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AN EVALUATION OF THE WELDON SPRING FEED PREPARATION AND SAMPLING PLANT

By

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J. E. Todd, and M. N. Kuehn

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ABSTRACT

A description of the new Weldon Spring Feed Preparation and Sampling Plant for uranium concentrates is given Prior to the startup of this plant the auger to be later installed was used in an evaluation program to test reliability for representative sampling and uniformity both within drums and between drums of various concentrates. Results of this program were used as a reference for the sampling plant evaluation which involved successive auger and mechanical sampling of a series of lots of several concentrates, followed by moisture determinations, uranium assays, and statistical analyses of the data. From the final results conclusions are drawn concerning the suitability of the mechanical sampling system for the concentrates examined

INTRODUCTION

Mallinckrodt Chemical Works, Uranium Division, operates uranium processing facilities for the U. S. Atomic Energy Commission near Weldon Spring, Missouri, and, from 1942 until recently, had operated similar facilities in St Louis.

Sampling of uranium concentrates for payment purposes began in 1954 with Beaverlodge concentrate, and in June, 1957, Mallinckrodt was designated an official sampler of all Canadian concentrates to be consumed in its plants Other sampling of incoming ore concentrates was done to assure accurate accountability of the uranium received and processed by Mallinckrodt

The need for sampling for accountability purposes arose soon after processing of raw pitchblende ore began in 1946 when differences in material balances appeared In September, 1951, material balances indicated that there was a serious bias between the uranium content of the material sampled and the uranium content of the sample taken by the AEC sampling station at Middlesex, New Jersey. Also, a bias was found between the Middlesex samples and the vendor's (African Metals) samples Further evidence of a sampling bias was shown in April, 1952, following an AEC survey in which samples were taken from a random selection of drums in the MCW inventory

A temporary auger station was installed in February, 1954, for payment sampling of Beaverlodge concentrate and for accountability sampling of Portuguese Ore concentrate, South African concentrate, and intra-plant residues More than twenty different materials were sampled at this auger station from February, 1954, to January, 1958. No attempt was made to evaluate completely this auger station originally intended to be temporary The scant equipment on hand at that time precluded the completion of any thorough testing before the urgent need for use of the station arose.

When plans were made in 1955 for a new feed material processing center, a feed material preparation and sampling plant was included This plant was to provide statistical sampling for accountability purposes of all feed materials used in the processing center, including sampling of materials previously sampled elsewhere, such as Colorado concentrates and South African concentrate, and sampling of previously unsampled materials, such as Portuguese ore concentrate Intra-plant residues from the processing plants would also be sampled Auger or mechanical sampling would be used, depending on the characteristics of the material to be sampled. Roasting and grinding equipment was included for the treatment, if necessary, of feed materials and intra-plant residues. In 1956 the possibility arose that Mallinckrodt would payment-sample uranium concentrates. Since good accountability sampling must be just as accurately and carefully done as payment sampling, it was decided that the feed materials preparation and sampling plant then under construction should be adequate for payment sampling

FEED PREPARATION AND SAMPLING PLANT

The Feed Preparation and Sampling Plant is a five-story building roughly 80 feet wide, 100 feet long, and 100 feet high, serviced by a storage pad of 1.4 acres Ore concentrates can be unloaded from trucks or railroad cars directly onto the storage pad by fork trucks.

The building includes facilities for mechanical and auger sampling, for repackaging of material from drums into transfer hoppers or vice versa, for roasting, for crushing of ore concentrates or recycle feeds, and for determination of moisture. Figure 1 shows the ground floor plan of the mechanical and auger sampling facilities. The mechanical sampling system is shown in Figure 2. Figures 3a and 3b are flow diagrams for the sampling systems and the miscellaneous materials handling systems.

Drums (usually 30- or 55-gal) of ore concentrates to be mechanically sampled are transported from the storage pad by fork truck onto one of two roller conveyors which lead into the building to scales. Following gross weighing of the drums, the lids are removed, and the drums are then conveyed to the inlet of a large drum elevator. The full drums are mechanically pushed onto the drum elevator and moved to the fifth level where they are pushed onto another roller conveyor. By means of an alligator switch the drums are fed to either of two drum inverters. The contents of the drums are dumped onto a 3-in × 3-in. screen over a receiving hopper The drums are rapped several times to assure complete dumping, then are pushed off the inverter onto a chain conveyor, thence to a roller conveyor The drums roll back to the top of the drum elevator where the drums are pushed onto the elevator and carried down to the ground level as full drums are being brought up to the fifth level The empty drums are pushed off at the bottom of the elevator, conveyed to an inverter by roller conveyors, inverted, and moved upside down by a combination of roller and chain conveyors through a washer and drier The dried drums and lids are reassembled, and the tare weights are measured

The concentrate which passes through the 3-in × 3-in screen on the fifth level drops to the receiving hopper and is fed from the hopper through a rotary feeder to a natural-frequency vibrating conveyor which moves the powder to an impactor Any particles which will not pass a ⅜-in. × ⅜-in. scalping screen under the impactor drop to an oversize packaging station on the ground level The bulk of the powder drops to a surge hopper above the sampling system All the equipment up through this point is serviced by a Hershey-type dust collector which continuously feeds any dust collected back to the surge hopper

The material is fed out of the surge hopper through a rotary feeder to an electromagnetic vibrating feeder which feeds to the first stage of the sampling train The sampling train consists of a three-stage Geary-Jennings-type mechanical sampler manufactured by the Galigher Company The adjustable sample cutters move at a uniform velocity through and at right angles to the stream

SAMPLING PLANT
(GROUND FLOOR)

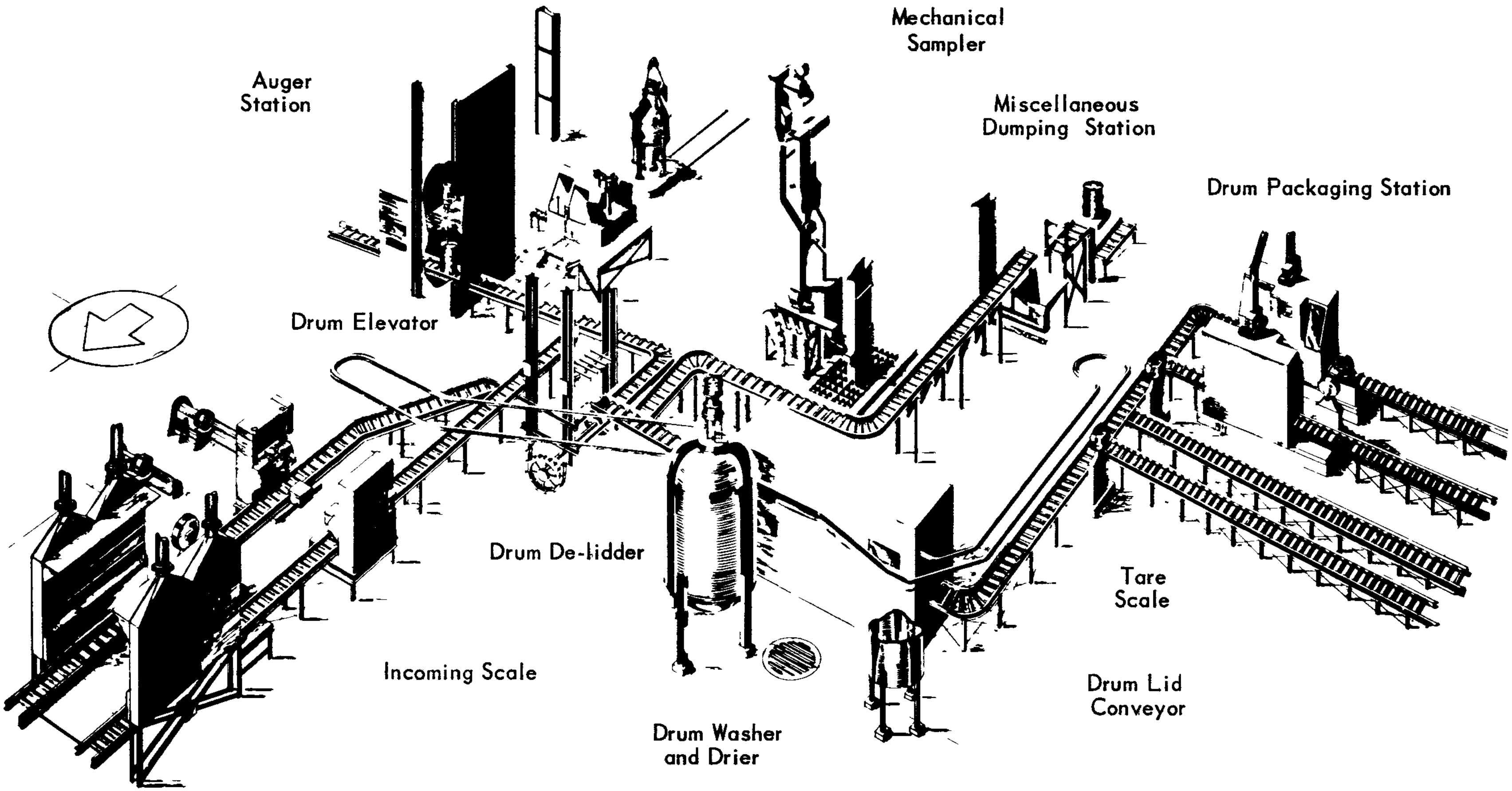


Figure 1

Figure 2

MECHANICAL SAMPLING SYSTEM

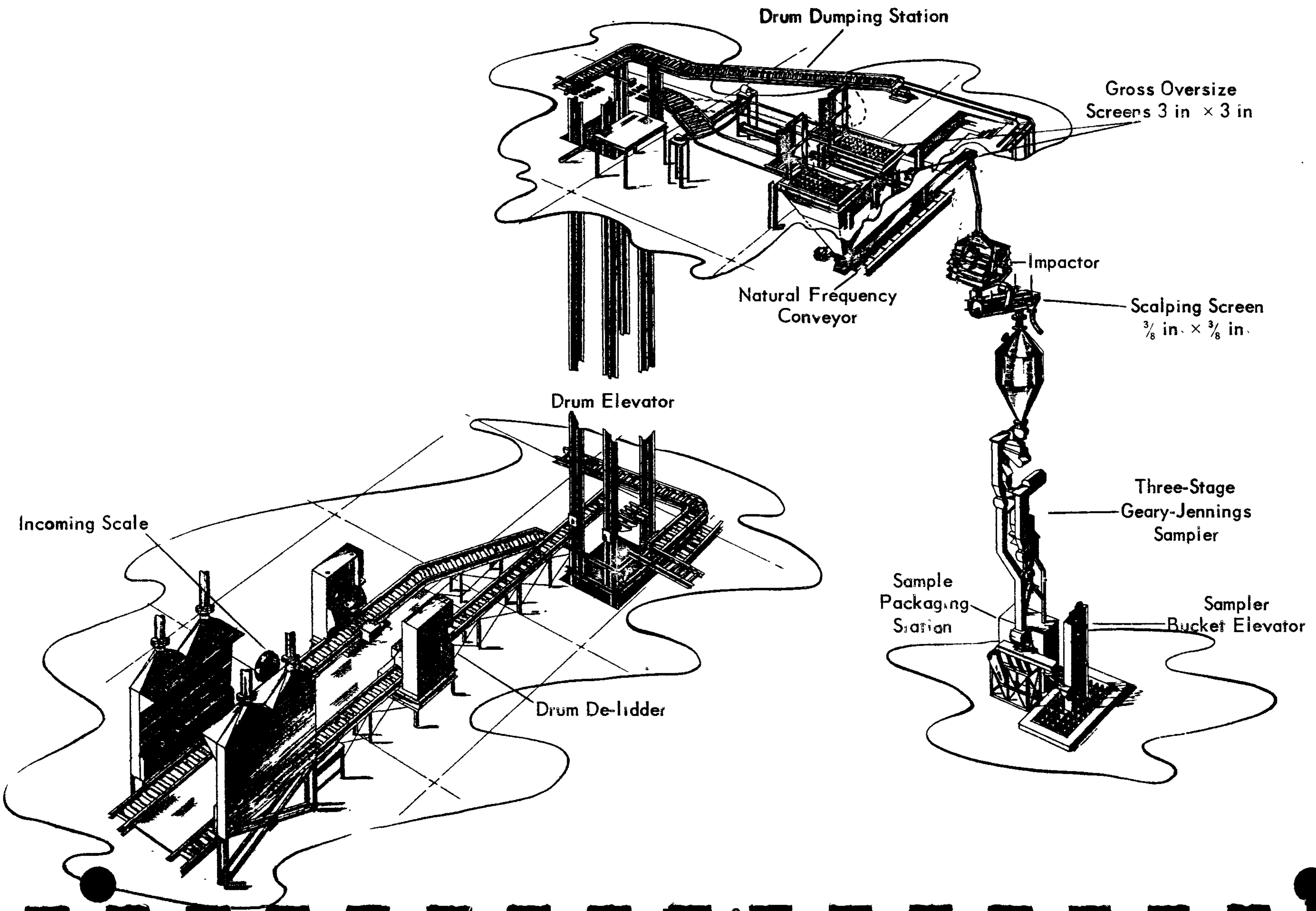
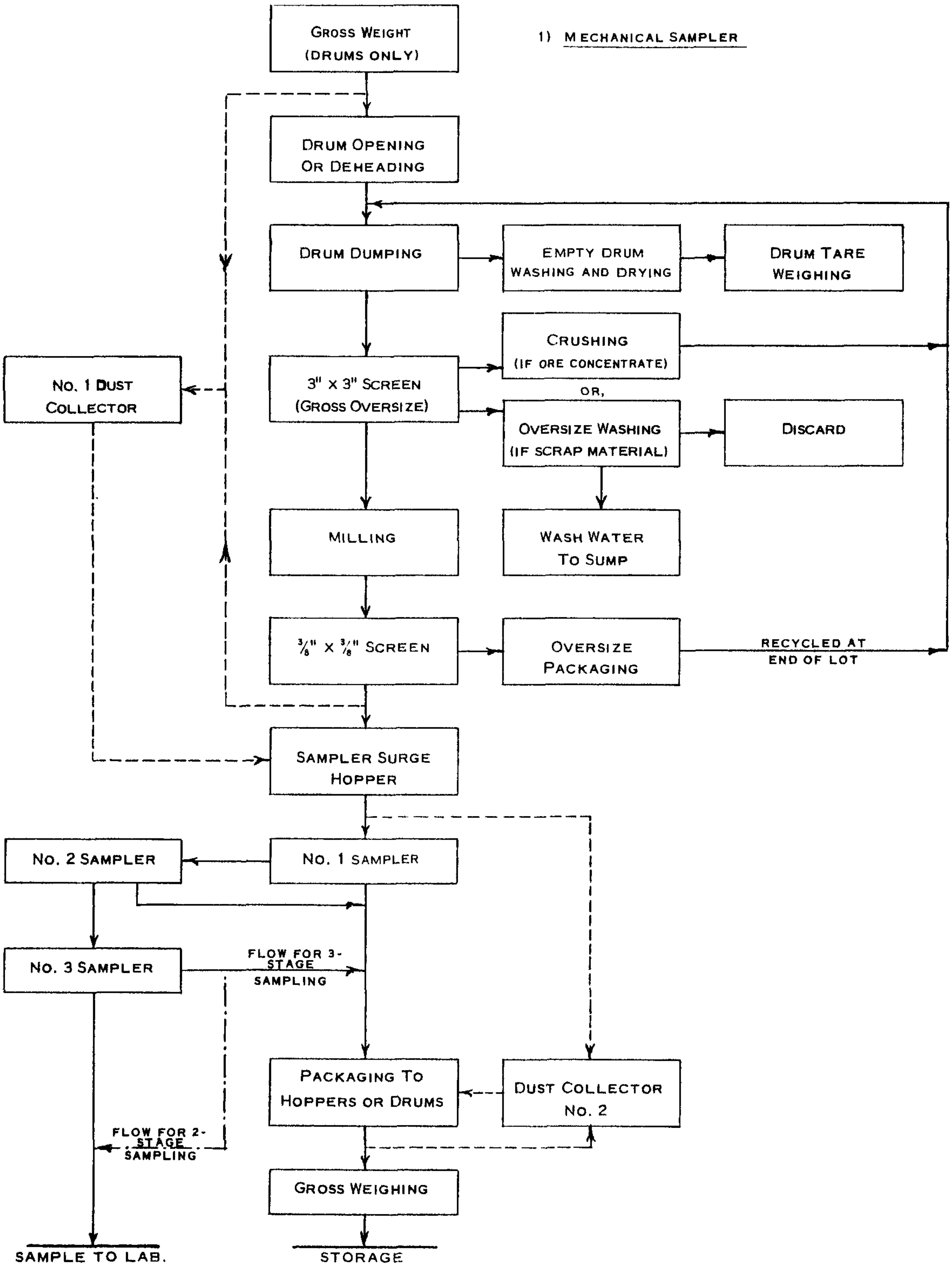


