OF DATA POINTS";P
40 FOR I=1 TO P
50 READ X(I),Y(I)
60 NEXT I
70 INPUT "WINDOW WIDTH IN CM";W
75 INPUT "SCALE FACTOR";G !MAKE G*W/CM=1.2
80 K=0
90 INPUT "RANGE: BOTTOM, TOP, & INCREMENT";L,U,S
100 S=-S
110 PRINT\PRINT\PRINT "LL(CM)", "LITERS", "L/CM"
120 FOR N=(U-S) TO L STEP S
125 B=0
130 FOR J=1 TO P
140 IF ABS(X(J)-N)>W THEN 230
150 T=1
160 FOR I=1 TO P
170 IF ABS(X(I)-N)>W THEN 200
180 IF I=J THEN 200
185 IF X(I)=X(J) THEN 230
190 T=T*(N-X(I))/(X(J)-X(I))
200 NEXT I
210 B=B+T*Y(J)
220 B(N)=INT(B*1000+.5)/1000
230 NEXT J
240 IF K=0 THEN 280
245 Z=-S
250 R=INT(((B(N+Z)-B(N))/Z)*1000+.5)/1000
260 D=INT(R/G*100)
270 IF D>131 THEN D=131
280 IF K=0 THEN K=K+1\GOTO 290
285 PRINT N,B(N),R;TAB(200-D);"*";TAB(D);"*"
290 NEXT N\PRINT\PRINT\RESTORE\GOTO 30
295 REM: AW PASS 3
300 DATA 3.16,105.801,6.258,124.968,9.263,144.096,12.332,163.158,15.258,181.907,18.221,200.588,21.122,218.809,23.991,237.026
310 DATA 26.811,255.179,29.616,272.534,32.446,290.061,35.199,307.612,37.751,323.448,38.39,327.656,41.634,347.433,44.812,367.732
320 DATA 47.923,387.72,51.005,406.935,54.051,426.472,57.056,445.358,60.018,464.226,62.958,482.755,65.83,500.93,68.689,518.93,71.48
330 DATA 536.706,74.272,554.333,76.983,571.653,79.681,588.546,82.327,605.452,84.921,621.575,87.419,637.317,89.894,652.902,91.74
340 DATA 664.785,91.873,665.08,94.851,683.679,97.869,703.824,101.14,723.8,104.145,743.322,107.269,762.414,110.354,782.032
350 DATA 113.317,801.196,116.308,820.021,119.235,838.796,122.197,857.241,125.15,875.77,128.074,893.691,130.813,911.904
360 DATA 133.618,929.727,136.37,947.356,139.214,964.921,141.821,981.78,144.693,998.511,145.093,1000.15,147.897,1018.23
370 DATA 150.569,1035.55,153.322,1052.9,156.072,1070.07,158.757,1086.24
>

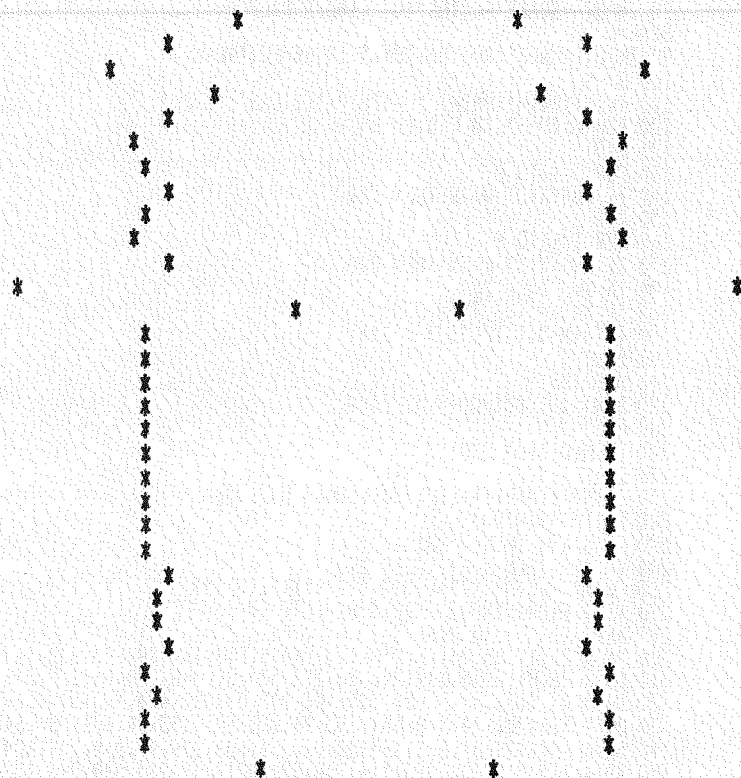
```

APPENDIX A-2

RUN TKPRO
TANK PROFILE

NUMBER OF DATA POINTS? 58
WINDOW WIDTH IN CM? 13
SCALE FACTOR? 0.19
RANGE: BOTTOM, TOP, & INCREMENT? 0, 155, 5

LL (CM)	LITERS	L/CM
155	1063.55	5.936
150	1032.36	6.237
145	999.764	6.519
140	969.731	6.007
135	938.631	6.22
130	906.527	6.421
125	874.851	6.335
120	843.611	6.248
115	811.788	6.365
110	779.738	6.41
105	748.624	6.223
100	714.038	6.917
95	685.651	5.677
90	653.87	6.356
85	622.196	6.335
80	590.617	6.316
75	558.994	6.325
70	527.282	6.342
65	495.69	6.318
60	464.112	6.316
55	432.457	6.331
50	400.644	6.363
45	368.982	6.332
40	337.89	6.218
35	306.403	6.297
30	274.868	6.307
25	243.552	6.263
20	211.757	6.359
15	180.257	6.3
10	148.653	6.321
5	116.984	6.334
0	87.92	5.813



NUMBER OF DATA POINTS?

APPENDIX A-3

```
PIP TI:=PPLL.B25
10 DIM X(35),Y(35)\S=-5\W=13
20 READ N,T$
30 FOR I=1 TO N\S=S+5\X(I)=S\NEXT I
40 FOR I=1 TO N\READ Y(I)\NEXT I
70 PRINT 'LL(CH) TO BE INTERPOLATED: 'T$;\INPUT A\B=0
90 FOR J=1 TO N
92 IF ABS(X(J)-A)>W THEN 140
94 T=1
96 FOR I=1 TO N
100 IF ABS(X(I)-A)>W THEN 125
110 IF I=J THEN 125
120 T=T*(A-X(I))/(X(J)-X(I))
125 NEXT I
130 B=B+T*Y(J)
140 NEXT J
145 B=INT(B*100+0.5)/100
150 PRINT B;' LITERS'
160 GOTO 70
500 DATA 18,AW TANK,87.92,116.98,148.65,180.26,211.76,243.55,274.87,306.40,337.89,368.98,400.64,432.46,464.11,495.69
510 DATA 527.28,558.99,590.62,622.20
>
```

```
RUN PPLL
LL(CH) TO BE INTERPOLATED: AW TANK? 2.5
101.96 LITERS
LL(CH) TO BE INTERPOLATED: AW TANK? 10
148.65 LITERS
LL(CH) TO BE INTERPOLATED: AW TANK? 10.10
149.29 LITERS
LL(CH) TO BE INTERPOLATED: AW TANK? 52.5
416.56 LITERS
LL(CH) TO BE INTERPOLATED: AW TANK?
```

APPENDIX A-4

```

PIP TI:=CATC.B2S
10 DIM X(30),Y(30),G(100),B(100)\N=26\S=0\W=13\CHANZ(1)=673\CHANZ(2)=677\T$='AW-07006'\B(S)=998.511
20 PRINT 'CALIBRATION PASS FOR 'T$;' BEGINNING AT 'TIME$(0);' ON 'DATE$(0)\PRINT
30 PRINT '4-MIN ADD','LL(CM)(DEL)','VOL(L)(DEL)','LL(CM)(REC)','VOL(L)(REC)',\PRINT
40 FOR I=1 TO N\READ Y(I)\X(I)=(5*(I-1))\NEXT I
50 FOR K=1 TO 2\CALL RTPCOM(1Z,CHANZ(K),R0,R1,R2,R3,R4,STATUSZ)
60 RDG(K)=INT(R0*2.54*1000+0.5)/1000
70 NEXT K\IF RDG(2)<0.5 THEN RDG(2)=0
115 B=0
120 FOR J=1 TO N
130 IF ABS(X(J)-RDG(1))>W THEN 210
140 T=1
150 FOR I=1 TO N
160 IF ABS(X(I)-RDG(1))>W THEN 190
170 IF I=J THEN 190
175 IF X(J)=X(I) THEN 190
180 T=T*(RDG(1)-X(I))/(X(J)-X(I))
190 NEXT I
200 B=B+T*Y(J)\G(S)=B
210 NEXT J
215 IF S=0 THEN 223
220 B(S)=INT((G(S-1)-G(S)+B(S-1))*1000+.05)/1000
223 PRINT S,RDG(1),G(S),RDG(2),B(S)
230 S=S+1\SLEEP 240\GOTO 50
1000 DATA 30.48,44.62,58.62,72.96,87.34,101.25,115.58,129.85,144.1,158.33,172.59,186.84,201.03,215.23,229.49,243.73,257.9
1010 DATA 272.1,286.23,300.37,314.6,328.74,342.89,357.15,370.98,385.19
10000 END
>

```

RUN CATC
CALIBRATION PASS FOR BP-07014 BEGINNING AT 09:33 AM ON 06-Apr-81

4-MIN ADD	LL(CM)(DEL)	VOL(L)(DEL)	LL(CM)(REC)	VOL(L)(REC)
0	89.611	285.131	0	0
1	89.033	283.499	0	1.632
2	86.992	277.737	2.503	7.394
3	84.948	271.953	7.197	13.179
4	82.955	266.295	11.739	18.837
5	80.86	260.341	16.444	24.791
6	78.921	254.84	21.008	30.292
7	76.931	249.209	25.498	35.923
8	74.834	243.258	30.224	41.873
9	72.79	237.444	34.863	47.688
10	70.8	231.771	39.394	53.36
11	68.861	226.241	43.949	58.891
12	66.817	220.407	48.534	64.725
13	64.878	214.883	53.015	70.249
14	62.942	209.379	57.536	75.753
15	60.949	203.723	62.067	81.409
16	58.905	197.924	66.74	87.208
17	56.81	191.983	71.357	93.149
18	54.925	186.627	75.805	98.505
19	52.881	180.807	80.336	104.325
20	50.942	175.277	84.955	109.855
21	48.95	169.595	89.53	115.537
22	46.959	163.914	94.042	121.218
23	44.864	157.943	98.799	127.189
24	42.867	152.258	103.353	132.873
25	40.823	146.443	107.929	138.688
26	38.884	140.922	112.483	144.209
27	36.843	135.104	117.219	150.027

APPENDIX A-5

RUN PPI
 INPUT WHICH ENGINEERING LAB RUN NO.
 (USES LATEST IF NO OTHER) ? 6
 THE LAST RECORD IS 102
 START WITH ? 2
 END WITH ? 88
 INTERVAL ? 2

VOLUME HISTORY FOR ENGINEERING LAB RUN NO. #6
 STARTS WITH RECORD 2
 AND GOES TO RECORD 88

		AS	AF	AX	BX	AW	BW	BP	TAY(L)	LOSS(L)	CUM LOSS(L)
2	08:16 AM	289.171	353.189	108.486	109.46	247.094	0	0	1129.9	0	0
4	08:38 AM	289.037	353.064	108.477	109.451	247.094	0	0	1129.6	.298584	.298584
6	08:46 AM	288.522	353.064	96.274	92.673	247.098	0	0	1102.28	27.3208	27.6194
8	08:54 AM	287.803	353.189	78.724	67.281	247.009	0	0	1061.8	40.4757	68.0951
10	09:02 AM	287.116	353.064	70.927	52.914	247.005	0	0	1040.17	21.6368	89.7319
12	09:10 AM	286.34	349.008	68.846	48.866	246.916	0	0	1028.84	11.3214	101.053
14	09:18 AM	285.527	344.578	68.393	48.517	230.67	0	0	1036.9	-8.05591	92.9974
16	09:26 AM	284.777	340.051	68.2	48.354	232.66	0	0	1038.89	-1.99121	91.0062
18	09:34 AM	283.995	335.55	68.064	48.212	235.152	2.569	0	1041.8	-2.90625	88.1
20	09:42 AM	283.309	331.193	67.925	48.052	239.011	6.602	0	1045.07	-3.26868	84.8313
22	09:50 AM	282.528	326.956	67.789	47.892	243.286	9.779	5.21	1052.11	-7.04492	77.7864
24	09:58 AM	281.778	322.591	67.663	47.732	247.735	12.897	6.375	1055.74	-3.6272	74.1592
26	10:06 AM	281.099	318.227	67.529	47.563	252.73	13.609	9.949	1059.42	-3.67737	70.4818
28	10:14 AM	280.254	313.843	67.394	47.412	257.964	15.516	12.146	1062.54	-3.12085	67.361
30	10:22 AM	279.569	309.454	67.249	47.289	262.364	16.648	14.368	1065.02	-2.4823	64.8787
32	10:30 AM	278.756	305.174	67.134	47.11	267.496	18.72	16.578	1068.28	-3.26099	61.6177
34	10:38 AM	278.039	300.786	66.999	46.96	272.044	21.469	18.802	1072.34	-4.06274	57.5549
36	10:46 AM	277.385	296.402	66.846	46.809	277.266	22.946	20.763	1074.51	-2.17273	55.3822
38	10:54 AM	276.604	292.038	66.711	46.65	281.282	24.978	22.346	1077.26	-2.74292	52.6393
40	11:02 AM	275.862	287.805	66.597	46.5	286.5	27.027	24.069	1080.44	-3.18152	49.4578
42	11:10 AM	275.075	283.438	66.481	46.34	291.54	28.8	26.03	1083.15	-2.70581	46.752
44	11:18 AM	274.296	279.205	66.347	46.192	296.214	30.232	28.485	1086.45	-3.30505	43.4469
46	11:26 AM	273.713	274.968	66.214	46.051	301.464	31.765	30.845	1090.24	-3.79431	39.6526
48	11:38 AM	272.58	268.532	66.013	45.817	307.782	34.297	34.179	1094.86	-4.61816	35.0344
50	11:46 AM	271.834	264.27	65.909	45.649	312.669	37.931	36.388	1099.65	-4.78406	30.2504
52	11:54 AM	271.057	259.882	65.775	45.499	317.683	39.727	38.681	1102.94	-3.29224	26.9581
54	12:02 PM	270.475	255.755	65.653	45.331	322.245	41.61	40.773	1105.68	-2.74561	24.2125
56	12:10 PM	269.761	251.383	65.538	45.183	327.186	43.206	42.975	1109.73	-4.0459	20.1666
58	12:18 PM	268.984	247.263	65.397	45.033	332.518	44.846	45.093	1112.97	-3.24451	16.9221
60	12:26 PM	268.112	242.881	65.282	44.884	336.733	46.761	47.251	1116.07	-3.09302	13.8291
62	12:34 PM	267.5	238.618	65.149	44.716	341.477	48.494	49.107	1118.92	-2.84851	10.9806
64	12:42 PM	266.66	234.344	65.017	44.567	345.652	51.384	50.183	1121.82	-2.90344	8.07715
66	12:50 PM	265.915	230.069	64.903	44.418	350.56	53.383	52.082	1124.51	-2.68652	5.39063
68	12:58 PM	265.138	225.792	64.157	43.358	355.674	55.248	54.16	1126.13	-1.62646	3.76416
70	01:06 PM	264.33	221.646	62.245	41.019	359.395	56.831	56.316	1125.76	.375244	4.1394
72	01:14 PM	263.676	217.37	60.248	38.667	364.898	58.775	58.491	1126.04	-.277954	3.86145
74	01:22 PM	262.899	213.103	58.256	36.367	369.426	60.972	60.696	1125.14	.898315	4.75977
76	01:30 PM	262.09	208.968	56.331	34.002	374.969	63.062	62.864	1125.37	-.232056	4.52771
78	01:38 PM	261.458	204.713	54.439	31.658	378.691	64.203	64.991	1124.57	.797607	5.32532
80	01:46 PM	260.549	200.591	52.548	29.24	383.299	65.836	67.035	1123.85	.717041	6.04236
82	01:54 PM	259.899	196.338	50.561	26.814	389.142	67.716	69.099	1123.45	.401367	6.44373
84	02:02 PM	259.145	192.086	48.44	24.401	393.852	69.735	71.169	1122.81	.639404	7.08313
86	02:10 PM	258.979	190.921	47.797	23.699	394.708	70.769	71.941	1123.6	-.781616	6.30151
88	02:18 PM	258.979	190.921	47.807	23.72	394.714	70.827	71.957	1123.69	-.0943604	6.20715

APPENDIX A-6

RUN PP3
 INPUT WHICH ENGINEERING LAB RUN NO.
 (USES LATEST IF NO OTHER) ? 6
 THE LAST RECORD IS 102
 START WITH ? 5
 END WITH ? 74
 INTERVAL ? 1

PP COL DEN AND WT READINGS DURING RUN NO. 6
 STARTS WITH RECORD 5 AND ENDS WITH RECORD 74

T=A COL DEN(TOP); B=A COL DEN(BOT); W=A COL WT; S=B COL DEN; †=B COL WT

RCD	TIME	0.80	0.85	0.90	0.95	1.00	1.05
5	08:42AM	T	B	W	*	†	
6	08:46AM		T	B	*	†	
7	08:50AM		T	B	*	†	
8	08:54AM		T	B	*	†	
9	08:58AM		T	B	*	†	
10	09:02AM		T	B	*	†	
11	09:06AM		T	B	*	†	
12	09:10AM		T	B	*	†	
13	09:14AM		T	B	*	†	
14	09:18AM		T	B	*	†	
15	09:22AM		T	B	*	†	
16	09:26AM		T	B	*	†	
17	09:30AM		T	B	*	†	
18	09:34AM		T	B	*	†	
19	09:38AM		T	B	*	†	
20	09:42AM		T	B	*	†	
21	09:46AM		T	B	*	†	
22	09:50AM		T	B	*	†	
23	09:54AM		T	B	*	†	
24	09:58AM		T	B	*	†	
25	10:02AM		T	B	*	†	
26	10:06AM		T	B	*	†	
27	10:10AM		T	B	*	†	
28	10:14AM		T	B	*	†	
29	10:18AM		T	B	*	†	
30	10:22AM		T	B	*	†	
31	10:26AM		T	B	*	†	
32	10:30AM		T	B	*	†	
33	10:34AM		T	B	*	†	
34	10:38AM		T	B	*	†	
35	10:42AM		T	B	*	†	
36	10:46AM		T	B	*	†	
37	10:50AM		T	B	*	†	
38	10:54AM		T	B	*	†	
39	10:58AM		T	B	*	†	
40	11:02AM		T	B	*	†	
41	11:06AM		T	B	*	†	
42	11:10AM		T	B	*	†	
43	11:14AM		T	B	*	†	
44	11:18AM		T	B	*	†	
45	11:22AM		T	B	*	†	
46	11:26AM		T	B	*	†	
47	11:30AM		T	B	*	†	
48	11:38AM		T	B	*	†	
49	11:42AM		T	B	*	†	
50	11:46AM		T	B	*	†	
51	11:50AM		T	B	*	†	
52	11:54AM		T	B	*	†	
53	11:58AM		T	B	*	†	
54	12:02PM		T	B	*	†	
55	12:06PM		T	B	*	†	
56	12:10PM		T	B	*	†	
57	12:14PM		T	B	*	†	
58	12:18PM		T	B	*	†	
59	12:22PM		T	B	*	†	
60	12:26PM		T	B	*	†	
61	12:30PM		T	B	*	†	
62	12:34PM		T	B	*	†	
63	12:38PM		T	B	*	†	
64	12:42PM		T	B	*	†	
65	12:46PM		T	B	*	†	
66	12:50PM		T	B	*	†	
67	12:54PM		T	B	*	†	
68	12:58PM		T	B	*	†	
69	01:02PM		T	B	*	†	
70	01:06PM		T	B	*	†	
71	01:10PM		T	B	*	†	
72	01:14PM		T	B	*	†	
73	01:18PM		T	B	*	†	

APPENDIX A-7

RUN PP4
 INPUT WHICH ENGINEERING LAB RUN NO.
 (USES LATEST IF NO OTHER) ? 10
 U-CONC (G/L) IN AF FEED? 40.13
 THE LAST RECORD IS 83
 START WITH ? 20
 END WITH ? 73
 INTERVAL ? 1

PP URANIUM CONCENTRATIONS (G/L) DURING RUN NO. 10
 STARTS WITH RECORD 20 AND ENDS WITH RECORD 73

F=AF STREAM: P=BP STREAM: A=AP STREAM: W=BW STREAM

RCD	TIME	0	10	20	30	40	50	60	70
		1	1	1	1	1	1	1	1
20	09:42AM	P				F			
21	09:46AM	P A				F			
22	09:50AM	P A				F			
23	09:54AM	W P A				F			
24	09:58AM	W P A				F			
25	10:02AM	W P A				F			
26	10:06AM	W P A				F			
27	10:10AM	W P A				F			
28	10:14AM	W P A				F			
29	10:18AM	W P A				F			
30	10:22AM	W P A				F			
31	10:26AM	W P A				F			
32	10:30AM	W P A				F			
33	10:34AM	W P A				F			
34	10:38AM	W P A				F			
35	10:42AM	W P A				F			
36	10:46AM	W P A				F			
37	10:50AM	W P A				F			
38	10:54AM	W P A				F			
39	10:58AM	W P A				F			
40	11:02AM	W P A				F			
41	11:06AM	W P A				F			
42	11:10AM	W P A				F			
43	11:14AM	W P A				F			
44	11:18AM	W P A				F			
45	11:22AM	W P A				F			
46	11:26AM	W P A				F			
47	11:30AM	W P A				F			
48	11:34AM	W P A				F			
49	11:38AM	W P A				F			
50	11:42AM	W P A				F			
51	11:46AM	W P A				F			
52	11:50AM	W P A				F			
53	11:54AM	W P A				F			
54	11:58AM	W P A				F			
55	12:02PM	W P A				F			
56	12:06PM	W P A				F			
57	12:10PM	W P A				F			
58	12:14PM	W P A				F			
59	12:18PM	W P A				F			
60	12:22PM	W P A				F			
61	12:26PM	W P A				F			
62	12:30PM	W P A				F			
63	12:34PM	W P A				F			
64	12:38PM	W P A				F			
65	12:42PM	W P A				F			
66	12:46PM	W P A				F			
67	12:50PM	W P A				F			
68	12:54PM	W P A				F			
69	12:58PM	W P A				F			
70	01:02PM	W P A				F			
71	01:06PM	W P A				F			
72	01:10PM	W P A				F			

APPENDIX A-8

```

PIP TI:=PP4.82S
10 REM: THIS PROGRAM PLOTS PP XRFA DATA
80 PRINT 'INPUT WHICH ENGINEERING LAB RUN NO.'
  \INPUT ' (USES LATEST IF NO OTHER) 'RN$;R$=RN$
  \IF RN$<>' THEN RN$='';+RN$
82 FIL1$='MP:1307,100JELDT1.DAT'+RN$
90 ON ERROR GO TO 9200
95 INPUT 'U-CONC (G/L) IN AF FEED';U(2)
105 MAP (ELDAT) D$,T$,RDG(20),DMAZ(4),DMA1,DMA1,DMA2,DMA2,XRFL(3),XRFL$(3)=20,DYNATR,ACID
  \OPEN FIL1$ AS FILE 3%, RELATIVE , ACCESS READ, ALLOW MODIFY, MAP ELDAT
  \GET #3, RECORD 1
  \PRINT 'THE LAST RECORD IS 'RDG(0)
110 INPUT ' START WITH 'STRT
  \INPUT ' END WITH 'LST
  \INPUT ' INTERVAL 'INTV
  \IF INTV=0 THEN INTV=1
300 PRINT TAB(30);'PP URANIUM CONCENTRATIONS (G/L) DURING RUN NO. 'R$
310 PRINT TAB(30);'STARTS WITH RECORD';STRT;' AND ENDS WITH RECORD';LST\PRINT
340 PRINT 'F=AF STREAM: P=BP STREAM: A=AP STREAM: W=BW STREAM'\PRINT STRING$(130%,45%)
350 PRINT 'RCD TIME';TAB(16);'0';TAB(31);'10';TAB(46);'20';TAB(61);'30';TAB(76);'40';TAB(91);'50';TAB(106);'60';TAB(121);'70'
360 PRINT TAB(16);'1';TAB(31);'1';TAB(46);'1';TAB(61);'1';TAB(76);'1';TAB(91);'1';TAB(106);'1';TAB(121);'1'
370 PRINT STRING$(130%,61%)
399 I=STRT
400 GET #3,RECORD I\ PRINT I;TAB(6);EDIT$(T$,2%);
410 P=INT(XRFL(0)*1.5+16.5)\A=INT(XRFL(1)*1.5+16.5)\W=INT(XRFL(3)*1.5+16.5)\F=INT(U(2)*1.5+16.5)
422 P(1)=P\A(2)=A\W(3)=W\F(4)=F
424 SM=P(1)
426 FOR K=2 TO 4\IF P(K)<SM THEN SM=P(K)
428 NEXT K
430 FOR K=1 TO 4\IF P(K)=SM THEN P(K)=500
431 NEXT K
432 IF SM=P THEN PRINT TAB(P);'P';\GOTO 424
434 IF SM=A THEN PRINT TAB(A);'A';\GOTO 424
436 IF SM=W THEN PRINT TAB(W);'W';\GOTO 424
438 IF SM=F THEN PRINT TAB(F);'F';\GOTO 424
450 PRINT
500 I=I+INTV
  \IF I<LST GO TO 400
8000 CLOSE 3%
  \GO TO 10000
9200 IF (ERR=136%) AND (ERL=105%) THEN SLEEP 1%
9250 IF (ERR=155%) AND (ERL=400%) THEN RESUME 500
9300 PRINT 'ERROR';ERR;' AT LINE';ERL
10000 END
>
  
```

APPENDIX A-9

X-RAY FLUORESCENCE DATA HISTORY COMPARED TO U CALCS STARTS WITH RECORD 20 AND GOES TO RECORD 73 FOR ENGINEERING LAB RUN 10 ON 26-Jun-81

		UNIT 1...BP STREAM			UNIT 2...AP STREAM			UNIT 4...BW STREAM	
		XRFA	AG U CALC	XRF-CALC	XRFA	OR U CALC	XRF-CALC	XRFA	
20	09:42AM	0	.8	-.8	0	8.21	-8.21	0	AT 09:35 AM
21	09:46AM	0	-.68	.68	1.1048	3.92	-2.82	0	AT 09:35 AM
22	09:50AM	0	-2.27	2.27	2.8264	8288.96	-8286.13	0	AT 09:35 AM
23	09:54AM	1.4978	.73	.77	4.2635	6.22	-1.96	0	AT 09:35 AM
24	09:58AM	1.6835	1.27	.41	7.3009	-4.5	11.8	0	AT 09:35 AM
25	10:02AM	1.6491	1.33	.32	12.0165	14.41	-2.39	0	AT 09:58 AM
26	10:06AM	2.0695	1.52	.55	16.4136	16.71	-.3	0	AT 09:58 AM
27	10:14AM	2.7494	2.26	.49	21.21	18.93	2.28	0	AT 09:58 AM
28	10:18AM	2.9082	3.02	-.11	23.1532	21.15	2	0	AT 09:58 AM
29	10:22AM	3.7416	3.49	.25	32.0068	26323.4	-26291.4	0	AT 09:58 AM
30	10:26AM	3.5054	3.87	-.36	37.6462	35.66	1.99	0	AT 10:22 AM
31	10:30AM	5.3378	4.53	.81	40.6479	37.18	3.47	0	AT 10:22 AM
32	10:34AM	6.8669	5.72	1.15	42.9022	38.54	4.36	0	AT 10:22 AM
33	10:38AM	8.8886	8.32	.57	44.4975	41.05	3.45	0	AT 10:22 AM
34	10:42AM	10.0064	9.65	.36	44.4975	42.03	2.47	0	AT 10:22 AM
35	10:46AM	12.4088	12.47	-.06	45.5235	40.06	5.46	0	AT 10:45 AM
36	10:54AM	16.1821	15.13	1.05	48.7966	45.37	3.43	0	AT 10:45 AM
37	10:58AM	17.4759	17.64	-.16	49.8244	-20.73	70.55	0	AT 10:45 AM
38	11:02AM	18.8192	32.47	-13.65	50.6569	-20.42	71.08	0	AT 10:45 AM
39	11:06AM	21.3615	21.27	.09	51.0435	47.27	3.77	0	AT 10:45 AM
40	11:10AM	21.3615	22.38	-1.02	52.7757	47.35	5.43	2.139	AT 11:08 AM
41	11:14AM	21.3615	23.41	-2.05	52.7757	47.5	5.28	2.139	AT 11:08 AM
42	11:18AM	24.6018	25.33	-.73	52.7399	47.8	4.94	5.0691	AT 11:14 AM
43	11:22AM	26.266	26.46	-.19	51.3247	47.8	3.52	5.7926	AT 11:18 AM
44	11:26AM	26.8254	28.02	-1.19	51.7948	47.8	3.99	6.5046	AT 11:22 AM
45	11:30AM	28.6026	28.76	-.16	51.8478	47.95	3.9	6.9981	AT 11:26 AM
46	11:34AM	29.2543	30.09	-.84	51.8478	47.88	3.97	7.5678	AT 11:31 AM
47	11:38AM	29.0009	30.68	-1.68	52.1326	48.03	4.1	7.5968	AT 11:35 AM
48	11:42AM	30.1878	31.28	-1.09	52.1326	44.76	7.37	8.2635	AT 11:39 AM
49	11:46AM	31.1579	32.24	-1.08	52.4073	48.1	4.31	7.9997	AT 11:43 AM
50	11:50AM	31.7137	32.85	-1.14	51.6493	48.1	3.55	7.4444	AT 11:48 AM
51	11:54AM	31.6163	33.67	-2.05	52.6292	48.26	4.37	8.1983	AT 11:52 AM
52	11:58AM	33.5843	34.11	-.53	51.7918	48.33	3.46	8.3681	AT 11:56 AM
53	12:02PM	33.5843	34.56	-.98	52.1066	44.39	7.72	7.9842	AT 12:00 PM
54	12:06PM	33.9701	35.15	-1.18	52.4936	48.41	4.08	8.318	AT 12:05 PM
55	12:10PM	34.4591	35.52	-1.06	53.7469	48.41	5.34	8.1519	AT 12:09 PM
56	12:14PM	34.9324	36.29	-1.36	51.7578	48.56	3.2	7.6647	AT 12:13 PM
57	12:18PM	0	36.52	-36.52	53.4825	48.94	4.54	7.2924	AT 12:17 PM
58	12:22PM	0	36.66	-36.66	53.9478	49.09	4.86	7.2924	AT 12:17 PM
59	12:26PM	35.1161	37.04	-1.92	54.5717	49.47	5.1	6.9397	AT 12:22 PM
60	12:30PM	37.1506	37.19	-.04	52.6255	49.93	2.7	7.381	AT 12:26 PM
61	12:34PM	36.4812	37.56	-1.08	53.2949	50.3	2.99	7.0155	AT 12:31 PM
62	12:38PM	35.8849	37.56	-1.68	53.2949	50.3	2.99	6.988	AT 12:35 PM
63	12:42PM	35.8849	37.56	-1.68	53.2949	50.3	2.99	6.988	AT 12:35 PM
64	12:46PM	35.8849	37.71	-1.83	53.1467	85687.5	-85634.3	6.988	AT 12:35 PM
65	12:50PM	35.8849	38.32	-2.44	53.1467	50	3.15	8.2742	AT 12:49 PM
66	12:54PM	37.6129	38.62	-1.01	53.9513	48.79	5.16	8.3565	AT 12:54 PM
67	12:58PM	35.5315	38.84	-3.31	51.8998	48.03	3.87	8.3321	AT 12:57 PM
68	01:02PM	37.1043	38.98	-1.88	51.8501	47.65	4.2	8.627	AT 01:02 PM
69	01:06PM	35.1152	39.36	-4.24	52.5569	47.5	5.06	8.627	AT 01:02 PM
70	01:10PM	37.3307	39.43	-2.1	52.939	47.8	5.14	8.8823	AT 01:06 PM
71	01:14PM	37.1047	39.51	-2.41	52.2639	-18.82	71.08	9.0885	AT 01:11 PM
72	01:18PM	38.68	39.52	-.84	53.6751	48.41	5.27	9.6739	AT 01:15 PM
73	01:22PM	37.5091	39.53	-2.02	53.6751	48.56	5.12	9.7002	AT 01:19 PM

APPENDIX A-10

RUN PP2
 INPUT WHICH ENGINEERING LAB RUN NO.
 (USES LATEST IF NO OTHER) ? 12
 THE LAST RECORD IS 107
 START WITH ? 32
 END WITH ? 90
 INTERVAL ? 4

FLOW RATE HISTORY FOR ENGINEERING LAB RUN NO. #12
 STARTS WITH RECORD 32
 AND GOES TO RECORD 90
 RESULTS GIVEN IN LITERS PER MINUTE: MINUS=OUTFLOW, PLUS=INFLOW

	AS	AF	AX	BX	AW	BW	BP	NET FLOW
36 10:16 AM	-.114	-.314	-.275	-.268	.686	0	0	-.285
40 10:32 AM	-.111	-.33	-.268	-.292	.532	.178	0	-.292
44 10:48 AM	-.122	-.323	-.274	-.289	.52	.289	.519	.321
48 11:04 AM	-.104	-.331	-.268	-.28	.451	.241	.232	-.058
52 11:20 AM	-.113	-.316	-.278	-.278	.423	.293	.257	-.011
56 11:36 AM	-.105	-.324	-.26	-.274	.424	.219	.266	-.054
60 11:52 AM	-.094	-.324	-.257	-.245	.451	.294	.267	.092
64 12:08 PM	-.105	-.324	-.262	-.297	.379	.205	.257	-.146
68 12:24 PM	-.102	-.316	-.261	-.27	.401	.293	.25	-.005
72 12:40 PM	-.093	-.331	-.256	-.279	.416	.271	.251	-.021
76 12:56 PM	-.089	-.315	-.262	-.28	.419	.29	.258	.021
80 01:12 PM	-.101	-.315	-.259	-.28	.404	.219	.258	-.074
84 01:28 PM	-.104	-.316	-.256	-.281	.402	.247	.252	-.057
88 01:44 PM	-.103	-.324	-.282	-.275	.396	.286	.262	-.041

RUN PP2
 INPUT WHICH ENGINEERING LAB RUN NO.