Figure 2

FIGURE 3 A

FEED PREPARATION AND SAMPLING PLANT



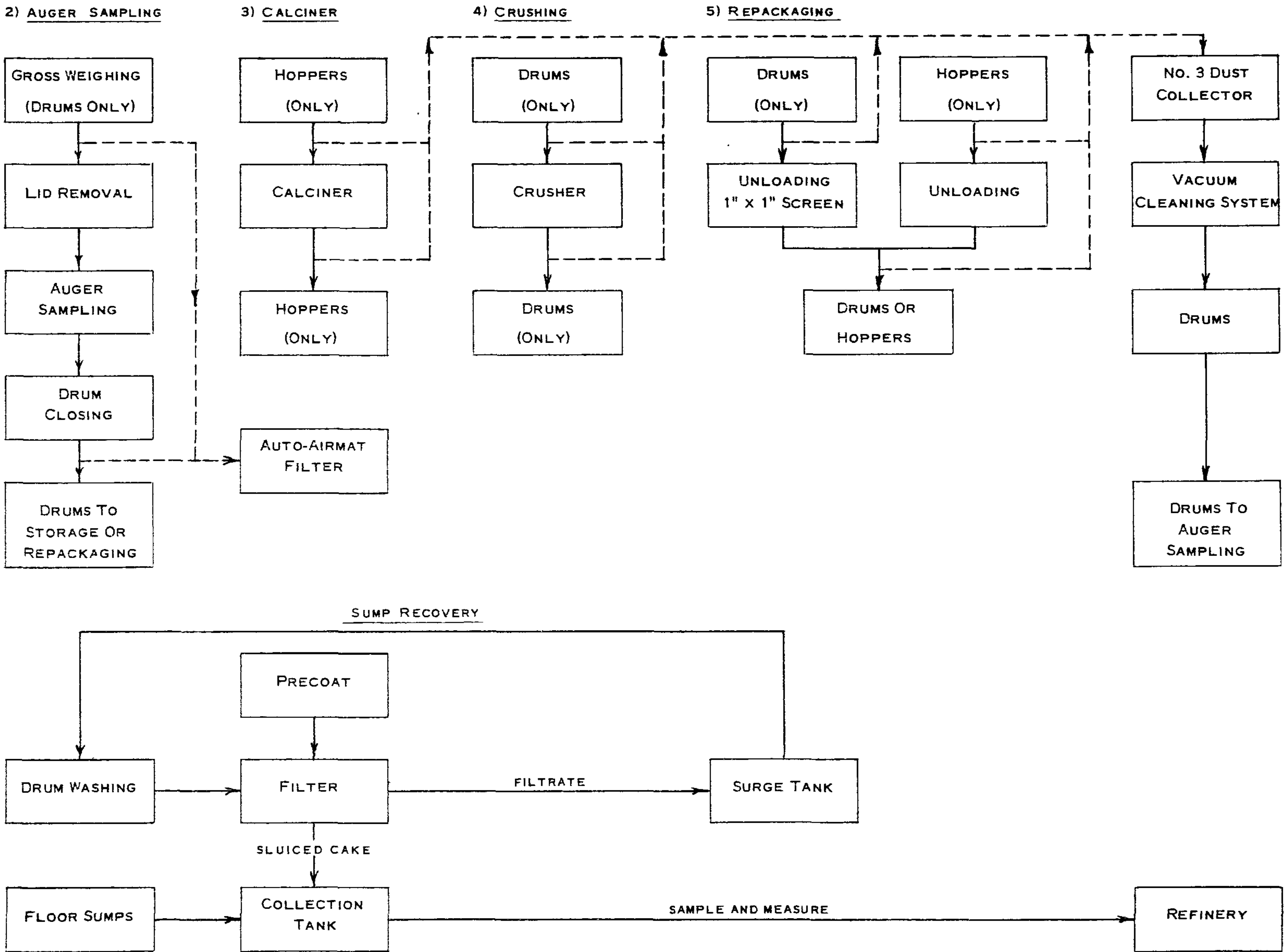


Figure 3B

FEED PREPARATION AND SAMPLING PLANT

sampled. The samplers move back and forth across the powder stream and completely out of the stream at the end of both the forward and backward strokes. The sample from the first stage drops through a pipe to a vibrating feeder thence to the second stage. The sample from the second stage follows a similar path to the third stage.

The sample and reject from the third stage can be recombined to give, in effect, a two-stage sampling. At present each sampler stage takes approximately a 10% cut giving a 0.1% overall sample with three-stage sampling. With adjustment of the cutter openings, however, the sample from three stages can be varied from a minimum cut of about 0.04% to a maximum cut of about 1.0%. If only two stages are used, a maximum cut of approximately 4.4% can be obtained. The reject (the bulk of the material) from each stage flows through a rotary feeder into a common chute which discharges through a rotary feeder into a natural frequency vibrating conveyor feeding a bucket elevator The bucket elevator lifts the material to the top of the plant where it discharges by gravity through a diverter valve to either the transfer hopper packaging station or drum packaging station fill hoppers. Normally the ore concentrate is packaged in transfer hoppers for supplying the uranium trioxide plant.

The equipment past the sample surge hopper including the sampling train, the bucket elevator, and the packaging station is serviced by another dust collector. This dust collector continuously discharges material through a rotary feeder to the boot of the bucket elevator.

Materials not amenable to mechanical sampling or lots too small for practical handling by the mechanical system can be auger sampled. Drums are fed to the auger sampling station from the same incoming conveyors used for weighing and mechanical sampling, except that the drum elevator is by-passed and the drums are allowed to roll around a corner into the auger station. The auger sampler is housed in an enclosure from which air is exhausted through a dust filter. There are openings in the enclosure to permit removal of drum lids and re-lidding of the drums.

The auger sampler used for the auger evaluation program and the sampling plant evaluation is a counter-weighted unit which is manually fed into the drum of material to be sampled. The auger is a single-pitched helical screw 1 5 inches in diameter and is contained in a steel sleeve. The auger extends about $\frac{5}{8}$ inch below the sleeve. When the auger reaches the bottom of the drum the rotation of the auger is stopped and the auger assembly is lifted from the drum The sample is removed from the auger by placing the lower end of the auger assembly into the sample container and reversing the direction of rotation of the auger

Although the previously described auger is still available for use, a fixed position, power-driven auger assembly has been installed. This assembly requires less manpower than the manually fed auger and provides a more nearly uniform rate of descent into the material to be sampled. A drum to be sampled is first positioned under the auger by means of a reversible power conveyor.

The auger assembly, a single-pitched helical screw 1.6 inches in diameter contained in a hardened steel sleeve which extends slightly below the screw, is power-driven into the material while the auger is simultaneously rotated inside the sleeve. When the sleeve reaches the bottom of the drum, the auger stops rotating and the sleeve is raised. Then the direction of rotation of the auger is reversed, and the material is discharged, either into a chute connected to a drum for lot sampling or directly into a jar for individual drum sampling. The sampled drum is re-lidded and conveyed outside the building for storage or repackaging.

In addition to the two types of sampling facilities described, several auxiliary installations increase the versatility of overall plant operation. Drums of material not requiring sampling or drums which have been auger sampled may be dumped into portable transfer hoppers in the miscellaneous dumping and packaging station. Drums enter the plant on a roller conveyor and are dumped in a manner similar to that described for the mechanical sampling system. The dumped concentrate passes through a 1-in. × 1-in. screen into a dumping hopper and thence through a screw conveyor to a bucket elevator which carries it to the fifth level. From there the material can be routed for packaging in either transfer hoppers or drums, as desired. It is also possible to dump transfer hoppers at this location, feeding the output to the same bucket elevator. Thus, any combination of repackaging from drums or hoppers into drums or hoppers is possible.

Material which is too large to pass readily through the gross oversize screen in the miscellaneous repackaging station can be crushed in the jaw crusher. (Only material in drums can be handled in the jaw crushing system) The drums of material to be crushed are placed under a hoist which extends outside the building. The drums are lifted to a roller conveyor, the lids are removed, and the drum is pushed onto an inverter The material is dumped into the crusher and caught in a drum on the ground level. The empty drums are removed by the same conveyor and hoist used for the full drums. This system is serviced by a Hershey-type dust collector which also serves the roaster and miscellaneous repackaging station.

A hopper of material to be roasted is set on a gasketed plenum ring, the hopper discharge valve is opened, and the material is allowed to fall into a screw conveyor. The screw conveyor feeds a bucket elevator which carries the material to the top of the roaster, a direct gas-fired Nichols-Herrshoff furnace having seven hearths. The hot roasted powder discharges from the bottom of the furnace onto a forced-air-cooled screw conveyor and then is packaged in a transfer hopper. The exhaust gases from the system go to a dust collector which also services the miscellaneous repackaging system and the jaw crusher.

Drums which have been dumped proceed to the drum washer The water used to wash drums in the first stage of the drum washer is caught in a pan underneath the washer and is pumped to a pressure filter which discharges the filtrate to a surge tank The filtrate in the surge tank is pumped through a heat exchanger to spray nozzles for reuse in cleaning drums. The cake on the filter is sluiced down periodically to a collection tank. Floor sumps in the various areas in the plant also empty into the collection tank After the tank is filled, the slurry is sampled and pumped to the refinery

Among the early concepts of the Weldon Spring Sampling Plant was the belief that the majority of materials sampled would be those from the Western United States. These concentrates had been handled for a long time and no problems in refinery operation had been encountered due to moisture content or sensitivity. In the analytical laboratory the dried samples had been handled and were considered moisture insensitive compared to the similarly dried and prepared samples of pitchblende ore and MgX (MgX is a magnesium precipitate of concentrated pitchblende tailings.)

For sampling plant operation, however, the characteristics of the materials as-received were of concern rather than the sensitivities of their dried samples. Furthermore, since transit time through the plant would be a matter of minutes, information was needed on the short-term aspects, *i.e.,* how much moisture change could occur in, say, ten or thirty minutes? Questions of this type led to an investigative program in the laboratory. Much of this work has been reported previously [1,2] It was not until the approach of completion of construction that it became apparent that sensitivity to atmospheric humidity would be a potential problem not only with the Western or Colorado concentrates but also with practically every refinery feed material

Several equipment modifications were made to reduce moisture change in the material during mechanical sampling In many cases in the original design, dust collection ducts had been connected directly into equipment, causing high air flows over the powder being processed. Changes were made in design to reduce these air flows to a minimum Originally, a dust collection inlet had been located directly over the drum inverting station This inlet was blanked off. Also the area including the drum inverters and receiving hopper was partitioned off with remote controlled doors for ingress of full drums and egress of empty drums

The direct venting of each stage of the sampling train to the dust collector was disconnected, and internal venting between adjacent stages was substituted. For maintaining health standards the whole sampling train was enclosed with general dust collection for the enclosure to prevent any possible leakage from contaminating the general plant area Direct venting was discontinued from hoppers to dust collectors, and internal venting was substituted In the case of the sample

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[1] Ziegler, W. A., Nelson, E. N., Christopherson, H. L., and Dowdy, J. D., *Process Development Quarterly Report, Part I,* Mallinckrodt Chemical Works, *MCW-1403* (July 1, 1957) pp 145-74

[2] Ziegler, W. A., "Evaluation of the Weldon Spring Sampling Plant," presented at AEC-Contractor SS Materials Management Meeting, Germantown, Maryland, May 20, 1958

surge hopper the vent line was run to the enclosure around the receiving hopper. A vent line from the chute above the scalping screen was also connected into this line. Another line was installed above the impactor to relieve pressure build-up between the rotary feeder and the impactor.

Many revisions were made in the plant other than those mentioned previously to assure smoothness of operation. Most of these changes were minor adjustments of existing equipment to attain the designed performance. Other revisions were more involved.

Remote buttons were installed for actuating the scale printers to prevent errors due to jarring of the scale. The outside scale for weighing portable hoppers was partially enclosed to reduce errors caused by wind. Improvements were made in the power conveyors at the scales.

A rotary magnetic separator had originally been installed between the natural frequency feeder conveying material to the impactor, and the impactor. The separator was removed to reduce powder leakage, air interchange, and handling of side streams. The removal was possible with little danger to the equipment because of the nature of the feed, the protection afforded by the 3-in × 3-in. gross oversize screen, and the fact that the impactor had no retaining grate.

The rotary feeder under the receiving hopper had not been included in the first design of the plant. This feeder was installed to reduce periodic overloading of the impactor and to reduce air interchange.