 (USES LATEST IF NO OTHER) ? 12
 THE LAST RECORD IS 107
 START WITH ? 48
 END WITH ? 88
 INTERVAL ? 40

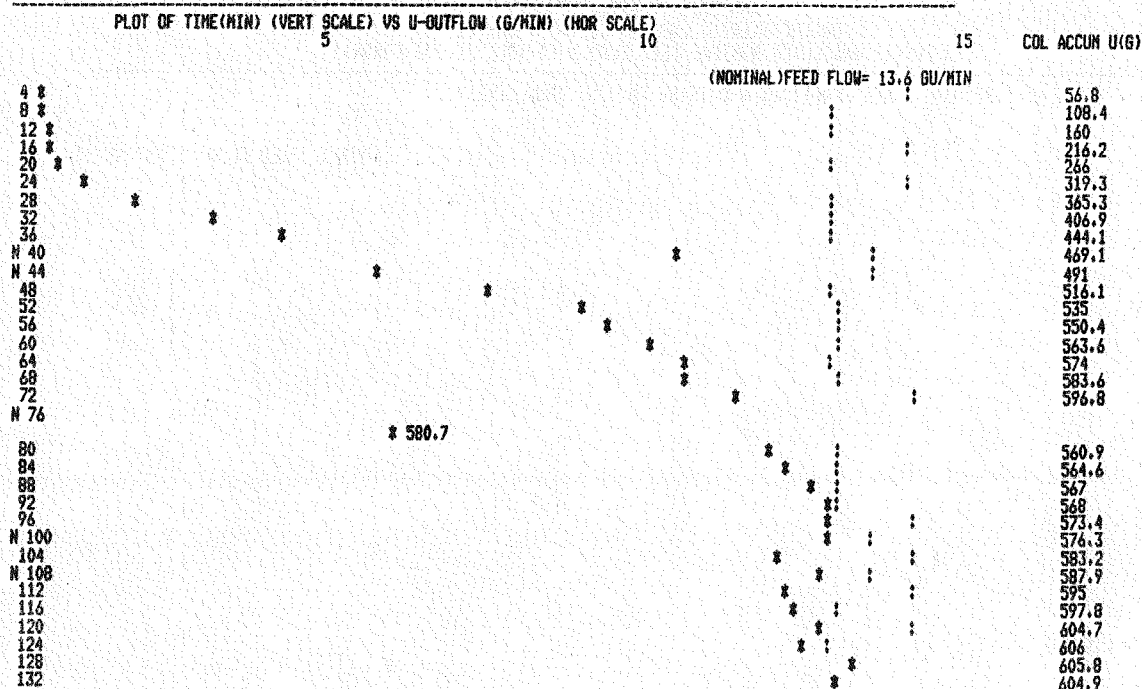
FLOW RATE HISTORY FOR ENGINEERING LAB RUN NO. #12
 STARTS WITH RECORD 48
 AND GOES TO RECORD 88
 RESULTS GIVEN IN LITERS PER MINUTE: MINUS=OUTFLOW, PLUS=INFLOW

	AS	AF	AX	BX	AW	BW	BP	NET FLOW
88 01:44 PM	-.101	-.32	-.263	-.276	.411	.26	.254	-.035

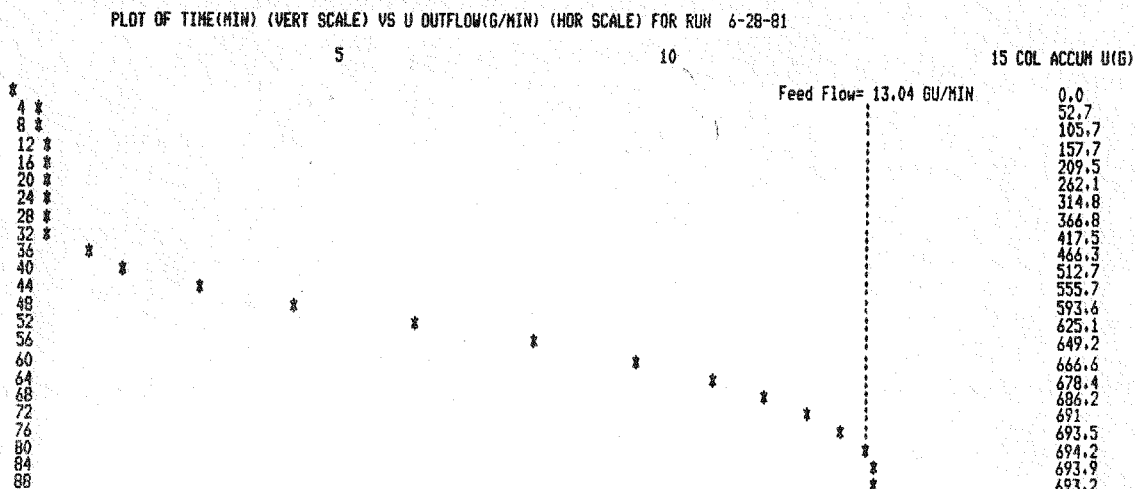
APPENDIX A-11

RUN PP10
 INPUT WHICH ENGINEERING LAB RUN NO.
 (USES LATEST IF NO OTHER) ? 10
 THE LAST RECORD IS 83
 START WITH ? 17
 END WITH ? 50
 FEED U(G/L) AND NOMINAL FEED FLOW(L/H)? 40.13,0.339

A-COL HOLDUP, BASED ON XRFA DATA AND INCREMENTAL FLOW RATES (NEAR REAL TIME)
 STARTS WITH RECORD 17
 AND GOES TO RECORD 50
 FOR ENGINEERING LAB RUN 10 ON 26-Jun-81
 (N PREFIX INDICATES NOMINAL FEED FLOW USED (DUE TO 10% ERROR))



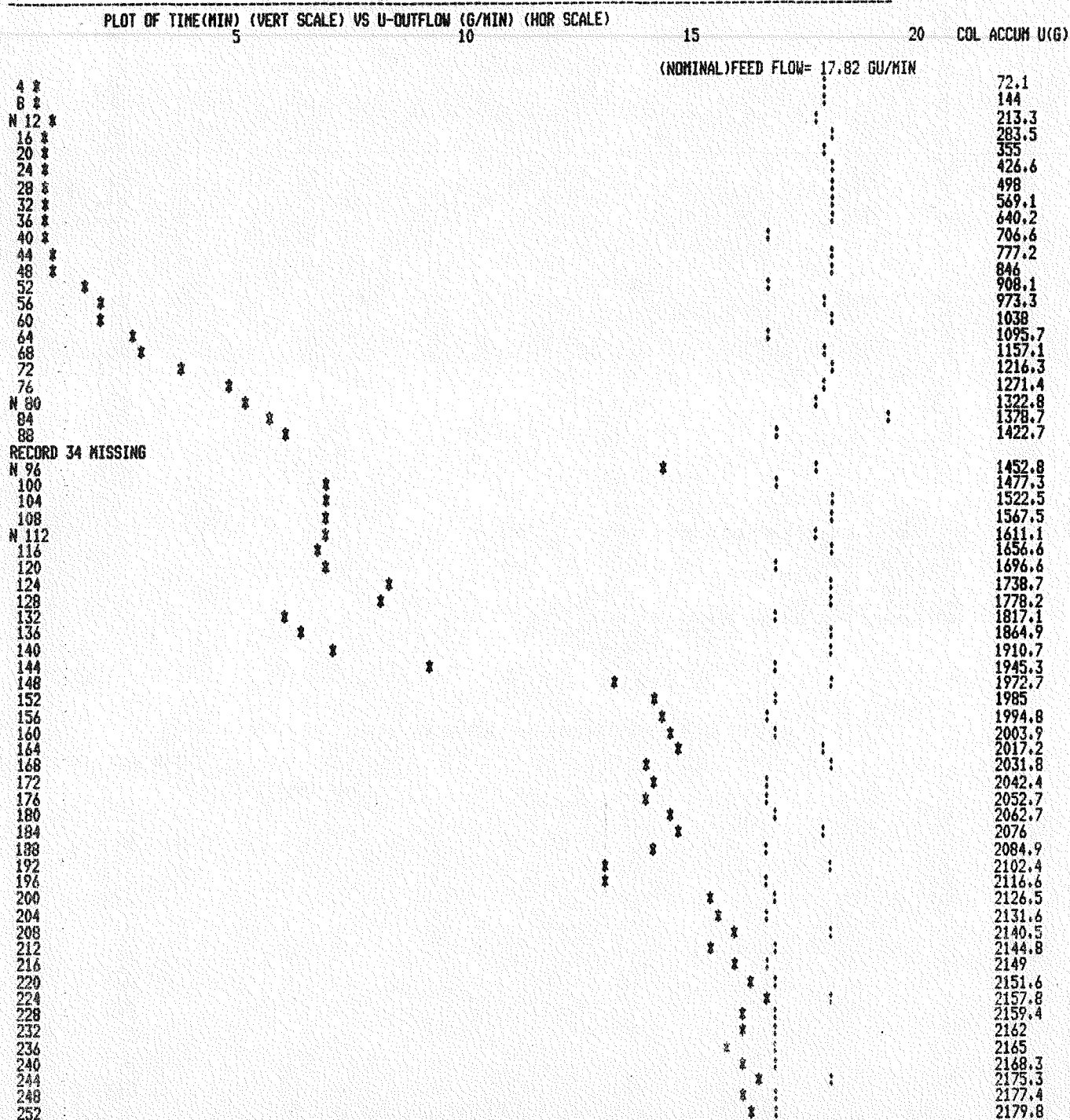
>
 RUN ACOL
 FEED U (G/L) & FEED FLOW (L/H)? 40.13,0.325
 WINDOW WIDTH (MINUTES)? 35
 NUMBER OF DATA POINTS? 6
 DENOMINATOR OF VERT SCALING FACTOR? 4
 DATE OF RUN? 6-28-81
 AX FLOW RATE, L/MIN? 0.265
 ENTER ELAPSED TIME AND GRAHS U/L FOR POINT 1 ? 15,0
 POINT 2 ? 30,1.3
 POINT 3 ? 45,11.9
 POINT 4 ? 60,35.1
 POINT 5 ? 75,46.5
 POINT 6 ? 90,48.5



APPENDIX A-12

RUN PP11
 INPUT WHICH ENGINEERING LAB RUN NO.
 (USES LATEST IF NO OTHER) ? 11
 THE LAST RECORD IS 84
 START WITH ? 11
 END WITH ? 74
 FEED U(G/L) AND NOMINAL FEED FLOW(L/H)? 40.13,0.444

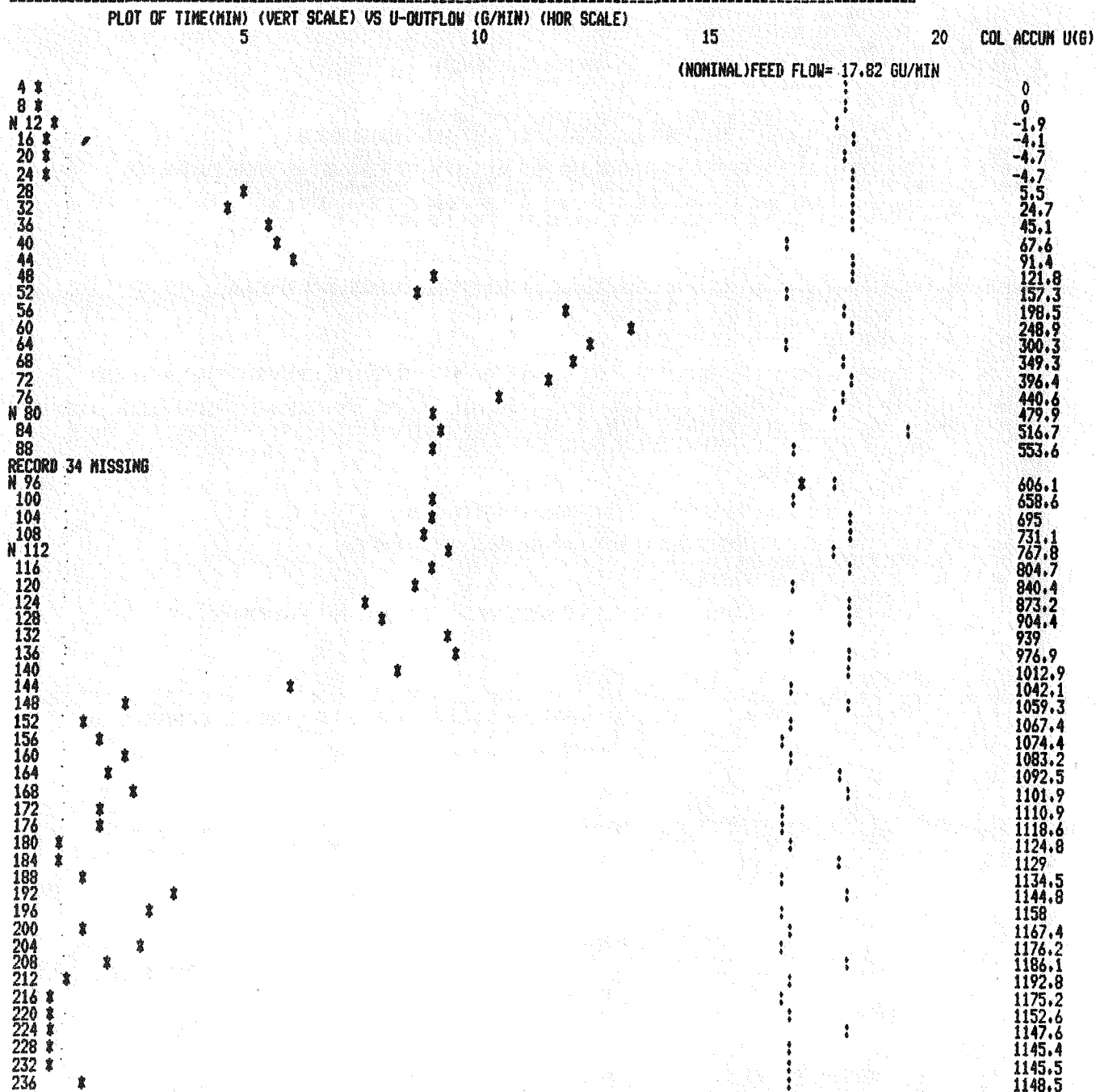
AB-COL HOLDUP, BASED ON XRFA DATA AND INCREMENTAL FLOW RATES (NEAR REAL TIME)
 STARTS WITH RECORD 11
 AND GOES TO RECORD 74
 FOR ENGINEERING LAB RUN 11 ON 30-Jun-81
 (N PREFIX INDICATES NOMINAL FEED FLOW USED (DUE TO 10% ERROR))



APPENDIX A-13

RUN PP12
 INPUT WHICH ENGINEERING LAB RUN NO.
 (USES LATEST IF NO OTHER) ? 11
 THE LAST RECORD IS 84
 START WITH ? 11
 END WITH ? 70
 FEED U(G/L) AND NOMINAL FEED FLOW(L/H)? 40.13,0.444

B-COL RETENTION, BASED ON XRFA DATA AND INCREMENTAL FLOW RATES (NEAR REAL TIME)
 STARTS WITH RECORD 11
 AND GOES TO RECORD 70
 FOR ENGINEERING LAB RUN 11 ON 30-Jun-81
 (N PREFIX INDICATES NOMINAL FEED FLOW USED (DUE TO 10% ERROR))



APPENDIX A-14

PIP TI:=PILOT.B2S

PILOT PLANT DATA MANIPULATION PROGRAM

```

11      2
12
13 REM: THIS PROGRAM PRINTS OUT BOTH RAW DATA AND PROCESSED DATA
14 DATA LT-1 ,AS LEV ,672, 2
15         LT-2 ,AF LEV ,673, 2
16         LT-3 ,AX LEV ,674, 2
17         LT-4 ,BX LEV ,675, 2
18         DT-4 ,AW DEN ,676, 2
19         LT-5 ,AW LEV ,677, 2
20         DT-8 ,BW DEN ,678, 2
21         LT-6 ,BW LEV ,679, 2
22         DT-9 ,BP DEN ,680, 2
23         LT-7 ,BP LEV ,681, 2
24         WT-1 ,A COL WR ,682, 2
25         DT-12 ,A DEN (B) ,683, 2
26         DT-13 ,A DEN (T) ,684, 2
27         CIT-6 ,BP H+ ,685, 2
28         DE-3 ,DYNATROL ,686, 2
29         WT-2 ,B COL WR ,687, 2
30         DT-14 ,B COL DEN ,688
31
32 DATA AS,AF,AX,BX,AW,BW,BP
33 DIM INS$(20),APPL$(20),CHANZ(20),P(20),B(15),E(15),D3(100),V(15),RD(20)
34 READ INS$(1),APPL$(1),CHANZ(1) FOR I=1 TO 17: C=-1: Z7,ECUM=0
35 READ TNK$(1) FOR I=1 TO 7
36 FOR K=1 TO 17: CALL RTPCOM(1Z,CHANZ(K),R0,R1,R2,R3,R4,STATUSZ)\RD(K)=R0: NEXT K
37 MAP (ELDAT) D6,T6,RD6(20),DMAZ(4),DMA1,DMA1,DMA2,DMA2,XRFL(3),XRFL(3)=20,DYNATR,ACID
38 MAP (VOLUME) PT,PT6,VOL(40)
39 OPEN 'HP:1307,100JELDT1.DAT' AS FILE 3Z:RELATIVE,ACCESS READ,ALLOW READ,MAP ELDAT\GET #3,RECORD 1\REC=RD6(0)
40 GET #3:RECORD REC\PRINT TAB(30):PILOT PLANT STATUS AT 'TIME$(0):' ON 'DATE$(0)\PRINT\PRINT
41 MAP (XRUC) SEQ.NO$(4)=6,XRF,TH$(4)=20,XRU,CONC(4),XRU,VAR(4)\UXRF.FIL#='HP:1250,100JXRFA.DAT'
42 OPEN UXRF.FIL$ FOR INPUT AS FILE 5Z:SEQUENTIAL FIXED, ACCESS READ, MAP XRUC\GET #5
43 WNDW=13
44 DIM LEV(40)
45 LEV(I)=(I-1)*5 FOR I=1 TO 40
46 P(5)=20.63\P(7)=19.40\P(9)=20.047\P(11)=281.75\P(12)=166.0\P(13)=115.75\P(16)=230.0\P(17)=230.0
47 D(1)=1.0276\D(2)=1.1328\D(3)=0.8102\D(4)=1.0058
48 U(1)=0\U(2)=26.8\U(3)=0\U(4)=0\U(5)=0.003\U(6)=8.02
49 H(1)=1.00\H(2)=3.10\H(3)=0\H(4)=0.32\H(6)=0.04
50 CLOSE 1Z\C=C+1
51 PRINT\PRINT STRING$(76Z,45Z)\PRINT 'RDG','INST','APPL','CHAN','RAW DATA'\TAB(70):PS(IN)\PRINT STRING$(76Z,61Z)
52 PRINT K, INS$(K),APPL$(K),CHANZ(K),RD(K),TAB(70):P(K) FOR K=1 TO 17
53 PRINT\PRINT 'DMS-45= 'DMA1: 'E':DMA1: 'DPR-412= 'DMA2: 'E':DMA2: 'DYNATROL DEN = 'DYNATR: 'CIT-5 ACID = 'ACID
54 PRINT 'XRFA-1 IS:XRFL(0):' AT 'XRFL(0):', XRFA-2 IS:XRFL(1):' AT 'XRFL(1):'
55 PRINT 'XRFA-4 IS:XRFL(3):' AT 'XRFL(3):'\CLOSE 3Z\CLOSE 5Z
56 D(5)=RD(5)/P(5)\D(6)=RD(7)/P(7)
57 T(K)=DMA1 FOR K=1 TO 7\D(7)=DMA1
58 IF D(7)>1.2 THEN D(7)=RD(9)/P(9)
59 D(8)=DMA2\T(8)=DMA2\W(8)=0.1\U(8)=XRFL(1)\IF D(7)<1 THEN D(7)=RD(9)/P(9)
60 U(7)=XRFL(0)\U(6)=XRFL(3)
61 H(5)=27.284+24.39946\H(5)+2.90571\H(5)+H(5)=INT(H(5)*100+0.5)/100\H(7)=ACID
62 PRINT\PRINT STRING$(130Z,45Z)\RG=0
63 FOR K=1 TO 7\RG=RG+1\IF RG=>5 THEN RG=RG+1
64 LL(K)=RD(RG)/D(K)\NEXT K
65 FOR K=1 TO 7\TK$=TNK$(K)\LL(K)=2.54*LL(K)\LEVEL=LL(K)\GOSUB 15000\B(K)=B\LL(K)=INT(LL(K)*1000+0.5)/1000
66 E(K)=B(K)*D(K)\E7=E7+E(K)
67 NEXT K\IF C=0 THEN EOUT=0\GOTO 466
68 EOUT=E7-EMAS
69 ECUM=ECUM+EOUT\EMAS=E7\PRINT
70 FOR K=1 TO 7\IF C=0 THEN GOTO 520
71 R=E(K)-E(K+7)\Z=INT(R/D(K)*1000+0.5)/1000\V(K)=INT(Z*250+0.5)/1000\L(K)=V(K)+V(K+7)\A(K)=INT(L(K)/C*1000+0.5)/1000
72 E(K+7)=E(K)\V(K+7)=L(K)\B(K)=INT(B(K)*1000+0.5)/1000
73 NEXT K\B3(C+1)=B(1)+B(2)+B(3)+B(4)+B(5)+B(6)+B(7)\D4=D3(C+1)-D3(C)\IF C=0 THEN D4=0
74 PRINT 'TOTAL TAYLOR VOLUME (L) = 'E7:
75 PRINT TAB(65): 'TOTAL SOLUTION VOLUME (L) = 'D3(C+1)
76 PRINT '4-MINUTE TAYLOR CHANGE (L) = 'EOUT:
77 PRINT TAB(65): '4-MINUTE SOLUTION CHANGE (L) = 'D4\Z7=Z7+D4
78 PRINT 'CUMULATIVE TAYLOR CHANGE (L) = 'ECUM:
79 PRINT TAB(65): 'CUMULATIVE SOLUTION CHANGE (L) = 'Z7
80 PRINT\PRINT STRING$(126Z,45Z)\PRINT:
81 ' TANK LL(CH) V(25)(L) FR(L/MIN) CUM(L/MIN) T(DEG C) D(G/ML) H+(H) U(G/L) U(KG)'
82 PRINT STRING$(126Z,61Z)
83 FOR K=1 TO 5\U1(K)=B(K)*U(K)/1000\NEXT K
84 U(7)=U(7)\D2(7)=D(7)\D(7)=RD(9)/P(9)\K=7\GOSUB 20000\D(7)=D2(7)\U1(7)=U(7)\U(7)=UR(7)\U1(7)=INT(U1(7)*B(7))/1000
85 UR(6)=U(6)\K=6\GOSUB 10000\U2(6)=U(6)\U(6)=UR(6)\U2(6)=INT(U2(6)*B(6))/1000\H(6)=0.04
86 FOR K=1 TO 7 \PRINT TNK$(K):TAB(13):LL(K):TAB(26):B(K):TAB(39):V(K):TAB(52):A(K):('4#C:'):TAB(65):T(K):TAB(78):D(K):
87 PRINT TAB(91):H(K): TAB(104):U(K):TAB(117):U1(K)\NEXT K
88 U2=U2+U1(K) FOR K=1 TO 7\U2=INT(U2*1000+0.5)/1000\PRINT STRING$(126Z,45Z)\PRINT \PRINT 'TANKS: '
89 PRINT 'TOTAL AQ = 'B(1)+B(2)+B(4)+B(5)+B(7):'L' TOTAL ORG = 'B(3)+B(6):'L':TAB(92):'TOTAL U IN TANKS (KG) = 'U2
90 PRINT STRING$(126Z,45Z)\U3=(1.72*U(2)+3.96*U(5)+6.11*U(8)+3.91*U(6)+5.00*U(7))/1000\U3=INT(U3*1000+0.5)/1000
91 PRINT\PRINT 'LINES: TOTAL AQ = 13.53 L TOTAL ORG = 12.06 L'
92 PRINT TAB(90):'U HOLD-UP IN LINES (KG) = 'U3\PRINT STRING$(126Z,45Z)\PRINT\PRINT:
93 ' COLUMN DR(B) DR(T) WR FF(L/MIN) SF(L/MIN) FD-U(G/L) U(KG) FD-D(G/ML)'

```

APPENDIX A-14 (CONTINUED)

```

710 PRINT STRING$(126Z,61Z)
720 FOR K=1 TO 4\A(K)=-1\A(K)\NEXT K
730 F2=U(2)\U5=U(2)\S2=U(3)\GOSUB 30000
740 PRINT 'A-07003';TAB(13);RD(12)/P(12);TAB(26);RD(13)/P(13);TAB(39);RD(11)/P(11);TAB(52);V(2);TAB(65);V(3);TAB(78);U(2);
      TAB(91);K2;TAB(104);D(2)\K3=K3+K2
750 GOSUB 30200
760 F2=A3\U5=U(8)\S2=U(4)\GOSUB 30020
770 PRINT 'B-07004';TAB(13);RD(17)/P(17);TAB(26);' --';TAB(39);RD(16)/P(16);TAB(52);A3;TAB(65);V(4);TAB(78);U(8);
      TAB(91);K2;TAB(104);D(8)\K3=K3+K2\K3=INT(K3*1000+0.5)/1000
780 PRINT STRING$(126Z,45Z)
790 PRINT STRING$(126Z,61Z)\PRINT\PRINT
800 PRINT TAB(76);'TOTAL U IN COLUMNS (KG) = 'K3
810 PRINT TAB(72);'COLUMN U BY DIFFERENCE (KG) = 'U4-U2-U3
820 PRINT TAB(77);'TOTAL U INVENTORY (KG) = 'U2+U3+K3
830 PRINT TAB(84);'STARTING U (KG) = 'U4\PRINT\PRINT\VE7,U2,K3=0\I=1\INTV
990 PRINT\PRINT\SLEEP 240\GOTO 94
8000 CLOSE 1Z\CLOSE 3Z\GOTO 31000
9250 IF (ERR=155Z) AND (ERL=400Z) THEN RESUME 420
9300 PRINT 'ERROR';ERR;' AT LINE';ERL
9900 GO TO 31000
10000 REM: ORGU
10010 IF M(K)<0.1 THEN M(K)=0.1
10020 IF M(K)>0.9 THEN M(K)=0.9
10025 IF T(K)<20 THEN T(K)=25
10027 IF T(K)>28 THEN T(K)=25
10030 S1=((T(K)-25)*0.00092+1)*D(K)
10040 IF S1>0.84395 THEN 10100
10050 U(K)=(S1-0.81379-0.027034*M)/0.00130016
10060 U(K)=INT(U(K)*100+0.5)/100
10090 GOTO 10110
10100 U(K)=(S1-0.81442-0.027131*M)/0.00131169\GOTO 10060
10110 IF U(K)<0 THEN U(K)=0
10120 RETURN
15000 FIL3$='MP:[307,100]'TK$+'.DAT'
      \OPEN FIL3$ AS FILE 5Z, RELATIVE, ACCESS READ, MAP VOLUME
      \GET #5, RECORD 1
15015 B=0
15020 FOR J=1 TO PT
15025 IF LEVEL<0.5 THEN VOLUME=0 \GO TO 15130
15030 IF ABS(LEV(J)-LEVEL) > WNDW THEN 15110
15040 T=1
15050 FOR L=1 TO PT
15060 IF ABS(LEV(L)-LEVEL)>WNDW THEN 15090
15070 IF L=J THEN 15090
15072 IF LEV(J)=LEV(L) THEN 15090
15080 T=T*(LEVEL-LEV(L))/(LEV(J)-LEV(L))
15090 NEXT L
15100 B=B+T*VOL(J)
15110 NEXT J
15130 CLOSE 5Z\RETURN
20000 REM: AQU
20010 IF M(K)<0.1 THEN M(K)=0.1
20020 IF M(K)>3.5 THEN M(K)=3.5
20025 IF T(K)<20 THEN T(K)=25
20027 IF T(K)>28 THEN T(K)=25
20030 Y1=(M(K)-1.767)/1.400565\Z1=(T(K)-29.96)/4.178783
20040 A1=0.00199196\B1=0.04978369+0.00168559*Y1-0.00013578*Z1
20050 C1=1.12670857-D(K)+0.04793604*Y1-0.00209437*Z1-0.00050179*Y1*Z1-0.00042916*Y1*Y1-9.64E-06*Z1*Z1
20060 H4=(B1*B1-4*A1*C1)\IF H4<0 THEN H4=0
20070 X1=(-B1+SQR(H4))/(2*A1)
20080 U(K)=(30.889848*X1+48.795328)*D(K)
20090 U(K)=INT(U(K)*100+0.5)/100
20120 IF U(K)<0 THEN U(K)=0
20130 RETURN
30000 REM: COLAB
30001 IF S2=0 THEN PRINT 'NO STRIP FLOW--NO ENTRY FOR U MADE'\K2=0\GOTO 30080
30002 R2=F2/S2*U5\IF R2>50 GOTO 30006
30004 K2=0.44*30.6*R2\GOTO 30060
30006 K2=0.84*30.6*(R2-30)\GOTO 30060
30020 IF S2=0 THEN PRINT 'NO STRIP FLOW--NO ENTRY FOR U MADE'\K2=0\GOTO 30080
30030 K2=0.45*30.6*F2/S2*U5\GOTO 30060
30060 K2=INT(K2+0.5)/1000
30080 RETURN
30200 REM: FLOW RATE FOR B COL FEED
30230 A4=0.0486+U(8)/238.03\A3=V(3)*(1+A4/(11.8-A4))\A3=INT(A3*1000+0.5)/1000
30240 RETURN
31000 END
>

```

APPENDIX A-15

PILOT PLANT STATUS AT 11:22 AM

ON 04-Aug-81

PP RUN # 13

RECORD # 28

RDG	INST	APPL	CHAN	RAW DATA	PS(IN)
1	LT-1	AS LEV	672	8.11707	0
2	LT-2	AF LEV	673	30.9949	0
3	LT-3	AX LEV	674	29.4189	0
4	LT-4	BX LEV	675	33.1842	0
5	DT-4	AW DEN	676	22.2973	20.63
6	LT-5	AW LEV	677	35.8309	0
7	DT-8	BW DEN	678	15.9186	19.4
8	LT-6	BW LEV	679	12.0465	0
9	DT-9	BP DEN	680	20.7588	20.047
10	LT-7	BP LEV	681	5.69366	0
11	WT-1	A COL WR	682	203.583	281.75
12	DT-12	A DEN (B)	683	127.094	166
13	DT-13	A DEN (T)	684	114.161	115.75
14	CIT-6	BP HT	685	41.5649	0
15	DE-3	DYNATROL	686	-24.7349	0
16	WT-2	B COL WR	687	237.821	230
17	DT-14	B COL DEN	688	230.134	230

DMS-45= 1.0484 @ 23.66 , DPR-412= .9012 @ 24.18 , DYNATROL DEN = .9485 , CIT-6 ACID = .23

XRFA-1 IS 31.0813 AT 04-Aug-81 11:20 AM , XRFA-2 IS 62.6924 AT 04-Aug-81 11:19 AM , XRFA-4 IS 3.2528 AT 04-Aug-81 11:18 AM

TOTAL TAYLOR VOLUME (L) = 1197.3
 16 -MINUTE TAYLOR CHANGE (L) = .81958
 CUMULATIVE TAYLOR CHANGE (L) = -1.98254

TOTAL SOLUTION VOLUME (L) = 1133.58
 16 -MINUTE SOLUTION CHANGE (L) = .601929
 CUMULATIVE SOLUTION CHANGE (L) = -1.92908

TANK	LL(CH)	V(25)(L)	FR(L/MIN)	CUM(L/MIN)	T(DEG C)	D(G/ML)	HT(M)	U(G/L)	U(KG)
AS	20.064	85.347	-.122	-.101 (32)	23.66	1.0276	1	0	0
AF	69.498	228.057	-.758	-.76 (32)	23.66	1.1328	3.1	26.8	6.11193
AX	92.229	80.059	-.291	-.302 (32)	23.66	.8102	0	0	0
BX	83.802	73.561	-.298	-.303 (32)	23.66	1.0058	.32	0	0
AW	84.205	617.017	.973	.902 (32)	23.66	1.08082	2.48	.003	.00185105
BW	37.29	28.158	.208	.23 (32)	23.66	.820545	.04	3.2528	.124
BP	13.794	21.377	.332	.279 (32)	23.66	1.0484	.23	31.0813	.485

TANKS: TOTAL AQ = 1025.36 L TOTAL DRG = 108.217 L TOTAL U IN TANKS (KG) = 6.723

LINES: TOTAL AQ = 13.53 L TOTAL DRG = 12.06 L U HOLD-UP IN LINES (KG) = .597

COLUMN	DR(B)	DR(T)	WR	FF(L/MIN)	SF(L/MIN)	FD-U(G/L)	U(KG)	FD-D(G/ML)
A-07003	.765627	.986276	.722567	-.758	-.291	26.8	1.023	1.1328
B-07004	1.00058	--	1.034	-.299	-.298	62.6924	.866	.9012

TOTAL U IN COLUMNS (KG) = 1.889
 COLUMN U BY DIFFERENCE (KG) = .7
 TOTAL U INVENTORY (KG) = 9.209
 STARTING U (KG) = 8.02

APPENDIX B

COMPUTER PRINTOUTS

(Column Holdup Program and Test Results)

APPENDIX B-1

PILOT PLANT A-COL HOLDUP (NEAR REAL TIME)

```

PIP TIT=PP10.825
11
11
11
10 DATA LT-1 ,AS LEV ,672, 2
      LT-2 ,AF LEV ,673, 2
      LT-3 ,AX LEV ,674, 2
      LT-4 ,BX LEV ,675, 2
      DT-4 ,AM DEN ,676, 2
      LT-5 ,AW LEV ,677, 2
      DT-8 ,BW DEN ,678, 2
      LT-6 ,BW LEV ,679, 2
      DT-9 ,BP DEN ,680, 2
      LT-7 ,BP LEV ,681, 2
      WT-1 ,A COL WR ,682, 2
      DT-12 ,A DEN (B) ,683, 2
      DT-13 ,A DEN (T) ,684, 2
      CIT-6 ,BP HT ,685, 2
      DE-3 ,DYNATROL ,686, 2
      WT-2 ,B COL WR ,687, 2
      DT-14 ,B COL DEN ,688, 2

80 PRINT 'INPUT WHICH ENGINEERING LAB RUN NO.'
   \INPUT ' (USES LATEST IF NO OTHER) ' ;RN$
   \IF RN$<>' THEN RN$=' ;RN$
82 FIL1$='MP:[307,100]ELDT1.DAT ;RN$
   \FIL2$='MP:[307,100]ELANA.DAT ;RN$
90 ON ERROR GO TO 9200
100 DIM INS$(20),APPL$(20),CHAN$(20),E(20)
   \MAP (ELDAT) D$,T$,RDG(20),DMAZ(4),DMA1,DMA2,DMAZ2,XRFL(3),XRFL$(3)=20,DYNATR,ACID
   \MAP (ELANA) TANK$,LN,AC,DE,UC,TP,PS
   \MAP (VOLUME) PT,PT$,VOL(40)
105 OPEN FIL1$ AS FILE 32, RELATIVE, ACCESS READ, ALLOW MODIFY, MAP ELDAT
   \GET #3, RECORD 1
   \PRINT 'THE LAST RECORD IS ' ;RDG(0)
110 INPUT ' START WITH ' ;STRT
   \INPUT ' END WITH ' ;LST
   \INTU=1
145 INPUT 'FEED U(G/L) AND NOMINAL FEED FLOW(L/H)';C,EN\F=C*EN\G=100/F\PRINT\PRINT
150 READ INS$(1),APPL$(1),CHAN$(1) FOR I=1 TO 17
160 DATA AS,AF,AX
165 READ TANK$(I) FOR I=1 TO 3
170 WNDW=13
   \DIM LEV(40)
   \LEV(1)=(I-1)*5 FOR I=1 TO 40
180 \OPEN FIL2$ AS FILE 12, RELATIVE, ACCESS READ, MAP ELANA
   \FOR I=1 TO 3
   \GET #1, RECORD 1
   \DF(I)=0E
185 NEXT I\CT=0
189 CLOSE 12
500 PRINT TAB(39);'A-COL HOLDUP, BASED ON XRFA DATA AND INCREMENTAL FLOW RATES (NEAR REAL TIME)'
   \PRINT TAB(45);'STARTS WITH RECORD';STRT
   \PRINT TAB(45);'AND GOES TO RECORD';LST
   \GET #3, RECORD 2
   \PRINT TAB(36);'FOR ENGINEERING LAB RUN ' ;RIGHT(RN$,22);' ON ' ;D$
   \PRINT TAB(25);' (N PREFIX INDICATES NOMINAL FEED FLOW USED (DUE TO 10% ERROR)) '\PRINT STRING$(110Z,45Z)
510 PRINT TAB(12);'PLOT OF TIME(MIN) (VERT SCALE) VS U-OUTFLOW (G/MIN) (HOR SCALE)'
520 FOR J=5 TO 55 STEP 5\IF (G&J-1)<=115 THEN PRINT TAB(G&J-1);J;
530 NEXT J\PRINT TAB(118);'COL ACCUM U(G)'\PRINT L=INT(G&F+0.5)
540 PRINT TAB(L-19);'NOMINAL FEED FLOW=' ;INT(F*100+0.5)/100; 'GU/MIN'\BF=0
545 I=STRT
550 GET #3, RECORD 1
555 LL(1)=RDG(1)/DF(1)\LL(2)=RDG(2)/DF(2)\LL(3)=RDG(3)/DF(3)
560 FOR K=1 TO 3\TK$=TANK$(K)\LEVEL=2.5*LL(K)\GOSUB 20000\U(K)=VOLUME
565 E(K)=U(K)*BF\DIFF(K)=E(K+7)-E(K)\E(K+7)=E(K)\NEXT K
567 IF CT=0 THEN CT=1\CNT=1\I=I+INTU\GOTO 550
568 FOR K=1 TO 3
570 RATE(K)=(DIFF(K)/DF(K))/(4*INTU)\RATE(K)=INT(RATE(K)*1000+0.5)/1000\NEXT K
575 E=RATE(2)\IF (ABS(E-EN))/EN<0.1 THEN E=EN\PRINT 'N';
577 AX=RATE(3)\F=C*E\L=INT(G&F+0.5)
602 X=4*CNT\Z=XRFL(1)\Z=Z*0.9259\W=Z/238.03+0.0486\Y=W/(11.8-W)+1)*AX*Z\D=INT(Y*G+0.5)
604 R=4*(F-(Y*BF)/2)\S=S+R\Q=INT(S*10+0.5)/10\BF=Y
606 IF B<=(L-1) THEN PRINT X;TAB(D);'*';TAB(L);';';TAB(122);Q\GOTO 620
608 PRINT X;TAB(D);'*';TAB(122);Q
620 I=I+INTU
   \CNT=CNT+1
   \IF I<=LST THEN GOTO 550
8000 CLOSE 12
   \GO TO 30000
9200 IF (ERR=136Z) AND (ERI=105Z) THEN SLEEP 1Z \ RESUME 105
9210 IF (ERR=155Z) AND (ERI=550Z) THEN PRINT 'RECORD';I;'MISSING'\RESUME 620
9300 PRINT 'ERROR';ERR;' AT LINE';ERI
9900 GO TO 30000
20000 FIL3$='MP:[307,100]' ;TK$+'.DAT'
   \OPEN FIL3$ AS FILE 52, RELATIVE, ACCESS READ, MAP VOLUME
   \GET #5, RECORD 1
20015 B=0
20020 FOR J=1 TO PT
20025 IF LEVEL<0.5 THEN VOLUME=0 \GO TO 21000
20030 IF ABS(LEV(J)-LEVEL) > WNDW THEN 20110
20040 T=1
20050 FOR L=1 TO PT
20060 IF ABS(LEV(L)-LEVEL)>WNDW THEN 20090
20070 IF L=J THEN 20090
20080 T=T*(LEVEL-LEV(L))/(LEV(J)-LEV(L))
20090 NEXT L
20100 B=B+T*VOL(J)
20110 NEXT J
20120 VOLUME=INT(B*1000+0.5)/1000
21000 RETURN
30000 END
>

```


APPENDIX B-2

TANK VOLUME VERSUS TIME COMPUTER DATA: TEST 3AM-3

RUN PF1
 INPUT WHICH ENGINEERING LAB RUN NO.