Six Despatch ovens (Model V-31) and a dry box were installed in the maintenance area of the Feed Materials Preparation and Sampling Plant to provide the additional drying space required after estimates were made of the space required for the number of lots to be sampled for payment purposes. The air input to the ovens and dry box is pre-dried by a Pittsburgh Lectrodryer. A Lectrodryer was also installed in the Analytical Department to supply pre-dried air to the three ovens in the oven room

AUGER EVALUATION PROGRAM

It was expected that some materials might be augered exclusively, so it was desirable to have information concerning the reliability of the auger method *per se*, but of more importance was the fact that this program was used to establish an absolute basis as a reference for the mechanical system. The auger program consisted of a comparison of samples from the unblended, as-received drums to samples from the same drums after blending The latter samples, of course, had to be representative because they were removed from a uniform mixture Then if the samples from unblended drums exhibited no significant difference from the blended-drum samples, the original auger sampling method was validated If the comparison is carried one step further, the mechanical sampler can be verified by comparing its samples to those of the proven auger But the ultimate reference is blended-drum sampling

In most cases in the auger evaluation two drums of ore concentrate were selected at random from each of two or more lots of each type of available feed material More types of feed materials were included in the auger evaluation program than those selected for use in the sampling plant evaluation, and some feed materials used in the sampling plant evaluation were not in existence during the time of the auger evaluation program.

Three auger samples, taken with the auger later installed in the Weldon Spring sampling plant, were removed from each drum through a template designed to provide uniform sampling locations. The template for 55-gallon drums contained three holes two inches in diameter with centers the following distances from the center of the drum: No. 1, $9\frac{5}{8}$ inches, No. 2, $4\frac{13}{16}$ inches; and No. 3, $\frac{1}{8}$ inch; and for 30-gallon drums: No. 1, 7 inches; No. 2, $3\frac{1}{2}$ inches; and No. 3, at the center of the drum. The samples were immediately discharged from the auger into respective bottles and the bottles were tightly capped. The contents of each drum were then transferred alternately, by hand scooping, to as many 30-gallon drums as were needed to limit the level of the material to half the depth of the 30-gallon drum. Each 30-gallon drum was then blended on a drum tumbler, end over end, for a minimum of fifteen minutes. After blending, the contents of the 30-gallon drums were transferred to the original drum, again by hand scooping, alternating the scoops from the 30-gallon drums to the original drum. Three auger samples were then removed from the blended drum using the same auger and template as with the unblended material

From these experiments two general types of information were obtained. The first was the comparison of blended and unblended drums which indicates the likelihood of obtaining a bias in auger sampling, and the second was the study of assay and moisture variation within drums. An extension of the second type of information was obtained during the later mechanical system evaluation in which one randomly selected drum from each lot handled was augered in all three positions.

In the earlier auger program only uranium assays on the dry basis were obtained on the samples. Moisture values could not be compared, the handling and blending operations would affect the moisture content. For the purpose of obtaining accurate uranium results, however, small-scale laboratory moisture determinations were made so that all uranium assays could be corrected to the dry basis. Thus, only uranium assays were used for the comparisons of blended and unblended drums However, in the position studies made in connection with the mechanical evaluation, the samples could be processed (*v.i.*) so as to enable obtaining both moisture and uranium concentrations.

Where possible, all results have been grouped together and are listed in the Appendix, Tables A-I through A-XXXII. Summaries and statistical evaluations of these data are given by material type in the following discussions. In these discussions conventional statistical terminology regarding significance is used. Significance levels indicate the assurance that an average difference really differs from zero. The meanings of these levels are usually taken as follows:

a. Less than 90% - not significant; no evidence to suggest that a difference exists.

b. Between 90% and 95% - possibly significant; more data required to reach a conclusion.

c. Between 95% and 99% - significant; a difference is indicated.

d. More than 99% - highly significant.

Position comparisons were obtained by "analysis of variance." In order to assess the adequacy of the data and to express an indication of the sensitivity of the statistical test, the "minimum detectable difference," the difference between any two position averages required for significance at the 95% confidence level, was calculated from the residual variance by use of a suitable "t" factor.

Anaconda Acid. In total, eleven drums, each from a different lot, were sampled and tested for moisture position bias, yielding the results of Table I. The drum from lot 1118 contained one highly deviant value (Position No. 1) which decreased the sensitivity in detecting a true bias. The differences between the extreme position averages are not significant above the 60% confidence level. The minimum detectable difference between any two of the position averages required for significance at the 95% confidence level is 0.28%. Therefore, no bias was deemed to exist although the minimum detectable difference is somewhat large for good sensitivity of the statistical test.

Table I

Anaconda Acid

Auger Position Bias Study -- Moisture

	Position		
	1	2	3
Average, per cent moisture	6.42	6.63	6.56

In the examination for position bias with respect to uranium assay, results were obtained from six drums in the auger evaluation program, five drums in the first series of Anaconda acid lots run in the mechanical evaluation program, and five drums in the second series, making a total of sixteen drums. Results are given in Table II.

Table II

Anaconda Acid

Auger Position Bias Study-- Uranium Assay

	Experimental Series	
	Auger & 1st SPE[a]	2nd SPE[a]
Position 1, average per cent U	69.66	70.58
Position 2, average per cent U	69.79	69.74
Position 3, average per cent U	69.73	69.30
Significance level of differences between position averages, per cent	85	95
Minimum detectable difference, per cent U	0.14	1.00

[a]Sampling Plant Evaluation (mechanical system)

Statistically it was not possible to combine all the sets of data. Only the results of the auger program and of the first series of runs through the mechanical system proved to belong to the same population. No significant position bias was indicated by this grouping, but a singular change had occurred in the material by the time the second mechanical series was run. Not only was a significant position bias demonstrated, but also the relative values of the positions had changed. It has been reported that Anaconda made process modifications approximately coincident with lot 1089, but there is no evident break in the data at this lot number. Some obvious differences in the characteristics of the material, however, were evidenced at the three different sampling periods. The average uranium assays, dry basis, of all the concentrate handled in the auger evaluation and the first and second series of the mechanical evaluation were 72.58%, 66.09%, and 70.61%, respectively. Within groups the assays remained relatively constant. The bulk density, or at least the packing of the drums, was quite different; during the first mechanical series there was an average 460 pounds of concentrate per drum, but this fell to 382 pounds per drum during the second series. A further difference was evidenced during repackaging of the material in the mechanical runs. During the first series the concentrate condensed to 0.93 of its initial volume, but in the second series it fluffed up to require 1.18 of the original number of drums to contain it. Unknown or unannounced minor adjustments in drum-filling techniques would be suspected to exert the most influence on the radial concentration gradients within drums. However, the occurrence of a bias in only a part of the data and the gross fluctuations within drums most emphatically illustrate the need for variation and randomization of auger position not only rotationally about the axis of the drum but also radially.

In Table II an anomalous situation appears to occur in the results of the second plant evaluation. The observed difference between positions 1 and 3, significant at the 95% confidence level, is considerably greater than the difference shown to be required at the same level by the minimum detectable difference. This is expected[3] to occur occasionally where comparison of the highest and lowest values of a set of values is made, and this circumstance is not considered critical.

The decisive indication of the validity of auger sampling is shown by the comparison of unblended and blended drum sample results. Weighted drum averages of dry-basis uranium assays were obtained by weighting the individual auger position results according to the representation of the respective template positions used, *i.e.*, each position result was weighted by a factor equal to the fractional volume of the drum that position represented. Analysis of the data yielded results as follows:

Unblended drum avg. - blended drum avg., per cent U	+ 0.057
Significance level, per cent	75
Minimum detectable difference, per cent U	0.10

Therefore, since the low minimum detectable difference indicated a good test sensitivity, the observed difference was not significant, and the auger sampling method used was shown to be a satisfactory reference for the mechanical plant evaluation.

Rifle. Five drums of Rifle were tested for moisture position bias, and the results are given in Table III. The difference between position averages is not significant above the 60% confidence level. The minimum detectable difference between any two of the position averages required for significance at the 95% confidence level is a satisfactorily low 0.04% absolute. Therefore, individual Rifle drums appeared to be quite uniform in moisture content.

Table III

Rifle

Auger Position Bias Study-- Moisture

	Position		
	1	2	3
Average, per cent moisture	0.07	0.07	0.05

With respect to uranium assay the position bias study included four drums from the auger program and five drums from the mechanical program It was possible statistically to combine all the data to obtain the results of Table IV The differences between position averages are not

[3] Davies, Owen L., "Statistical Methods in Research and Production," Oliver and Boyd, London, 1949, Second Edition Revised, p 71

significant (less than the 50% confidence level). The minimum detectable difference between any two of the position averages required for significance at the 95% confidence level is 0.66% uranium. No bias is evident although more data would be desirable for reducing the minimum detectable difference.

Table IV

Rifle

Auger Position Bias Study--Uranium Assay

	Position		
	1	2	3
Average, per cent U	67.98	67.69	67.67

In the comparison of blended and unblended drums the following results were obtained:

Unblended drum avg. - blended drum avg., per cent U	- 0.17
Significance level, per cent	98
Minimum detectable difference, per cent U	0.12

A bias is indicated here with the effect that routine auger sampling would give low results. A possible explanation is that the heavier and more concentrated particles settled to the bottom, and it is a well-known fact that an auger samples the bottom of a container very poorly. It was noted during the auger evaluation program that, because of the numerous large particles, this material was not particularly amenable to good auger sampling.

Uranium Reduction. Five drums of Uranium Reduction were tested for moisture position bias at the time of the mechanical evaluation, and the results are given in Table V. The differences between extreme position averages is significant at the 98% confidence level, with position 1 being high. The minimum detectable difference between any two of the position averages required for significance at the 95% confidence level is 0 09%.

Table V

Uranium Reduction

Auger Position Bias Study--Moisture

	Position		
	1	2	3
Average, per cent moisture	0.17	0 04	0.02

Moisture levels of the five randomly selected drums were considerably lower than those of the lots from which these drums were chosen. This resulted from the fact that a large variation of moisture values existed between drums of a lot with only a few extremely high values appearing in each case. The majority of values were in a range of 0.00 to about 0.50% water. Table VI shows the overall drum ranges observed for each lot.

Table VI

Uranium Reduction

Range of Drum Moisture Contents within Lots

Lot No.	Range, per cent Water
298	0.00 to 10.3
299	.00 to 9.66
304	.00 to 2.24
305	00 to 3.10
307	.00 to 7.71

In the position bias study with respect to uranium assay, results from the four drums of the auger evaluation program could not be combined with results from the five drums of the mechanical evaluation program. Between the two programs Uranium Reduction switched from 30-gallon drums to 55-gallon drums, entirely changing the relative uranium distribution pattern within drums. In Table VII are given the auger data, along with the mechanical program data, but the former are of no current benefit.

Table VII

Uranium Reduction

Auger Position Bias Study-- Uranium Assay

	Experimental Program	
	Auger	SPE
Position 1, average per cent U	61.61	67.88
Position 2, average per cent U	61.60	66.37
Position 3, average per cent U	61.70	65.61
Significance level of differences between position averages, per cent	50	>99
Minimum detectable difference, per cent U	0.26	0.71

While a serious position bias as shown in the later data is undesirable, its adverse effect is nullified by a randomization of the order of use of a group of properly located auger positions in sampling the drums of a lot of concentrate.

No comparison of unblended and blended drums has yet been made on the 55-gallon size, and therefore, information relating to auger sample validity for current production is not available.

Uravan. Six drums of material were tested for moisture position bias, yielding the data in Table VIII. The difference between position averages is not significant above the 75% confidence level. The minimum detectable difference between any two of the position averages required for significance at the 95% confidence level is 0.19%. Although no moisture position bias was exhibited, the minimum detectable difference is somewhat high in comparison to the moisture content of the material.

Table VIII

Uravan

Auger Position Bias Study -- Moisture

	Position		
	1	2	3
Average, per cent moisture	0 17	0 03	0.03

The uranium assay data for position study was obtained from four drums during the auger program and from six drums during the mechanical plant evaluation program. These data are presented in Table IX. It is not possible statistically to combine the two sets of data. Some change in the nature of the material or its packaging apparently occurred before the second set of experiments. Whereas no biases were detected in the auger program, the latter program shows that position 3 is biased lower than position 1 and possibly lower than position 2.

Table IX

Uravan

Auger Position Bias Study-- Uranium Assay

	Experimental Program	
	Auger	SPE
Position 1, average per cent U	65.96	65.08
Position 2, average per cent U	65 97	64.92
Position 3, average per cent U	66.04	64.62
Significance level of differences between extreme position averages, per cent	<50	98
Minimum detectable difference, per cent U	0.37	0.31

The comparison of unblended and blended drums was very good and yielded the following results:

Unblended drum avg. - blended drum avg, per cent U	– 0.04
Significance level, per cent	32
Minimum detectable difference, per cent U	0.19

Since no significant bias is indicated and since the position differences can be nullified by proper randomization of auger positions, the Uravan data provides a satisfactory reference.

Anaconda Carbonate. Five drums were tested for moisture position bias during the plant evaluation program. Results are given in Table X. The differences between position averages are not significant (less than the 50% confidence level). The minimum detectable difference between any two of the position averages required for significance at the 95% confidence level is 0.18% water. This material, therefore, appears quite uniform with respect to moisture content.

Table X

Anaconda Carbonate

Auger Position Bias Study-- Moisture

	Position		
	1	2	3
Average, per cent moisture	2.35	2.31	2.40

It was possible to combine results from six drums in the auger program and five drums in the mechanical program for evaluating the possibility of assay position bias. These results are shown in Table XI.

Table XI

Anaconda Carbonate

Auger Position Bias Study--Uranium Assay

	Position		
	1	2	3
Average, per cent U	64.69	64 86	64.78

The difference between extreme position averages is significant at the 92% confidence level. The minimum detectable difference between any two of the position averages required for significance at the 95% confidence level is 0.19% uranium. Thus, although moisture distribution appeared uniform throughout the drums, a possibility of assay position bias exists.

The comparison of blended and unblended drums gave the following results:

Unblended drum avg. - blended drum avg, per cent U	– 0.112
Significance level, per cent	88
Minimum detectable difference, per cent U	0.14

The absence of a significant bias coupled with a satisfactory minimum detectable difference indicates the suitability of the Anaconda carbonate data as a reference standard.

Texas-Zinc. Since the Texas-Zinc mill had not started production at the time of the auger evaluation program, its product was not included. During the sampling plant evaluation only the auger position study was made, and there has not been a comparison of blended and unblended drums.

A summary of the results for moisture on five drums is given in Table XII. For all drums the differences between position averages are not significant above the 60% confidence level. The minimum detectable difference between any two of the position averages required for significance at the 95% confidence level is 1.69% water. There is no significant position bias indicated; however, the experiment is very insensitive for detecting position bias because of a high experimental error resulting from the abnormal value appearing in position 2 of drum 1 from lot 12. Thorough checks have indicated the validity of this result; however, if it were assumed that such an abnormality would be extremely infrequent and the data were excluded, averages of the remaining four drums indicate even less possibility for position bias.

Table XII

Texas-Zinc

Auger Position Bias Study -- Moisture

	Position		
	1	2	3
Average, 5 drums, per cent moisture	3.25	4.12	3.21
Average, 4 drums[a], per cent moisture	3.66	3.65	3.62

[a]Excludes drum 1 from lot 12.

Samples from the same drums were used for the uranium assay study and yielded the data of Table XIII. No abnormal values were found as in the case of the moisture analysis. The differences between position averages are not significant (less than the 50% confidence level). The minimum detectable difference between any two of the position averages required for significance at the 95% confidence level is 0.35% uranium. This latter value is rather high, but no bias is evident.

Table XIII

Texas-Zinc

Auger Position Bias Study -- Uranium Assay

	Position		
	1	2	3
Average, per cent U	68.02	68.12	68.09

Western Nuclear. This material also came into existence after the auger evaluation program and was, therefore, included only in the sampling plant evaluation. Only auger position studies are available.

Six drums were included in the study for moisture position bias. Results are given in Table XIV. The differences between position averages are not significant above the 83% confidence level. The minimum detectable difference between any two of the position averages required for significance at the 95% confidence level is 0.28% water.

Table XIV

Western Nuclear

Auger Position Bias Study -- Moisture

	Position		
	1	2	3
Average, per cent moisture	2 14	1.88	1.93

Data from the position bias study with respect to uranium assay are given in Table XV. The differences between position averages are not significant (less than the 50% confidence level). The minimum detectable difference between any two of the position averages required for significance at the 95% confidence level is 0 14% uranium. Within drums Western Nuclear had one of the most uniform distributions of uranium of any material tested.

Table XV

Western Nuclear

Auger Position Bias Study -- Uranium Assay

	Position		
	1	2	3
Average, per cent U	64.59	64 59	64 59

Anaconda Pilot Plant. This and the succeeding materials were used in the auger evaluation program only, and only uranium assay data were obtained The results of the position study are listed in Table XVI

Table XVI

Anaconda Pilot Plant

Auger Position Bias Study--Uranium Assay

	Position		
	1	2	3
Average, per cent U	65 82	65.67	65.66

The differences between position averages are not significant (less than the 50% confidence level). The minimum detectable difference between any two of the position averages required for significance at the 95% confidence level is 0 95% absolute. No bias is, therefore, indicated although the test was rather insensitive

The comparison of blended and unblended drums gave the following results:

Unblended drum avg. - blended drum avg., per cent U	+ 0 27
Significance level, per cent	75
Minimum detectable difference, per cent U	0 48

Durango. Four drums of Durango gave the assay position data summarized in Table XVII. The differences between position averages are not significant (less than the 50% confidence level). The minimum detectable difference between any two of the position averages required for significance at the 95% confidence level is 0.34% uranium

Table XVII

Durango

Auger Position Bias Study--Uranium Assay

	Position		
	1	2	3
Average, per cent U	72 69	72 54	72 57

Comparisons of drums before and after blending yielded the following:

Unblended drum avg. - blended drum avg., per cent U	− 0.09
Significance level, per cent	80
Minimum detectable difference, per cent U	0.14

No significant bias is indicated.

Kerr-McGee. Table XVIII summarizes the uranium assay position data obtained from four drums in the auger program. The differences between position averages are not significant (less than the 50% confidence level) The minimum detectable difference between any two of the position averages required for significance at the 95% confidence level is 0.21% uranium.

Table XVIII

Kerr-McGee

Auger Position Bias Study--Uranium Assay

	Position		
	1	2	3
Average, per cent U	65.98	65 87	65 91

Comparison of blended and unblended drums was obtained as follows:

Unblended drum avg - blended drum avg , per cent U	− 0 17
Significance level, per cent	> 99
Minimum detectable difference, per cent U	0 11

Here again the significant bias might be due to the settling of heavier and more concentrated particles to the bottoms of the drums

Mines Development. Four drums of Mines Development, or Edgemont, material were examined, and the results are given in Table XIX The differences between position averages are not significant (less than the 50% confidence level). The minimum detectable difference between any two of the position averages required for significance at the 95% confidence level is 0.26% uranium. Although the minimum detectable difference is somewhat high, the low confidence level indicates good agreement among positions

Table XIX

Mines Development

Auger Position Bias Study-- Uranium Assay

	Position		
	1	2	3
Average, per cent U	60.50	60.47	60.58

In the comparison of blended and unblended drums the following results were obtained:

Unblended drum avg. - blended drum avg., per cent U	+ 0.02
Significance level, per cent	35
Minimum detectable difference, per cent U	0.10

Excellent agreement was obtained, and no bias is indicated.

Monticello Acid. Position results from eight drums of this material are summarized in Table XX. The differences between position averages are not significant (less than the 50% confidence level). The minimum detectable difference between any two of the position averages required for significance at the 95% confidence level is 0.27% uranium. Agreement of positions on Monticello acid was not quite as good as that on Mines Development because twice the number of drums were required to obtain approximately the same minimum detectable difference as on the latter material.

Table XX

Monticello Acid

Auger Position Bias Study-- Uranium Assay

	Position		
	1	2	3
Average, per cent U	62.24	62 13	62.09

Comparison of the blended and unblended drum results gives the following:

Unblended drum avg. - blended drum avg., per cent U	+ 0.10
Significance level, per cent	94
Minimum detectable difference, per cent U	0.11

Thus, a possibility of bias exists, but additional data are necessary for reaching a conclusion

Naturita. Four drums were sampled, the position study results of which are given in Table XXI. The difference between position averages is not significant (less than the 50% confidence level). The minimum detectable difference between any two of the position averages required for significance at the 95% confidence level is 0.43% uranium.

Table XXI

Naturita

Auger Position Bias Study-- Uranium Assay

	Position		
	1	2	3
Average, per cent U	69.48	69.48	69.65

The blended-unblended drum comparison resulted in the following:

Unblended drum avg - blended drum avg , per cent U	– 0.03
Significance level, per cent	30
Minimum detectable difference, per cent U	0 17

Therefore, no bias of any kind was indicated for Naturita

Rare Metals. For this material examination of four drums gave the position study results of Table XXII. The difference between extreme position averages is not significant above the 60% confidence level. The minimum detectable difference between any two of the position averages is 0.63% uranium - - a high value for good test sensitivity.

Table XXII

Rare Metals

Auger Position Bias Study-- Uranium Assay

	Position		
	1	2	3
Average, per cent U	65 96	66.24	65.85

In the comparison of blended and unblended drums the following summary of results was obtained:

Unblended drum avg. - blended drum avg , per cent U	+ 0 16
Significance level, per cent	77
Minimum detectable difference, per cent U	0 27

No significant bias is indicated.

The auger evaluation work validated a method for use in the later mechanical system evaluation. On only three of the materials examined was a significant bias found in the original auger sample. In every one of these cases results were low, lending support to the possibility that during the jolting of the drums, probably largely during transportation, the heavier particles more concentrated in uranium settled to the bottom of the drums where they were less available to auger sampling Even though such a bias is obtained, the method can still be used for comparison with other sampling methods by applying the amount of the bias as a correction.

Position bias within drums was observed in the cases of a few concentrates, but position fluctuations were observed in every concentrate It should also be noted that not only the position order of biases, when they occurred, differed from one material to another but also the order could vary on the same material with respect to time This situation indicates the necessity of sampling multiple radial positions with proper weighting and randomization, both radially and rotationally, of positions used

SAMPLING PLANT EVALUATION

For evaluating the accuracy and precision of the mechanical sampling system a program was required which would provide adequate data for statistical evaluation and conclusions; yet the amount of work had to be tempered by the feasibility of handling the enormous number of samples and assays in the laboratory. It was decided to multiple-sample five lots of each of eight types of uranium concentrate with more lots to be added if the first data indicated the need. The eight materials were chosen to include a wide variety of compositions and characteristics. One of the chosen mills, Naturita, ceased operations before the program was completed, and five more lots of Anaconda A were added to increase the data on that material. Therefore, the concentrates used were Anaconda acid and carbonate, Uravan, Rifle, Uranium Reduction, Texas-Zinc, and Western Nuclear.

The schedule of sampling started with the taking of at least a single auger sample from each drum of the lot. The frequency of the three positions used was weighted to give proportional representation to the respective sections of the drum, and the order of positions used was randomized. One randomly selected drum from each lot was augered in all three positions for furthering the data from the auger evaluation program. The manually-operated auger described above was used throughout the auger evaluation program and on all the sampling plant evaluation except the last four lots of Western Nuclear on which the power-driven auger was used.

After the first auger sampling was completed, the lot was then passed through the mechanical system and re-drummed A second auger sample was taken similar to the first one except that there was no triple augering of any drum. Then followed a second pass through the mechanical system. Moisture determinations and uranium assays were run on all samples taken. The gross samples taken were processed, as indicated by their characteristics, according to one of the following procedures:

A. Auger-sampled coarse material (that is, initially coarse material obtained from first auger sampling).

   An auger sample from each drum of a lot is placed in a two-quart mason bottle with a two-piece sealing-type lid. One drum will be chosen at random from each lot, and this drum will be augered three times, each sample being placed in one of three individual bottles

   1 Pour each bottle of sample into a tared stainless steel pan and weigh on a Mettler four-kilogram balance.

   2 Transfer all pans to the oven.

   3. Dry in Despatch oven set at 114° C This temperature is chosen so that all parts of the oven will be at least 110° Not more than one lot of material should be placed in one oven.

4. Remove all pans from the oven and reweigh after every twenty-four hour drying period until constant weight is attained or a gain in weight is noted on three consecutive weighings.

5. Record all weights for each pan and use the lowest value to calculate per cent moisture. (Pans are to be reweighed hot immediately after removal from the oven.)

6. Using the Braun pulverizer, grind the contents of each pan individually to 60-mesh. Screening is not necessary at this point.

7. Transfer each drum sample to a two-quart bottle on a Fisher-Kendall mixer for ten minutes.

8. From the individual samples, make a weighted lot composite based on the net dry drum weights such that a final lot sample of ten to eighteen pounds is obtained.

9. Blend in an eight-quart Patterson-Kelley twin-shell blender with intensifier bar for one hour.

10. Riffle to a sample weight of two to three pounds.

11. Screen through a U.S. Standard No. 100 screen. Repulverize the oversize and re-screen. Repeat until all material passes through the screen.

12. Combine fractions in a Patterson-Kelley twin-shell blender. Blend for fifteen minutes.

13. Place in a single stainless steel pan and return to the oven for at least forty-eight hours at 114° C.

14. Transfer 100-gram samples to five hot mason bottles. Replace in the oven uncapped for four to six hours. Remove singly from the oven, cap with hot Kerr lids and set aside for cooling.

15. Label and distribute samples

B. Galigher samples

The sampling plant will collect the sample in a six-gallon drum having a plastic bag liner. This liner will be tied so as to exclude dead air space

1. Pour or scoop the material from the drum into a sufficient number of stainless steel pans to hold the entire bulk sample (Note: When transfer is by pouring, the lip

of the bag must be in contact with the bottom of the pan so that the flow of material is directly onto the pan and not through the air. Keep the bag closed except for the small pouring spout.) The depth of material in the pans should be approximately three-fourths inch Weigh each filled pan immediately to the nearest half-gram on the Mettler four-kilogram balance.

2 Stack pans on a cart and transfer to the oven.

3-5. Continue with steps 3-5 of procedure A.

6. Combine all individual pans from the lot in a Patterson-Kelley twin-shell blender (one or three cubic foot capacity, as required) with intensifier bar. Blend one hour.

7. Riffle sample, using a Jones riffle, down to a weight of three and one-half to eight pounds.

8. Using the Braun pulverizer, grind to approximately 100-mesh

9. Blend fifteen minutes in a Patterson-Kelley twin-shell blender

10-15. Continue with steps 10-15 of procedure A

C. Auger-sampled fine material (that is, any material which has been passed through the mechanical sampling system, or initially fine material such as Anaconda).

Gross samples will be supplied in the same manner as for procedure A.

The installation of the forced-draft Despatch ovens supplied with dried air as previously described was not completed by the start of the sampling plant evaluation. Moisture determinations and sample preparation during the first part of the program were carried out at modified existing facilities at the Destrehan Plant. The ovens there were Despatch gravity-convected ovens, the exhausts of which fed into a common header fitted with an exhaust fan to provide a moderate forced flow. At the air intakes of the ovens were connected six-gallon cans full of calcium chloride through which the room air passed before entering the ovens. During the period these ovens were used the average relative humidity approximated 25% Processed at Destrehan were the first series of Anaconda acid, Rifle, Uranium Reduction, Uravan, and Anaconda carbonate Samples of Texas-Zinc, the second series of Anaconda acid, and Western Nuclear were dried and prepared at Weldon Spring.

In the assaying of these samples, portions for both laboratory moisture and uranium determinations were weighed with corrections made for moisture pickup during weighing. All assays were run at least in duplicate.

Obtained in the study were data on moisture, assay, and the combination of all measurements -- total pounds of uranium per lot. All data obtained in the evaluation program were subjected to statistical evaluation and examined for the following indications:

1. Accuracy of the mechanical sampler A difference between the first auger and first Galigher sample data indicates a bias between the two types of samples. The auger sample is assumed to represent the true value as shown by the auger evaluation program.

2. Moisture change during mechanical sampling. This is shown by variant moisture results between the first auger and first Galigher samples. Further changes in the bulk of the material after it had passed the Galigher sample cutters are shown by comparing the second auger results with the first auger and first Galigher results. Such latter changes are of no appreciable importance in routine sampling since weight measurements and sample removal have been completed prior to the changes.

3. Selective holdup in the mechanical system. Differences in the uranium assays, dry basis, between the two auger samples demonstrate this.

4. Reliability of auger sampling. Data from the triply-augered drums show whether there is position bias within drums and add to the knowledge of the auger evaluation program. These data are combined and discussed above with the auger evaluation.

5. Precision of auger and Galigher sampling. Such precision data can be calculated but is not especially reliable because the plant was designed to avoid holdup in the system only prior to and including the Galigher samplers. Holdups can occur in the remaining part of the system; therefore, the lot weight recovery at the end of the first Galigher sampling may not be exactly 100%, and errors can develop.

The evaluation program was subject to one hazard not normally encountered in routine work - - the possibility of change, such as moisture pickup, in the material between samplings. The best defense against such changes was to operate rapidly, keep drums of material under shelter, *etc.*, but such defenses were not always practically possible. Here again were opportunities for small errors to creep in and worsen precision figures.

Virgin data obtained in the program are tabulated in Appendix Tables A-XXXIII-XXXIX and are the basis of all subsequent results and calculations herein reported. Summaries and statistical evaluations of these data appear in the following discussions of each material type.