 (USES LATEST IF NO OTHER) ? 11
 THE LAST RECORD IS 84
 START WITH ? 2
 END WITH ? 84
 INTERVAL ? 2

VOLUME HISTORY FOR ENGINEERING LAB RUN NO. 111
 STARTS WITH RECORD 2
 AND GOES TO RECORD 84

		AS	AF	AX	BX	AW	BW	BP	TAY(L)	LOSS(L)	CUM LOSS(L)
2	08:06 AM	157.26	287.566	110.709	110.984	796.621	0	0	1425.07	0	0
4	08:14 AM	157.027	287.566	110.529	110.805	796.531	0	0	1424.42	.648804	.648804
6	08:22 AM	156.36	287.566	108.402	108.488	796.531	0	0	1419.68	4.74548	5.39429
8	08:30 AM	155.37	286.539	106.224	106.275	796.621	0	0	1413.56	6.11719	11.5115
10	08:38 AM	154.705	282.95	103.979	104.108	722.602	0	0	1412.4	1.1615	12.673
12	08:46 AM	153.653	279.356	101.903	102.096	715.868	0	0	1409.27	3.12451	15.7975
14	08:58 AM	152.268	274.221	98.748	99.016	701.565	4.719	6.459	1417.43	-8.15308	7.64441
16	09:06 AM	151.444	270.621	96.574	96.846	699.514	6.539	8.372	1416.39	1.03894	8.68335
18	09:14 AM	150.686	267.009	94.385	94.536	698.273	8.368	10.379	1416.63	-2.45728	8.43762
20	09:22 AM	149.866	263.39	92.292	92.231	700.792	10.639	12.39	1416.29	.343384	8.78101
22	09:30 AM	149.078	259.908	90.181	89.937	703.638	12.381	14.455	1415.35	.941772	9.72278
24	09:38 AM	148.194	256.428	87.992	87.782	706.158	13.955	16.399	1414.23	1.12097	10.8438
26	09:46 AM	147.211	252.825	85.779	85.593	709.634	16.453	18.349	1413.84	.389404	11.2332
28	09:54 AM	146.425	249.357	83.635	83.376	714.026	18.61	20.385	1413.86	-.0205078	11.2126
30	10:02 AM	145.646	245.753	81.566	81.177	718.723	19.836	22.361	1412.98	.878906	12.0916
32	10:10 AM	144.664	242.27	79.616	79.047	722.811	21.75	24.277	1412.49	.484009	12.5756
34	10:18 AM	144.664	242.27	79.616	79.047	722.811	21.75	24.277	1412.49	0	12.5756
36	10:26 AM	142.939	235.287	75.488	74.81	731.685	26.508	28.116	1412.37	.124023	12.6996
38	10:34 AM	142.252	231.663	73.416	72.964	735.618	28.382	29.88	1412.53	-.157593	12.542
40	10:42 AM	141.178	228.292	71.326	71.023	740.493	30.433	31.638	1411.97	.562012	13.104
42	10:50 AM	140.562	224.793	69.254	68.745	744.663	32.329	33.617	1412.22	-.256592	12.8474
44	10:58 AM	139.521	221.292	67.191	66.442	748.68	34.038	35.478	1411.06	1.16199	14.0094
46	11:06 AM	138.773	217.667	65.139	64.305	753.465	36.043	37.152	1410.78	.280273	14.2897
48	11:14 AM	137.771	214.175	63.116	62.201	756.853	38.361	39.09	1410.35	.430542	14.7202
50	11:22 AM	137.149	210.82	61.05	60.084	761.676	40.625	41.06	1411.52	-1.16907	13.5511
52	11:30 AM	136.211	207.337	58.929	57.94	765.896	42.582	43.067	1410.15	1.3739	14.925
54	11:38 AM	135.463	203.857	56.856	55.739	769.14	44.431	44.95	1409.76	.389771	15.3148
56	11:46 AM	134.589	200.503	54.838	53.553	773.205	46.463	46.814	1410.06	.367373	15.6874
58	11:54 AM	133.777	197.03	52.817	51.4	779.712	48.354	48.705	1409.46	.600586	15.608
60	12:02 PM	132.898	193.552	50.722	49.265	782.729	49.516	50.538	1408.17	1.2887	16.8967
62	12:10 PM	132.111	190.197	48.471	47.12	785.918	52.257	52.374	1408.62	-.449585	16.4471
64	12:18 PM	131.188	186.711	46.245	44.977	790.771	54.785	54.304	1408.02	.603638	17.0508
66	12:26 PM	130.467	183.353	44.26	42.913	793.72	56.939	56.256	1408.15	-.126343	16.9244
68	12:34 PM	129.409	179.858	42.259	40.779	799.03	58.812	58.272	1407.56	.58313	17.5076
70	12:42 PM	128.677	176.492	40.18	38.712	802.633	60.838	60.179	1408.01	-.450806	17.0568
72	12:50 PM	127.774	172.994	38.062	36.639	807.077	62.905	62.102	1407.41	.599609	17.6564
74	12:58 PM	126.777	169.622	35.962	34.54	812.036	64.942	64.005	1407.01	.401489	18.0579
76	01:06 PM	126.209	166.255	33.923	32.472	816.337	66.468	65.905	1406.74	.268433	18.3263
78	01:14 PM	125.233	162.882	31.914	30.324	819.367	68.517	67.454	1405.21	1.53259	19.8589
80	01:22 PM	124.328	159.519	29.878	28.192	824.694	70.695	69.412	1405.56	-.343872	19.515
82	01:30 PM	124.262	159.26	29.839	28.143	823.265	71.017	69.696	1406.04	-.484985	19.03
84	01:38 PM	124.36	159.26	29.839	28.143	823.052	71.052	69.708	1406.02	.0211182	19.0511

APPENDIX B-3

FLOW RATE VERSUS TIME COMPUTER DATA

RUN PP2
 INPUT WHICH ENGINEERING LAB RUN NO.-----
 (USES LATEST IF NO OTHER) ? 11
 THE LAST RECORD IS 84
 START WITH ? 2
 END WITH ? 84
 INTERVAL ? 4

Test 3AM-3

FLOW RATE HISTORY FOR ENGINEERING LAB RUN NO. #11
 STARTS WITH RECORD 2
 AND GOES TO RECORD 84
 RESULTS GIVEN IN LITERS PER MINUTE; MINUS=OUTFLOW, PLUS=INFLOW

		AS	AF	AX	BX	AW	BW	BP	NET FLOW
6	08:22 AM	-.056	0	-.144	-.156	-.006	0	0	-.362
10	08:38 AM	-.103	-.289	-.276	-.274	.423	.97	.404	-.468
14	08:58 AM	-.152	-.546	-.327	-.318	.97	.295	.245	-.325
18	09:14 AM	-.099	-.451	-.273	-.28	.589	.228	.245	-.04
22	09:30 AM	-.1	-.444	-.263	-.207	.525	.251	.246	-.063
26	09:46 AM	-.117	-.443	-.275	-.271	.523	.253	.248	-.081
30	10:02 AM	-.098	-.442	-.263	-.276	.556	.212	.259	-.052
34	10:02 AM	0	0	0	0	0	0	0	0
38	10:34 AM	-.212	-.981	-.509	-.513	1.07	.541	.496	-.008
42	10:50 AM	-.106	-.329	-.26	-.264	.537	.253	.25	-.018
46	11:06 AM	-.112	-.445	-.257	-.278	.53	.238	.235	-.087
50	11:22 AM	-.101	-.428	-.256	-.264	.55	.292	.256	.049
54	11:30 AM	-.106	-.435	-.262	-.272	.467	.244	.253	-.109
58	11:54 AM	-.105	-.427	-.252	-.271	.543	.249	.242	-.023
62	12:10 PM	-.104	-.427	-.272	-.268	.529	.242	.237	-.062
66	12:26 PM	-.103	-.428	-.263	-.263	.489	.297	.245	-.025
70	12:42 PM	-.112	-.429	-.255	-.263	.538	.256	.25	-.015
74	12:58 PM	-.119	-.429	-.264	-.261	.505	.255	.245	-.066
78	01:14 PM	-.097	-.421	-.253	-.264	.481	.217	.217	-.118
82	01:30 PM	-.061	-.226	-.13	-.136	.307	.153	.142	.049

FLOW RATE HISTORY FOR ENGINEERING LAB RUN NO. #10
 STARTS WITH RECORD 2
 AND GOES TO RECORD 82
 RESULTS GIVEN IN LITERS PER MINUTE; MINUS=OUTFLOW, PLUS=INFLOW

TEST 3AM-4

		AS	AF	AX	BX	AW	BW	BP	
4	08:38 AM	-.024	0	-.183	-.025	-.022	0	0	-.128
6	08:46 AM	-.154	0	-.231	-.315	-.034	0	0	-.734
8	08:54 AM	-.084	0	-.274	-.282	.056	0	0	-.584
10	09:02 AM	-.103	0	-.279	-.278	1.22	0	0	.5
12	09:10 AM	-.116	-.209	-.256	-.258	.032	0	0	-.807
14	09:18 AM	-.099	-.338	-.261	-.261	.418	0	1.189	-.647
16	09:26 AM	-.128	-.322	-.271	-.275	.585	0	.003	-.408
18	09:34 AM	-.082	-.354	-.268	-.268	.633	.361	.002	.004
20	09:42 AM	-.135	-.321	-.262	-.269	.59	.152	.385	.05
22	09:50 AM	-.118	-.338	-.258	-.294	.451	.25	.215	-.094
24	09:58 AM	-.074	-.339	-.271	-.28	.494	.342	.029	-.027
26	10:06 AM	-.142	-.393	-.272	-.278	.517	.245	.166	-.09
28	10:18 AM	-.149	-.518	-.396	-.421	.583	.126	.455	-.32
30	10:26 AM	-.045	-.323	-.252	-.277	.448	.284	.253	-.068
32	10:34 AM	-.113	-.324	-.246	-.274	.377	.337	.286	.024
34	10:42 AM	-.121	-.323	-.252	-.267	.447	.344	.244	.09
36	10:54 AM	-.173	-.518	-.391	-.392	.635	.488	.397	.046
38	11:02 AM	-.048	-.324	-.255	-.227	.412	.282	.239	.098
40	11:10 AM	-.157	-.324	-.261	-.277	.429	.298	.256	-.034
42	11:18 AM	-.089	-.324	-.258	-.306	.411	.28	.257	-.028
44	11:26 AM	-.084	-.324	-.255	-.278	.415	.283	.239	.015
46	11:34 AM	-.113	-.339	-.25	-.267	.428	.25	.259	-.021
48	11:42 AM	-.154	-.339	-.256	-.268	.464	.22	.252	-.051
50	11:50 AM	-.065	-.322	-.268	-.283	.429	.275	.251	.017
52	11:58 AM	-.073	-.323	-.257	-.281	.447	.257	.274	.045
54	12:06 PM	-.134	-.322	-.251	-.283	.424	.191	.277	-.099
56	12:14 PM	-.11	-.322	-.261	-.278	.255	.206	.277	-.225
58	12:22 PM	-.074	-.323	-.255	-.273	.255	.243	.264	.047
60	12:30 PM	-.143	-.322	-.278	-.28	.41	.245	.26	-.108
62	12:38 PM	-.075	-.338	-.281	-.277	.47	.262	.254	-.036
64	12:46 PM	-.14	-.323	-.255	-.272	.423	.255	.218	-.095
66	12:54 PM	-.066	-.322	-.243	-.27	.354	.267	.212	-.068
68	01:02 PM	-.148	-.324	-.257	-.269	.437	.234	.329	.004
70	01:10 PM	-.12	-.323	-.262	-.27	.378	.228	.294	-.075
72	01:18 PM	-.104	-.324	-.263	-.27	.424	.336	.158	-.043
74	01:26 PM	-.099	-.324	-.256	-.274	.459	.345	.201	.043
76	01:34 PM	-.12	-.324	-.249	-.276	.366	.285	.31	-.009
78	01:42 PM	-.075	-.34	-.253	-.278	.419	.185	.166	-.176
80	01:50 PM	-.099	-.308	-.257	-.276	.365	.223	.203	-.148
82	01:50 PM	0	0	0	0	0	0	0	0

FLOW RATE HISTORY FOR ENGINEERING LAB RUN NO. #12
 STARTS WITH RECORD 32
 AND GOES TO RECORD 100
 RESULTS GIVEN IN LITERS PER MINUTE; MINUS=OUTFLOW, PLUS=INFLOW

Test 3AM-5

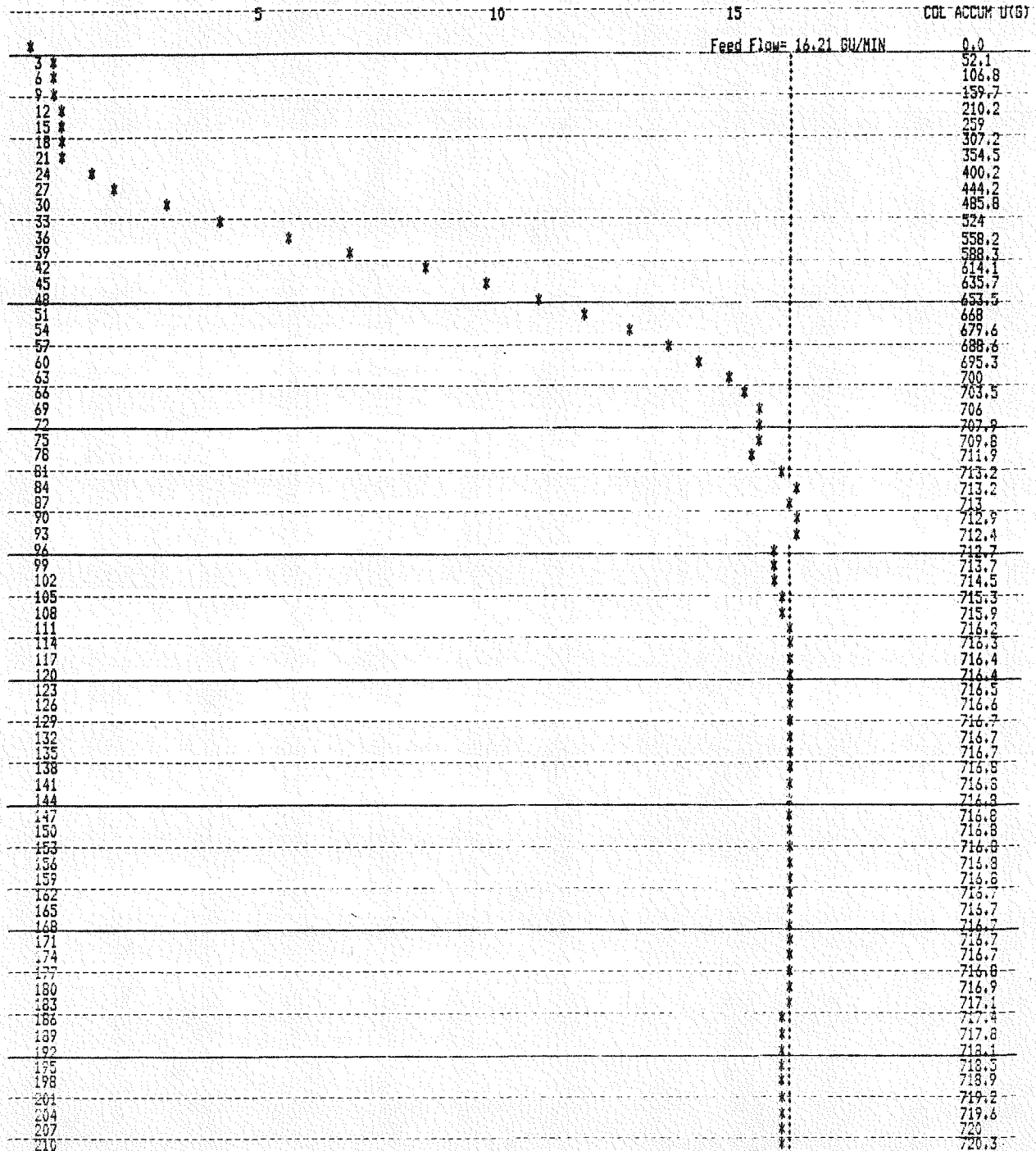
		AS	AF	AX	BX	AW	BW	
40	10:32 AM	-.112	-.322	-.271	-.28	.5	.089	0
48	11:04 AM	-.113	-.327	-.271	-.284	.483	.265	.375
56	11:36 AM	-.107	-.32	-.268	-.276	.424	.256	.26
64	12:08 PM	-.1	-.324	-.259	-.271	.415	.247	.261
72	12:40 PM	-.067	-.313	-.259	-.276	.409	.281	.25
80	01:12 PM	-.095	-.315	-.26	-.28	.411	.254	.258
88	01:44 PM	-.104	-.32	-.269	-.278	.399	.266	.256
96	02:16 PM	-.108	-.316	-.259	-.275	.404	.242	.234

APPENDIX B-4

COMPUTER URANIUM MASS RATE DIAGRAM AND COLUMN INVENTORY FROM ANALYTICAL DATA: 1A COLUMN, TEST 2AM-2

RUN ACCLT
 FEED U (G/L) & FEED FLOW (L/M)? 26.40, 0.614
 WINDOW WIDTH (MINUTES)? 35
 NUMBER OF DATA POINTS? 8
 DENOMINATOR OF VERT SCALING FACTOR? 3
 DATE OF RUN? 2AM-2
 AP FLOW RATE, L/MIN? 0.313
 ENTER ELAPSED TIME AND GRAMS U/L FOR POINT 1 ? 15, 0
 POINT 2 ? 30, 9.2
 POINT 3 ? 45, 30.9
 POINT 4 ? 60, 45.8
 POINT 5 ? 75, 49.8
 POINT 6 ? 120, 51.7
 POINT 7 ? 150, 51.8
 POINT 8 ? 210, 51.4

PLOT OF TIME(MIN) (VERT SCALE) VS U OUTFLOW(G/MIN) (HOR SCALE) FOR RUN 2AM-2

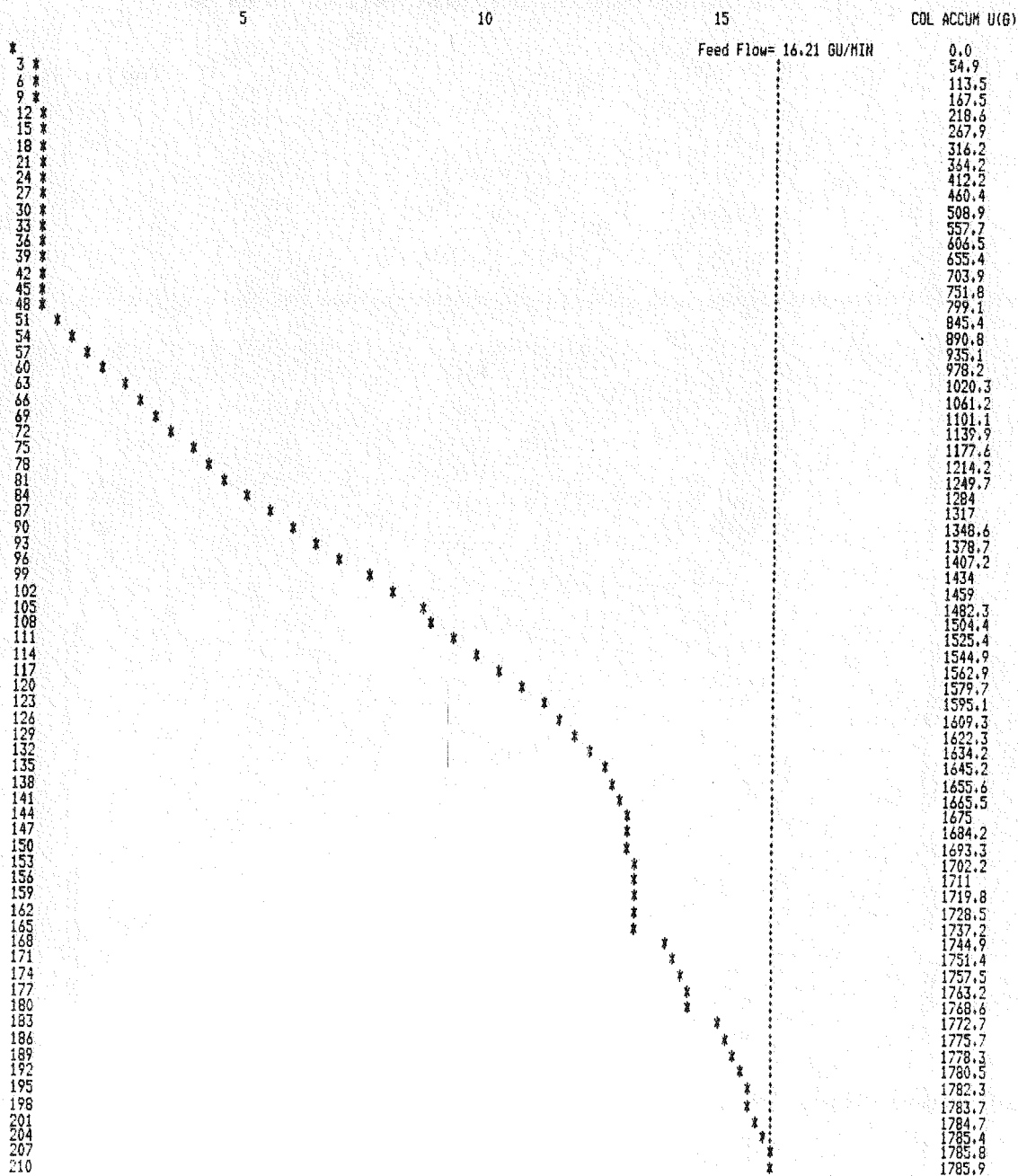


APPENDIX B-5

COMPUTER URANIUM MASS RATE DIAGRAM AND COLUMN INVENTORY FROM ANALYTICAL DATA: 1A AND 1BS COLUMNS WITH 1AP HEAD POT, TEST 2AM-2

RUN ABCOL
FEED U (G/L) & FEED FLOW (L/M)? 26.40,0.64
WINDOW WIDTH (MINUTES)? 90
DENOMINATOR OF VERT SCALING FACTOR? 3
NUMBER OF DATA POINTS? 9
DATE OF RUN? 2AM-2
BW FLOW RATE, L/MIN? 0.307
BP FLOW RATE, L/MIN? 0.325
ENTER ELAPSED TIME, BW GU/L, AND BP GU/L FOR POINT 1 ? 15,0,0
POINT 2 ? 30,0,0
POINT 3 ? 45,0,1.0
POINT 4 ? 60,0,6.2
POINT 5 ? 75,0,9,10.9
POINT 6 ? 90,3,3,8,14.8
POINT 7 ? 120,9,1,24.7
POINT 8 ? 150,11,8,29.3
POINT 9 ? 210,14,9,35.5

PLOT OF TIME(MIN) (VERT SCALE) VS U OUTFLOW(G/MIN) (HOR SCALE) FOR RUN 2AM-2



?Subscript out of range at line 300 in 'ABCOL'

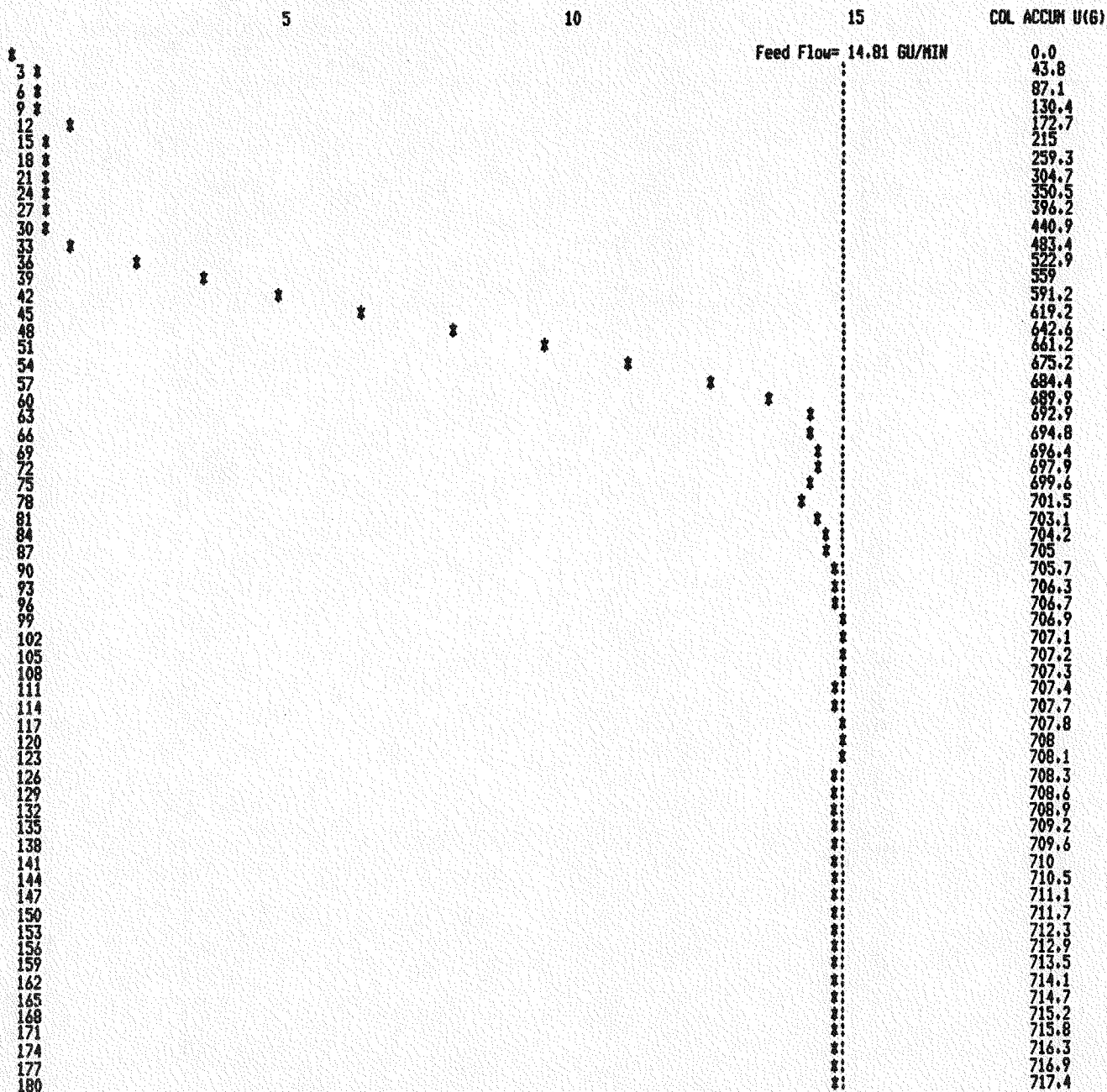
APPENDIX B-6

COMPUTER URANIUM MASS RATE DIAGRAM AND COLUMN INVENTORY FROM ANALYTICAL DATA: 1A COLUMN, TEST 2AM-3

RUN ACOLT1
FEED U (G/L) & FEED FLOW (L/H)? 26.40,0.561
WINDOW WIDTH (MINUTES)? 35
NUMBER OF DATA POINTS? 9
DENOMINATOR OF VERT SCALING FACTOR? 3
DATE OF RUN? 2AM-3
AP FLOW RATE, L/HIN? 0.321
ENTER ELAPSED TIME AND GRAMS U/L FOR POINT 1 ? 15,1.0

POINT 2 ? 30,0.7
POINT 3 ? 45,19.4
POINT 4 ? 60,42.0
POINT 5 ? 75,44.3
POINT 6 ? 90,45.5
POINT 7 ? 120,46.0
POINT 8 ? 150,45.5
POINT 9 ? 180,45.6

PLOT OF TIME(MIN) (VERT SCALE) VS U OUTFLOW(G/HIN) (HOR SCALE) FOR RUN 2AM-3

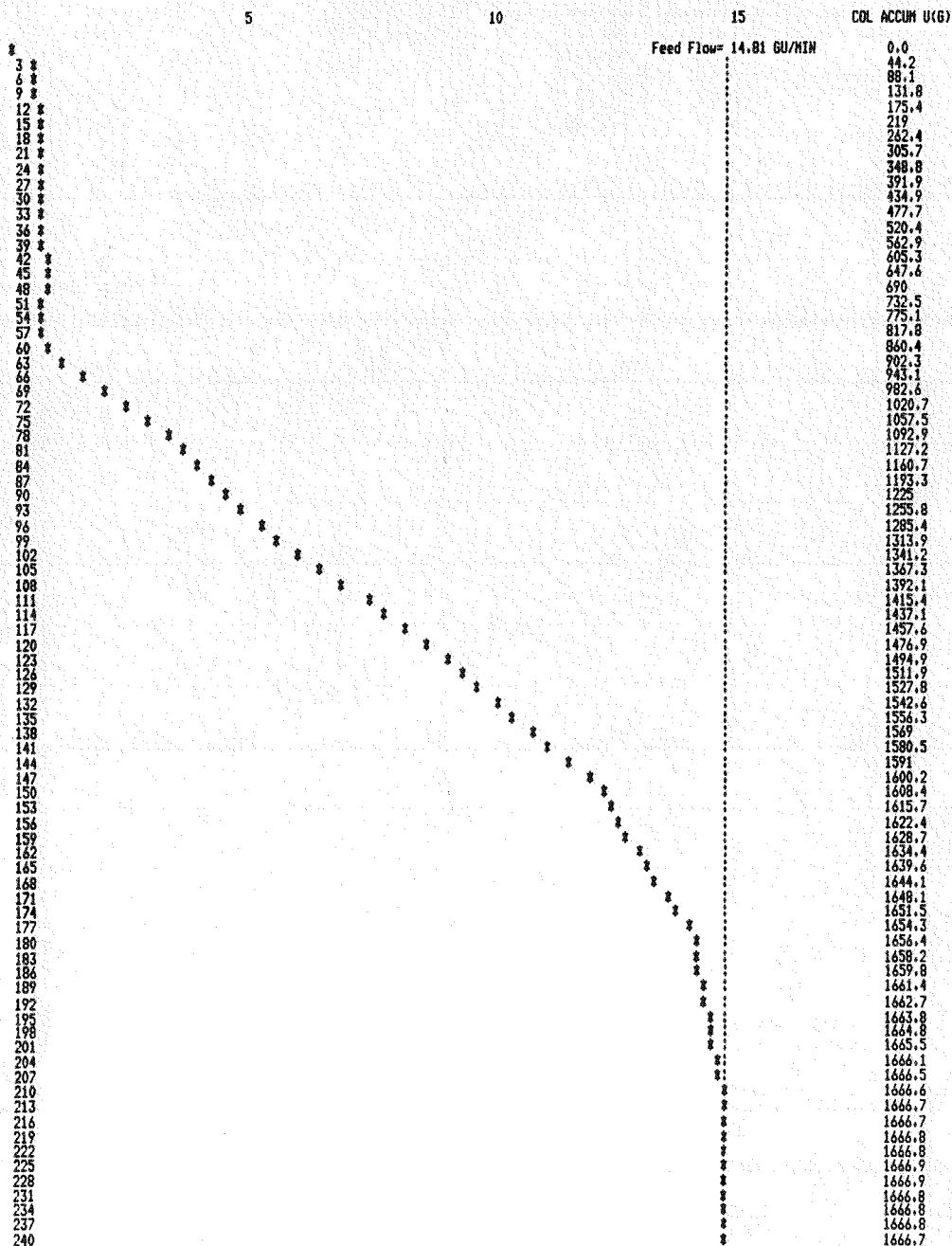


APPENDIX B-7

COMPUTER URANIUM MASS RATE DIAGRAM AND COLUMN INVENTORY FROM ANALYTICAL DATA: 1A AND 1BS COLUMNS WITH 1AP HEAD POT, TEST 2AM-3

RUN ABOVE
FEED U (G/L) & FEED FLOW (L/H)? 26.40,0.561
WINDOW WIDTH (MINUTES)? 35
DENOMINATOR OF VERT. SCALING FACTOR? 3
NUMBER OF DATA POINTS? 11
DATE OF RUN? 2AM-3
BW FLOW RATE, L/MIN? 0.317
BP FLOW RATE, L/MIN? 0.322
ENTER ELAPSED TIME, BW GU/L, AND BP GU/L FOR POINT 1 ? 15,0,1.0
POINT 2 ? 30,0,1.6
POINT 3 ? 45,0,2.2
POINT 4 ? 60,0,2.2
POINT 5 ? 75,1,0,7.7
POINT 6 ? 90,2,3,11.4
POINT 7 ? 120,6,5,20.3
POINT 8 ? 150,12,6,25.5
POINT 9 ? 180,15,0,29.0
POINT 10 ? 210,15,6,30.3
POINT 11 ? 240,15,6,30.5

PLOT OF TIME(MIN) (VERT SCALE) VS U OUTFLOW(G/MIN) (HOR SCALE) FOR RUN 2AM-3



APPENDIX B-8

COMPUTER URANIUM MASS RATE DIAGRAM AND COLUMN INVENTORY FROM ANALYTICAL DATA: 1A COLUMN, TEST 2AM-4

MCR>ABQ
09:19:50 TASK 'TT11' TERMINATED
ABORTED VIA DIRECTIVE OR MCR
AND WITH PENDING IO REQUESTS

>RUN A COLT-U
RUN ACOLT

FEED U (G/L) & FEED FLOW (L/M)? 26.40,0.325

WINDOW WIDTH (MINUTES)? 35

NUMBER OF DATA POINTS? 7

DENOMINATOR OF VERT SCALING FACTOR? 3

DATE OF RUN? 2AM-4

AP FLOW RATE, L/MIN? 0.300

ENTER ELAPSED TIME AND GRAMS U/L FOR POINT 1 ? 15,0

POINT 2 ? 30,4.1

POINT 3 ? 45,16.9

POINT 4 ? 60,23.3

POINT 5 ? 75,27.8

POINT 6 ? 90,28.5

POINT 7 ? 120,28.5

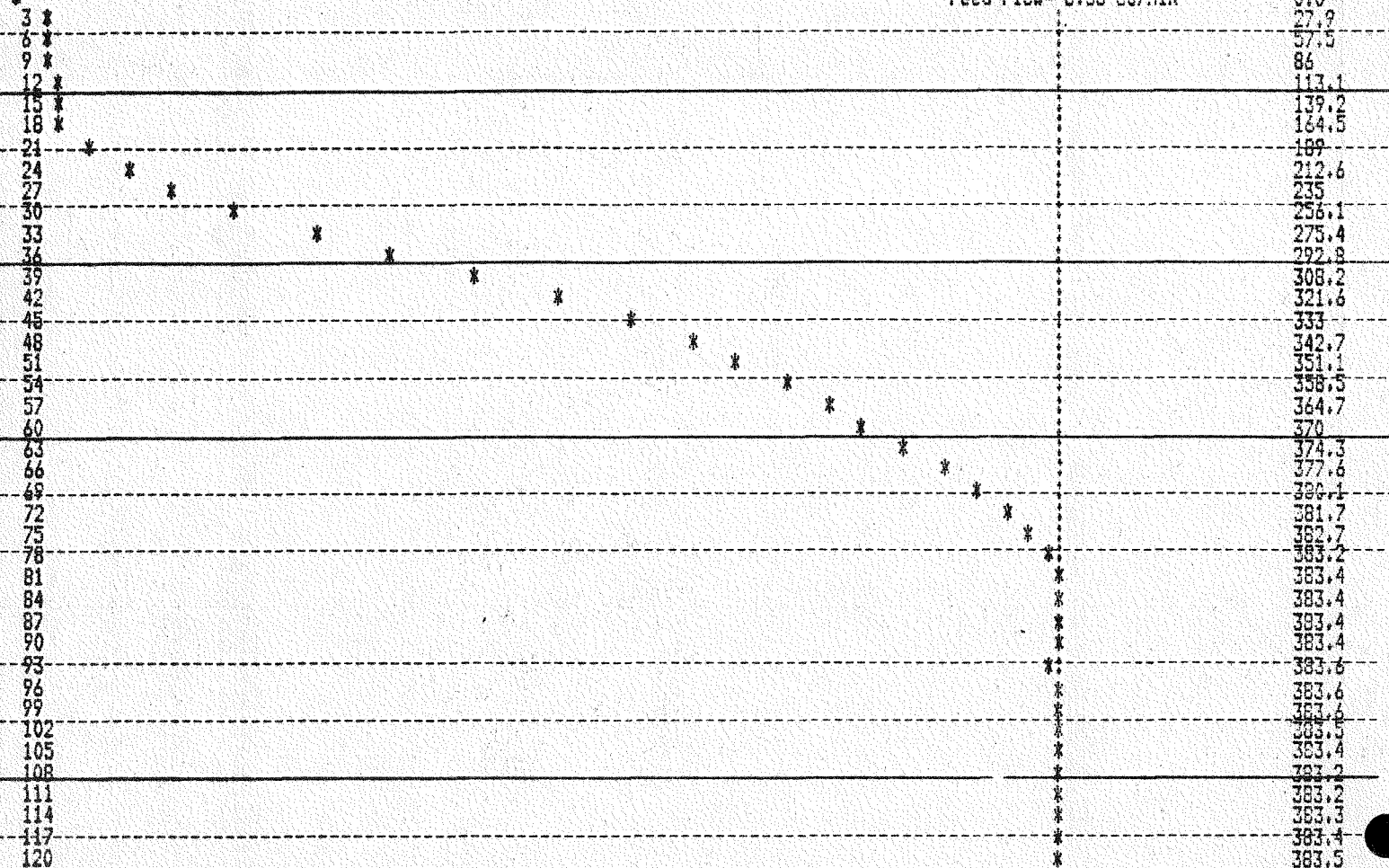
PLOT OF TIME(MIN) (VERT SCALE) VS U OUTFLOW(G/MIN) (HOR SCALE) FOR RUN 2AM-4

5

COL ACCUM U(G)

Feed Flow= 8.58 GU/MIN

0.0

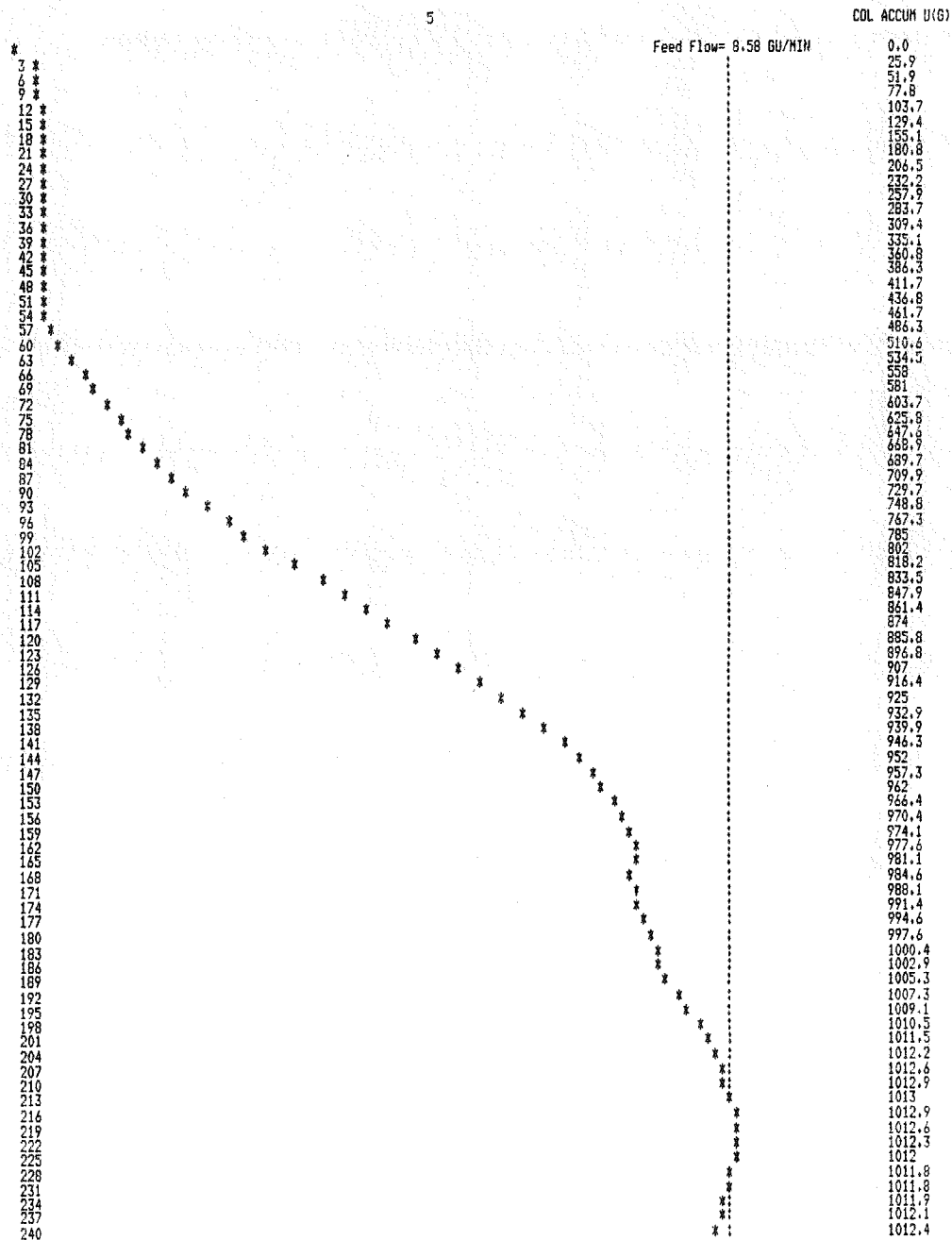


APPENDIX B-9

COMPUTER URANIUM MASS RATE DIAGRAM AND COLUMN INVENTORY FROM ANALYTICAL DATA: 1A AND 1BS COLUMNS WITH 1AP HEAD POT, TEST 2AM-4

RUN ABCOL
FEED U (G/L) & FEED FLOW (L/M)? 26.40,0.325
WINDOW WIDTH (MINUTES)? 75
DENOMINATOR OF VERT SCALING FACTOR? 3
NUMBER OF DATA POINTS? 10
DATE OF RUN? 2AM-4
BW FLOW RATE, L/MIN? 0.298
BP FLOW RATE, L/MIN? 0.306
ENTER ELAPSED TIME, BW GU/L, AND BP GU/L FOR POINT 1 ? 15,0,0
POINT 2 ? 30,0,0
POINT 3 ? 45,0,0.3
POINT 4 ? 60,0,1.8
POINT 5 ? 90,1.3,5.6
POINT 6 ? 120,5.6,10.2
POINT 7 ? 150,8.2,15.1
POINT 8 ? 180,8.0,17.1
POINT 9 ? 210,8.9,19.2
POINT 10 ? 240,9.1,18.7

PLOT OF TIME(MIN) (VERT SCALE) VS U OUTFLOW(G/MIN) (HOR SCALE) FOR RUN 2AM-4



?Subscript out of range at line 300 in 'ABCOL '

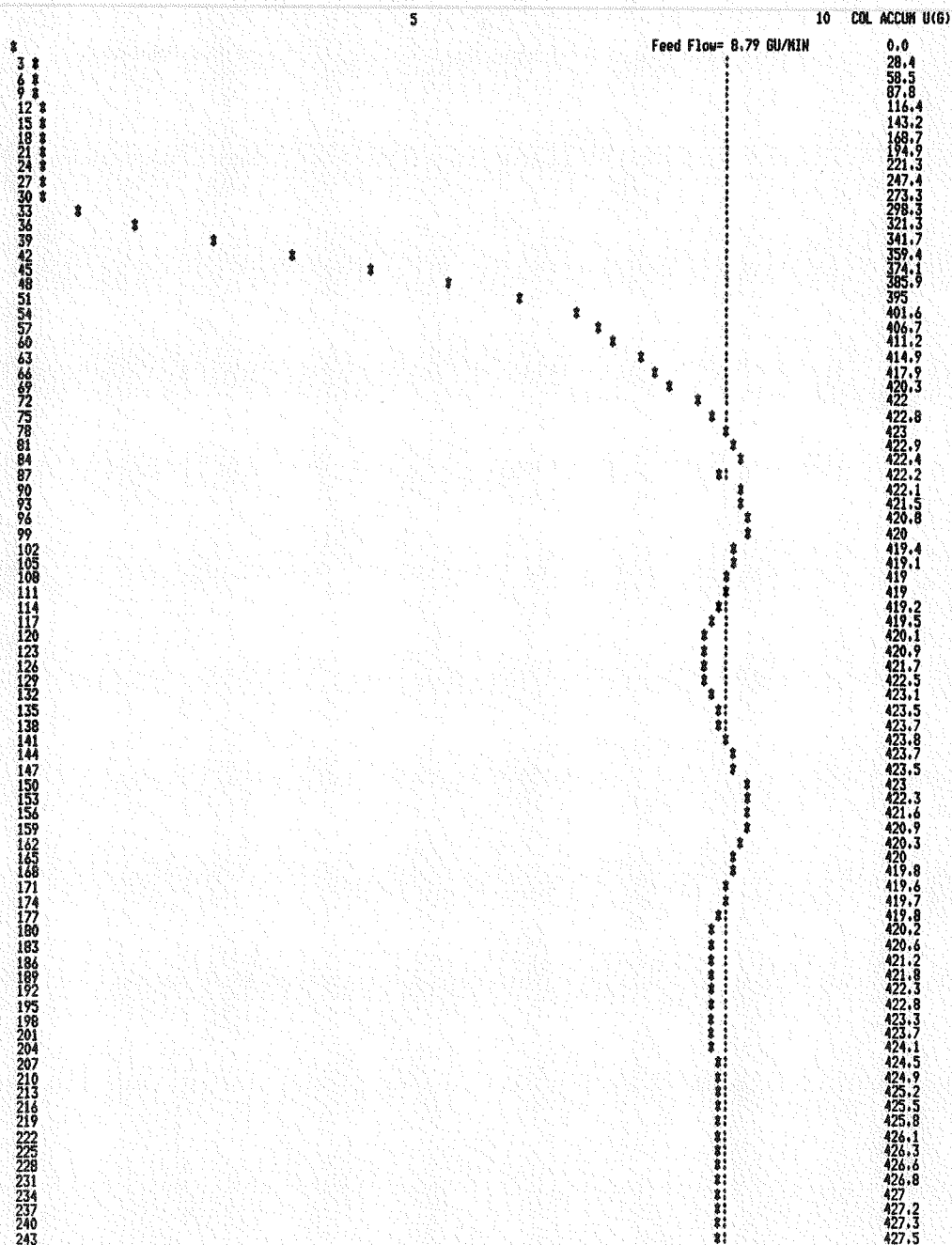
>

APPENDIX B-10

COMPUTER URANIUM MASS RATE DIAGRAM AND COLUMN INVENTORY FROM ANALYTICAL DATA: 1A COLUMN, TEST 2AM-5

RUN ACOLTI
FEED U (G/L) & FEED FLOW (L/H)? 26.40/0.333
WINDOW WIDTH (MINUTES)? 35
NUMBER OF DATA POINTS? 10
DENOMINATOR OF VERT SCALING FACTOR? 3
DATE OF RUN? 2AM-5
AP FLOW RATE, L/HIN? 0.284
ENTER ELAPSED TIME AND GRAMS U/L FOR POINT 1 ? 20,0.1
POINT 2 ? 35,4.4
POINT 3 ? 50,20.9
POINT 4 ? 65,27.6
POINT 5 ? 75,31.8
POINT 6 ? 125,30.0
POINT 7 ? 155,31.8
POINT 8 ? 185,30.3
POINT 9 ? 215,30.6
POINT 10 ? 245,30.91918

PLOT OF TIME(MIN) (VERT SCALE) VS U OUTFLOW(G/MIN) (HOR SCALE) FOR RUN 2AM-5

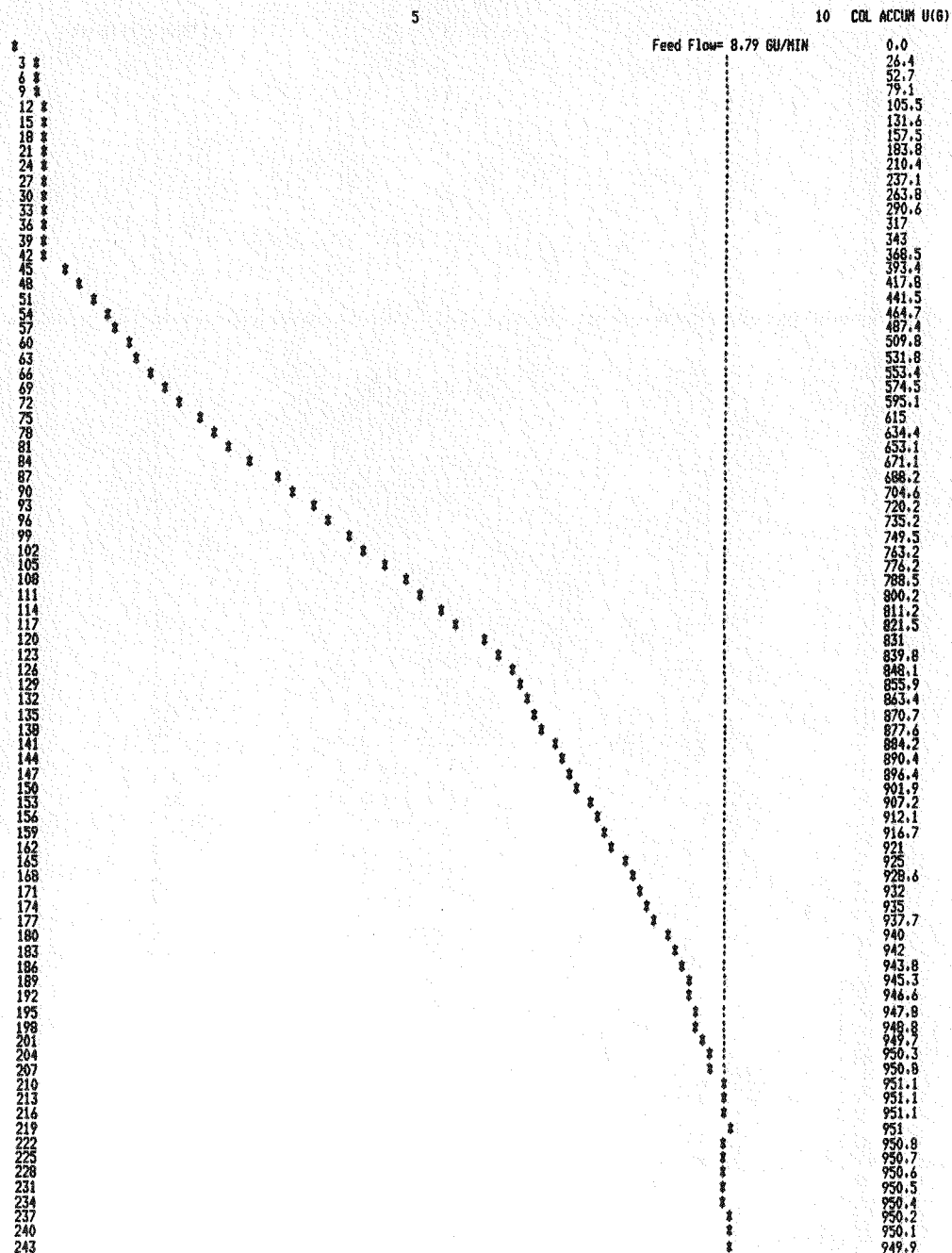


APPENDIX B-11

COMPUTER URANIUM MASS RATE DIAGRAM AND COLUMN INVENTORY FROM ANALYTICAL DATA: 1A AND 1BS COLUMNS WITH 1AP HEAD POT, TEST 2AM-5

RUN ABOLU
FEED U (G/L) & FEED FLOW (L/H)? 26.40,0.333
WINDOW WIDTH (MINUTES)? 35
DENOMINATOR OF VERT SCALING FACTOR? 3
NUMBER OF DATA POINTS? 10
DATE OF RUN? 2AM-5
BW FLOW RATE, L/HIN? 0.282
BP FLOW RATE, L/HIN? 0.305
ENTER ELAPSED TIME, BW GU/L, AND BP GU/L FOR POINT 1 ? 20,0,0
POINT 2 ? 35,0,0
POINT 3 ? 50,0,1,2.9
POINT 4 ? 65,1,0,4.4
POINT 5 ? 80,4,4,8.5
POINT 6 ? 125,5,6,14.7
POINT 7 ? 155,7,9,16.2
POINT 8 ? 185,9,8,17.6
POINT 9 ? 215,10,9,18.8
POINT 10 ? 245,10,8,19.0

PLOT OF TIME(MIN) (VERT SCALE) VS U OUTFLOW(G/HIN) (HOR SCALE) FOR RUN 2AM-5



APPENDIX B-12

COMPUTER URANIUM MASS RATE DIAGRAM AND COLUMN INVENTORY FROM ANALYTICAL DATA: 1BS COLUMN WITH 1AP HEAD POT, TEST 2AM-5

RUN BCOLT
FEED U (G/L) & FEED FLOW (L/H)? 26.40,0.333

WINDOW WIDTH (MINUTES)? 75
DENOMINATOR OF VERT SCALING FACTOR? 3

NUMBER OF DATA POINTS? 10

DATE OF RUN? 2AM-5

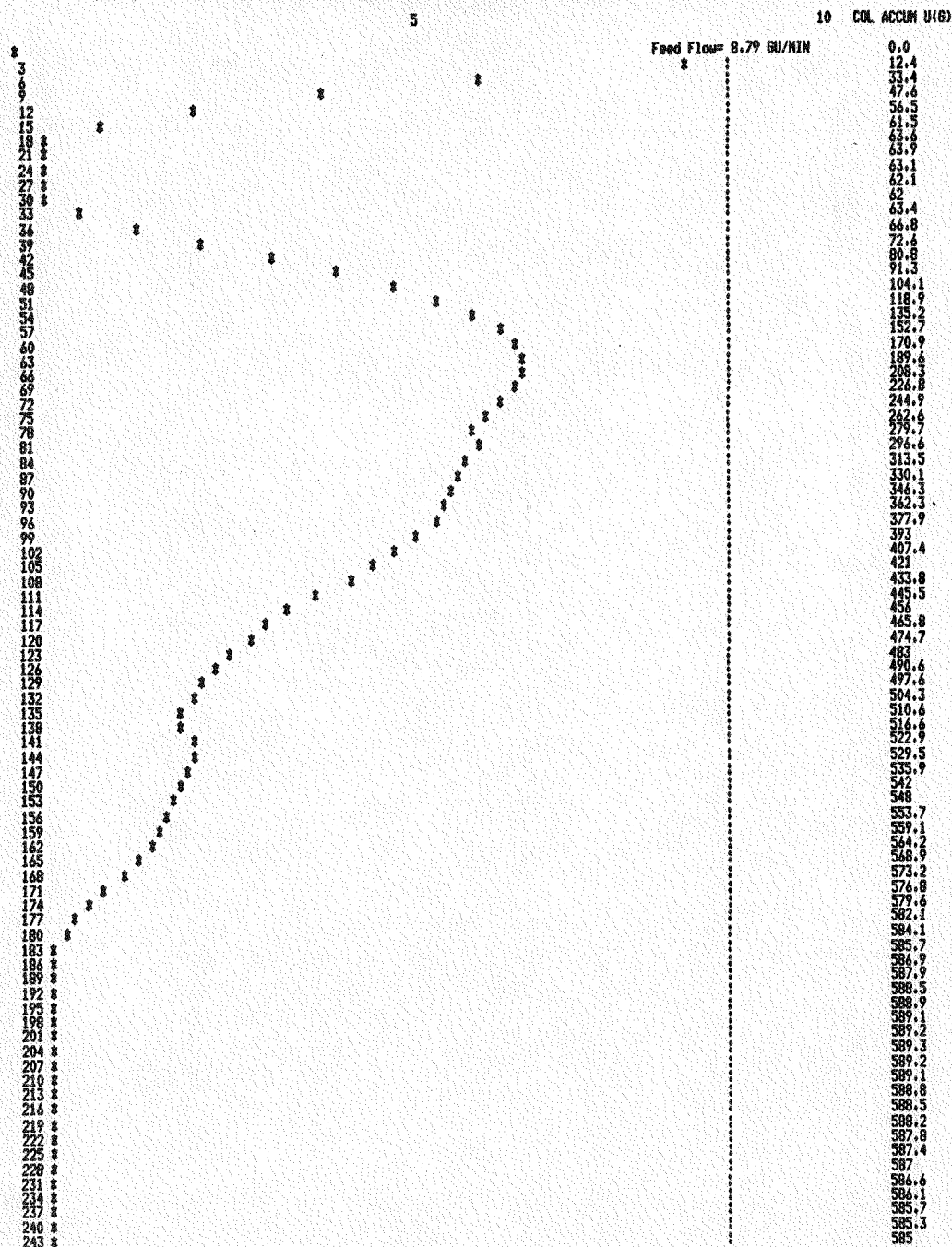
AP FLOW RATE, L/RIN? 0.285

BP FLOW RATE, L/RIN? 0.283

DP FLOW RATE, L/RIN? 0.305

ENTER ELAPSED TIME, IN GU/L, BP GU/L, AND AP GU/L FOR POINT 1 ? 20.0,0.0,0.1
POINT 2 ? 35.0,0.0,4.4
POINT 3 ? 50.0,1.2,9.20.9