Anaconda Acid. Two series of Anaconda acid lots were run, giving at least partial data on eleven lots. Where possible all data were combined for statistical analysis to gain greater certainty, but the material changes previously alluded to in the auger discussion prevented combination in some cases.

In the case of moisture analyses, it was possible to combine data, the statistical summary of which appears in Table XXIII. In the second series duplicate Auger I samples were taken from each lot to enable a precision comparison between duplicate samples taken from the undisturbed material and the Auger I-Auger II pairs as regularly made. Auger I values used in all other comparisons of the second series are the averages of these duplicates. Because of a mechanical breakdown during the running of lot 1259, only Auger I and Galigher I data were obtained. Excellent agreement is exhibited between the Auger I and Galigher I samples. The Auger II sample, however, indicates the possibility of a bias. This combination of results denotes the possibility of a moisture pickup in the system following the Galigher samplers.

Table XXIII

Anaconda Acid

Sampling Plant Evaluation -- Moisture

Algebraic differences between samples in absolute per cent H_2O:

Lot No.	Auger I minus Galigher I	Auger I minus Auger II
First series		
1087	−0.03	−0.03
1103	− .06	− .40
1112	+ .03	− .10
1117	− .13	− .26
1118	− .02	+ .10
Second series		
1249	.00	− .06
1259	− .05	−
1270	+ .19	+ .12
1275	− .08	− .15
1276	− .04	− .09
1277	− .02	− .10
Average difference	−0.02	−0.10
Significance level	55%	93%
Minimum detectable difference	0.05	0.11

The uranium determinations produced results all of which could not be statistically combined. Therefore, in Table XXIV first- and second-series results on the Auger I-Auger II comparison are treated separately because of difference with respect to degree of variation. Generally, no bias is indicated by the analysis; however, possibility of a preferential holdup is suggested by the results of the second series of the Auger I-Auger II comparison. If such holdup existed, a similar bias could be expected in a Galigher I-minus-Galigher II result. Calculations for this comparison show an average difference of −0.07% uranium with a significance level of 73% and a minimum detectable difference of 0 15%. Thus, the suggestion of a bias, or holdup, is not supported.

Table XXIV

Anaconda Acid

Sampling Plant Evaluation -- Uranium Assay

Algebraic differences between samples in absolute per cent U, dry basis:

Lot No.	Auger I minus Galigher I	Auger I minus Auger II	
		1st series	2nd series
1087	+0.08	+0.14	
1103	− .14	− .27	
1112	− 06	+ .04	
1117	+ .06	+ .04	
1118	+ .13	+ .14	
1249	+ .46		+0.09
1259	+ .20		---
1270	− .18		+ .04
1275	+ .15		+ 09
1276	+ .08		+ .08
1277	+ 02		− .03
Average difference	+0 07	+0 02	+0.05
Significance level	80%	17%	92%
Minimum detectable difference	0 14	0.21	0.06

In the calculation of pounds of uranium contained per lot an adjustment of the lot wet input weight was necessary for obtaining comparable results on pounds of uranium for successive sampling stages. An example of such calculation for lot 1087 is given here. The gross input wet weight consists of the 33 drums (excluding Lucius Pitkin, Inc.'s sample reject drum) weighed as the total lot.

Gross input wet weight	16,676.0 lb.
Tare weight	– 1,751.5 lb.
Net Auger I input wet weight	14,924.5 lb.

Use of the Auger I moisture and assay results enable the calculation of uranium content.

$$14{,}924.5\text{ lb.} \times \left(1.0000 - \frac{6.38\%\ H_2O}{100.0\ \%}\right) \times \frac{67.60\%\ U}{100.00\%} = 9{,}455\text{ lb.U}$$

The input weight to the Galigher I sampling was measured and is equal to the Auger I input weight minus the Auger I sample removed and any positive or negative weighing errors. For lot 1087 these weights were:

Net Auger I input wet weight	14,924.5 lb.
Net Galigher I input wet weight	– 14,863.0 lb.
Auger I sample weight plus weighing errors	61.5 lb.

The uranium content indicated by the Galigher I sample is corrected to the Auger I input basis by a correction calculated from the Auger I sample weight plus weighing errors and the moisture and assay results on the Auger I sample. Calculation of the total uranium content as a result of the Galigher I sample appears as follows:

$$14{,}863.0\text{ lb.} \times \left(1.0000 - \frac{6.41\%\ H_2O}{100.0\ \%}\right) \times \frac{67.52\%\ U}{100.00\%}$$

$$+\ 61.5\text{ lb.} \times \left(1.0000 - \frac{6.38\%\ H_2O}{100.0\ \%}\right) \times \frac{67.60\%\ U}{100.00\%} = 9{,}431\text{ lb.U}$$

The calculation of the uranium content found by the Auger II sample is similar except that an additional term is added to account for the difference in input weights to the Galigher I and Auger II sampling stages.

Net Galigher I input wet weight	14,863.00 lb.
Net Auger II input wet weight	– 14,692.75 lb.
Galigher I sample weight plus weighing errors plus holdup errors	170.25 lb.

$$14{,}692.75 \text{ lb.} \times \left(1.0000 - \frac{6.41\% \ H_2O}{100.0 \ \%}\right) \times \frac{67.46\% \ U}{100.00\%}$$

$$+ 170.25 \text{ lb.} \times \left(1.0000 - \frac{6.41\% \ H_2O}{100.0 \ \%}\right) \times \frac{67.52\% \ U}{100.00\%}$$

$$+ 61.5 \text{ lb.} \times \left(1.0000 - \frac{6.38\% \ H_2O}{100.0 \ \%}\right) \times \frac{67.60\% \ U}{100.00\%} = 9{,}423 \text{ lb. U}$$

Holdup errors may be either positive or negative and arise from filling the "holes" in the latter part of the mechanical system or from release of material deposited in these "holes" from previous lots.

It was possible to combine statistically the data on lot uranium content as given in Table XXV. Agreement between Auger I and Galigher I is excellent, thus proving the validity of the Galigher sample. A significant bias is indicated between the auger samples, however. References to Tables XXIII and XXIV show that the Auger II average moisture was possibly biased high and that the Auger II assays appeared lower than Auger I with the second series being possibly significant. These two effects of possible bias reinforce each other in the calculation of total pounds of uranium and lead to significance.

Table XXV

Anaconda Acid

Sampling Plant Evaluation--Lot Uranium Content

Algebraic differences between samples in pounds of uranium per lot:

Lot No.	Auger I minus Galigher I	Auger I minus Auger II
First series		
1087	+ 14	+ 22
1103	– 15	+ 1
1112	– 11	+ 15
1117	+ 36	+ 53
1118	+ 20	+ 10
Second series		
1249	– 56	+ 17
1259	+ 27	–
1270	– 41	– 7
1275	+ 22	+ 22
1276	+ 13	+ 17
1277	+ 3	+ 5
Average difference	+ 1.1	+ 15.5
Significance level	10%	99%
Minimum detectable difference	19.5	11.6

However, calculated pounds of uranium do not necessarily indicate selective holdup as is the case with assay data This can be seen by considering the calculation of total uranium content determined from subsequent sampling stages A minor consideration is the amassing of errors due to repeated weighings, but of major importance is the correction for difference in input weights to the Galigher I and Auger II stages. In the example given for Anaconda acid lot 1087 this difference in input weights of concentrate was 170.25 pounds. But the Galigher I sample weight actually removed was 13 93 pounds, so that approximately 156 32 pounds of this difference were due to holdup in the latter part of the system and to the relatively small weighing errors which could hardly have exceeded ten pounds The true amount of holdup is actually an unknown value, for if there were any moisture pickup (or loss) in this material it would have a weight different from 156 32 pounds The calculation assumes the holdup to have the same moisture content as the sample removed, but this may or may not be true. There is no way of weighing or measuring the moisture content of the holdup as it exists in the system (The material can be recovered upon cleanout, but changes during cleanout would probably still make a concentrate material balance impossible.)

Mathematically, these relationships for the general case can be shown as follows: Assume a system in which a lot of concentrate is sampled successively and in which the material is subject to both holdup and moisture change after the taking of the first sample but before it is emptied from the system to be available for the second run. Let

U = lb. of uranium found by sampling and analyzing,
W = net wet input lb. of concentrate to sampling system,
S = lb. of sample removed,
H = lb. of holdup occurring,
w = fraction of the material that is water,
a = fraction of the material that is uranium,

and subscripts denote the successive order of sampling. Then

$$U_1 = W_1(1 - w_1)\, a_1. \tag{1}$$

Reduction of the concentrate to a dry weight basis produces the following relationship:

$$W_2(1 - w_2) = W_1(1 - w_1) - S_1(1 - w_1) - H_1(1 - w') \tag{2}$$

where $w_1 \leqslant w' \leqslant w_2$ if there is a moisture gain or $w_1 \geqslant w' \geqslant w_2$ if there is a loss Measurement of w' is impossible because the material represented by H_1 is unavailable without risk of change Equation (2) simplifies to

$$W_2 = \frac{(W_1 - S_1)(1 - w_1) - H_1(1 - w')}{1 - w_2} \tag{3}$$

The uranium content found is then given by

$$U_2 = W_2(1 - w_2)a_2 + S_1(1 - w_1)a_1 + H_1(1 - w')a_1$$
$$= [(W_1 - S_1)(1 - w_1) - H_1(1 - w')]\, a_2 + [S_1(1 - w_1) + H_1(1 - w')]\, a_1. \qquad (4)$$

Further sampling stage calculations can be extended similarly. Since neither w' nor H_1 were directly determinable, all calculations made on the data in the sampling plant evaluation program followed the pattern of the example given and in effect were based on the assumptions that

$$S_1 + H_1 \approx W_2 - W_1$$

and

$$w_1 \approx w'.$$

Thus, as actually used, the second term of the right side of equation (4) became $[(W_2 - W_1)(1 - w_1)a_1]$. In this approximation lie the errors which disprove calculations of uranium weight content trom Auger II and Galigher II data and calculations of precision based on such data.

No appreciable moisture gain was found for lot 1087, but the average gain for the ten lots of Anaconda acid studied was 0.10% between Auger I and Auger II so that moisture gain by the holdup material as a contributing error factor is a definite probability. This can readily be shown by use of the Anaconda acid results in the above equations applied to the Auger I-Auger II comparison. Random weighing errors, which approach relatively less significance over a long series of operations, are ignored in this treatment.

The average net wet Auger I input weight was 14,921.2 pounds (W_1). Average analyses yield 6.68% ($w_1 = 0.0668$) water and 68.34% ($a_1 = 0.6834$) uranium. Total sample removed in both Auger I and Galigher I samplings averaged 80.5 pounds (S_1); both these samplings are lumped together for this particular example. By equation (1) the uranium content of the Auger I input was:

$$(14{,}921.2 \text{ lb.})\,(1.0000 - 0.0668)\,(0.6834) = 9{,}515.8 \text{ pounds of uranium.}$$

If no changes occurred in the material before its introduction to the Auger II sampling operation, the net wet input weight would have been 14,921.2 − 80.5 = 14,840.7 pounds. But the data of Table XXIII show that at the 93% confidence level the moisture content increased 0.10% or to a new value of 6.78% ($w_2 = 0.0678$). If there were no change in the assay and no holdup to be considered, then the actual weighed Auger II input would be

$$\frac{14{,}840.7 \text{ lb. } (1.0000 - 0.0668)}{1.0000 - 0.0678},$$

and the uranium content would be

$$\frac{(14{,}840.7)\,(1\ 0000 - 0\ 0668)\,(1.0000 - 0.0678)\,(0.6834)}{1.0000 - 0.0678}$$

$$+ (80\ 5)\,(1\ 0000 - 0.0668)\,(0\ 6834) = 9{,}515.8 \text{ pounds of uranium.}$$

But since the holdup had to be considered, the 80.5-pound factor of the second term above becomes the difference between the Auger I and Auger II input weights, and the calculated content was

$$\frac{(14{,}840.7)\,(1.0000 - 0.0668)\,(1.0000 - 0.0678)\,(0.6834)}{1.0000 - 0.0678}$$

$$+ \left[14{,}921.2 - \frac{(14{,}840.7)\,(1.0000 - 0.0668)}{1.0000 - 0\ 0678}\right](1.0000 - 0.668)\,(0.6834) = 9{,}505.6 \text{ pounds of uranium.}$$

Therefore, the total error was 9,515 8 – 9,505.6 = 10.2 pounds of uranium due to the moisture error contribution alone. If this is subtracted from the error of 15.5 pounds given in Table XXV, only 5.3 pounds remain, which is far below that required for significance.

It can be shown in still another way that a truly real and significant selective holdup does not not exist. If such did exist, a comparable bias would be expected between the two Galigher samples. However, for Galigher I minus Galigher II the difference is –6.6 pounds of uranium or in the opposite direction from the auger result. This figure is not significant above the 86% confidence level, and the minimum detectable difference is 8.9 pounds.

The results of the evaluation on Anaconda acid are summarized in Table XXVI according to the considerations for which the program was designed. Additional position data would be desirable on the auger method, but the effects of position fluctuation and bias can be canceled with randomization among a proper choice of auger positions. A possibility of moisture gain is indicated in the system following the sample cutters, but this does not affect the sample. In view of the excellent agreement with the reference sampling method, the lack of interfering moisture changes, and the absence of a selective holdup, the mechanical system is demonstrated to be very admirably suited for the routine sampling of Anaconda acid concentrate

Table XXVI

Anaconda Acid

Sampling Plant Evaluation Summary

Criteria	H_2O, %	U, %	Lb. U per lot
1. Accuracy	No bias	No bias	No bias
2. Moisture change			
Auger I – Galigher I	None	--	--
Auger I – Auger II	Probable gain	--	--
3. Selective holdup	--	None	--
4. Auger reliability	No position bias	No overall bias, more data desired on position study	--
5. Precision[a]			
Auger			
1st series	--	± 0.33% U	--
	--	± .50% R.	
2nd series	--	± .14% U	--
	--	± .20% R	--
2nd series, Auger I duplicates	--	± .15% U	± 29 lb.
	--	± 21% R.	± 0 35% R.
Combined series	± 0.22% H_2O	--	± 32 lb.
	± 3.3 % R.	--	± 0.34% R.
Galigher			
1st series	± 0.28% H_2O	± 0.06% U[b]	--
	± 4.3 % R.	± .09% R.	--
2nd series	± 0.09% H_2O	± .24% U	--
	± 1.3 % R.	± .34% R.	--
Combined series	--	--	± 24 lb.
	--	--	± 0.25% R.
Difference between methods	[c]	Not significant[d]	Not significant

[a] Precision data has been pooled where statistically possible, and only the pooled results are given in these cases For each measurement group absolute precision figures are given with values relative to the average amount of the constituent found underneath and denoted by "R " All results are at the 95% confidence level

[b] Though actually obtained, this value is not realistic since it includes the assay uncertainty of ±0.12%.