POINT 4 ? 65.1,0.4,4.27.6
POINT 5 ? 75.4,4.8,5.31.8
POINT 6 ? 125.5,6.14,7.30.0
POINT 7 ? 155.7,9.16,2.31.8
POINT 8 ? 185.9,8.17,9.30.3
POINT 9 ? 215.10.9,18.8,30.6
POINT 10 ? 245.10.8,19.0,30.8

PLOT OF TIME(MIN) (VERT SCALE) VS U RETENTION(G/MIN) (HOR SCALE) FOR RUN 2AM-5

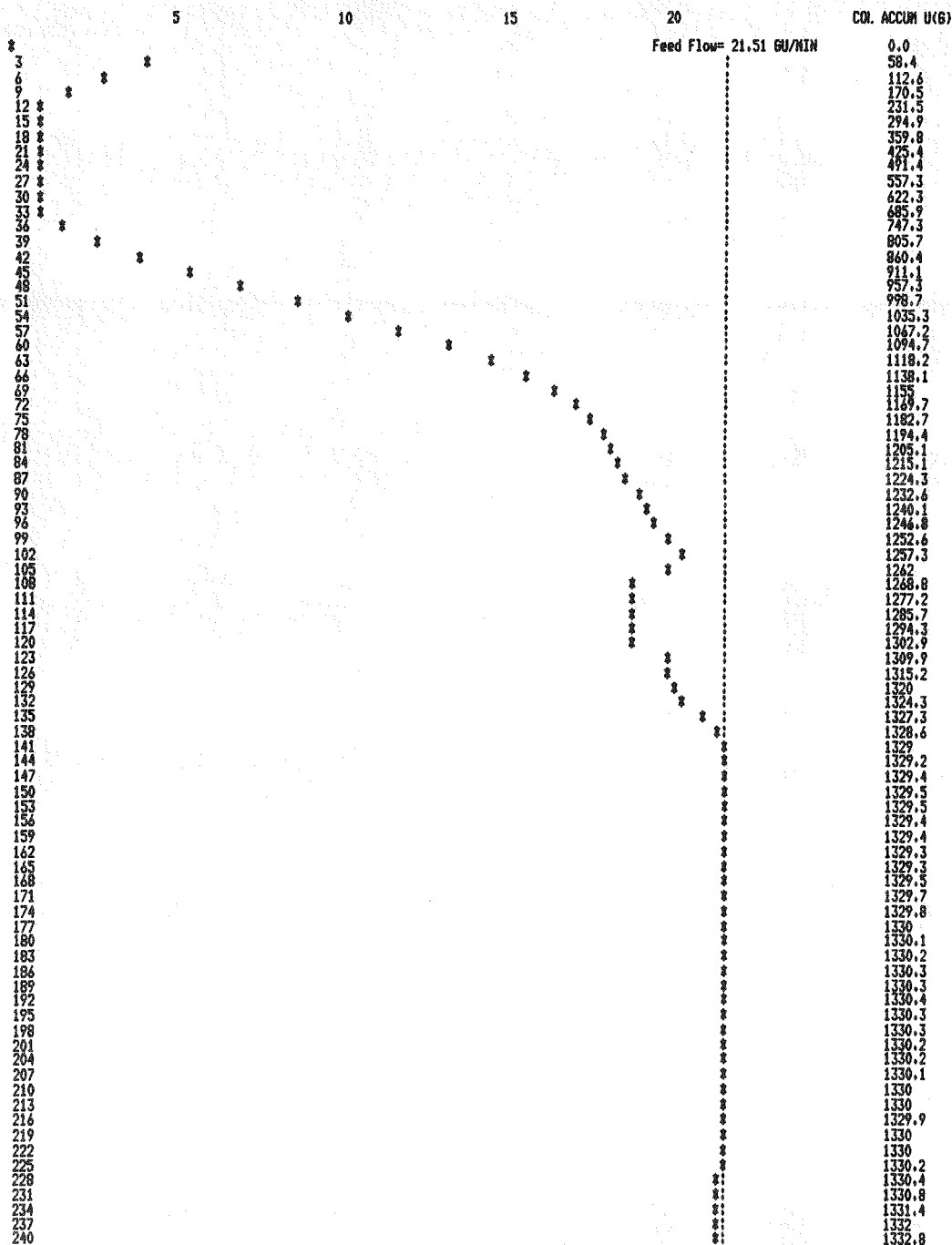


APPENDIX B-13

COMPUTER URANIUM MASS RATE DIAGRAM AND COLUMN INVENTORY FROM ANALYTICAL DATA: 1A COLUMN, TEST 3AM-1

RUN ACCLT
FEED U (G/L) & FEED FLOW (L/H)? 40.13,0.536
WINDOW WIDTH (MINUTES)? 75
NUMBER OF DATA POINTS? 10
DENOMINATOR OF VERT SCALING FACTOR? 3
DATE OF RUN? 3AM-1
AP FLOW RATE, L/HIN? 0.266
AM FLOW RATE, L/HIN? 0.630
ENTER ELAPSED TIME AND GRAMS U/L IN AP AND AM FOR POINT 1 ? 15,0.0
POINT 2 ? 30,0.0
POINT 3 ? 45,20.1,0
POINT 4 ? 60,49.1,0
POINT 5 ? 75,65.5,0
POINT 6 ? 90,69.0,0.9
POINT 7 ? 150,71.6,3.9
POINT 8 ? 180,72.9,3.3
POINT 9 ? 210,71.0,4.2
POINT 10 ? 240,70.3,4.0

PLOT OF TIME(MIN) (VERT SCALE) VS U OUTFLOW(G/HIN) (HOR SCALE) FOR RUN 3AM-1

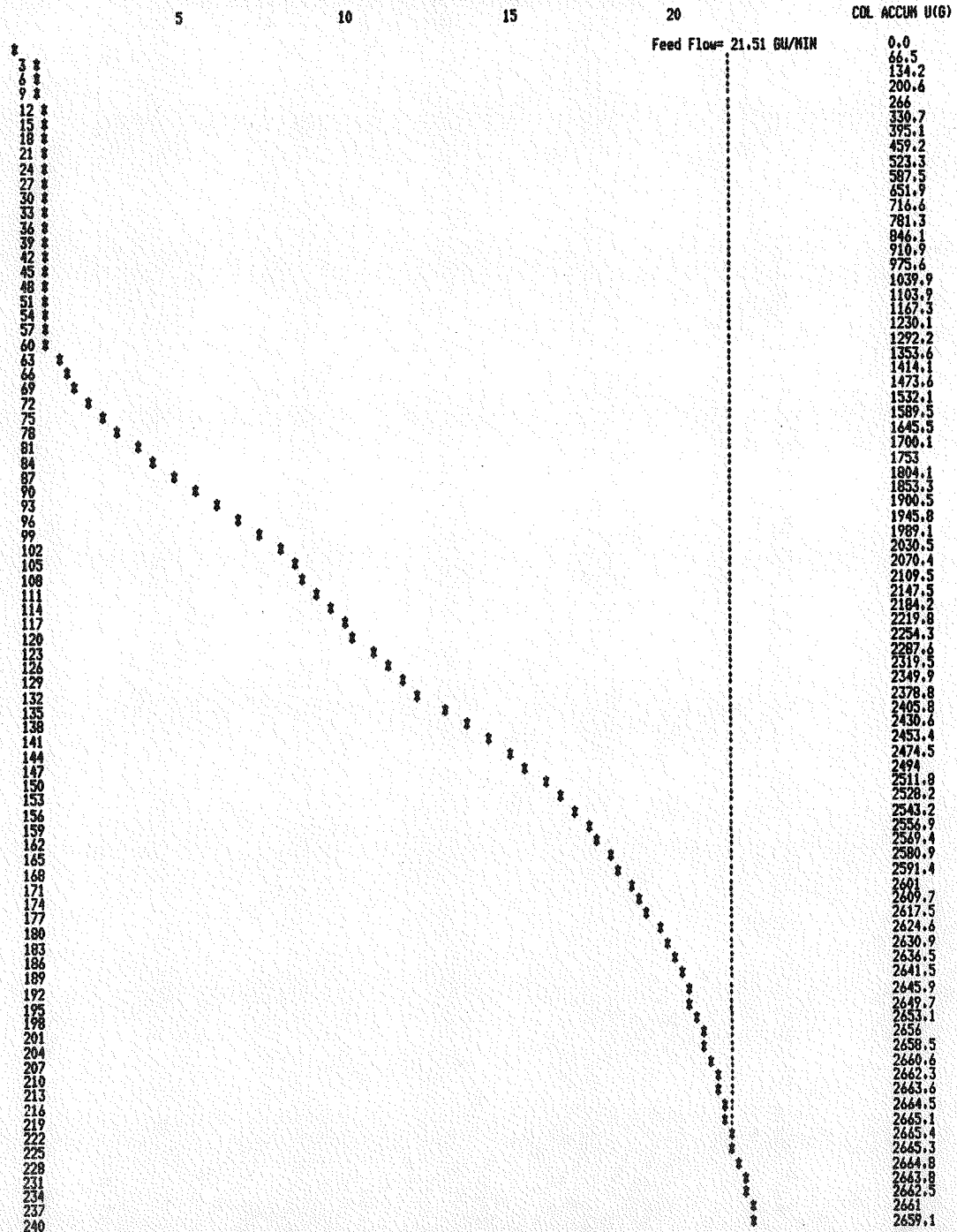


APPENDIX B-14

COMPUTER URANIUM MASS RATE DIAGRAM AND COLUMN INVENTORY FROM ANALYTICAL DATA: 1A AND 1BS COLUMNS WITH LAP HEAD POT, TEST 3AM-1

RUN ABCOL
FEED U (G/L) & FEED FLOW (L/H)? 40.13,0.536
WINDOW WIDTH (MINUTES)? 75
DENOMINATOR OF VERT SCALING FACTOR? 3
NUMBER OF DATA POINTS? 11
DATE OF RUN? 3AM-1
BU FLOW RATE, L/H? 0.258
BP FLOW RATE, L/H? 0.306
ENTER ELAPSED TIME, BU GU/L, AND BP GU/L FOR POINT 1 ? 15,0,0
POINT 2 ? 30,0,0
POINT 3 ? 45,0,0
POINT 4 ? 60,0,3.02
POINT 5 ? 75,0,8.5
POINT 6 ? 90,0,17.8
POINT 7 ? 122,2,0,0,33.1
POINT 8 ? 150,2,6,48.5
POINT 9 ? 180,5,6,56.5
POINT 10 ? 210,5,6,61.5
POINT 11 ? 240,6,8,63.9

PLOT OF TIME(MIN) (VERT SCALE) VS U OUTFLOW(G/HIN) (HOR SCALE) FOR RUN 3AM-1



APPENDIX B-15

COMPUTER URANIUM MASS RATE DIAGRAM AND COLUMN INVENTORY FROM ANALYTICAL DATA: 1A COLUMN, TEST 3AM-2

RUN ACOL1

FEED U (G/L) & FEED FLOW (L/H)? 40.13,0.452

WINDOW WIDTH (MINUTES)? 35

NUMBER OF DATA POINTS? 10

DENOMINATOR OF VERT SCALING FACTOR? 3

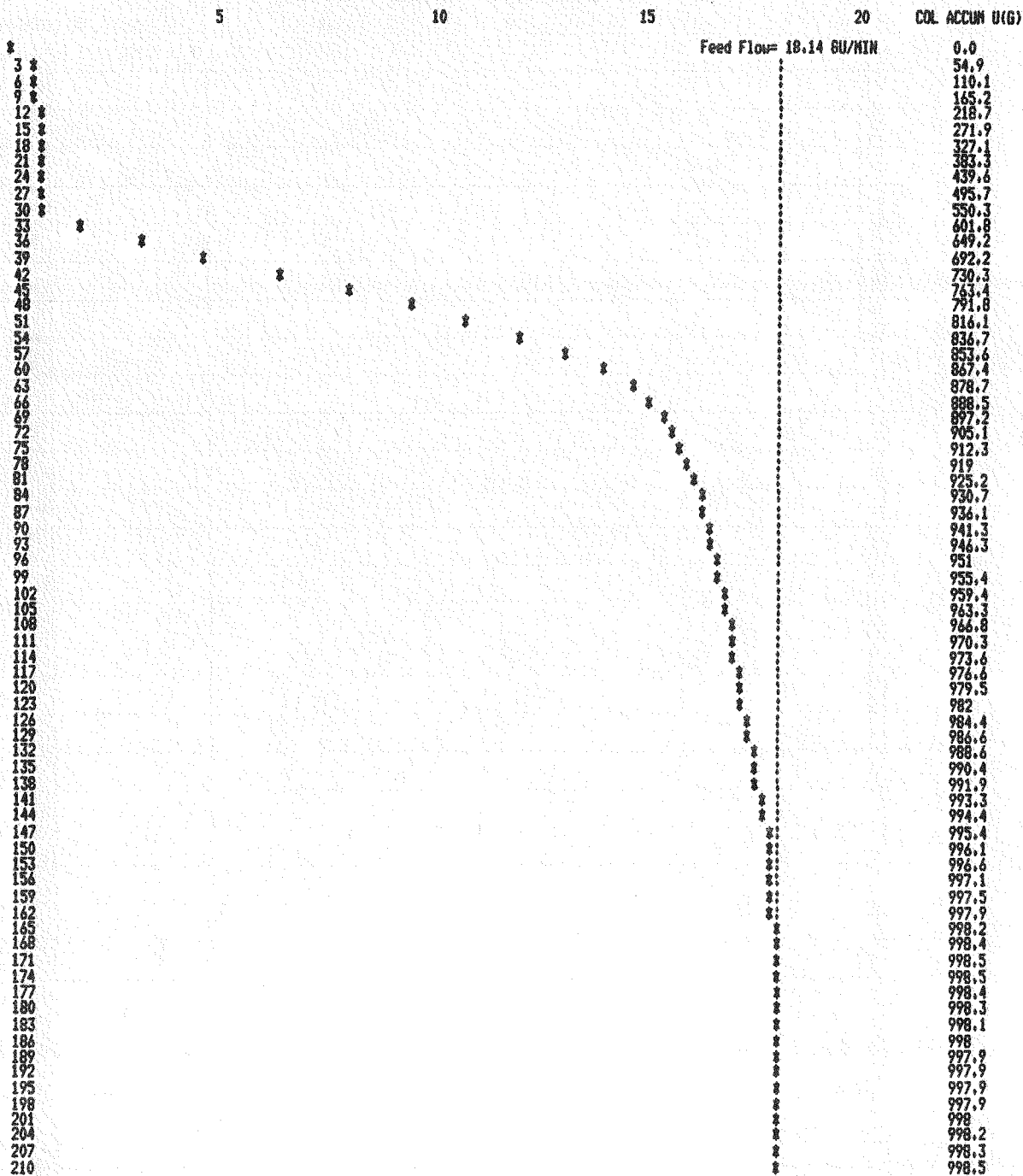
DATE OF RUN? 3AM-2

AP FLOW RATE: L/HIN? 0.266

ENTER ELAPSED TIME AND GRAMS U/L FOR

POINT	TIME (MIN)	GRAMS U/L
1	15.0	
2	30.1.5	
3	45.29.7	
4	60.32.6	
5	75.39.5	
6	90.61.8	
7	120.64.8	
8	150.67.4	
9	180.68.4	
10	210.67.9	

PLOT OF TIME(MIN) (VERT SCALE) VS U OUTFLOW(G/MIN) (HOR SCALE) FOR RUN 3AM-2

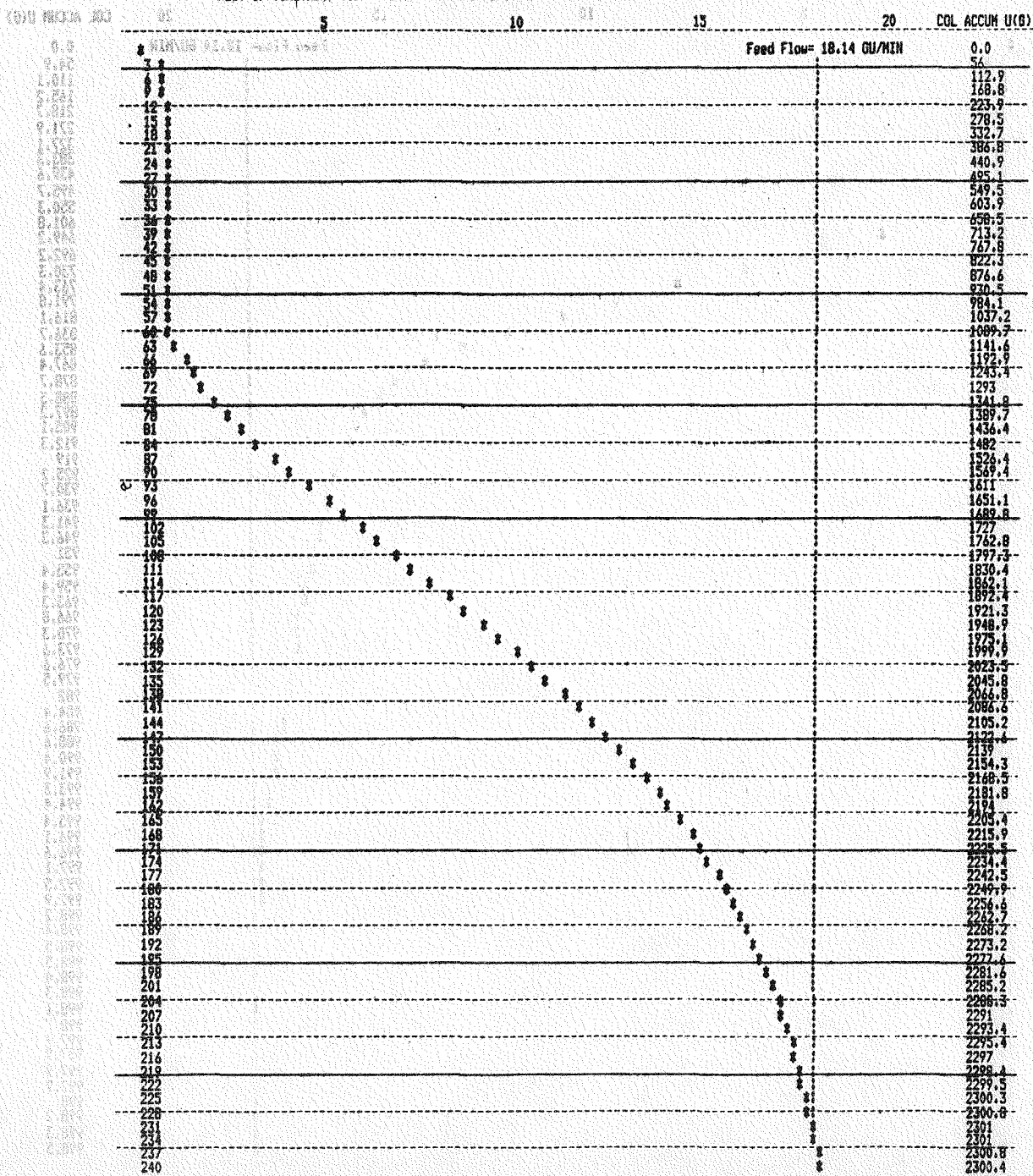


APPENDIX B-16

COMPUTER URANIUM MASS RATE DIAGRAM AND COLUMN INVENTORY FROM ANALYTICAL DATA: 1A AND 1BS COLUMNS WITH LAP HEAD POT, TEST 3AM-2

RUN ABCOL
 FEED U (G/L) & FEED FLOW (L/MIN) 40.13, 0.452
 MINIMUM WIDTH (INCHES) 1.75
 DENOMINATOR OF VERT SCALING FACTOR? 3
 NUMBER OF DATA POINTS? 11
 DATE OF RUN: JAN-2
 IN FLOW RATE, L/MIN? 0.260, 1
 OP FLOW RATE, L/MIN? 0.279
 ENTER ELAPSED TIME, IN G/L, AND OP BUZL FOR POINT 1 ? 13:00.0
 POINT 2 ? 30:0.0
 POINT 3 ? 45:0.0
 POINT 4 ? 60:0.2.6
 POINT 5 ? 75:1.8, 5.6, 1.5
 POINT 6 ? 90:3.2, 11.5
 POINT 7 ? 120:5.8, 25.8
 POINT 8 ? 150:6.5, 39.6
 POINT 9 ? 180:10.2, 46.7
 POINT 10 ? 210:12.5, 49.6
 POINT 11 ? 240:12.4, 52.4

PLOT OF TIME (MIN) (VERT SCALE) VS U OUTFLOW (G/MIN) (HOR SCALE) FOR RUN JAN-2

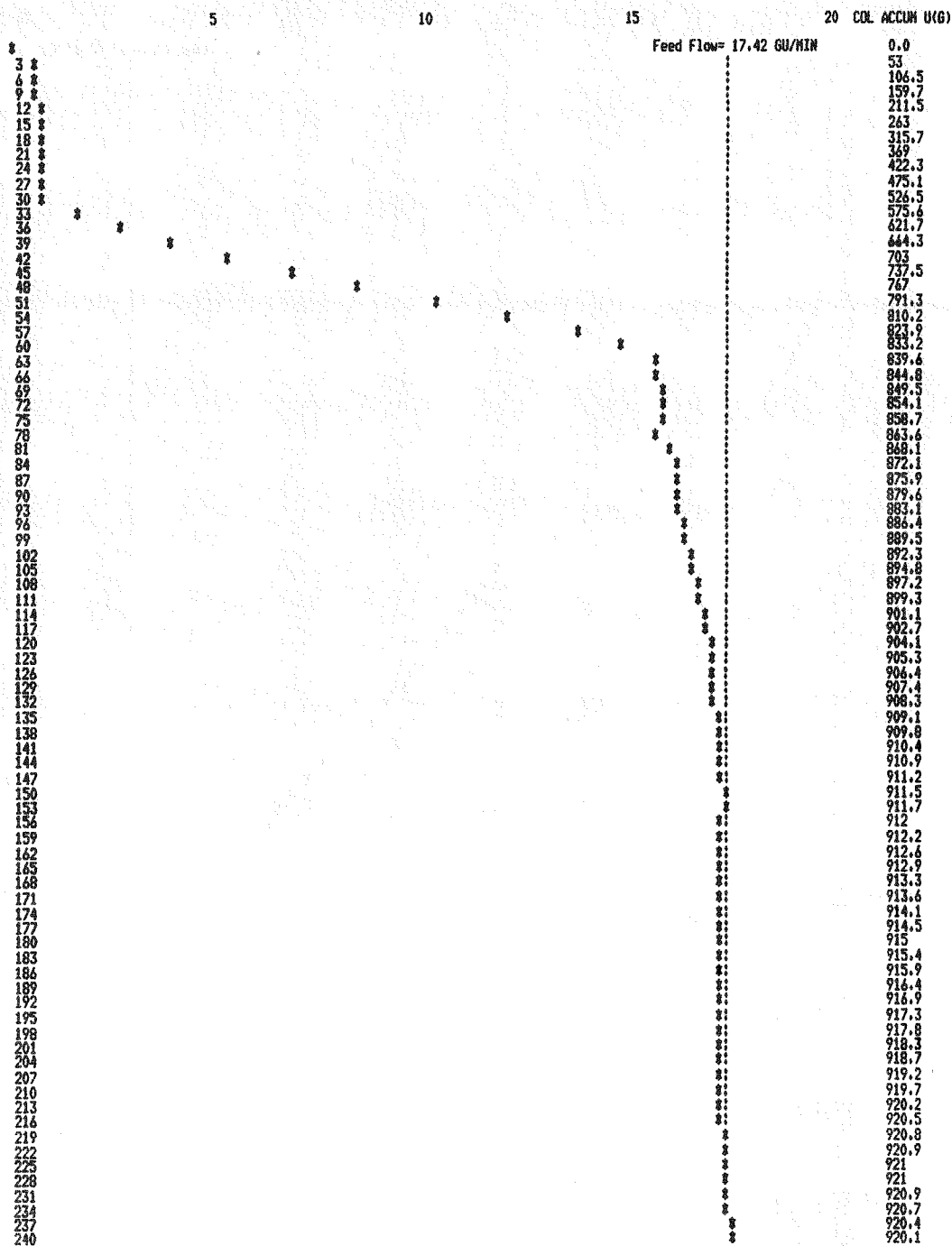


APPENDIX B-17

COMPUTER URANIUM MASS RATE DIAGRAM AND COLUMN INVENTORY FROM ANALYTICAL DATA: 1A COLUMN, TEST 3AM-3

RUN ACOL1
FEED U (G/L) & FEED FLOW (L/M)? 40.13+0.434
WINDOW WIDTH (MINUTES)? 35
NUMBER OF DATA POINTS? 11
DENOMINATOR OF VERT SCALING FACTOR? 3
DATE OF RUN? 3AM-3
AP FLOW RATE, L/MIN? 0.268
ENTER ELAPSED TIME AND GRAMS U/L FOR POINT 1 ? 15+0
POINT 2 ? 30+2.3
POINT 3 ? 45+25.1
POINT 4 ? 60+55.5
POINT 5 ? 75+59.1
POINT 6 ? 90+60.5
POINT 7 ? 120+63.4
POINT 8 ? 150+64.7
POINT 9 ? 180+64.4
POINT 10 ? 210+64.4
POINT 11 ? 240+65.5

PLOT OF TIME(MIN) (VERT SCALE) VS U OUTFLOW(G/MIN) (HOR SCALE) FOR RUN 3AM-3



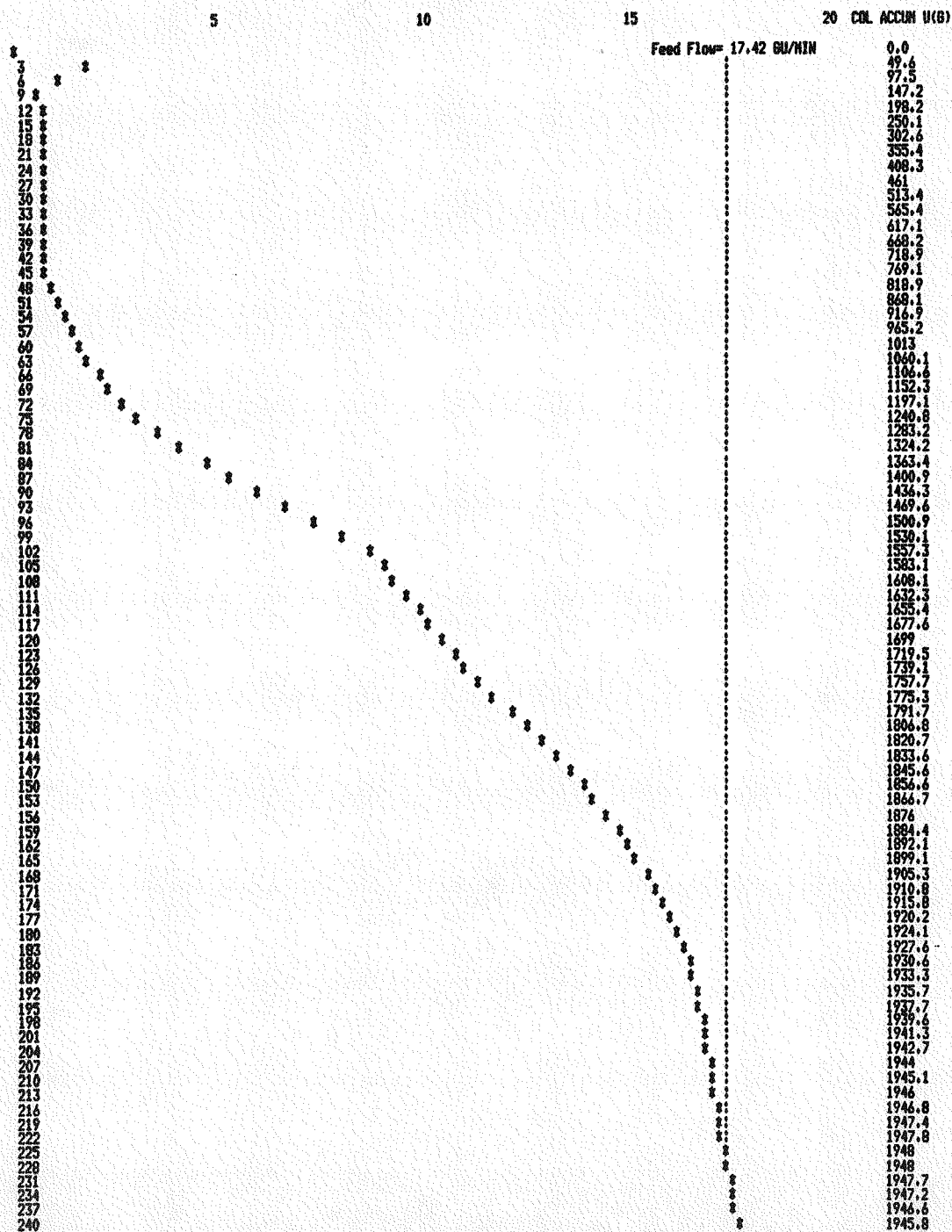
APPENDIX B-18

COMPUTER URANIUM MASS RATE DIAGRAM AND COLUMN INVENTORY FROM ANALYTICAL DATA: 1A AND 1BS COLUMNS WITH 1AP HEAD POT, TEST 3AM-3

RUN ABCOL
FEED U (G/L) & FEED FLOW (L/H)? 40.13,0.434
WINDOW WIDTH (MINUTES)? 75
DENOMINATOR OF VERT SCALING FACTOR? 3
NUMBER OF DATA POINTS? 11
DATE OF RUN? 3AM-3
BU FLOW RATE, L/H? 0.262
BP FLOW RATE, L/H? 0.270
ENTER ELAPSED TIME, BU GU/L, AND BP GU/L FOR POINT 1 ? 15:0:0

POINT 2 ? 30:0:0
POINT 3 ? 45:0:2.8
POINT 4 ? 60:0:5.9
POINT 5 ? 75:0:11.3
POINT 6 ? 90:1:3:20.8
POINT 7 ? 120:5:4:32.9
POINT 8 ? 150:8:5:42.6
POINT 9 ? 180:11:5:47.8
POINT 10 ? 210:12:1:50.3
POINT 11 ? 240:12:7:51.9

PLOT OF TIME(MIN) (VERT SCALE) VS U OUTFLOW(G/MIN) (HOR SCALE) FOR RUN 3AM-3



APPENDIX B-19

COMPUTER URANIUM MASS RATE DIAGRAM AND COLUMN INVENTORY FROM ANALYTICAL DATA: 1BS COLUMN WITH 1AP HEAD POT, TEST 3AM-3

RUN DCBLT

FEED U (G/L) & FEED FLOW (L/H)? 40.3,0.434

WINDOW WIDTH (MINUTES)? 75

DENOMINATOR OF VERY SCALING FACTOR? 3

NUMBER OF DATA POINTS? 11

DATE OF RUN? 3AM-3

AP FLOW RATE, L/H? 0.269

BW FLOW RATE, L/H? 0.263

BP FLOW RATE, L/H? 0.270

ENTER ELAPSED TIME, BW GU/L, BP GU/L, AND AP GU/L FOR POINT 1 ? 15,0,0,0

POINT 2 ? 30,0,0,2.3

POINT 3 ? 45,0,2.8,25.1

POINT 4 ? 60,0,5.9,53.5

POINT 5 ? 75,0,11.3,59.1

POINT 6 ? 90,1.3,20.8,60.5

POINT 7 ? 120,5.6,32.9,63.4

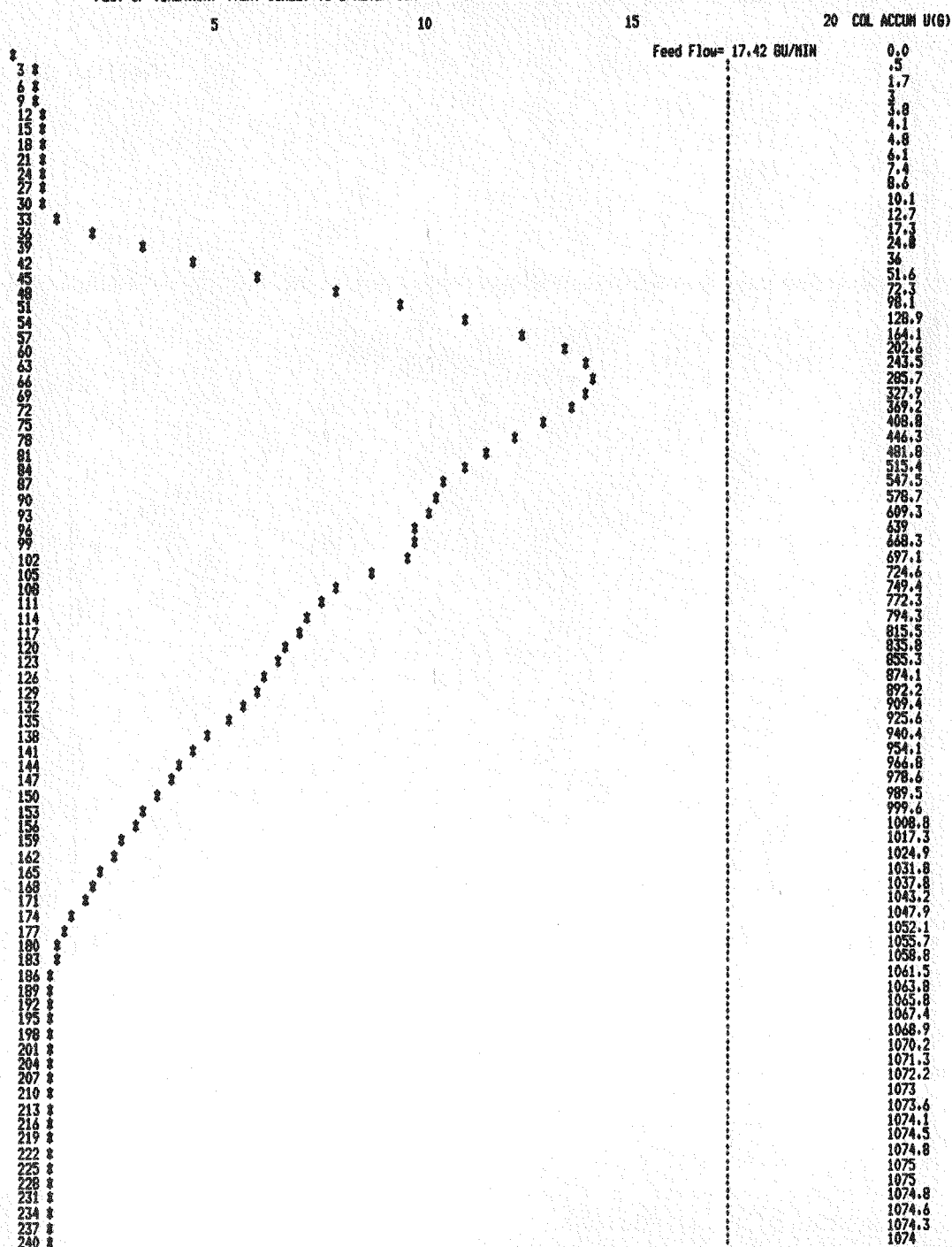
POINT 8 ? 150,8.5,42.6,64.7

POINT 9 ? 180,11.5,47.8,64.4

POINT 10 ? 210,12.1,50.3,64.4

POINT 11 ? 240,12.7,51.9,63.5

PLOT OF TIME(MIN) (VERT SCALE) VS U RETENTION(G/MIN) (HOR SCALE) FOR RUN 3AM-3



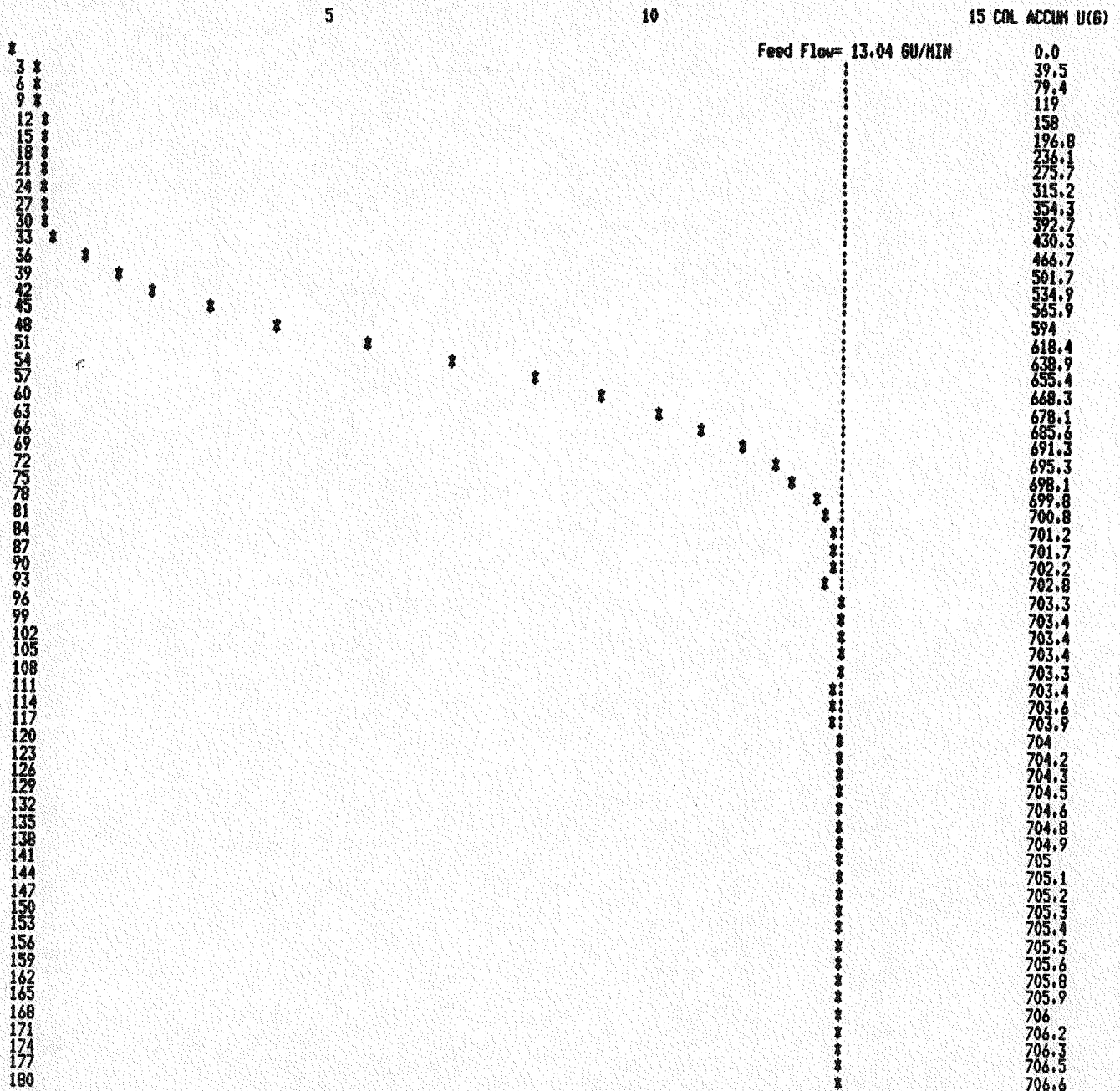
APPENDIX B-20

COMPUTER URANIUM MASS RATE DIAGRAM AND COLUMN INVENTORY FROM ANALYTICAL DATA: 1A COLUMN, TEST 3AM-4

RUN ACCT: 1
FEED U (G/L) & FEED FLOW (L/M)? 40.13, 0.325
WINDOW WIDTH (MINUTES)? 35
NUMBER OF DATA POINTS? 9
DENOMINATOR OF VERT SCALING FACTOR? 3
DATE OF RUN? 3AM-4
AP FLOW RATE, L/MIN? 0.265
ENTER ELAPSED TIME AND GRAMS U/L FOR

POINT 1 ? 15,0
POINT 2 ? 30,1.3
POINT 3 ? 45,11.9
POINT 4 ? 60,35.1
POINT 5 ? 75,46.5
POINT 6 ? 90,48.5
POINT 7 ? 120,49.0
POINT 8 ? 150,49.1
POINT 9 ? 180,49.0

PLOT OF TIME(MIN) (VERT SCALE) VS U OUTFLOW(G/MIN) (HOR SCALE) FOR RUN 3AM-4

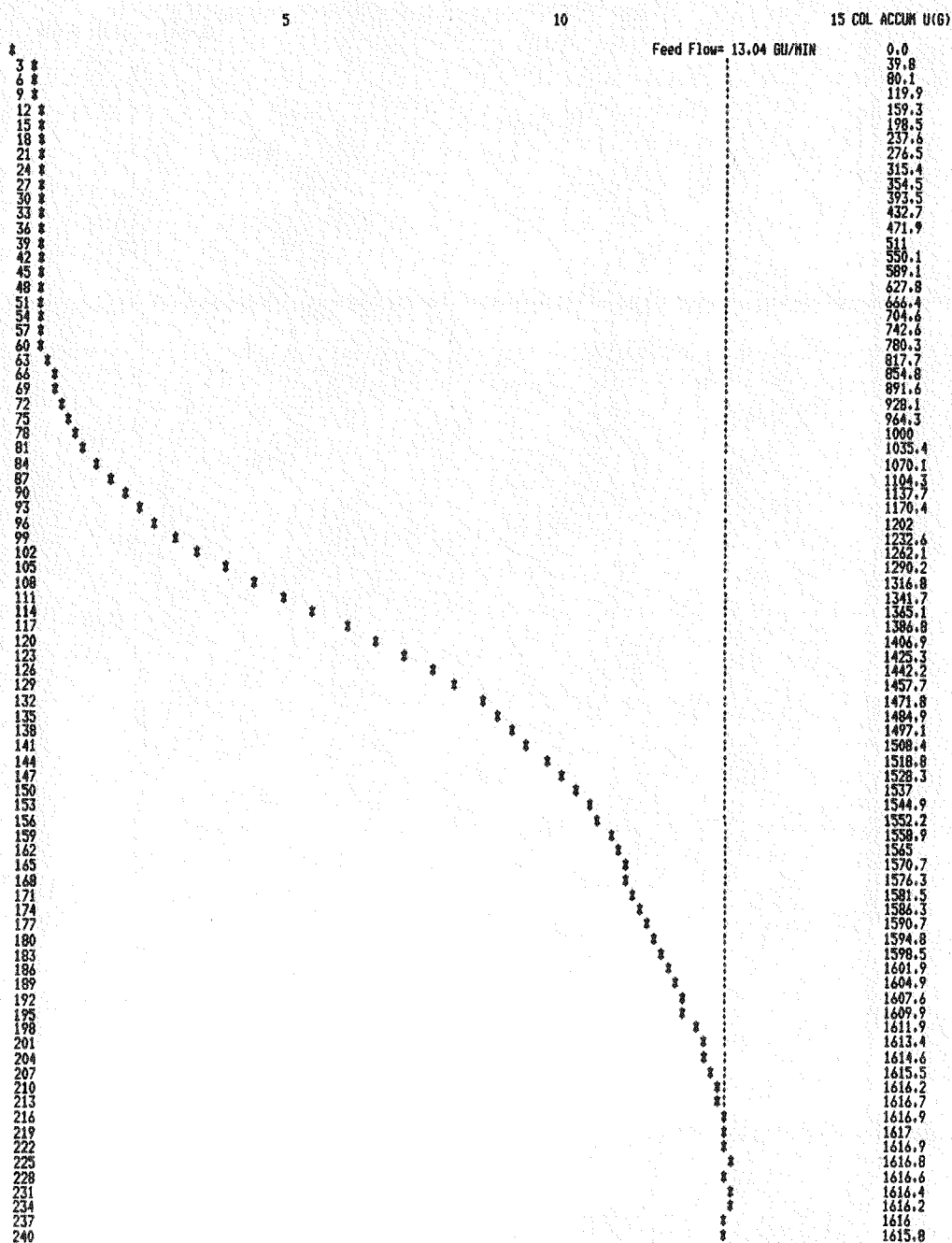


APPENDIX B-21

COMPUTER URANIUM MASS RATE DIAGRAM AND COLUMN INVENTORY FROM ANALYTICAL DATA: 1A AND 1BS COLUMNS WITH 1AP HEAD POT, TEST 3AM-4

RUN ABCOL
 FEED U (G/L) & FEED FLOW (L/H)? 40.13;0.325
 WINDOW WIDTH (MINUTES)? 75
 DENOMINATOR OF VERT SCALING FACTOR? 3
 NUMBER OF DATA POINTS? 11
 DATE OF RUN? 3AM-4
 BW FLOW RATE, L/HIN? 0.260
 BP FLOW RATE, L/HIN? 0.277
 ENTER ELAPSED TIME, BW GU/L, AND BP GU/L FOR POINT 1 ? 15:0:0
 POINT 2 ? 30:0:0
 POINT 3 ? 45:0:0.3
 POINT 4 ? 60:0:1.9
 POINT 5 ? 75:0:3.8
 POINT 6 ? 90:1:2.6.2
 POINT 7 ? 120:2:1.22.0
 POINT 8 ? 150:6:2.31.1
 POINT 9 ? 180:6.8.35.7
 POINT 10 ? 210:7.2.39.2
 POINT 11 ? 240:7.3.39.9

PLOT OF TIME(MIN) (VERT SCALE) VS U OUTFLOW(G/HIN) (HOR SCALE) FOR RUN 3AM-4

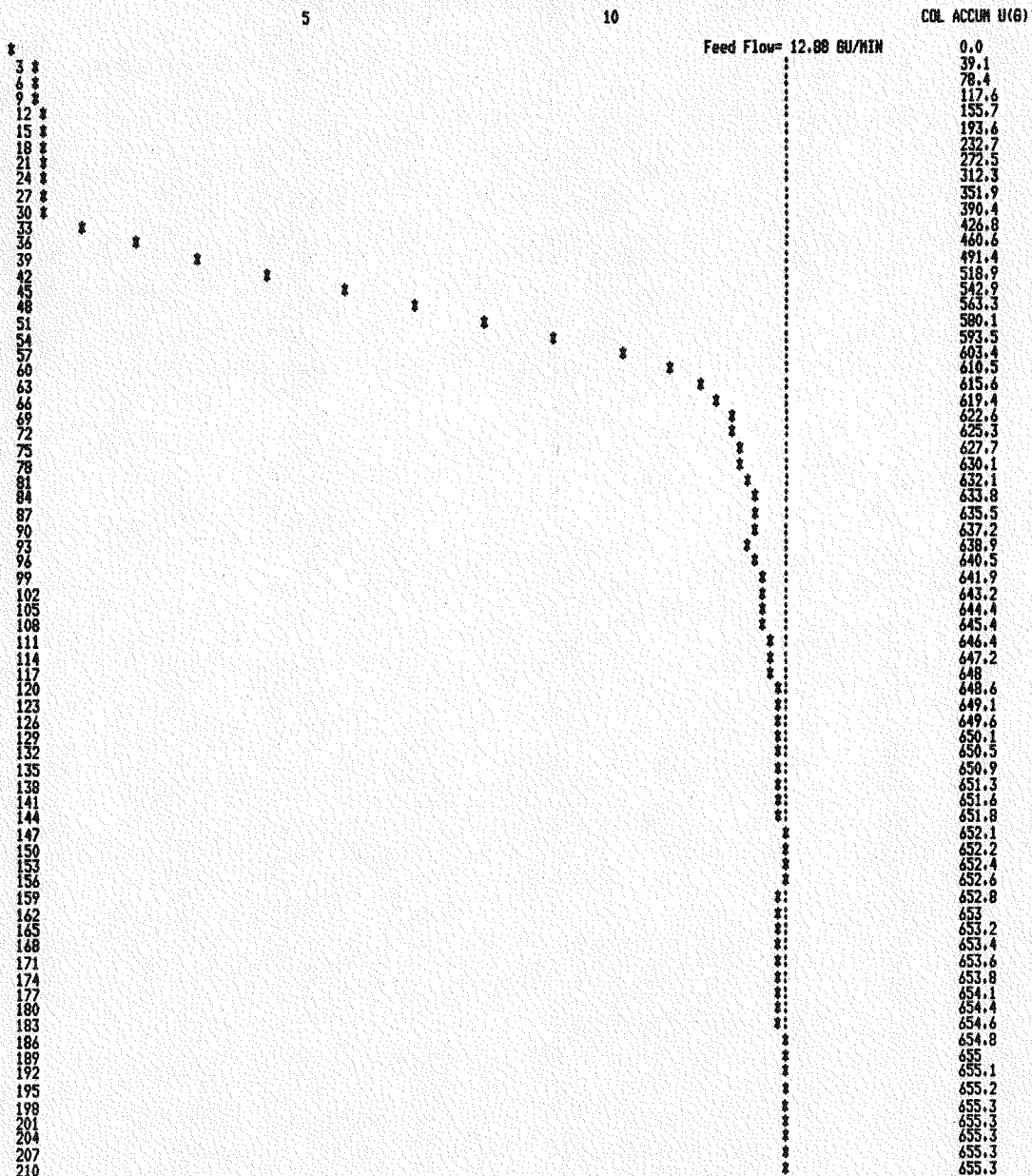


APPENDIX B-22

COMPUTER URANIUM MASS RATE DIAGRAM AND COLUMN INVENTORY FROM ANALYTICAL DATA: 1A COLUMN, TEST 3AM-5

RUN ACCLT1
FEED U (G/L) & FEED FLOW (L/H)? 40.13+0.321
WINDOW WIDTH (MINUTES)? 35
NUMBER OF DATA POINTS? 10
DENOMINATOR OF VERT SCALING FACTOR? 3
DATE OF RUN? 3AM-5
AP FLOW RATE, L/HIN? 0.270
ENTER ELAPSED TIME AND GRAHS U/L FOR POINT 1 ? 15+0
POINT 2 ? 30+1.3
POINT 3 ? 45+20.
POINT 4 ? 60+40.
POINT 5 ? 75+44.8
POINT 6 ? 90+45.6
POINT 7 ? 120+47.0
POINT 8 ? 150+47.5
POINT 9 ? 180+47.4
POINT 10 ? 210+47.8

PLOT OF TIME(MIN) (VERT SCALE) VS U OUTFLOW(G/MIN) (HOR SCALE) FOR RUN 3AM-5



APPENDIX B-23

COMPUTER URANIUM MASS RATE DIAGRAM AND COLUMN INVENTORY FROM ANALYTICAL DATA: 1A AND 1BS COLUMNS WITH 1AP HEAD POT, TEST 3AM-5

RUN ABCOL

FEED U (G/L) & FEED FLOW (L/M)? 40.13,0.321

WINDOW WIDTH (MINUTES)? 75

NUMERATOR OF VERT SCALING FACTOR? 3

NUMBER OF DATA POINTS? 9

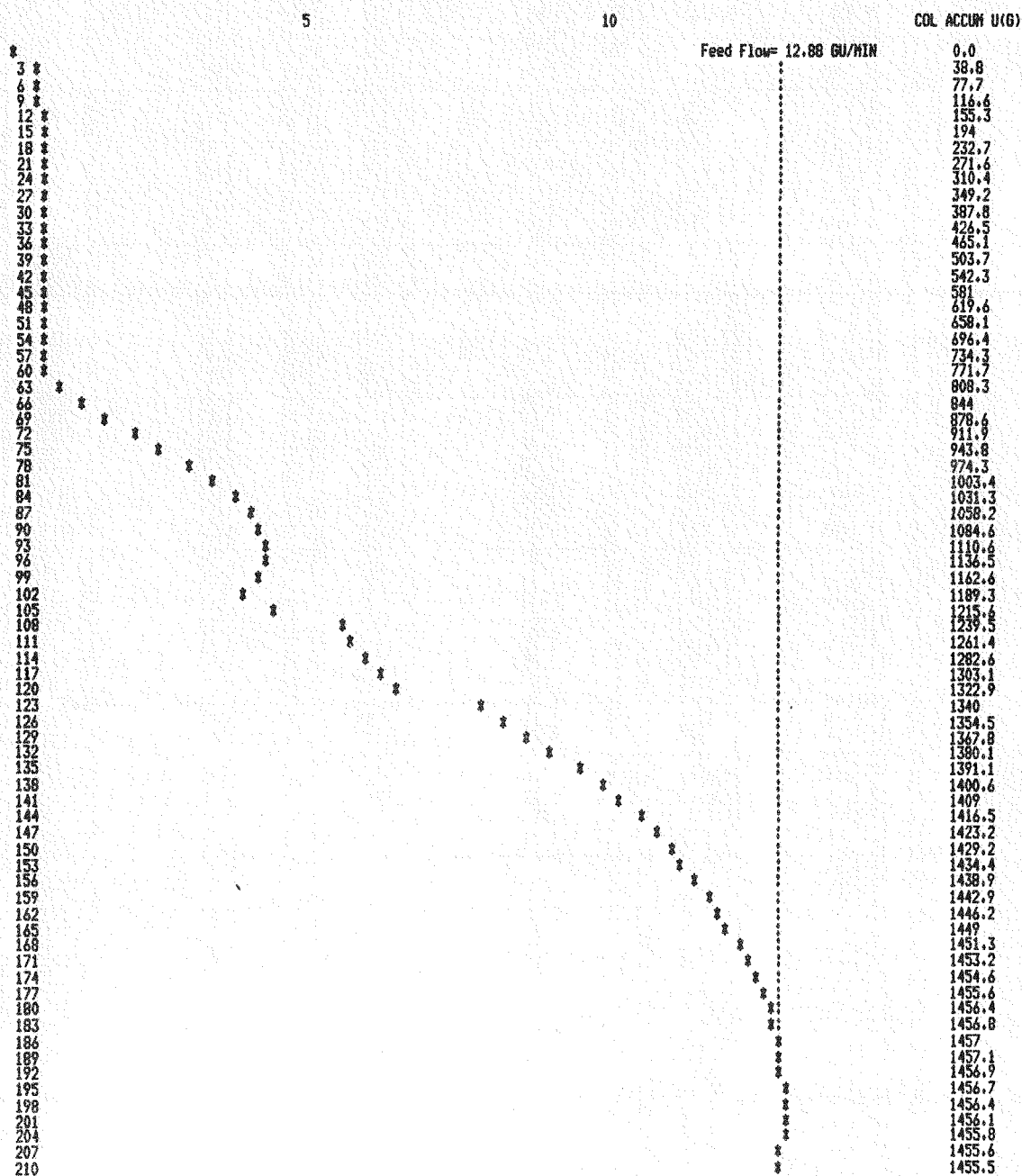
DATE OF RUN? 3AM-5

BW FLOW RATE, L/MIN? 0.265

BP FLOW RATE, L/MIN? 0.278

ENTER ELAPSED TIME, BW GU/L, AND BP GU/L FOR POINT 1 ? 15,0,0
POINT 2 ? 30,0,0
POINT 3 ? 45,0,0
POINT 4 ? 60,0,1.9
POINT 5 ? 75,0,9.0
POINT 6 ? 90,0,15.0
POINT 7 ? 150,5.6,34.1
POINT 8 ? 180,7.6,38.0
POINT 9 ? 210,7.6,38.7

PLOT OF TIME(MIN) (VERT SCALE) VS U OUTFLOW(G/MIN) (HOR SCALE) FOR RUN 3AM-5



APPENDIX B-24

THE XRFA URANIUM CONCENTRATION DATA: TEST 3AM-3

X-RAY FLUORESCENCE DATA HISTORY
 COMPARED TO U CALCS
 STARTS WITH RECORD 12
 AND GOES TO RECORD 80
 FOR ENGINEERING LAB RUN 11 ON 30-Jun-81

		UNIT 1...BP STREAM			UNIT 2...AP STREAM			UNIT 4...BW STREAM	
		XRFA	AQ U CALC	XRF-CALC	XRFA	OR U CALC	XRF-CALC	XRFA	
12	08:46AM	0	.54	-.54	0	-1.05	1.05	0	AT 08:32 AM
13	08:50AM	0	.66	-.66	0	-.52	.52	0	AT 08:32 AM
14	08:58AM	.5967	.54	.06	0	-.52	.52	0	AT 08:57 AM
15	09:02AM	.5967	.93	-.33	0	-.37	.37	0	AT 08:57 AM
16	09:06AM	.5967	.76	-.16	0	.02	-.02	0	AT 08:57 AM
17	09:10AM	.986	.83	.16	1.5201	12042.2	-12040.7	0	AT 08:57 AM
18	09:14AM	.986	1.1	-.11	20.6919	20.38	.31	0	AT 08:57 AM
19	09:18AM	1.6151	1.92	-.3	20.6919	22.6	-1.91	0	AT 09:15 AM
20	09:22AM	1.6151	2.27	-.65	24.216	23.29	.93	0	AT 09:15 AM
21	09:26AM	0	2.69	-2.69	24.216	24.43	-.21	0	AT 09:15 AM
22	09:30AM	3.728	4.25	-.52	27.726	33.46	-5.73	0	AT 09:15 AM
23	09:34AM	3.728	5.14	-1.41	39.3069	40.29	-.98	0	AT 09:32 AM
24	09:38AM	6.447	6.77	-.32	39.3069	48.41	-9.1	0	AT 09:32 AM
25	09:42AM	7.7955	7.41	.39	52.2074	52.13	.08	0	AT 09:32 AM
26	09:46AM	7.7955	8.23	-.43	58.864	53.87	4.99	0	AT 09:32 AM
27	09:50AM	10.3617	10.74	-.38	58.864	56.45	2.41	0	AT 09:49 AM
28	09:54AM	10.3617	12.37	-2.01	58.864	57.13	1.73	0	AT 09:49 AM
29	09:58AM	14.8681	15.7	-.73	62.0833	58.35	3.73	0	AT 09:49 AM
30	10:02AM	18.0645	17.47	.59	62.8275	59.11	3.72	0	AT 09:49 AM
31	10:06AM	20.2723	18.8	1.47	62.7728	59.41	3.36	0	AT 09:49 AM
32	10:10AM	21.177	21.39	-.21	63.4657	59.84	3.53	1.0555	AT 10:08 AM
33	10:14AM	22.15	22.42	-.27	63.2743	60.25	3.02	1.0555	AT 10:08 AM
35	10:22AM	26.5455	26.4	.15	64.4511	61.46	2.99	1.0555	AT 10:08 AM
36	10:26AM	27.9672	27.73	.24	64.7017	61.92	2.78	1.0555	AT 10:08 AM
37	10:30AM	27.9672	30.09	-2.12	64.7017	62.67	2.03	1.0555	AT 10:08 AM
38	10:34AM	27.9672	31.13	-3.16	64.7017	62.98	1.72	1.0555	AT 10:08 AM
39	10:38AM	27.9672	33.34	-5.37	64.7017	63.28	1.42	1.0555	AT 10:08 AM
40	10:42AM	27.9672	34.23	-6.26	64.7017	63.43	1.27	1.0555	AT 10:08 AM
41	10:46AM	27.9672	35.17	-7.22	64.7017	63.43	1.27	1.0555	AT 10:08 AM
42	10:50AM	27.9672	37.26	-9.29	64.7017	63.58	1.12	1.0555	AT 10:08 AM
43	10:54AM	27.9672	38.07	-10.1	64.7017	63.66	1.04	1.0555	AT 10:08 AM
44	10:58AM	27.9672	39.47	-11.5	64.7017	63.58	1.12	1.0555	AT 10:08 AM
45	11:02AM	27.9672	40.06	-12.09	64.7017	63.58	1.12	1.0555	AT 10:08 AM
46	11:06AM	27.9672	40.73	-12.76	64.7017	63.51	1.19	3.3436	AT 11:05 AM
47	11:10AM	29.3119	41.84	-12.53	64.8204	63.28	1.54	7.4079	AT 11:08 AM
48	11:14AM	41.8369	42.36	-.52	65.0209	63.28	1.74	7.4079	AT 11:08 AM
49	11:18AM	41.8369	43.48	-1.64	65.0209	59.41	5.61	11.1183	AT 11:18 AM
50	11:22AM	43.1086	43.92	-.81	66.4129	63.43	2.98	12.1944	AT 11:21 AM
51	11:26AM	43.2201	44.44	-1.22	67.596	63.43	4.17	12.6748	AT 11:25 AM
52	11:30AM	45.0954	45.33	-.23	67.6902	63.58	4.11	13.2557	AT 11:29 AM
53	11:34AM	45.3513	45.7	-.35	66.7049	63.58	3.12	13.1597	AT 11:34 AM
54	11:38AM	43.7169	46.44	-2.72	66.5912	63.58	3.01	13.393	AT 11:38 AM
55	11:42AM	44.7733	46.82	-2.05	67.2734	63.74	3.53	12.96	AT 11:42 AM
56	11:46AM	46.8592	47.11	-.25	65.4518	63.74	1.71	12.96	AT 11:42 AM
57	11:50AM	45.01	47.63	-1.02	65.8706	63.74	2.13	13.5704	AT 11:46 AM
58	11:54AM	46.8132	47.94	-1.13	66.6583	63.89	2.77	13.5905	AT 11:50 AM
59	11:58AM	46.7288	48.39	-1.66	68.2431	63.74	4.5	13.8553	AT 11:54 AM
60	12:02PM	47.742	48.54	-.8	64.7485	63.74	1.01	14.1654	AT 11:58 AM
61	12:06PM	46.8044	48.69	-1.89	65.9462	63.58	2.37	13.4312	AT 12:02 PM
62	12:10PM	47.6612	48.84	-1.18	66.8267	63.43	3.45	12.3468	AT 12:06 PM
63	12:14PM	49.873	48.92	.95	66.8767	63.43	3.45	12.564	AT 12:10 PM
64	12:18PM	47.2779	49.22	-1.94	65.4199	63.66	1.76	12.6909	AT 12:15 PM
65	12:22PM	47.5812	49.22	-1.64	24.3572	63.66	39.3	13.9932	AT 12:19 PM
66	12:26PM	50.0399	49.82	.22	66.9885	64.19	2.8	15.5165	AT 12:23 PM
67	12:30PM	48.5613	50.04	-1.48	66.6977	64.5	2.2	16.4798	AT 12:27 PM
68	12:34PM	48.1033	50.25	-2.15	67.1201	65.1	2.02	17.0927	AT 12:32 PM
69	12:38PM	48.0795	50.47	-2.39	67.0701	65.33	1.74	16.9117	AT 12:36 PM
70	12:42PM	47.6213	50.62	-2.93	69.321	65.33	3.99	16.6782	AT 12:40 PM
71	12:46PM	48.7089	51.07	-2.36	67.1265	65.1	2.03	16.0948	AT 12:44 PM
72	12:50PM	50.6816	51.39	-.71	67.9105	64.8	3.11	15.745	AT 12:49 PM
73	12:54PM	50.706	51.69	-.98	66.0258	64.57	1.46	15.6977	AT 12:53 PM
74	12:58PM	51.5489	51.69	-.14	234.454	64.57	169.88	15.2287	AT 12:57 PM
75	01:02PM	51.5489	51.69	-.14	66.5637	64.57	1.99	14.4124	AT 01:01 PM
76	01:06PM	50.0979	51.69	-1.59	65.9984	64.57	1.43	14.8009	AT 01:05 PM
77	01:10PM	50.9527	51.69	-.74	66.8809	64.57	2.31	14.8009	AT 01:05 PM
78	01:14PM	49.2127	51.69	-2.48	65.4361	64.57	.87	14.9021	AT 01:10 PM
79	01:18PM	50.6165	51.69	-1.07	65.0395	64.57	.47	13.8963	AT 01:14 PM
80	01:22PM	50.1241	51.69	-1.57	65.0395	64.57	.47	14.0324	AT 01:18 PM

APPENDIX B-25

THE XRFA URANIUM CONCENTRATION DATA: TEST 3AM-4

X-RAY FLUORESCENCE DATA HISTORY
 COMPARED TO U CALCS
 STARTS WITH RECORD 2
 AND GOES TO RECORD 82
 FOR ENGINEERING LAB RUN 10 ON 26-Jun-81

		UNIT 1...BP STREAM			UNIT 2...AP STREAM			UNIT 4...BW STREAM	
		XRFA	AD U CALC	XRF-CALC	XRFA	DR U CALC	XRF-CALC	XRFA	
2	08:30AM	-----	1111.74	-----	-----	66.39	-----	-----	
3	08:34AM	-----	1111.74	-----	-----	66.39	-----	-----	
4	08:38AM	-----	1111.74	-----	-----	66.39	-----	-----	
5	08:42AM	-----	1111.74	-----	-----	66.39	-----	-----	
6	08:46AM	-----	1109.71	-----	-----	66.39	-----	-----	
7	08:50AM	-----	1108.02	-----	-----	66.39	-----	-----	
8	08:54AM	-----	13.92	-----	-----	4.23	-----	-----	
9	08:58AM	-----	.84	-----	-----	4.53	-----	-----	
10	09:02AM	-----	.78	-----	-----	.63	-----	-----	
11	09:06AM	-----	.31	-----	4.669	4.69	-4.22	-----	
12	09:10AM	-----	.64	-----	5.459	4.76	-4.21	-----	
13	09:14AM	0	.78	-.78	5.459	4.84	-4.29	-----	
14	09:18AM	1.2283	.96	.27	0	4.84	-4.84	-----	
15	09:22AM	0	.98	-.98	0	4.84	-4.84	-----	
16	09:26AM	1.2571	1.07	.19	0	4.92	-4.92	-----	
17	09:30AM	1.1179	1.08	.04	0	4.84	-4.84	-----	
18	09:34AM	.9871	1.1	-.11	0	4.92	-4.92	-----	
19	09:38AM	1.0178	.86	.16	0	4.92	-4.92	0	AT 09:35 AM
20	09:42AM	0	.8	-.8	0	8.21	-8.21	0	AT 09:35 AM
21	09:46AM	0	-.68	.68	1.1048	3.92	-2.82	0	AT 09:35 AM
22	09:50AM	0	-2.27	2.27	2.8264	8288.96	-8288.13	0	AT 09:35 AM
23	09:54AM	1.4978	.73	.77	4.2633	2.22	-1.95	0	AT 09:35 AM
24	09:58AM	1.6835	1.27	.41	7.3809	4.5	11.8	0	AT 09:35 AM
25	10:02AM	1.6491	1.33	.32	12.0165	14.41	-2.39	0	AT 09:58 AM
26	10:06AM	2.0695	1.32	.55	16.4136	16.71	-3	0	AT 09:58 AM
27	10:10AM	2.7494	2.26	.49	21.21	19.93	2.28	0	AT 09:58 AM
28	10:14AM	2.9082	3.02	-.11	23.1532	21.15	2	0	AT 09:58 AM
29	10:18AM	3.7416	3.49	.25	32.0068	23323.4	-28291.4	0	AT 09:58 AM
30	10:22AM	3.5054	3.87	-.36	37.6462	35.66	1.99	0	AT 10:22 AM
31	10:26AM	5.3378	4.53	.81	40.6479	37.18	3.47	0	AT 10:22 AM
32	10:30AM	6.8669	5.72	1.15	42.9022	38.54	4.36	0	AT 10:22 AM
33	10:34AM	8.8884	8.32	.57	44.4975	41.05	3.45	0	AT 10:22 AM
34	10:38AM	10.0064	9.65	.36	44.4975	42.03	2.47	0	AT 10:22 AM
35	10:42AM	12.4088	12.47	-.06	45.5235	40.06	5.46	0	AT 10:45 AM
36	10:46AM	16.1821	15.13	1.05	48.7966	45.37	3.43	0	AT 10:45 AM
37	10:50AM	17.4759	17.64	-.16	49.8244	-20.73	70.55	0	AT 10:45 AM
38	10:54AM	18.8192	32.47	-13.65	50.6569	-20.42	71.08	0	AT 10:45 AM
39	10:58AM	21.3615	21.27	.09	51.0435	47.27	3.77	0	AT 10:45 AM
40	11:02AM	21.3615	22.38	-1.02	52.7757	47.35	5.43	2.139	AT 11:08 AM
41	11:06AM	21.3615	23.41	-2.05	52.7757	47.5	5.28	2.139	AT 11:08 AM
42	11:10AM	24.5018	25.33	-.83	52.7399	47.8	4.94	5.0691	AT 11:14 AM
43	11:14AM	26.266	26.46	-.19	51.3247	47.8	3.52	5.7926	AT 11:18 AM
44	11:18AM	26.8254	28.02	-1.19	51.7948	47.8	3.99	6.5046	AT 11:22 AM
45	11:22AM	28.6026	28.76	-.16	51.8478	47.95	3.9	6.9981	AT 11:26 AM
46	11:26AM	29.2543	30.09	-.84	51.8478	47.88	3.97	7.5678	AT 11:31 AM
47	11:30AM	29.0009	30.68	-1.68	52.1326	48.03	4.1	7.5968	AT 11:35 AM
48	11:34AM	30.1878	31.28	-1.09	52.1326	44.76	7.37	8.2635	AT 11:39 AM
49	11:38AM	31.1579	32.24	-1.08	52.4073	48.1	4.31	7.9927	AT 11:43 AM
50	11:42AM	31.7137	32.85	-1.14	51.6493	48.1	3.55	7.4444	AT 11:48 AM
51	11:46AM	31.6163	33.67	-2.05	52.6292	48.26	4.37	8.1983	AT 11:52 AM
52	11:50AM	33.5843	34.11	-.53	51.7918	48.33	3.46	8.3681	AT 11:56 AM
53	11:54AM	33.5843	34.56	-.98	52.1066	44.39	7.72	7.9842	AT 12:00 PM
54	11:58AM	33.9701	35.15	-1.18	52.4936	48.41	4.08	8.318	AT 12:05 PM
55	12:02PM	34.4591	35.52	-1.06	53.7469	48.41	5.34	8.1519	AT 12:09 PM
56	12:06PM	34.9324	36.29	-1.36	51.7578	48.56	3.2	7.6647	AT 12:13 PM
57	12:10PM	0	36.52	-36.52	53.4825	48.94	4.54	7.2924	AT 12:17 PM
58	12:14PM	0	36.66	-36.66	53.9478	49.09	4.88	7.2924	AT 12:21 PM
59	12:18PM	35.1161	37.04	-1.92	54.5717	49.47	5.1	6.9397	AT 12:25 PM
60	12:22PM	37.1506	37.19	-.04	52.6255	49.93	2.7	7.381	AT 12:29 PM
61	12:26PM	36.4812	37.56	-1.08	53.2949	50.3	2.99	7.0155	AT 12:33 PM
62	12:30PM	35.8849	37.56	-1.68	53.2949	50.3	2.99	6.988	AT 12:37 PM
63	12:34PM	35.8849	37.56	-1.68	53.2949	50.3	2.99	6.988	AT 12:41 PM
64	12:38PM	35.8849	37.71	-1.83	53.1467	85687.5	-85634.3	6.988	AT 12:45 PM
65	12:42PM	35.8849	38.32	-2.44	53.1467	50	3.15	8.2742	AT 12:49 PM
66	12:46PM	37.6129	38.62	-1.01	53.9513	48.79	5.16	8.3565	AT 12:53 PM
67	12:50PM	35.5315	38.84	-3.31	51.8998	48.03	3.67	8.3321	AT 12:57 PM
68	12:54PM	37.1043	38.98	-1.88	51.8501	47.65	4.2	8.627	AT 01:01 PM
69	12:58PM	35.1152	39.36	-4.24	52.5569	47.5	5.06	8.627	AT 01:05 PM
70	01:02PM	37.3307	39.43	-2.1	52.939	47.8	5.14	8.8823	AT 01:09 PM
71	01:06PM	37.1047	39.51	-2.41	52.2639	48.82	71.08	9.0885	AT 01:13 PM
72	01:10PM	38.68	39.52	-.84	53.6751	48.41	5.27	9.6739	AT 01:17 PM
73	01:14PM	37.5091	39.53	-2.02	53.6751	48.56	5.12	9.7002	AT 01:21 PM
74	01:18PM	37.5149	42.11	-4.6	51.7176	48.13	32.85	10.2448	AT 01:25 PM
75	01:22PM	36.549	43.52	-6.97	52.4245	48.13	53.7	11.6722	AT 01:29 PM
76	01:26PM	38.4222	39.5	-1.08	51.4777	48.03	3.45	12.7442	AT 01:33 PM
77	01:30PM	36.6057	39.58	-2.97	52.292	47.95	4.34	12.5055	AT 01:37 PM
78	01:34PM	36.6057	39.66	-3.05	51.3599	48.03	3.33	12.6176	AT 01:41 PM
79	01:38PM	38.8026	39.74	-.94	52.3278	47.88	4.45	11.877	AT 01:45 PM
80	01:42PM	38.3932	39.83	-1.44	52.7296	48.18	4.55	10.7395	AT 01:49 PM
81	01:46PM	37.171	39.89	-2.72	52.4416	48.41	4.03	10.7395	AT 01:53 PM

APPENDIX B-26

THE XRFA URANIUM CONCENTRATION DATA: TEST 3AM-5

X-RAY FLUORESCENCE DATA HISTORY

COMPARED TO U CALC'S
STARTS WITH RECORD 32
AND GOES TO RECORD 100

FOR ENGINEERING LAB RUN 12 ON 02-JUL-81

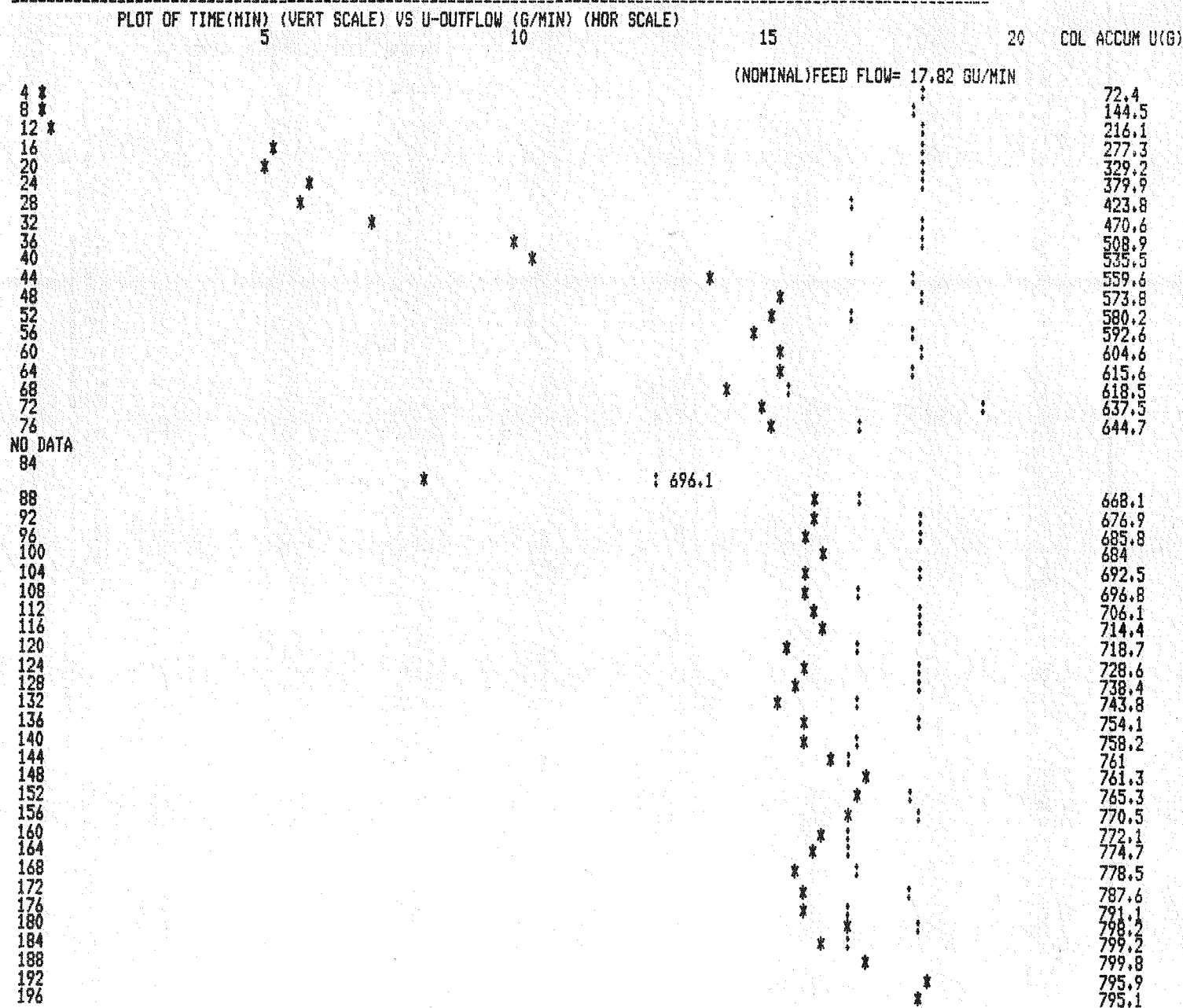
	UNIT 1...BP STREAM			UNIT 2...AP STREAM			UNIT 4...BU STREAM	
	XRFA	AD U CALC	XRFA-CALC	XRFA	OR U CALC	XRFA-CALC	XRFA	
32 10:00AM		33.51			567.14			
33 10:04AM		84318.3			566.83			
34 10:08AM		.36			1.17			
35 10:12AM	.7954	.11	.69	.5955	.63	-.03		
36 10:16AM	.7954	.12	.68	.5955	2255.42	-2254.82		
37 10:20AM	.7954	-.03	.83	.5955	1.09	-.49	0	AT 10:18 AM
38 10:24AM	0	.05	-.05	0	5013.38	-5013.38	0	AT 10:18 AM
39 10:28AM	0	.24	-.24	0	.17	-.17	0	AT 10:18 AM
40 10:32AM	0	.07	.07	0	.63	.63	0	AT 10:18 AM
41 10:36AM	0	.32	-.32	1.1659	1.24	-.07	0	AT 10:18 AM
42 10:40AM	0	.23	-.23	1.1659	3.23	-2.06	0	AT 10:18 AM
43 10:44AM	0	.21	-.21	4.7112	5.22	-.51	0	AT 10:41 AM
44 10:48AM	0	.35	-.35	12.5451	12.88	-.33	0	AT 10:41 AM
45 10:52AM	0	.34	-.34	19.4123	17.78	1.63	0	AT 10:41 AM
46 10:56AM	0	.88	-.88	19.4123	24.12	-4.71	0	AT 10:41 AM
47 11:00AM	0	1.01	-1.01	26.5145	27.61	-1.1	0	AT 10:41 AM
48 11:04AM	0	1.54	1.54	31.5844	33.69	2.11	0	AT 11:03 AM
49 11:08AM	2.7151	2.71	.01	39.3275	39.3	.03	0	AT 11:03 AM
50 11:12AM	2.7151	3.61	-.89	39.3275	40.67	-1.34	0	AT 11:03 AM
51 11:16AM	6.009	5.74	.27	44.0301	42.41	1.62	0	AT 11:03 AM
52 11:20AM	7.4047	7.09	.31	45.672	43.25	2.42	0	AT 11:03 AM
53 11:24AM	9.4865	8.57	.92	47.3188	43.63	3.69	0	AT 11:20 AM
54 11:28AM	11.4723	11.23	.24	48.8785	44.69	4.19	0	AT 11:20 AM
55 11:32AM	12.9552	12.49	.47	48.5854	44.92	3.67	0	AT 11:20 AM
56 11:36AM	14.1529	14.94	-.79	48.9886	45.37	3.62	0	AT 11:32 AM
57 11:40AM	15.9829	15.97	.01	49.616	45.37	4.25	0	AT 11:32 AM
58 11:44AM	18.558	17.08	1.48	49.616	45.52	4.1	.7531	AT 11:43 AM
59 11:48AM	18.7597	19.23	-.47	49.6652	45.6	4.07	.7531	AT 11:43 AM
60 11:52AM	20.1825	20.26	-.08	49.7602	45.6	4.16	.7531	AT 11:43 AM
61 11:56AM	22.0036	22.18	-.18	49.5102	45.68	3.83	22.0036	AT 11:55 AM
62 12:00PM	22.7655	23	-.23	48.7381	45.75	2.99	22.0036	AT 11:55 AM
63 12:04PM	24.1406	24.62	-.48	49.8033	46.13	3.67	22.0036	AT 11:55 AM
64 12:08PM	24.5213	25.36	-.84	49.7773	46.43	3.35	24.5213	AT 12:08 PM
65 12:12PM	24.5213	25.95	-1.43	51.3007	46.74	4.56	24.5213	AT 12:08 PM
66 12:16PM	26.0503	27.2	-1.15	51.6921	47.57	4.12	24.5213	AT 12:08 PM
67 12:20PM	27.0608	27.72	-.66	51.8983	47.95	3.95	2.844	AT 12:19 PM
68 12:24PM	28.0473	28.83	-.78	52.822	48.26	4.56	2.844	AT 12:19 PM
69 12:28PM	28.5143	29.25	-.74	52.7461	48.18	4.57	2.844	AT 12:19 PM
70 12:32PM	28.5075	29.77	-1.26	52.7461	48.26	4.49	5.9256	AT 12:31 PM
71 12:36PM	29.4782	30.96	-1.48	52.4886	47.8	4.69	5.9256	AT 12:31 PM
72 12:40PM	29.8624	31.4	-1.54	51.8999	47.35	4.53	5.9256	AT 12:31 PM
73 12:44PM	31.2844	32.29	-1.01	50.5298	46.51	4.02	8.036	AT 12:43 PM
74 12:48PM	31.2944	32.73	-1.45	50.558	46.43	4.13	8.036	AT 12:43 PM
75 12:52PM	32.3937	33.1	-.71	49.9999	46.43	4.57	50.558	AT 12:43 PM
76 12:56PM	33.33	33.77	-.44	49.9999	46.36	5.64	49.9999	AT 12:54 PM
77 01:00PM	32.9674	34.07	-1.1	49.985	46.43	5.35	9.2424	AT 12:56 PM
78 01:04PM	34.0447	34.59	-.55	49.985	46.43	5.35	9.2522	AT 01:00 PM
79 01:08PM	32.8582	34.74	-1.88	50.6636	46.59	4.07	9.0574	AT 01:07 PM
80 01:12PM	32.8582	34.97	-2.11	50.1288	46.59	3.54	8.7383	AT 01:10 PM
81 01:16PM	34.9972	35.27	-.27	51.6187	46.59	5.03	8.0154	AT 01:15 PM
82 01:20PM	33.5317	35.43	-1.9	51.1386	46.59	4.55	8.5215	AT 01:19 PM
83 01:24PM	33.6353	35.73	-2.09	50.9533	46.43	4.52	7.8905	AT 01:23 PM
84 01:28PM	33.9331	35.82	-1.89	50.2224	46.59	3.63	7.8559	AT 01:27 PM
85 01:32PM	35.6139	35.9	-.29	51.224	46.59	4.44	7.9256	AT 01:31 PM
86 01:36PM	35.3997	36.13	-.73	50.9376	46.81	4.13	8.2898	AT 01:35 PM
87 01:40PM	35.4972	36.29	-.79	50.6019	46.89	3.71	8.0772	AT 01:40 PM
88 01:44PM	35.6920	36.45	-.76	51.9663	47.19	4.71	8.0772	AT 01:44 PM
89 01:48PM	35.5322	36.61	-1.08	51.5505	47.19	4.36	9.4233	AT 01:44 PM
90 01:52PM	35.238	36.69	-1.43	51.5746	47.19	4.38	9.118	AT 01:48 PM
91 01:56PM	35.2732	36.92	-1.65	50.9847	46.97	4.01	8.282	AT 01:52 PM
92 02:00PM	34.9889	37	-2.01	52.1527	46.81	5.34	8.3258	AT 01:57 PM
93 02:04PM	34.5338	37.16	-.63	52.1527	46.74	5.41	8.8729	AT 02:01 PM
94 02:08PM	36.0701	37.24	-1.17	50.6354	46.74	3.9	9.2757	AT 02:05 PM
95 02:12PM	36.8934	37.34	-.45	50.9031	46.66	4.24	9.1152	AT 02:09 PM
96 02:16PM	35.0996	37.5	-2.4	47.4121	46.74	2.67	8.2309	AT 02:13 PM
97 02:20PM	35.0996	37.99	-2.89	52.1825	46.74	5.44	0	AT 02:19 PM
98 02:24PM	35.0996	38.48	-3.38	52.1825	46.74	5.44	0	AT 02:19 PM
99 02:28PM	35.0996	38.73	-3.63	52.1825	46.74	5.44	0	AT 02:19 PM
100 02:32PM	35.0996	38.73	-3.63	52.1825	46.74	5.44	0	AT 02:19 PM

APPENDIX B-27

COMPUTER URANIUM MASS RATE DIAGRAM AND COLUMN INVENTORY FROM XRFA CONCENTRATION DATA: 1A COLUMN, TEST 3AM-3, MEASURED FLOW RATES

RUN PP10
 INPUT WHICH ENGINEERING LAB RUN NO.