[c] The second series of Galigher samples is significantly different from the first series and from the auger result.

[d] The first series auger result is significantly different from the other auger results at only the 90% confidence level The second series Galigher result is not significantly different from the second series auger results.

Rifle. Five lots of Rifle uranium concentrate were sampled in the evaluation program. With this and the other materials handled, statistical treatment of the results was the same as for Anaconda acid except that there was only one series of runs for each material other than Anaconda acid.

Results of the moisture determinations are given in Table XXVII. Because of the low moisture levels of this material and the consequent good absolute precision, minimum detectable differences are quite low, leading to greater significance of the observed average differences. A possibility of moisture pickup is indicated by the first comparison, and a definite gain occurs between Auger I and Auger II.

Table XXVII

Rifle

Sampling Plant Evaluation--Moisture

Algebraic differences between samples in absolute per cent H_2O:

Lot No.	Auger I minus Galigher I	Auger I minus Auger II
35	– 0 05	– 0 08
38	– 02	– 02
40	– 08	– .09
41	+ 02	– .02
46	– 06	– 11
Average difference	– 0 03_8	– 0.06
Significance level	92%	97%
Minimum detectable difference	0.04_4	0 05

The statistical analysis of the uranium assay data is given in Table XXVIII Indicated agreement appears good However, during the auger evaluation it was found that Rifle is not particularly amenable to good auger sampling Furthermore, the auger samples underestimated the uranium content, when compared with blended material, by 0 11% uranium This, to some extent, explains in the auger-Galigher comparison the lot 46 result which is inconsistent with the other data and which was the major contributor to the high minimum detectable difference. If the values for this lot were ignored, the observed average difference for the comparison of Auger I minus Galigher I would be –0 08% uranium This average difference would appear to agree with the auger program result, *i.e.*, the auger value is lower than the blended value and would, therefore, be expected to be lower than the Galigher sample on the average. However, there is no valid justification for rejecting lot 46 results, so more data would be needed to resolve the question.

Table XXVIII

Rifle

Sampling Plant Evaluation--Uranium Assay

Algebraic differences between samples in absolute per cent U, dry basis:

Lot No.	Auger I minus Galigher I	Auger I minus Auger II
35	− 0 04	− 0.10
38	− .11	− 01
40	− 25	+ .04
41	+ .06	− .02
46	+ .36	+ .03
Average difference	+ 0 01	− 0 01
Significance level	<10%	36%
Minimum detectable difference	0 29	0 07

The lot uranium content summary is given in Table XXIX No significant differences are shown, but because of the low and uniform moisture content, the data of Table XXIX follow the uranium assays very closely, including the inconsistent lot 46 result

Table XXIX

Rifle

Sampling Plant Evaluation --Lot Uranium Content

Algebraic differences between samples in pounds of uranium per lot:

Lot No.	Auger I minus Galigher I	Auger I minus Auger II
35	− 1	− 9
38	− 19	+ 1
40	− 40	+ 20
41	+ 10	− 2
46	+ 59	+ 18
Average difference	+ 1.8	+ 5.6
Significance level	<10%	62%
Minimum detectable difference	46	16

A summarization of the statistical analyses of the Rifle results is presented in Table XXX. The possibility of a moisture pickup before the taking of the Galigher sample is not uncommonly serious, for if the indicated Auger I minus Galigher I difference were truly real, it would cause an error of less than five pounds per lot--considerably below the precision of the sampling and testing. Some more auger-Galigher comparisons accompanied by augering of unblended and blended drums would clarify the reference basis for this material as well as answer the moisture pickup possibility.

Table XXX

Rifle

Sampling Plant Evaluation--Summary

Criteria	H_2O, %	U, %	Lb. U per lot
1. Accuracy	Possible bias	No bias	No bias
2. Moisture change			
Auger I-Galigher I	Possible gain	--	--
Auger I-Auger II	Significant gain	--	--
3. Selective holdup	--	None	--
4. Auger reliability	No position bias	More data needed	--
5. Precision[a]			
Auger	± 0 08% H_2O	± 0.11% U	± 25 lb.
	± 120% R.	± .16% R.	± 0.19% R.
Galigher	± 0.04% H_2O	± 22% U	± 42 lb.
	± 38% R.	± .32% R.	± 0.32% R.
Difference between methods	Not significant	Not significant	Not significant

[a] For each sampling method absolute precision figures are given with values relative to the average amount of the constituent found underneath and denoted by "R." All results are at the 95% confidence level.

Uranium Reduction. The statistical summary of the moisture data yielded the results in Table XXXI. A significant moisture pickup occurred between the first two samples taken, but little change was noted thereafter. Comparable observed average differences appear in both columns of the table, but the Auger I-Auger II comparison did not test significant because of a larger experimental fluctuation.

Table XXXI

Uranium Reduction

Sampling Plant Evaluation--Moisture

Algebraic differences between samples in absolute per cent H_2O:

Lot No.	Auger I minus Galigher I	Auger I minus Auger II
298	– 0.08	– 0.16
299	– .04	+ .11
304	+ .01	– .07
305	– 11	– .15
307	– 08	– .08
Average difference	– 0 06	– 0 07
Significance level	96%	79%
Minimum detectable difference	0.06	0.13

Table XXXII lists the results of the uranium assays The auger-samples comparison shows significance, but it is hard to say that a selective holdup could have occurred in the mechanical system since a larger observed difference appears between Auger I and Galigher I but fails to test significant because of large fluctuations, notably due to lot 305. An examination of data from all four samplings shows that there was neither significant nor hardly appreciable change in assay subsequent to Galigher I. Therefore, in absence of an unblended-blended drum comparison and in consideration of the auger position bias found, the Auger I sample becomes most suspect in causing the large average differences of Table XXXII.

Table XXXII

Uranium Reduction

Sampling Plant Evaluation--Uranium Assay

Algebraic differences between samples in absolute per cent U, dry basis:

Lot No.	Auger I minus Galigher I	Auger I minus Auger II
298	+ 0.11	+ 0.05
299	+ .29	+ .28
304	+ .03	+ .10
305	+ .63	+ .24
307	− .06	+ .04
Average difference	+ 0.20	+ 0 14
Significance level	82%	95%
Minimum detectable difference	0.31	0.13

In Table XXXIII can be seen the comparisons of uranium weight content. The Galigher sample comparison with Auger I is satisfactory, but again, as in the case of Anaconda acid, an observed moisture gain and an assay decrease combined to give a significant difference between the auger samples. However, it can be seen from a Galigher I-minus-Galigher II comparison that the difference is only −0.2 pounds, which, of course, is far, far from significance. Similarly, there is an insignificant difference between Auger II and Galigher II results, so that the chance of a selective holdup occurring in the system following the taking of the Galigher I sample is very slight. As with the assays it appears that the Auger I results are the odd results with no auger evaluation for support.

Table XXXIII

Uranium Reduction

Sampling Plant Evaluation--Lot Uranium Content

Algebraic differences between samples in pounds of uranium per lot:

Lot No.	Auger I minus Galigher I	Auger I minus Auger II
298	+ 30	+ 28
299	+ 59	+ 40
304	+ 5	+ 27
305	+ 123	+ 61
307	− 2	+ 18
Average difference	+ 43.0	+ 34.8
Significance level	85%	99%
Minimum detectable difference	63.0	20.6

The statistical evaluations on Uranium Reduction have been summarized in Table XXXIV. As explained in the previous discussions the greatest stumbling block in the data is the lack of sufficient and definite auger results. With adequate additional blended-unblended drum comparisons the accuracy, selective holdup, and auger reliability problems could be clarified.

Table XXXIV

Uranium Reduction

Sampling Plant Evaluation--Summary

Criteria	H_2O, %	U, %	Lb. U per lot
1. Accuracy	Biased slightly high	No bias, more data needed	No bias, more data needed
2. Moisture change			
Auger I-Galigher I	Significant gain	--	--
Auger I-Auger II	None	--	--
3. Selective holdup	--	Probably none	--
4. Precision[a]			
Auger	± 0.21% H_2O	± 0.22% U	± 33 lb.
	± 3.8 % R.	± .34% R.	± 0.27% R.
Galigher	± 0.17% H_2O	± .32% U	± 55 lb.
	± 3.0 % R.	± 49% R.	± 0.45% R.
Difference between methods	Not significant	Not significant	Not significant

[a] For each sampling method absolute precision figures are given with values relative to the average amount of the constituent found underneath and denoted by "R." All results are at the 95% confidence level.

Uravan. Six lots of this material were sampled in the evaluation program. Complete data were obtained on only five lots; because of an accident following the moisture determination the Auger I sample of lot 645 was lost during preparation.

Analysis of the moisture data is presented in Table XXXV. Agreements were good, and no biases are indicated.

Table XXXV

Uravan

Sampling Plant Evaluation -- Moisture

Algebraic differences between samples in absolute per cent H_2O:

Lot No.	Auger I minus Galigher I	Auger I minus Auger II
643	− 0.01	+ 0.09
645	− .05	− .12
646	+ .10	+ .06
650	+ .10	+ .04
651	.00	+ .01
652	+ .08	+ .12
Average difference	+ 0.04	+ 0.03
Significance level	85%	65%
Minimum detectable difference	0.06	0.08

Uranium assay results are summarized in Table XXXVI. These, too, indicate agreement and the absence of selective holdup.

Table XXXVI

Uravan

Sampling Plant Evaluation -- Uranium Assay

Algebraic differences between samples in absolute per cent U, dry basis:

Lot No.	Auger I minus Galigher I	Auger I minus Auger II
643	− 0.06	− 0.11
646	+ .43	+ .18
650	+ .02	− .11
651	+ .13	+ .08
652	+ .02	+ .22
Average difference	+ 0.11	+ 0.05
Significance level	75%	50%
Minimum detectable difference	0.24	0.19

Data on the total uranium content per lot are listed in Table XXXVII. Again agreements are good.

Table XXXVII

Uravan

Sampling Plant Evaluation--Lot Uranium Content

Algebraic differences between samples in pounds of uranium per lot:

Lot No.	Auger I minus Galigher I	Auger I minus Auger II
643	− 9	− 26
646	+ 54	+ 21
650	− 7	− 20
651	+ 19	+ 9
652	− 5	+ 21
Average difference	+ 10.4	+ 1.0
Significance level	55%	<10%
Minimum detectable difference	33.4	28.0

A summarization of the statistical analyses of these tables is given in Table XXXVIII. Since the data on Uravan is quite satisfactory, it is evident the mechanical system is definitely suitable for the routine sampling of this material.

Table XXXVIII

Uravan

Sampling Plant Evaluation--Summary

Criteria	H_2O, %	U, %	Lb. U per lot
1. Accuracy	No bias	No bias	No bias
2. Moisture change			
Auger I-Galigher I	None	--	--
Auger I-Auger II	None	--	--
3. Selective holdup	--	None	--
4 Auger reliability	No position bias	No overall bias. More data desired on position study.	--
5 Precision[a]			
Auger	± 0.15% H_2O	± 0.31% U	± 44 lb.
	± 73% R.	± .48% R.	± 0.46% R.
Galigher	± 0.10% H_2O	± 22% U	± 34 lb.
	± 61% R.	± .34% R.	± 0.35% R.
Difference between methods	Not significant	Not significant	Not significant

[a] For each sampling method absolute precision figures are given with values relative to the average amount of the constituent found underneath and denoted by "R." All results are at the 95% confidence level.

Anaconda Carbonate. For the five lots sampled and tested the moisture data analysis appears in Table XXXIX. No significant biases are evident.

Table XXXIX

Anaconda Carbonate

Sampling Plant Evaluation--Moisture

Algebraic differences between samples in absolute per cent H_2O:

Lot No	Auger I minus Galigher I	Auger I minus Auger II
1187	+ 0.12	+ 0.15
1190	− .49	− .16
1196	− .28	− .19
1202	− .18	− .19
1208	− .02	− .09
Average difference	−0.17	−0.10
Significance level	81%	78%
Minimum detectable difference	0.29	0.18

An analysis of the assay data is given in Table XL. Here, too, agreement generally is very good, as is the case with the uranium content results given in Table XLI.

Table XL

Anaconda Carbonate

Sampling Plant Evaluation--Uranium Assay

Algebraic differences between samples in absolute per cent U, dry basis:

Lot No.	Auger I minus Galigher I	Auger I minus Auger II
1187	0.00	+ 0.02
1190	+ .02	− 05
1196	− .20	− .11
1202	− .09	− .05
1208	+ .06	+ .12
Average difference	− 0 04	− 0.01
Significance level	58%	25%
Minimum detectable difference	0 13	0 10

Table XLI

Anaconda Carbonate

Sampling Plant Evaluation--Lot Uranium Content

Algebraic differences between samples in pounds of uranium per lot:

Lot No.	Auger I minus Galigher I	Auger I minus Auger II
1187	− 17	− 17
1190	+ 78	+ 15
1196	− 3	+ 3
1202	+ 6	+ 17
1208	+ 16	+ 38
Average difference	+ 16.0	+ 11.2
Significance level	65%	71%
Minimum detectable difference	± 46	± 25

A summary of all results appears in Table XLII, which shows that the mechanical system is also quite suitable for the regular sampling of Anaconda carbonate concentrate.

Table XLII

Anaconda Carbonate

Sampling Plant Evaluation--Summary

Criteria	H_2O, %	U, %	Lb U per lot
1. Accuracy	No bias	No bias	No bias
2. Moisture change			
Auger I-Galigher I	None	--	--
Auger I-Auger II	None	--	--
3. Selective holdup	--	None	--
4. Auger reliability	No position bias	No overall bias Possible position bias	--
5. Precision[a]			
Auger	± 0.28% H_2O	± 0.17% U	± 40 lb.
	± 14% R	± 26% R	± 0.28% R
Galigher	± 0.33% H_2O	± 13% U	± 58 lb.
	± 15% R	± 20% R	± 0.41% R.
Difference between methods	Not significant	Not significant	Not significant

[a] For each sampling method absolute precision figures are given with values relative to the average amount of the constituent found underneath and denoted by "R." All results are at the 95% confidence level.

Texas-Zinc. The statistical analysis of the moisture results obtained on the five lots of Texas-Zinc concentrate is presented in Table XLIII. Pickup of moisture apparently occurred after the taking of the Galigher sample, but this gain, of course, does not affect the accuracy of that sample. Table XLIV contains the analysis of the assay data. No significant differences appear, indicating agreement between the auger and mechanical samples and no preferential holdup in the mechanical system.