 (USES LATEST IF NO OTHER) ? 11
 THE LAST RECORD IS 84
 START WITH ? 14
 END WITH ? 63
 FEED U(G/L) AND NOMINAL FEED FLOW(L/M)? 40.13
 ? 0.444

A-COL HOLDUP, BASED ON XRFA DATA AND INCREMENTAL FLOW RATES (NEAR REAL TIME)
 STARTS WITH RECORD 14
 AND GOES TO RECORD 63
 FOR ENGINEERING LAB RUN 11 ON 30-Jun-81

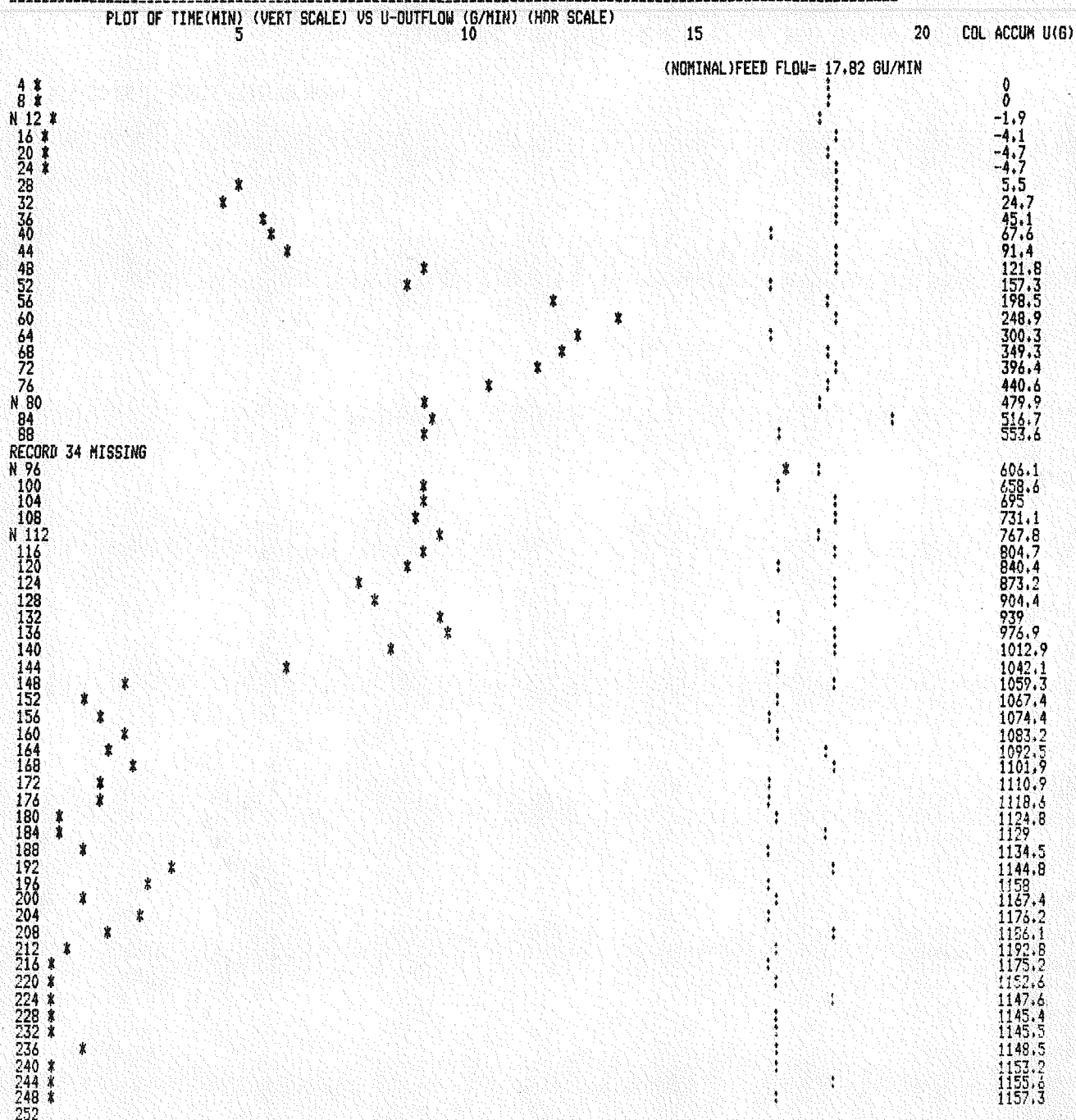


APPENDIX B-28

COMPUTER URANIUM MASS RATE DIAGRAM AND COLUMN INVENTORY FROM XRFA CONCENTRATION DATA: 1BS COLUMN WITH LAP HEAD POT, TEST 3AM-3, MEASURED FLOW RATES

RUN PP12
 INPUT WHICH ENGINEERING LAB RUN NO.
 (USES LATEST IF NO OTHER) ? 11
 THE LAST RECORD IS 84
 START WITH ? 11
 END WITH ? 74
 FEED U(G/L) AND NOMINAL FEED FLOW(L/H)? 40.13,0.444

B-COL RETENTION, BASED ON XRFA DATA AND INCREMENTAL FLOW RATES (NEAR REAL TIME)
 STARTS WITH RECORD 11
 AND GOES TO RECORD 74
 FOR ENGINEERING LAB RUN 11 ON 30-Jun-81
 (N PREFIX INDICATES NOMINAL FEED FLOW USED (DUE TO 10% ERROR))



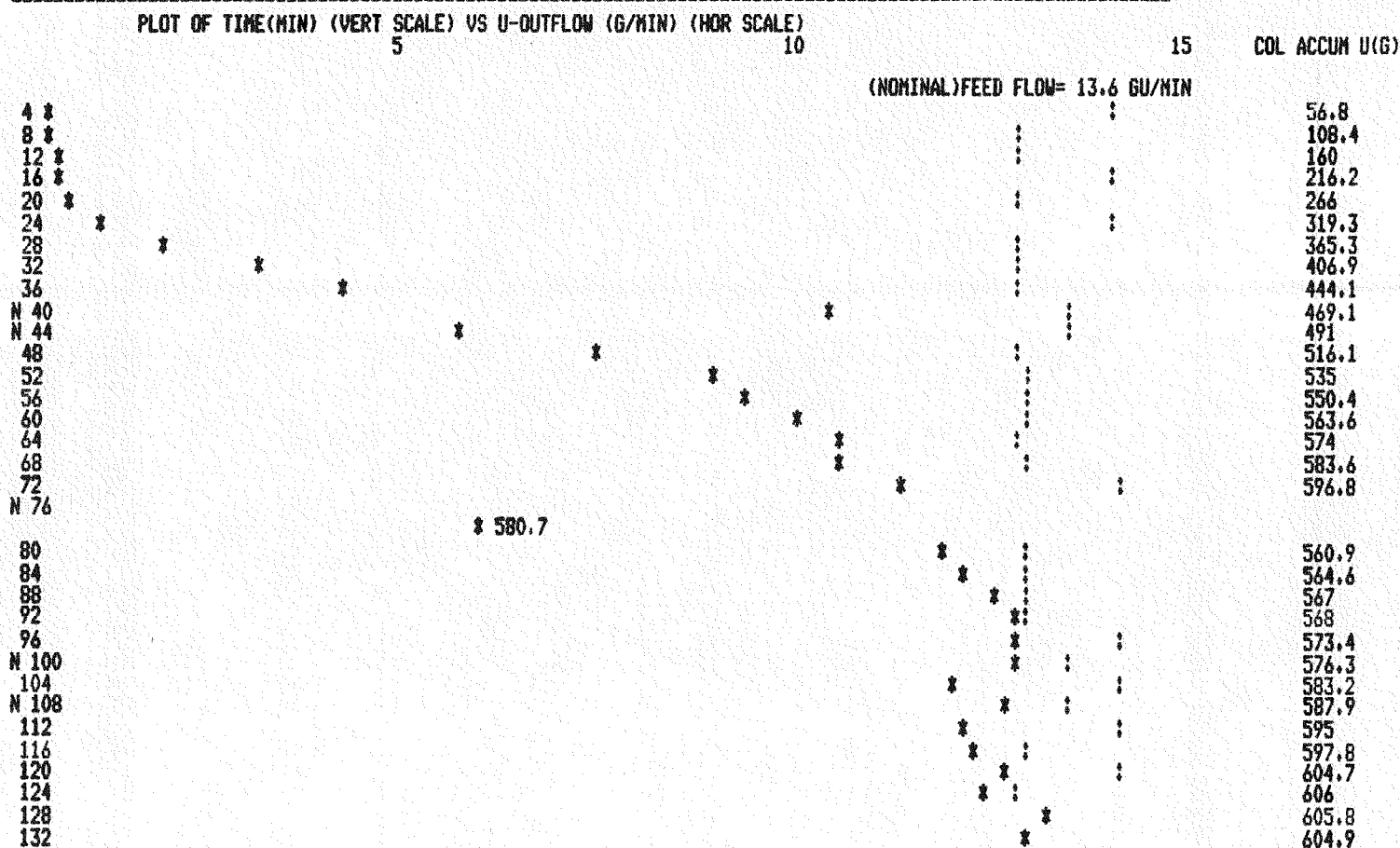
* 1248.5

APPENDIX B-29

COMPUTER URANIUM MASS RATE DIAGRAM AND COLUMN INVENTORY FROM XRFA CONCENTRATION DATA: 1A COLUMN, TEST 3AM-4, MEASURED FLOW RATES

RUN PP10
INPUT WHICH ENGINEERING LAB RUN NO.
(USES LATEST IF NO OTHER) ? 10
THE LAST RECORD IS 83
START WITH ? 17
END WITH ? 50
FEED U(G/L) AND NOMINAL FEED FLOW(L/H)? 40.13,0.339

A-COL HOLDUP, BASED ON XRFA DATA AND INCREMENTAL FLOW RATES (NEAR REAL TIME)
STARTS WITH RECORD 17
AND GOES TO RECORD 50
FOR ENGINEERING LAB RUN 10 ON 26-Jun-81
(N PREFIX INDICATES NOMINAL FEED FLOW USED (DUE TO 10% ERROR))

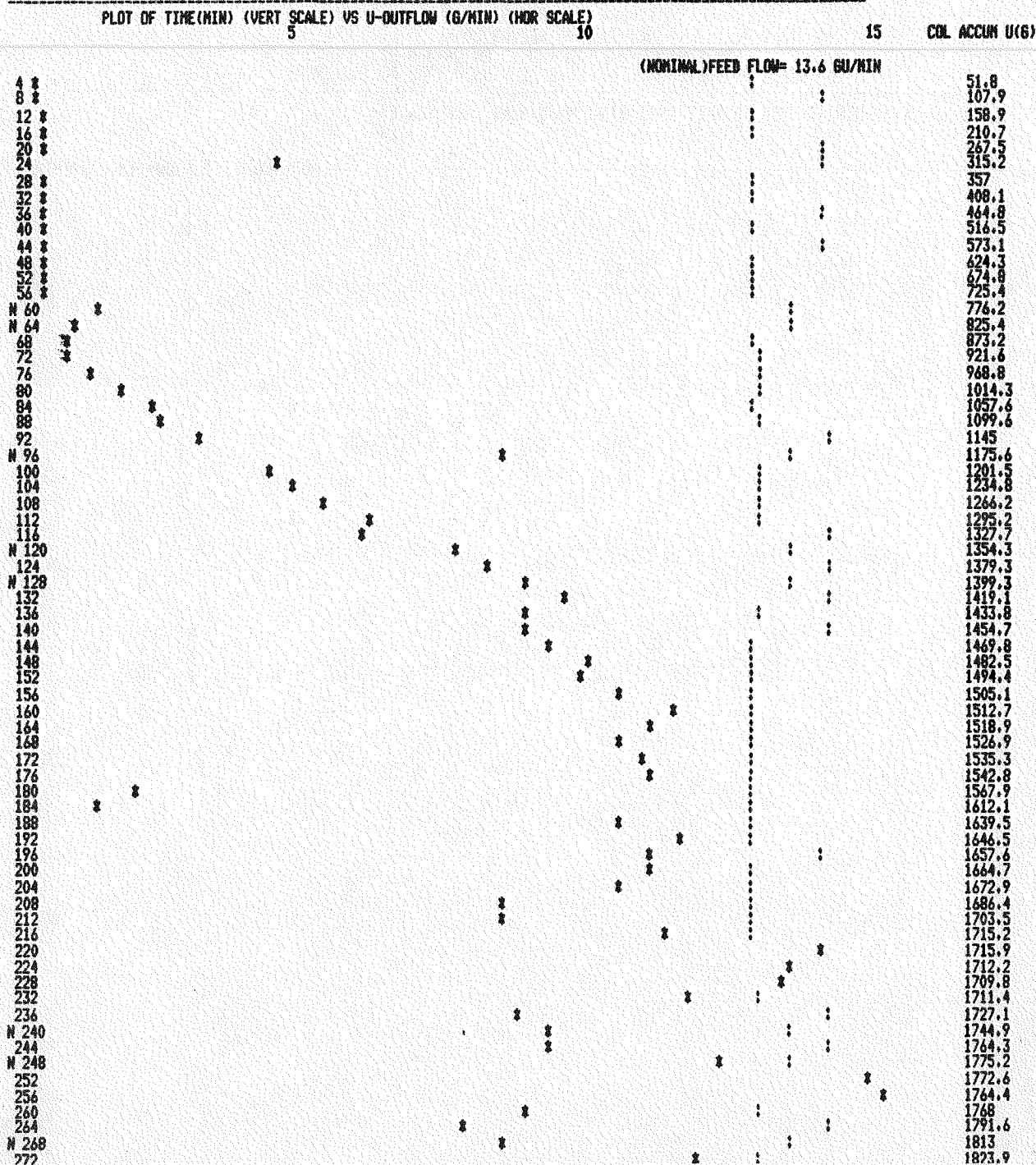


APPENDIX B-30

COMPUTER URANIUM MASS RATE DIAGRAM AND COLUMN INVENTORY FROM XRFA CONCENTRATION
DATA: 1A AND 1BS COLUMN WITH 1AP HEAD POT, TEST 3AM-4, MEASURED FLOW RATES

RUN PP11
INPUT WHICH ENGINEERING LAB RUN NO.
(USES LATEST IF NO OTHER) ? 10
THE LAST RECORD IS 83
START WITH ? 12
END WITH ? 80
FEED U(G/L) AND NOMINAL FEED FLOW(L/H)? 40.13,0.339

AB-COL HOLDUP, BASED ON XRFA DATA AND INCREMENTAL FLOW RATES (NEAR REAL TIME)
STARTS WITH RECORD 12
AND GOES TO RECORD 80
FOR ENGINEERING LAB RUN 10 ON 26-Jun-81
(N PREFIX INDICATES NOMINAL FEED FLOW USED (DUE TO 10% ERROR))



APPENDIX B-31

COMPUTER URANIUM MASS RATE DIAGRAM AND COLUMN INVENTORY FROM XRFA CONCENTRATION DATA: 1A COLUMN, TEST 3AM-5, MEASURED FLOW RATES

RUN PP10
INPUT WHICH ENGINEERING LAB RUN NO.
(USES LATEST IF NO OTHER) ? 12
THE LAST RECORD IS 107
START WITH ? 36
END WITH ? 73
INTERVAL ? 1
FEED U(G/L) AND NOMINAL FEED FLOW(L/M)? 40.13,0.321

A-COL HOLDUP, BASED ON XRFA DATA AND INCREMENTAL FLOW RATES (NEAR REAL TIME)
STARTS WITH RECORD 36
AND GOES TO RECORD 73
FOR ENGINEERING LAB RUN 12 ON 02-JUL-81

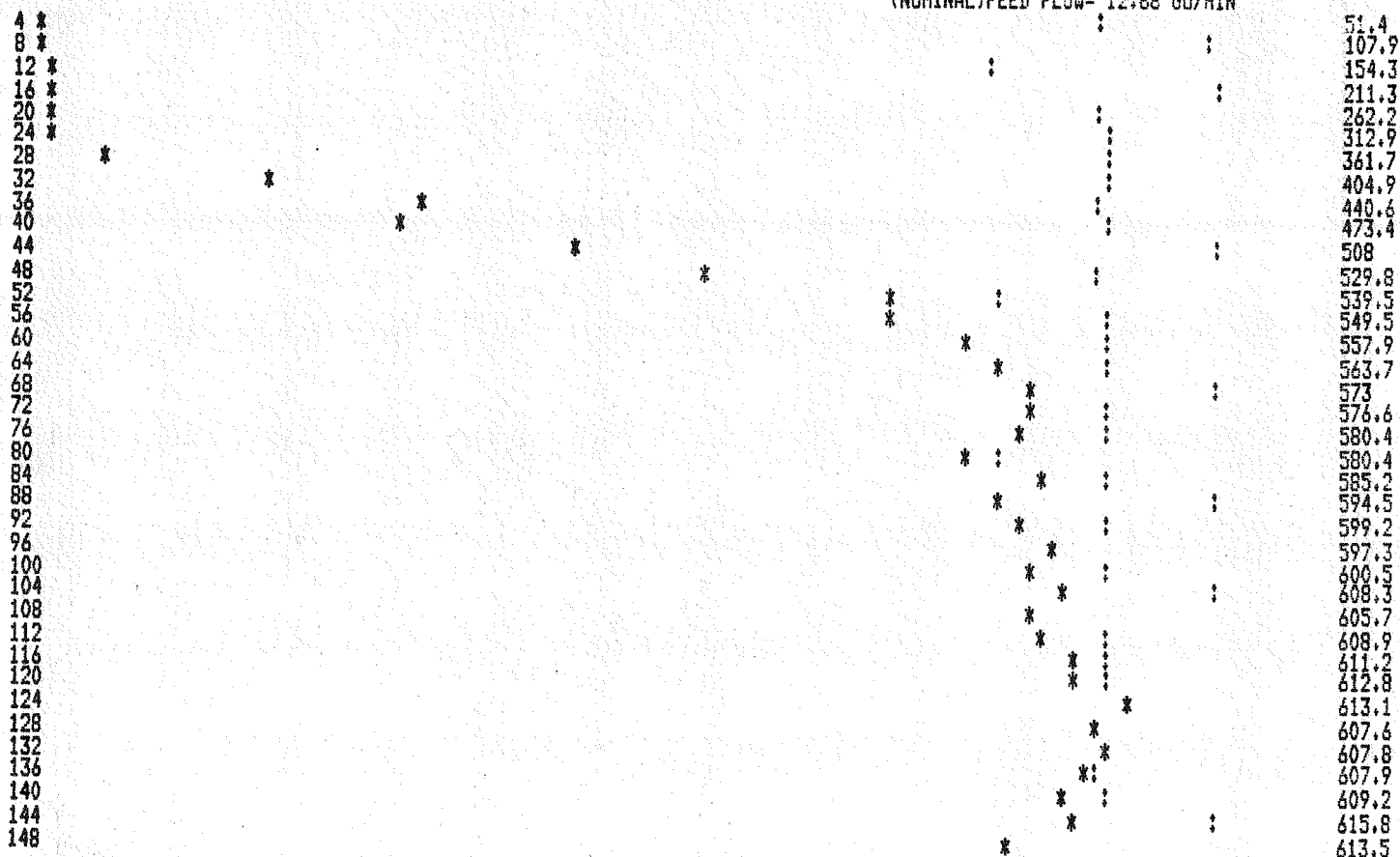
PLOT OF TIME(MIN) (VERT SCALE) VS U-OUTFLOW (G/MIN) (HOR SCALE)

5

10

COL ACCUM U(G)

(NOMINAL)FEED FLOW= 12.88 GU/MIN

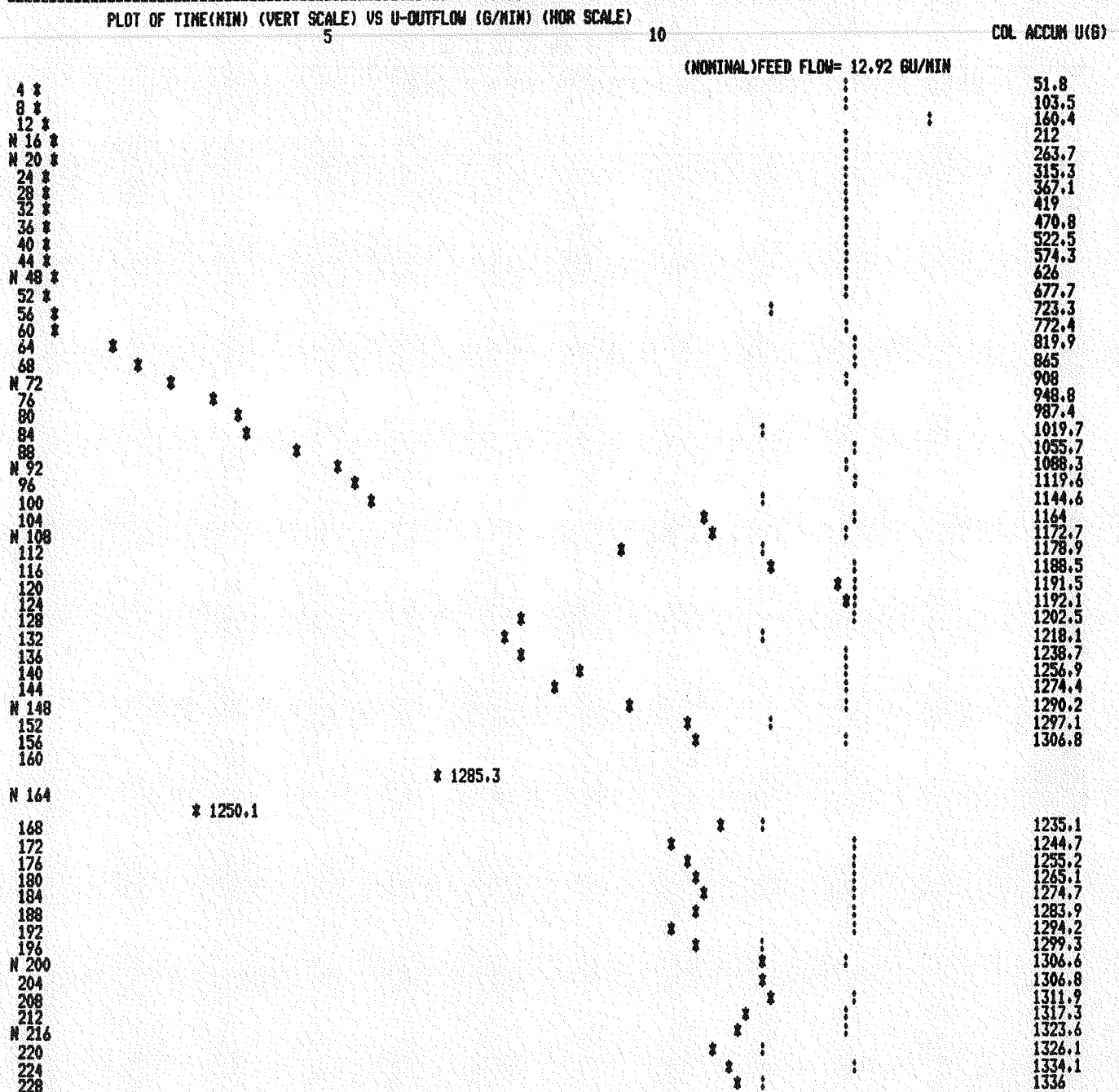


APPENDIX B-32

COMPUTER URANIUM MASS RATE DIAGRAM AND COLUMN INVENTORY FROM XRFA CONCENTRATION DATA: 1A AND 1BS COLUMNS WITH 1AP HEAD POT, TEST 3AM-5, MEASURED FLOW RATES

RUN PP11
 INPUT WHICH ENGINEERING LAB RUN NO.
 (USES LATEST IF NO OTHER) ? 12
 THE LAST RECORD IS 107
 START WITH ? 35
 END WITH ? 92
 FEED U(G/L) AND NOMINAL FEED FLOW(L/H)? 40.13,0.322

AB-COL HOLDUP, BASED ON XRFA DATA AND INCREMENTAL FLOW RATES (NEAR REAL TIME)
 STARTS WITH RECORD 35
 AND GOES TO RECORD 92
 FOR ENGINEERING LAB RUN 12 ON 02-Jul-81
 (N PREFIX INDICATES NOMINAL FEED FLOW USED (DUE TO 10% ERROR))



APPENDIX B-33

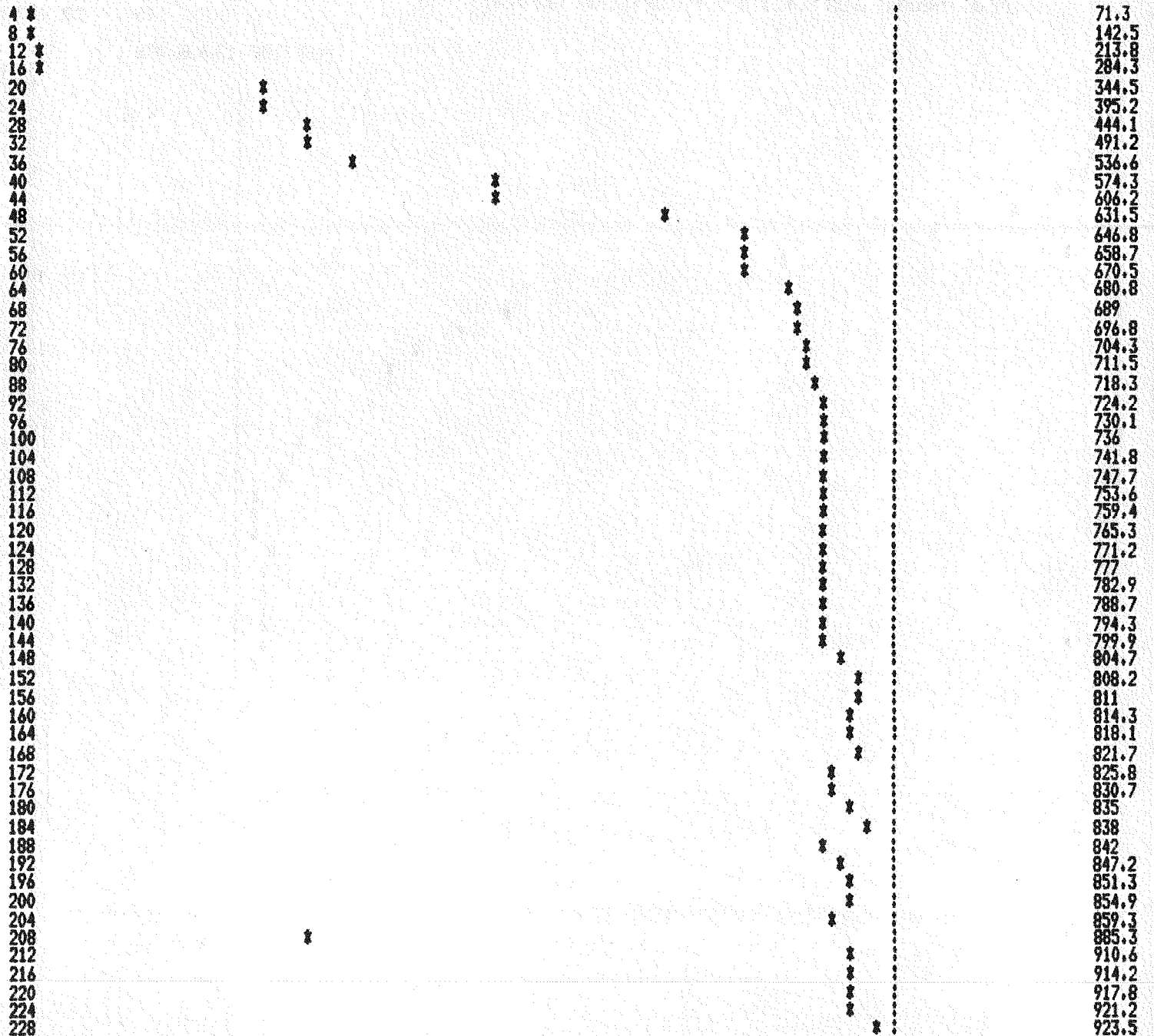
COMPUTER URANIUM MASS RATE DIAGRAM AND COLUMN INVENTORY FROM XRFA CONCENTRATION DATA: 1A COLUMN, TEST 3AM-3, AVERAGE FLOW RATES

RUN PP6
INPUT WHICH ENGINEERING LAB RUN NO.
(USES LATEST IF NO OTHER) ? 11
THE LAST RECORD IS 84
START WITH ? 14
END WITH ? 70
FEED U (G/L) AND FEED FLOW (L/H)? 40.13,0.444
AX FLOW RATE, L/MIN? 0.266

A-COL HOLDUP, BASED ON XRFA DATA
STARTS WITH RECORD 14
AND GOES TO RECORD 70
FOR ENGINEERING LAB RUN 11 ON 30-Jun-81

PLOT OF TIME(MIN) (VERT SCALE) VS U-OUTFLOW (G/MIN) (HOR SCALE)

FEED FLOW= 17.82 GU/MIN



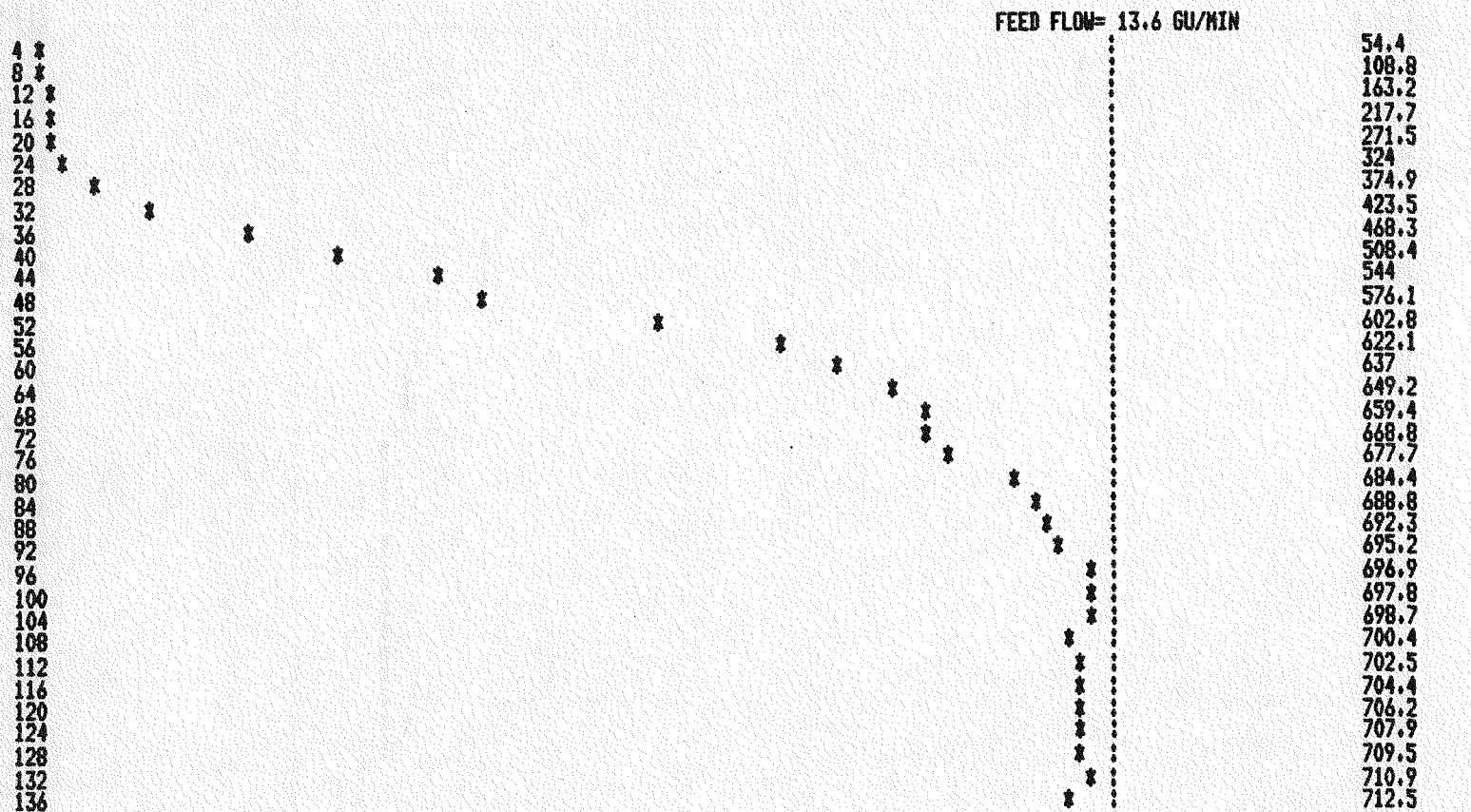
APPENDIX B-34

COMPUTER URANIUM MASS RATE DIAGRAM AND COLUMN INVENTORY FROM XRFA
 CONCENTRATION DATA: 1A COLUMN, TEST 3AM-4, AVERAGE FLOW RATES

RUN PP6
 INPUT WHICH ENGINEERING LAB RUN I.
 (USES LATEST IF NO OTHER) ...
 THE LAST RECORD IS 83
 START WITH ? 17
 END WITH ? 50
 FEED U (G/L) AND FEED FLOW (L/H)? 40.13,0.339
 AX FLOW RATE, L/HIN? 0.268

A-COL HOLDUP, BASED ON XRFA DATA
 STARTS WITH RECORD 17
 AND GOES TO RECORD 50
 FOR ENGINEERING LAB RUN 10 ON 26-Jun-81

PLOT OF TIME(MIN) (VERT SCALE) VS U-OUTFLOW (G/MIN) (HOR SCALE)

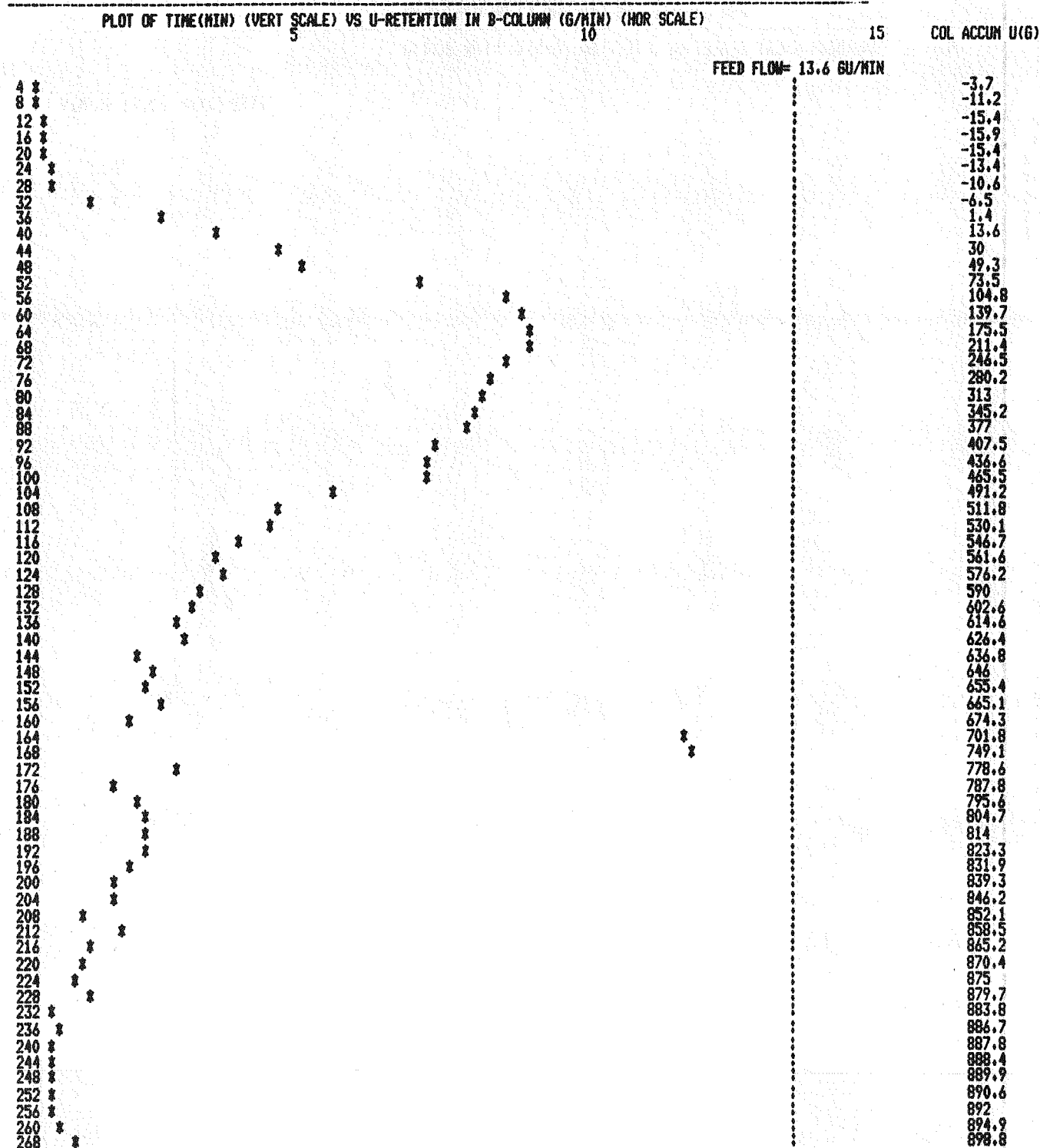


APPENDIX B-35

COMPUTER URANIUM MASS RATE DIAGRAM AND COLUMN INVENTORY FROM XRFA CONCENTRATION DATA: 1BS COLUMN AND LAP HEAD POT, TEST 3AM-4, AVERAGE FLOW RATES

RUN PP8
INPUT WHICH ENGINEERING LAB RUN NO.
(USES LATEST IF NO OTHER) ? 10
THE LAST RECORD IS 83
START WITH ? 17
END WITH ? 83
FEED U (G/L) AND FEED FLOW (L/H)? 40.13,0.339
AX FLOW RATE, L/MIN? 0.268
BY FLOW RATE, L/MIN? 0.249
BP FLOW RATE, L/MIN? 0.263

B-COL RETENTION, BASED ON XRFA DATA
STARTS WITH RECORD 17
AND GOES TO RECORD 83
FOR ENGINEERING LAB RUN 10 ON 26-Jun-81



APPENDIX B-36

COMPUTER URANIUM MASS RATE DIAGRAM AND COLUMN INVENTORY FROM XRFA CONCENTRATION DATA: 1A COLUMN, TEST 3AM-5, AVERAGE FLOW RATES

RUN PP6
INPUT WHICH ENGINEERING LAB RUN NO.
(USES LATEST IF NO OTHER) ? 12
THE LAST RECORD IS 107
START WITH ? 36
END WITH ? 73
FEED U (G/L) AND FEED FLOW (L/H)? 40.13,0.322
AX FLOW RATE, L/MIN? 0.265

A-COL HOLDUP, BASED ON XRFA DATA
STARTS WITH RECORD 36
AND GOES TO RECORD 73
FOR ENGINEERING LAB RUN 12 ON 02-Jul-81

PLOT OF TIME(MIN) (VERT SCALE) VS U-OUTFLOW (G/MIN) (HOR SCALE)

5

10

COL ACCUM U(G)

FEED FLOW= 12.92 GU/MIN

4 *
8 *
12 *
16 *
20 *
24 *
28 *
32 *
36 *
40 *
44 *
48 *
52 *
56 *
60 *
64 *
68 *
72 *
76 *
80 *
84 *
88 *
92 *
96 *
100 *
104 *
108 *
112 *
116 *
120 *
124 *
128 *
132 *
136 *
140 *
144 *
148 *
152 *

51.4
102.5
153.9
205.6
257.3
308.4
358.9
407.7
450.9
486.7
519.1
548
570.8
587.1
599.5
609.6
616.4
621.5
625.1
627.9
630.8
633.1
635
637
638.8
640.8
643.3
645.6
647.4
648.4
648.5
648.2
647.4
646.2
644.9
643.9
643.2
643.5

>

APPENDIX B-37

AVERAGE COLUMN DENSITY READINGS BY DT AND WT INSTRUMENTS: TEST 3AM-3

RUN PP3
INPUT WHICH ENGINEERING LAB RUN NO.
(USES LATEST IF NO OTHER) ? 11
THE LAST RECORD IS 84
START WITH ? 2
END WITH ? 84
INTERVAL ? 1

PP COL DEN AND WT READINGS DURING RUN NO. 11
STARTS WITH RECORD 2 AND ENDS WITH RECORD 84

J=A COL DEN(TOP); R=A COL DEN(BOT); W=A COL WT; X=B COL DEN; +=B COL WT

RCD	TIME	0.80	0.85	0.90	0.95	1.00	1.05
2	08:06AMWB	T				*	+
3	08:10AMWB		T			*	+
4	08:14AMWB		T			*	+
5	08:18AMWB		T			*	+
6	08:22AMWB		T			*	+
7	08:26AMWB		T			*	+
8	08:30AMWB		T			*	+
9	08:34AMWB		T			*	+
10	08:38AMWB		T			*	+
11	08:42AMWB		T			*	+
12	08:46AMWB		T			*	+
13	08:50AM			T		*	+
14	08:54AM			T		*	+
15	09:02AM			T		*	+
16	09:10AM			T	BW	*	+
17	09:14AM			T	BW	*	+
18	09:18AM			T	BW	*	+
19	09:22AM			T	BW	*	+
20	09:26AM			T	BW	*	+
21	09:30AM			T	BW	*	+
22	09:34AM			T	BW	*	+
23	09:38AM			T	BW	*	+
24	09:42AM			T	BW	*	+
25	09:46AM			T	BW	*	+
26	09:50AM			T	BW	*	+
27	09:54AM			T	BW	*	+
28	09:58AM			T	BW	*	+
29	10:02AM			T	BW	*	+
30	10:06AM			T	BW	*	+
31	10:10AM			T	BW	*	+
32	10:14AM			T	BW	*	+
33	10:18AM			T	BW	*	+
34	10:22AM			T	BW	*	+
35	10:26AM			T	BW	*	+
36	10:30AM			T	BW	*	+
37	10:34AM			T	BW	*	+
38	10:38AM			T	BW	*	+
39	10:42AM			T	BW	*	+
40	10:46AM			T	BW	*	+
41	10:50AM			T	BW	*	+
42	10:54AM			T	BW	*	+
43	10:58AM			T	BW	*	+
44	11:02AM			T	BW	*	+
45	11:06AM			T	BW	*	+
46	11:10AM			T	BW	*	+
47	11:14AM			T	BW	*	+
48	11:18AM			T	BW	*	+
49	11:22AM			T	BW	*	+
50	11:26AM			T	BW	*	+
51	11:30AM			T	BW	*	+
52	11:34AM			T	BW	*	+
53	11:38AM			T	BW	*	+
54	11:42AM			T	BW	*	+
55	11:46AM			T	BW	*	+
56	11:50AM			T	BW	*	+
57	11:54AM			T	BW	*	+
58	11:58AM			T	BW	*	+
59	12:02PM			T	BW	*	+
60	12:06PM			T	BW	*	+
61	12:10PM			T	BW	*	+
62	12:14PM			T	BW	*	+
63	12:18PM			T	BW	*	+
64	12:22PM			T	BW	*	+
65	12:26PM			T	BW	*	+
66	12:30PM			T	BW	*	+
67	12:34PM			T	BW	*	+
68	12:38PM			T	BW	*	+
69	12:42PM			T	BW	*	+
70	12:46PM			T	BW	*	+
71	12:50PM			T	BW	*	+
72	12:54PM			T	BW	*	+
73	12:58PM			T	BW	*	+
74	01:02PM			T	BW	*	+
75	01:06PM			T	BW	*	+
76	01:10PM			T	BW	*	+
77	01:14PM			T	BW	*	+
78	01:18PM			T	BW	*	+
79	01:22PM			T	BW	*	+
80	01:26PM			T	BW	*	+
81	01:30PM			T	BW	*	+
82	01:34PM			T	BW	*	+
83	01:38PM			T	BW	*	+

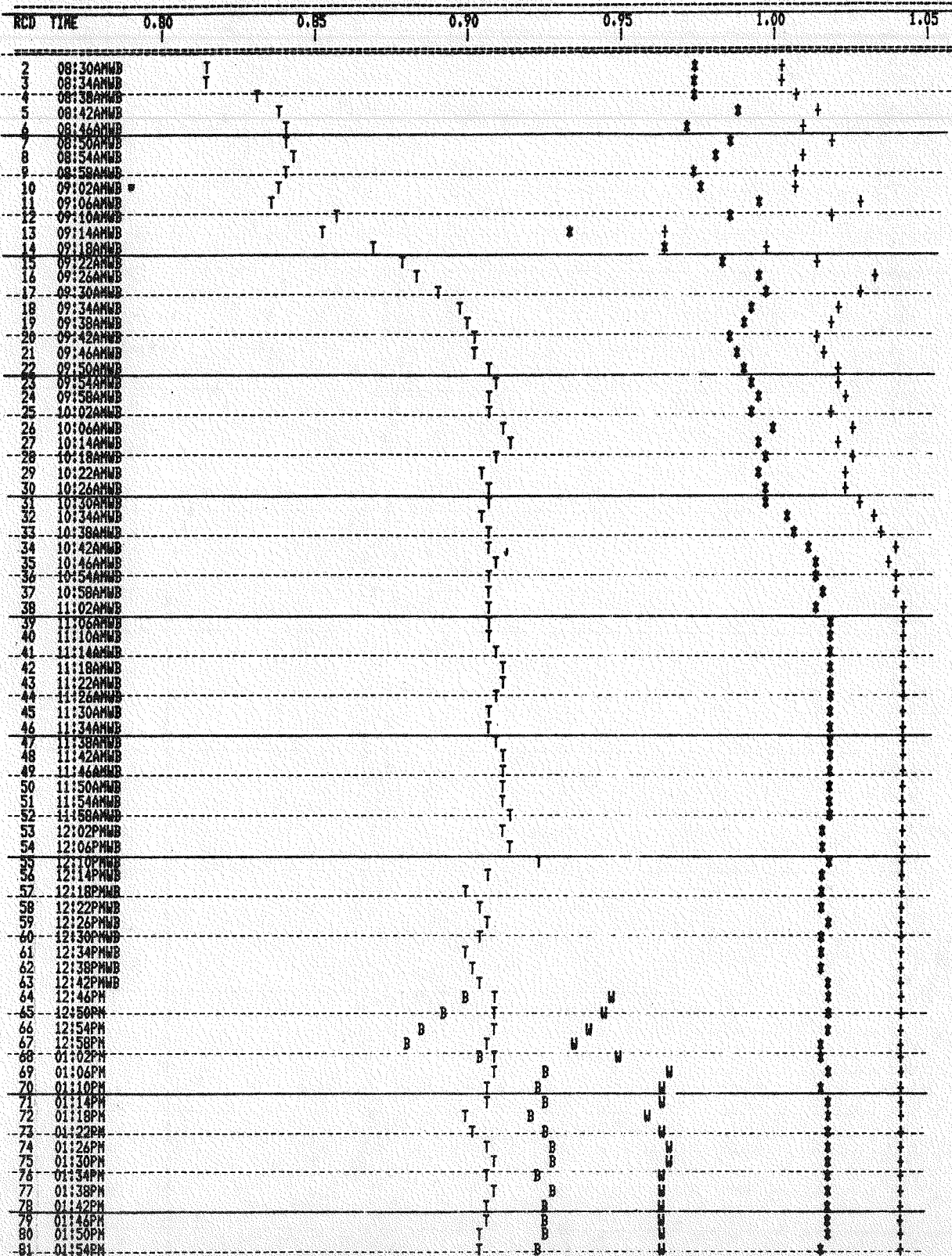
APPENDIX B-38

AVERAGE COLUMN DENSITY READINGS BY
DT AND WT INSTRUMENTS: TEST 3AM-4

RUN PP3
INPUT WHICH ENGINEERING LAB RUN NO.
(USES LATEST IF NO OTHER) ? 10
THE LAST RECORD IS 82
START WITH ? 2
END WITH ? 82
INTERVAL ? 1

PP COL DEN AND WT READINGS DURING RUN NO. 10
STARTS WITH RECORD 2 AND ENDS WITH RECORD 82

T=A COL DEN(TOP); B=A COL DEN(BOT); W=A COL WT; #=B COL DEN; +=B COL WT



APPENDIX B-39

AVERAGE COLUMN DENSITY READINGS BY DT AND WT INSTRUMENTS: TEST 3AM-5

>RUN PP3

INPUT WHICH ENGINEERING LAB RUN NO.:

(USES LATEST IF NO OTHER) ? 12

THE LAST RECORD IS 107

START WITH ? 32

END WITH ? 100

INTERVAL ? 1

PP COL DEN AND WT READINGS DURING RUN NO. 12
STARTS WITH RECORD 32 AND ENDS WITH RECORD 100

T=A COL DEN(TOP); B=A COL DEN(BOT); W=A COL WT; *B COL DEN; +B COL WT

RCD	TIME	0.80	0.85	0.90	0.95	1.00	1.05
32	10:00AM		T	W		*	+
33	10:04AM		T	WB		*	+
34	10:08AM		T	W		*	+
35	10:12AM		T	W		*	+
36	10:16AM		T	W		*	+
37	10:20AM		T	W		*	+
38	10:24AM		T	W		*	+
39	10:28AM		T	TB		*	+
40	10:32AM		T	TB		*	+
41	10:36AM		T	TB		*	+
42	10:40AM		T	TB		*	+
43	10:44AM		T	TB		*	+
44	10:48AM		T	TB		*	+
45	10:52AM		T	TB		*	+
46	10:56AM		T	TB		*	+
47	11:00AM		T	TB		*	+
48	11:04AM		T	TB		*	+
49	11:08AM		T	TB		*	+
50	11:12AM		T	TB		*	+
51	11:16AM		T	TB		*	+
52	11:20AM		T	TB		*	+
53	11:24AM		T	TB		*	+
54	11:28AM		T	TB		*	+
55	11:32AM		T	TB		*	+
56	11:36AM		T	TB		*	+
57	11:40AM		T	TB		*	+
58	11:44AM		T	TB		*	+
59	11:48AM		T	TB		*	+
60	11:52AM		T	TB		*	+
61	11:56AM		T	TB		*	+
62	12:00PM		T	TB		*	+
63	12:04PM		T	TB		*	+
64	12:08PM		T	TB		*	+
65	12:12PM		T	TB		*	+
66	12:16PM		T	TB		*	+
67	12:20PM		T	TB		*	+
68	12:24PM		T	TB		*	+
69	12:28PM		T	TB		*	+
70	12:32PM		T	TB		*	+
71	12:36PM		T	TB		*	+
72	12:40PM		T	TB		*	+
73	12:44PM		T	TB		*	+
74	12:48PM		T	TB		*	+
75	12:52PM		T	TB		*	+
76	12:56PM		T	TB		*	+
77	01:00PM		T	TB		*	+
78	01:04PM		T	TB		*	+
79	01:08PM	B	B	W		*	+
80	01:12PM	B	B	W		*	+
81	01:16PM	B	B	W		*	+
82	01:20PM	B	B	W		*	+
83	01:24PM	B	B	W		*	+
84	01:28PM	B	B	W		*	+
85	01:32PM	B	B	W		*	+
86	01:36PM	B	B	W		*	+
87	01:40PM	B	B	W		*	+
88	01:44PM	B	B	W		*	+
89	01:48PM	B	B	W		*	+
90	01:52PM	B	B	W		*	+
91	01:56PM	B	B	W		*	+
92	02:00PM	B	B	W		*	+
93	02:04PM	B	B	W		*	+
94	02:08PM	B	B	W		*	+
95	02:12PM	B	B	W		*	+
96	02:16PM	B	B	W		*	+
97	02:20PM	B	B	W		*	+
98	02:24PM	B	B	W		*	+
99	02:28PM	B	B	W		*	+

APPENDIX B-40

AVERAGE COLUMN DENSITY READINGS BY DT AND WT INSTRUMENTS: ADDITIONAL TEST FOR UPSET READING

RUN PP3
INPUT WHICH ENGINEERING LAB RUN NO.
(USES LATEST IF NO OTHER) ? 13
THE LAST RECORD IS 65
START WITH ? 2
END WITH ? 65
INTERVAL ? 1

PP COL DEN AND WT READINGS DURING RUN NO. 13
STARTS WITH RECORD 2 AND ENDS WITH RECORD 65

T=A COL DEN(TOP); B=A COL DEN(BOT); W=A COL WT; * = P COL DEN; + = B COL WT

RCD	TIME	0.80	0.85	0.90	0.95	1.00	1.05
2	09:34AMWB	T				*	+
3	09:38AMWB	T				*	+
4	09:46AMWB					*	+
5	09:50AMWB		T	*	+		
6	09:54AMWB		T	*	+		
7	09:58AMWB			*	+		
8	10:02AMWB			*	+		
9	10:06AMWB			*	+		
10	10:10AMWB			*	+		
11	10:14AMWB			*	+		
12	10:18AMWB			*	+		
13	10:22AMWB			*	+		
14	10:26AMWB			*	+		
15	10:30AMWB			*	+		
16	10:34AMWB			*	+		
17	10:38AMWB			*	+		
18	10:42AMWB			*	+		
19	10:46AMWB			*	+		
20	10:50AMWB			*	+		
21	10:54AMWB			*	+		
22	10:58AMWB			*	+		
23	11:02AMWB			*	+		
24	11:06AMWB			*	+		
25	11:10AMWB			*	+		
26	11:14AMWB			*	+		
27	11:18AMWB			*	+		
28	11:22AMWB			*	+		
29	11:26AMWB			*	+		
30	11:30AMWB			*	+		
31	11:34AMWB			*	+		
32	11:38AMWB			*	+		
33	11:42AMWB			*	+		
34	11:46AMWB			*	+		
35	11:50AMWB			*	+		
36	11:54AMWB			*	+		
37	11:58AMWB			*	+		
38	12:02PMWB			*	+		
39	12:06PMWB			*	+		
40	12:10PMWB			*	+		
41	12:14PMWB			*	+		
42	12:18PMWB			*	+		
43	12:22PMWB			*	+		
44	12:26PMWB			*	+		
45	12:30PMWB			*	+		
46	12:34PMWB			*	+		
47	12:38PM			*	+		
48	12:42PM			*	+		
49	12:46PM			*	+		
50	12:50PM			*	+		
51	12:54PM			*	+		
52	12:58PM			*	+		
53	01:02PM			*	+		
54	01:06PM			*	+		
55	01:10PM			*	+		
56	01:14PM			*	+		
57	01:18PM			*	+		
58	01:22PM			*	+		
59	01:26PM			*	+		
60	01:30PM			*	+		
61	01:34PM			*	+		
62	01:38PM			*	+		
63	01:42PM			*	+		
64	01:46PM			*	+		

DISTRIBUTION FOR TOPICAL AND FINAL REPORTS

AGNS/DOE CONTRACT NO. DE-AC09-78ET35900
UC-83

Report No.: AGNS-35900-2.5-142

Date Issued: October 30, 1981

Standard AGNS Internal Distribution:

K. J. Bambas (1)
J. A. Buckham (1)
R. J. Cholister (1)
R. C. Ravasz (1)
J. C. Smith (1)
G. T. Stribling (1)
W. B. Sumner (1)
A. K. Williams (1)
Library (1)
Records Management (25)

Additional AGNS Internal Distribution:

A. F. Cermak
J. C. Neace
R. G. Spaunburgh
J. H. Ellis
M. H. Ehinger

DOE Distribution:

Mr. J. W. Geiger, Project Engineer (2)
Waste and Fuel Cycle Technology Office
DOE Savannah River Operations Office
Post Office Box A
Aiken, South Carolina 29801

Dr. J. Spencer (3)
Savannah River Laboratory
E. I. du Pont de Nemours and Company
Aiken, South Carolina 29801

Mr. William Burch (3)
Oak Ridge National Laboratory
Post Office Box X
Oak Ridge, Tennessee 37830

Mr. S. W. O'Rear, TIC (1)
Savannah River Laboratory
E. I. du Pont de Nemours and Company
Aiken, South Carolina 29801

Mr. D. C. Drennon (1)
Contracting Officer
DOE Savannah River Operations Office
Post Office Box A
Aiken, South Carolina 29801

Mr. M. J. Lawrence (1)
Acting Director
Office of Nuclear Fuel Cycle
Office of Deputy Assistant Secretary
for Nuclear Waste Management and
Fuel Cycle Programs
U. S. Department of Energy Headquarters
Washington, D. C. 20545

TIC Distribution:

*DOE Technical Information Center (101)
Post Office Box 62
Oak Ridge, Tennessee 37830

Other External Distribution:

Per attached list

*Per attached list.

TIC STANDARD DISTRIBUTION (Total 101)
UC-83 Distribution List Converter Fuel Processing

DOE Operations Office

1	Albuquerque
1	Chicago
1	Savannah River, Manager
1	Savannah River, Contracting Officer
1	Idaho
1	Oak Ridge
1	Richland
1	San Francisco
1	Nevada
9	Savannah River, FCPO
1	Savannah River, Classification Officer

DOE Prime Contractors

1	Mound Lab, DAO
1	Rockwell International, RFP
1	Argonne National Lab, CH
1	Battelle Pacific Northwest Lab, RL
2	Savannah River Lab, SR
1	Hanford Engineering Development Lab, RL
2	Los Alamos Scientific Lab, AL
2	Oak Ridge National Lab, OR
1	Sandia Lab, AL
1	Lawrence Livermore Lab, SAN
1	Rockwell Hanford Operations, RL
1	Oak Ridge Gaseous Diffusion Plant, OR
1	EG&G Idaho Inc., ID
1	Brookhaven National Lab, Upton, NY
1	Exxon Nuclear Corporation, ID

Government, Other

3	DOE Nuclear Power Development, Fuel Cycle, Assistant Director HQ
1	DOE Division of Spent Fuel Storage and Transfer, Director, HQ
1	Library of Congress
1	DOE Nuclear Power Development Division, Director, HQ
1	DOE Rocky Flats Area Office, Golden, CO
25	DOE TIC
25	National Technical Information Service (COMM)
1	DOE Office of Safeguards and Security, HQ
2	DOE Waste Management Division, HQ
1	Air Research Lab, NOAA, MD
1	DOE Grand Junction Office, Grand Junction, CO
1	DOE Division of Uranium Resources and Enrichment, HQ

EXTERNAL DISTRIBUTION FOR TASK 2 DOE REPORTS

Frank Arsenault, Director
Division of Safeguards, Fuel Cycle, and
Environmental Research
Office of Nuclear Regulatory Research
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Dr. R. E. Brooksbank
Building 3019
Oak Ridge National Laboratory
Post Office Box X
Oak Ridge, Tennessee 37830

William H. Chambers (2)
Deputy Associate Director for
Safeguards & Security
Mail Stop 550
P. O. Box 1663
Los Alamos Scientific Laboratory
Los Alamos, New Mexico 87545

Dr. L. D. Chapman, Supervisor
Systems Analysis Division I
Sandia Laboratories
Albuquerque, New Mexico 87115

Frank P. Gillespie, Chief
Materials Protection Standards Branch
Division of Siting, Health, and
Safeguards Standards
Office of Standards Development
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Carl Henry (2)
Associate Division Leader for
Nuclear Safeguards
Q Division
Mail Stop 551
Post Office Box 1663
Los Alamos Scientific Laboratory
Los Alamos, New Mexico 87545

Dr. Andrew J. Poggio
NRC Safeguards Program, L-97
Lawrence Livermore Laboratory
Post Office Box 808
Livermore, California 94550

Dr. B. R. Dickey
Exxon Nuclear Company, Inc.
Idaho Chemical Processing Plant
Post Office Box 2800
Idaho Falls, Idaho 83401

R. G. Page, Special Assistant to the
Director for Licensing
Division of Safeguards
Office of Nuclear Material Safety
and Safeguards
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Dr. P. J. Persiani
Argonne National Laboratory
9700 South Cass Avenue
Argonne, Illinois 60439

V. Keith Smith, Supervisor
Entry Control Systems Division
Division 1757
Sandia Laboratories
Albuquerque, New Mexico 87115

Sylvester Suda
Technical Support Organization
Building 197
Brookhaven National Laboratory
Upton, Long Island, New York 11973

Ivan G. Waddoups, Supervisor
Systems Studies and Engineering
Division
Organization 1754
Sandia Laboratories
Albuquerque, New Mexico 87115

W. C. Scotten
Process Staff Engineer
Planning Analysis Department
Savannah River Plant
E. I. du Pont de Nemours & Company
Aiken, South Carolina 29801

Don Crandall
Bechtel, Inc.
Post Office Box 3965
San Francisco, California 94105

Newton H. Seebeck, Director (2)
Office of Safeguards & Security
U. S. Department of Energy
Savannah River Operations Office
Post Office Box A
Aiken, South Carolina 29801

R. J. Kofoed
Senior Research Scientist
Battelle Pacific Northwest Laboratories
Post Office Box 999
Richland, Washington 99352

R. W. Peterson
Battelle Project Management Division
Office of Nuclear Waste Isolation
505 King Avenue
Columbus, Ohio 43201

F. A. O'Hara
Battelle Columbus Laboratories
505 King Avenue
Columbus, Ohio 43201

J. H. Owen
Savannah River Plant
E. I. Du Pont de Nemours & Company
Document Transfer Station, 703-A
Aiken, South Carolina 29801

J. V. Cupo
Westinghouse Electric Corporation
Power Systems
Nuclear Center
Post Office Box 355
Pittsburgh, Pennsylvania 15230

Leon Green, Head
International Safeguards Project Office
Building 197
Brookhaven National Laboratory
Upton, New York 11973

H. T. Kerr, Safeguards Task Leader
Consolidated Fuel Reprocessing Programs
Engineering Technology Division
Oak Ridge National Laboratory-
Nuclear Division
P. O. Box Y
Oak Ridge, Tennessee 37830

J. E. Samsel
Savannah River Plant
E. I. du Pont de Nemours & Company
Document Transfer Station, 703-A
Aiken, South Carolina 29801

W. T. Dickenson
Savannah River Plant
E. I. du Pont de Nemours & Company
Document Transfer Station, 703-A
Aiken, South Carolina 29801

J. E. Deveney
Sandia Laboratories
Organization 1761
P. O. Box 5800
Albuquerque, New Mexico 87185

Mr. James D. Williams, Supervisor
Intrusion Detection and Assessment
Technology Division
Organization 1739
Sandia Laboratories
Albuquerque, New Mexico 87185

Dr. Joerg H. Menzel, Chief
Nuclear Safeguards Staff
Bureau of Nonproliferation
U. S. Arms Control & Disarmament Agency
Washington, DC 20451

Dr. S. C. T. McDowell, Director
Division of Safeguards Systems
Development and Implementation
Office of Safeguards & Security
U. S. Department of Energy
Mail Stop A21016, DP-30
Washington, DC 20545

Dr. J. F. Tinney, Director
Division of Policy and Analysis
Office of Safeguards and Security
U. S. Department of Energy
Washington, DC 20545

Mr. L. J. Evans, Chief
Regulatory Improvements Branch
Division of Safeguards
Office of Nuclear Materials Safety
and Safeguards
U. S. Nuclear Regulatory Commission
Washington, DC 20555

Mr. Gene Perchonok, Chief
Technical Planning and Information Branch
Division of Safeguards
Office of Nuclear Materials Safety
and Safeguards
U. S. Nuclear Regulatory Commission
Washington, DC 20555

Mr. George McCorkle, Chief
Physical Security Licensing Branch
Division of Safeguards
Office of Nuclear Materials Safety
and Safeguards
U. S. Nuclear Regulatory Commission
Washington, DC 20555

Mr. Bob Erickson, Chief
Physical Security Development Branch
Division of Safeguards
Office of Nuclear Materials Safety
and Safeguards
U. S. Nuclear Regulatory Commission
Washington, DC 20555

Mr. Jim Partlow, Chief
Materials Control and Accountability
Licensing Branch
U. S. Nuclear Regulatory Commission
Washington, DC 20555

Mr. Ted Sherr, Chief
Materials Control and Accountability
Development Branch
U. S. Nuclear Regulatory Commission
Washington, DC 20555

Dr. G. Robert Keepin
Los Alamos Scientific Laboratory
P. O. Box 1663
Los Alamos, New Mexico 87545

Mr. Thomas H. Isaacs
Deputy Director, Office of Safeguards
and Security
U. S. Department of Energy
Mail Stop A21016
Century 21 Building
Washington, DC 20545

Mr. D. L. Condotta, Vice-President
Technical Department
Exxon Nuclear Idaho Company, Inc.
P. O. Box 2800
Idaho Falls, Idaho 83401

Mr. R. L. Caudle, Acting Director
U. S. Department of Energy
Office of Safeguards & Security
Mail Station A2-1308
Washington, DC 20545