Table XLIII

Texas-Zinc

Sampling Plant Evaluation--Moisture

Algebraic differences between samples in absolute per cent H_2O:

Lot No.	Auger I minus Galigher I	Auger I minus Auger II
12	+ 0.12	– 0.18
13	– .04	– .13
14	– .04	– .11
15	+ .05	– .16
16	– .02	– .13
Average difference	+ 0.01	– 0.14
Significance level	35%	98%
Minimum detectable difference	0.09	0.11

Table XLIV

Texas-Zinc

Sampling Plant Evaluation--Uranium Assay

Lot No.	Auger I minus Galigher I	Auger I minus Auger II
12	+ 0.15	+ 0.04
13	+ .02	– .02
14	– .16	– .09
15	+ .16	+ .20
16	+ .01	+ .12
Average difference	+ 0.04	+ 0.05
Significance level	43%	62%
Minimum detectable difference	0.16	0.14

Results calculated on the basis of pounds of uranium found are given in Table XLV. Agreement between the Auger I and Galigher I samples is excellent. However, the comparison of the two auger samples indicates a possible bias. This result is due chiefly to the water pickup exhibited in Table XLIII. That this is true can be shown by making a calculation identical to that used for the analogous Auger I-minus-Auger II difference observed for Anaconda acid. Such a calculation shows that 11.1 of the 16.8 pounds difference found is due solely to the moisture pickup. The remainder of the difference is far below significance. In addition, a Galigher I-minus-Galigher II comparison for Texas-Zinc yields an average difference of +2.8 pounds of uranium per lot significant at only the 42% confidence level and having a minimum detectable difference of 12.6 pounds. Thus, it can be readily concluded that no real selective holdup occurs with Texas-Zinc.

Table XLV

Texas-Zinc

Sampling Plant Evaluation--Lot Uranium Content

Algebraic differences between samples in pounds of uranium per lot:

Lot No.	Auger I minus Galigher I	Auger I minus Auger II
12	+ 8	+ 18
13	+ 5	+ 8
14	− 15	− 2
15	+ 14	+ 35
16	+ 3	+ 25
Average difference	+ 3.0	+ 16.8
Significance level	42%	94%
Minimum detectable difference	+ 13.5	+ 17.9

In Table XLVI is given a summary of all the statistical analyses on this material. Although no unblended-blended drum comparison was made on this material, the concentrate's similarity to many others used in the auger evaluation and the general favorable quality of the auger data indicate the Auger I results to be a satisfactory reference. The rest of the summary attests to the fact that Texas-Zinc can be quite suitably sampled in the mechanical system.

Table XLVI

Texas-Zinc

Sampling Plant Evaluation--Summary

Criteria	H_2O, %	U, %	Lb. U per lot
1. Accuracy	No bias	No bias	No bias
2. Moisture change			
Auger I-Galigher I	None	--	--
Auger I-Auger II	Significant gain	--	--
3. Selective holdup	--	None	--
4. Auger reliability	No position bias	No position bias	--
5. Precision[a]			
Auger	± 0.17% H_2O	± 0.22% U	± 28 lb.
	± 7.1 % R.	± .33% R.	± 0.36% R.
Galigher	± 0.13% H_2O	± .17% U	± 20 lb.
	± 5.5 % R.	± .25% R.	± 0 26% R.
Difference between methods	Not significant	Not significant	Not significant

[a] For each sampling method absolute precision figures are given with values relative to the average amount of the constituent found underneath and denoted by "R." All results are at the 95% confidence level.

Western Nuclear. At least partial data on six lots of Western Nuclear were obtained. The flow characteristics of this material varied enough from lot to lot that some lots would not pass through the mechanical system. In general, although most moisture contents were relatively low, the material packed very readily and caused trouble by plugging particularly in the hammer mill and certain chutes, even though the latter were equipped with air vibrators. Consequently, only Auger I samples were obtained on six lots, Galigher I samples were obtained on four lots, and the complete program was accomplished on only three lots. Because of the limited amount of data statistical tests were not sensitive, as high minimum detectable differences and large precision values were obtained

The moisture data analysis is given in Table XLVII. No biases are indicated although the minimum detectable difference for the Auger I-Galigher I comparison is rather high.

Table XLVII

Western Nuclear

Sampling Plant Evaluation--Moisture

Algebraic differences between samples in absolute per cent H_2O:

Lot No.	Auger I minus Galigher I	Auger I minus Auger II
24	+ 0.01	--
27	− .05	+ 0.01
28	− .70	+ .07
30	− .38	+ .18
Average difference	− 0.28	+ 0.09
Significance level	81%	82%
Minimum detectable difference	0.52	0.21

Results of the uranium assay study are presented in Table XLVIII. The comparison of the auger samples, in spite of the limited data, was quite sensitive, and a possible bias is indicated. Note, however, that any selective holdup, if real, must have occurred following the taking of the Galigher I sample, for the agreement of the latter with the Auger I results is quite good. The Galigher I-minus-Galigher II comparison neither confirms nor denies the holdup question, for this test was very insensitive.

Table XLVIII

Western Nuclear

Sampling Plant Evaluation--Uranium Assay

Algebraic differences between samples in absolute per cent U, dry basis:

Lot No.	Auger I minus Galigher I	Auger I minus Auger II
24	+ 0.14	--
27	+ .09	+ 0.05
28	+ .12	+ .12
30	− .26	+ .07
Average difference	+ 0.02	+ 0.08
Significance level	15%	93%
Minimum detectable difference	0.30	0.09

The results on lot uranium content are summarized in Table XLIX. In general, agreement is shown, but the test of the auger-Galigher comparison is not very sensitive because of the rather high minimum detectable difference.

Table XLIX

Western Nuclear

Sampling Plant Evaluation--Lot Uranium Content

Algebraic differences between samples in pounds of uranium per lot:

Lot No.	Auger I minus Galigher I	Auger I minus Auger II
24	+ 21	--
27	+ 28	+ 10
28	+ 129	+ 18
30	− 3	− 12
Average difference	+ 44	+ 5
Significance level	75%	35%
Minimum detectable difference	93	38

All the Western Nuclear results are summarized in Table L. Because of the varying flow characteristics alone this material is not consistently amenable to mechanical sampling. The auger data appears quite good, and undoubtedly the precision would have been considerably better had there been more than three comparisons available for the calculation. Therefore, this material can be readily auger sampled, but its flow characteristics need improving for regular mechanical sampling.

Table L

Western Nuclear

Sampling Plant Evaluation--Summary

Criteria	H_2O, %	U, %	Lb. U per lot
1. Accuracy	No bias	No bias	No bias
2. Moisture change			
Auger I-Galigher I	None	--	--
Auger I-Auger II	None	--	--
3. Selective holdup	--	Possible after Galigher I, more data needed.	--
4. Auger reliability	No position bias	No position bias	--
5. Precision[a]			
Auger	± 0.26% H_2O	± 0.11% U	± 47 lb.
	± 18% R.	± .17% R.	± 0.31% R.
Galigher	± 1.4% H_2O	± .57% U	± 227 lb.
	± 78% R.	± .88% R.	± 1.50% R.
Difference between methods	Possibly significant	Possibly significant	Possibly significant

[a] For each sampling method absolute precision figures are given with values relative to the average amount of the constituent found underneath and denoted by "R." All results are at the 95% confidence level. More data is needed for obtaining realistic values.

Sample Cut. Calculations of the precision of the amount of sample withdrawn by the auger were made for the various materials handled in the sampling plant evaluation, and the results are shown in Table LI. In general, the Auger II sample was somewhat smaller than the Auger I sample, and the precision was somewhat worse in most cases. These observations are in line with the fluffing of the materials in passing through the mechanical system and expanding of bulk volume so that repackaging required an average 19% more drums than in which the materials originally arrived. Although the drums are vibrated at the packaging station, the degree of compaction in no sense equaled that obtained by the original vibration at the mill plus the jolting of over 1,300 miles of travel. Therefore, as the auger penetrated the more loosely packed material, the latter was more easily pushed aside, resulting not only in smaller samples but in lesser precision as well.

Table LI

Auger Sample Cut

Concentrate	Auger I		Auger II	
	Average Removed %	Precision[a] %	Average Removed %	Precision[a] %
Anaconda acid, 1st series	0.345	± 0.10	0.343	± 0.24
Anaconda acid, 2nd series	.287 .294	± .03	.311	± .09
Rifle	.483	± .10	.352	± .23
Uranium Reduction	.369	± .14	.362	± .34
Uravan	.434	± .06	.370	± .06
Anaconda carbonate	.304	± .09	.261	± .06
Texas-Zinc	392	± .06	.328	± .13
Western Nuclear	.334	± .09	.328	± .17

[a] Absolute precision at the 95% confidence level.

Since the materials sampled at the Auger I stage were representative of the materials normally received at the plant, the data for this stage is the more characteristic. The precisions of the Auger I sample cuts of all materials were pooled into two general levels which did not differ significantly within each level. However, some of the lower individual precisions (high ± values) of the higher level may not be significantly different from the higher precisions of the lower precision level. The pooled groups are as follows:

± 0.04%	± 0 08%
Anaconda A (2nd series)	Anaconda A (1st series)
Uravan	Rifle
Texas-Zinc	Uranium Reduction
	Anaconda C
	Western Nuclear

A similar treatment of the data from the Galigher samplers evolved the results in Table LII. Here there was no evident difference between Galigher I and Galigher II sample sizes, and none would be expected from compaction considerations. Therefore, all data were combined in producing the results of Table LII. Precisions were pooled according to the groupings as listed.

Table LII

Galigher Sample Cut

Concentrate	Average Sample Removed as Per Cent of Input	Absolute Precision at 95% Confidence Level, %
Anaconda Acid	0.099	± 0.007
Uranium Reduction	.093	
Anaconda carbonate	.102	
Texas-Zinc	.088	
Rifle	.102	± .014
Uravan	.100	± .028
Western Nuclear	.098	

It is obvious that the Galigher sampler is much more consistent than the auger in the amount of sample removed and that the precision of sample removal is also much better. These facts illustrate the superior proportional representation obtained with a mechanical sampling system.

SUMMARY

The auger evaluation applied to fifteen different uranium concentrates demonstrated a suitable method used for establishing a reference for the sampling plant evaluation. It was shown that, except for three materials, the original auger sample, taken according to a plan of randomizing auger positions facilitated by a three-hole template, could serve as a reference for comparison of the mechanically-taken, or Galigher, samples.

The mechanical system was found to take an accurate sample, and on not one of the seven concentrates studied was a bias proved between the Auger I and Galigher I samples with respect to uranium assay or the weight of uranium found per lot.

The problem of moisture change between opening of the drums and taking of the Galigher samples was largely solved by the revisions to the plant. Of the seven materials a moisture increase was noted in Rifle and a possibility of increase in Uranium Reduction. Moisture change following the sample cutters is a possibility with sensitive materials but does not interfere with the accuracy of the sample.

No instance of selective holdup was proved, although on Uranium Reduction conflicting results confused the interpretation and insufficient data on Western Nuclear implied the possibility of such holdup.

Precisions, as calculated, were essentially equivalent for both auger and Galigher methods. Because of holdup in the part of the mechanical system following the Galigher samplers, such precisions are not realistic and are probably worse than those actually attained.

The mechanical system was demonstrated to be superior to the auger in removing uniformly-sized samples, regardless of material variations.

The evaluation as a whole showed that more auger studies, particularly, and also some additional Galigher comparisons should be made on Rifle and Uranium Reduction. Because of the variable flow characteristics of Western Nuclear, use of the mechanical system routinely would not be advisable, but augering is very successfully accomplished. The mechanical system is quite amenable to the regular sampling of Anaconda acid and carbonate, Uravan, and Texas-Zinc uranium concentrates.

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DECLASSIFIED

A P P E N D I X

Tables Ia – XXXIXa

Table A-I

Anaconda Acid

Auger Position Bias Study – Per Cent Moisture

Drum Size: 55 gal.

Lot No.	Drum No.	Position 1	Position 2	Position 3
1087	04	5.55	5.87	5.67
1103	01	6.26	6.16	6.02
1112	07	7.89	7.88	7.80
1117	08	6.71	6.73	6.47
1118	03	4.41	5.91	6.00
1249	19	5 98	6.06	6.30
1259	19	5 56	5.70	5.47
1270	16	7.62	7.72	7 71
1275	15	8 31	8 56	7 88
1276	12	5 83	5 54	6 03
1277	09	6 54	6 78	6 84

Table A-II

Anaconda Acid

Auger Position Bias Study – Per Cent Uranium

Drum Size: 55 gal.

		Position					
		1		2		3	
		Analyst		Analyst		Analyst	
Lot No.	Drum No.	A	B	A	B	A	B
Auger Evaluation--Unblended Drums							
694	19	72.48	72.39	72.78	72.65	72.63	72.69
	29	71.22	71.26	71.17	71.19	71.19	71.19
698	13	73.09	73.15	73.48	73.51	73.14	73.09
	23	74.00	74.07	74.23	74.30	73.95	73.96
797	01	71.03	70.95	70.92	70 95	70.81	70.88
	12	73.46	73.42	73.29	73.29	73.38	73.24
Auger Evaluation--Blended Drums							
694	19	72.34	72 48	72.52	72 42	72.34	72.45
	29	71.29	71 38	70 94	70 94	71.15	71.11
698	13	73.24	73.23	73.68	73 56	73.44	73.46
	23	73.71	73.77	73.91	73.84	73 96	74 03
797	01	71.02	71.14	70 96	70 97	71.05	71.10
	12	73.24	73 23	73 26	73.37	73.22	73.24
Sampling Plant Evaluation--Unblended Drums, 1st Series							
1087	04	68.02	68 08	68.44	68 39	68.07	68.14
1103	01	65.73	65.74	65 92	65.76	65 87	65 72
1112	07	65.34	65.21	65 44	65.29	65.27	65 29
1117	08	65 67	65 76	65.89	65.91	66.42	66.46
1118	03	66.20	66 15	66 27	66.28	66.41	66.29
Sampling Plant Evaluation--Blended Drums, 2nd Series[a]							
1249	19	70 28	70 37	68 96	69.06	67.80	67.84
1270	16	67.21	67 28	65 22	65.28	64.29	64.26
1275	15	72.02	72.09	71.94	71.96	71.92	71.98
1276	12	71.47	71 59	71 08	71.09	71 11	71.22
1277	09	71.71	71 77	71 38	71.47	71 28	71 34

[a] In Table A-I moisture data is shown for lot 1259 However, assay position bias data was not obtained.

Table A-III

Anaconda Acid

Blended-Unblended Drum Study

Lot No.	Drum No.	Weighted Drum Averages, per cent U		
		Unblended(1)	Blended(2)	(1)−(2)
698	13	73.26	73.40	− 0.14
	23	74.11	73.81	+ 0.30
694	19	72.56	72.43	+ 0.13
	29	71.21	71.18	+ 0.03
797	01	70.96	71.04	− 0.08
	12	73.37	73.27	+ 0.10

Table A-IV

Rifle

Auger Position Bias Study − Per Cent Moisture

Drum Size: 55 gal.

Lot No.	Drum No.	Position		
		1	2	3
35	10	0 17	0.13	0.14
38	24	.08	.09	.09
40	11	08	.07	.00
41	05	.00	.00	.00
46	01	.00	.06	.00

Table A-V

Rifle

Auger Position Bias Study – Per Cent Uranium

Drum Size: 55 gal.

Lot No.	Drum No.	Position 1 Analyst A	Position 1 Analyst B	Position 2 Analyst A	Position 2 Analyst B	Position 3 Analyst A	Position 3 Analyst B
Auger Evaluation--Unblended Drums							
14	17	71.41	71.48	71.64	71.68	71.52	71.45
	19	71.94	71.79	71.98	71.91	71.88	71.92
16	04	70.76	70.76	71.05	70.92	71.42	71.34
	15	70.99	70.91	70.88	70.85	70.97	70.95
Auger Evaluation--Blended Drums							
14	17	71.79	71.72	71.81	71.82	71.61	71.58
	19	72.28	72.18	72.24	72.09	72.10	72.03
16	04	71.07	71.24	71.02	71.02	71.05	71.12
	15	70.86	70.84	70.85	70.96	70.83	70.92
Sampling Plant Evaluation--Unblended Drums							
35	10	73.29	73.38	73.11	73.28	73.17	73.13
38	24	67.82	67.81	67.96	67.93	67.60	67.58
40	11	65.68	65.71	62.59	62.69	62.31	62.28
41	05	49.17	49.11	49.34	49.29	49.53	49.46
46	01	70.80	70.72	70.72	70.60	70.73	70.76

Table A-VI

Rifle

Blended-Unblended Drum Study

Lot No.	Drum No.	Weighted Drum Averages, per cent U: Unblended(1)	Blended(2)	(1)–(2)
14	17	71.53	71.76	– 0.23
	19	71.90	72.19	– 0.29
16	04	70.92	70.87	+ 0.05
	15	70.90	71.10	– 0.20

Table A-VII

Uranium Reduction

Auger Position Bias Study – Per Cent Moisture

Drum Size: 55 gal.

Lot No.	Drum No.	Position 1	Position 2	Position 3
298	11	0.20	0.10	0.00
299	07	.28	.12	.12
304	29	.10	.00	.00
305	16	.27	.00	.00
307	11	.00	.00	.00

Table A-VIII

Uranium Reduction

Auger Position Bias Study – Per Cent Uranium

Drum Size: 30 gal. (Auger Evaluation)
55 gal. (Sampling Plant Evaluation)

		Position 1		Position 2		Position 3	
		Analyst		Analyst		Analyst	
Lot No.	Drum No.	A	B	A	B	A	B
Auger Evaluation--Unblended Drums							
1	06	60.91	60.83	60.88	60.74	61.10	60.98
	31	61.98	61.99	62.02	62 14	62.38	62.38
6	21	61.71	61.75	61 58	61.46	61.68	61.62
	31	61.89	61.84	61 94	62.00	61.79	61.66
Sampling Plant Evaluation--Unblended Drums							
298	11	66.57	66.36	64.38	64.41	63 99	63.98
299	07	64.41	64.26	62.30	62.22	61.85	61.79
304	29	66.44	66.46	65.60	65.48	63.36	63.30
305	16	71.29	71.31	69.94	69.86	69.48	69.51
307	11	70.83	70.84	69.70	69.77	69.42	69.44

Table A-IX

Uravan

Auger Position Bias Study – Per Cent Moisture

Drum Size: 55 gal.

Lot No.	Drum No.	Position 1	Position 2	Position 3
643	22	0.09	0.00	0.00
645	10	.76	.20	.09
646	18	.18	.00	.00
650	17	.00	.00	.00
651	04	.00	.00	.00
652	26	.00	.00	.10

Table A-X

Uravan

Auger Position Bias Study – Per Cent Uranium

Drum Size: 55 gal.

		Position					
		1		2		3	
		Analyst		Analyst		Analyst	
Lot No.	Drum No.	A	B	A	B	A	B
Auger Evaluation--Unblended Drums							
525	6	67.05	66.90	67.09	67 16	67.38	67.52
529	6	65.35	65.46	65.57	65.44	65.78	65.76
	25	66.87	66.93	66.93	66.83	66.55	66.53
530	13	64.52	64 58	64.38	64.39	64.44	64.35
Auger Evaluation--Blended Drums							
525	6	67.88	67.72	67.35	67.48	67.48	67.50
529	6	65.42	65.43	65 44	65.37	65.81	65.85
	25	66.73	66.66	66.73	66 72	66.27	66.16
530	13	64.35	64.44	64.12	64.21	64.35	64.27
Sampling Plant Evaluation--Unblended Drums							
643	22	67.17	67.04	67.04	66.94	66.89	66.81
645	10	65.00	64.82	64.67	64.51	64.49	64.46
646	18	65.67	65.52	65.44	65.42	65.33	65.18
650	17	62.13	62.20	62.21	62.12	61.04	60.99
651	4	64.25	64.30	63.98	64.05	64.00	64.04
652	26	66.40	66.43	66.25	66.38	66.14	66.06

Table A-XI

Uravan

Blended-Unblended Drum Study

Lot No.	Drum No.	Weighted Drum Averages, per cent U		
		Unblended(1)	Blended(2)	(1)–(2)
525	6	67.07	67.63	– 0.56
529	6	65.47	65.45	+ .02
	25	66.86	66.65	+ .21
530	13	64.47	64.30	+ .17

Table A-XII

Anaconda Carbonate

Auger Position Bias Study – Per Cent Moisture

Drum Size: 55 gal,

Lot No.	Drum No.	Position		
		1	2	3
1187	15	2.35	2.35	2.25
1190	30	2.19	2.12	2.44
1196	17	3.11	3.18	3.41
1202	24	1.96	2.00	1.98
1208	02	2.12	1.91	1.92

Table A-XIII

Anaconda Carbonate

Auger Position Bias Study – Per Cent Uranium

Drum Size: 55 gal.

		Position					
		1		2		3	
		Analyst		Analyst		Analyst	
Lot No.	Drum No.	A	B	A	B	A	B
Auger Evaluation--Unblended Drums							
699	09	63.18	63.09	63.61	63.50	63.09	63.20
	13	65.35	65 23	65.35	65.34	65.20	65.28
710	01	62.95	62.91	63.83	63.86	63.68	63.68
	25	63.48	63.43	63.71	63.68	63.66	63.78
796	16	65.69	65.77	65.77	65.77	65.75	65.78
	28	65.47	65.57	65 21	65.24	65.30	65.31
Auger Evaluation--Blended Drums							
699	09	63.66	63.64	63 70	63.55	63.64	63.66
	13	65.18	65.20	65 22	65.31	65.25	65.33
710	01	64.03	63 89	63 92	63.93	64.30	64.20
	25	63 66	63 68	63 70	63.72	63.36	63.43
796	16	65 72	65.63	65 76	65 76	65 71	65.72
	28	65.15	65.08	65 10	65.08	64 97	64.99
Sampling Plant Evaluation--Unblended Drums							
1187	15	65 38	65 31	65.42	65 34	65.48	65.36
1190	30	66.40	66 40	66.65	66 61	66.58	66.44
1196	17	63 43	63 34	63 40	63 39	63.23	63.21
1202	24	65.42	65 29	65.53	65 47	65 47	65.47
1208	02	65 02	65 01	65.17	65 18	65.14	65.13

Table A-XIV

Anaconda Carbonate

Blended-Unblended Drum Study

Lot No.	Drum No.	Weighted Drum Averages, per cent U		
		Unblended(1)	Blended(2)	(1)-(2)
699	09	63.29	63 64	− 0.35
	13	65.30	65.22	+ .08
710	01	63.33	63.97	− .64
	25	63.57	63.66	− .09
796	16	65.39	65.10	+ .29
	28	65.75	65.71	+ .04

Table A-XV

Texas-Zinc

Auger Position Bias Study – Per Cent Moisture

Drum Size: 55 gal.

Lot No.	Drum No	Position		
		1	2	3
12	01	1 60	6.01	1.54
13	08	2.17	2 43	2.54
14	08	2 58	2 42	2.12
15	12	1 91	2.00	2 17
16	20	8.00	7 74	7 66

Table A-XVI

Texas-Zinc

Auger Position Bias Study – Per Cent Uranium

Drum Size: 55 gal.

Lot No.	Drum No.	Position 1 Analyst A	Position 1 Analyst B	Position 2 Analyst A	Position 2 Analyst B	Position 3 Analyst A	Position 3 Analyst B
Sampling Plant Evaluation--Unblended Drums							
12	01	68.68	68.73	68.87	68.94	68.76	68.83
13	08	67.55	67.59	67.95	67.89	67.78	67.86
14	08	66.63	66.63	66.96	66.92	67.25	67.20
15	12	70.13	70.02	69.57	69.62	69.38	69.48
16	20	67.11	67.13	67.22	67.14	67.19	67.13

Table A-XVII

Western Nuclear

Auger Position Bias Study – Per Cent Moisture

Drum Size: 55 gal.

Lot No.	Drum No.	Position 1	Position 2	Position 3
24	54	8.19	7 12	7.65
27	30	0.14	0.00	0.00
28	21	0.00	0.00	0.00
30	19	1.18	1.03	1.13
33	39	0 78	0.58	0.39
34	08	2.53	2.55	2.42

Table A-XVIII

Western Nuclear

Auger Position Bias Study – Per Cent Uranium

Drum Size: 55 gal.

Lot No.	Drum No.	Position 1, Analyst A	Position 1, Analyst B	Position 2, Analyst A	Position 2, Analyst B	Position 3, Analyst A	Position 3, Analyst B
Sampling Plant Evaluation--Unblended Drums							
24	54	68.34	68.46	68.46	68.51	68.22	68.34
27	30	65.09	65.20	65.18	65.11	65.06	65.12
28	21	65.46	65.44	65.32	65.29	65.20	65.21
30	19	62.16	62.14	62.04	62.04	62.08	62.11
33	39	63.72	63.82	63.90	63.89	64.06	63.93
34	08	62.65	62.58	62.63	62.76	62.82	62.89

Table A-XIX

Anaconda Pilot Plant

Auger Position Bias Study – Per Cent Uranium

Drum Size: 55 gal.

Lot No.	Drum No.	Position 1, Analyst A	Position 1, Analyst B	Position 2, Analyst A	Position 2, Analyst B	Position 3, Analyst A	Position 3, Analyst B
Auger Evaluation--Unblended Drums							
691	03	66.75	66.67	65.00	65.17	65.67	65.67
	09	65.49	65.59	66.16	66.30	66.01	66.12
771	06	65.50	65.63	65.80	65.73	65.91	65.95
	07	65.45	65.48	65.62	65.59	64.99	65.00
Auger Evaluation--Blended Drums							
691	03	66.01	65.99	65.13	65.12	64.97	64.91
	09	65.73	65.87	64.27	64.39	64.42	64.44
771	06	65.92	66.01	65.65	65.69	65.32	65.32
	07	65.65	65.69	64.96	64.98	65.32	65.19

Table A-XX

Anaconda Pilot Plant

Blended–Unblended Drum Study

Lot No.	Drum No.	Weighted Drum Averages, per cent U: Unblended(1)	Blended(2)	(1)–(2)
691	03	66 02	65.59	+ 0.43
	09	65.84	65.14	+ .70
771	06	65 67	65 80	– .13
	07	65 47	65.38	+ .09

Table A-XXI

Durango

Auger Position Bias Study – Per Cent Uranium

Drum Size: 55 gal.

		Position 1		Position 2		Position 3	
		Analyst		Analyst		Analyst	
Lot No.	Drum No.	A	B	A	B	A	B
Auger Evaluation--Unblended Drums							
472	01	74 44	74.31	74 29	74.17	74.33	74.35
	24	72.85	72.80	72.50	72.38	72.92	72 99
482	05	72.09	72 10	72.30	72 21	71.86	71.96
	11	71 48	71.43	71.30	71.16	71.14	71.01
Auger Evaluation--Blended Drums							
472	01	74.15	74 29	74.14	74.29	74 29	74 18
	24	72.66	72.83	72.50	72 56	72.53	72.60
482	05	72 83	72 81	72.99	72.87	72.58	72.67
	11	71 19	71 12	71.10	71.18	71.09	71.17

Table A-XXII

Durango

Blended–Unblended Drum Study

Lot No.	Drum No.	Weighted Drum Averages, per cent U: Unblended(1)	Blended(2)	(1)–(2)
472	01	74.32	74.22	+ 0.10
	24	72.69	72.65	+ .04
482	05	72.14	72.84	– .70
	11	71.34	71.15	+ .19

Table A-XXIII

Kerr McGee

Auger Position Bias Study – Per Cent Uranium

Drum Size: 55 gal.

Lot No.	Drum No.	Position 1, Analyst A	Position 1, Analyst B	Position 2, Analyst A	Position 2, Analyst B	Position 3, Analyst A	Position 3, Analyst B
Auger Evaluation--Unblended Drums							
107	04	66.96	67 00	66.90	66.89	66 99	66.94
	41	64 49	64 56	64 23	64.22	64 25	64 26
108	21	65 11	65 02	65 29	65 15	65.30	65 28
	23	67.43	67 30	67 15	67 11	67.08	67.19
Auger Evaluation--Blended Drums							
107	04	66.16	66 25	66 24	66.35	66.10	66 27
	41	64.94	64 78	64 74	64 90	64.54	64.58
108	21	66.59	66.46	66 42	66.44	66.44	66.50
	23	66.84	66.83	66 96	67 01	66 79	66.64

Table A-XXIV

Kerr McGee

Blended-Unblended Drum Study

Lot No.	Drum No	Weighted Drum Averages, per cent U Unblended(1)	Blended(2)	(1)-(2)
107	04	66 95	66.24	+ 0.71
	41	64 39	64 82	- 0.43
108	21	65 14	66.48	- 1.34
	23	67 26	66.88	+ 0 38

Table A-XXV

Mines Development

Auger Position Bias Study - Per Cent Uranium

Drum Size: 55 gal.

		Position 1		2		3	
		Analyst		Analyst		Analyst	
Lot No	Drum No.	A	B	A	B	A	B
Auger Evaluation--Unblended Drums							
9	31	60 13	60 28	59 86	59 83	60.09	60 06
	34	59 85	59 85	59 75	59 80	60.09	60 11
13	07	60 89	61 05	61 14	61 08	60 96	60.92
	10	61 12	61 08	61 14	61 17	61 17	61.21
Auger Evaluation--Blended Drums							
9	31	60 13	60 11	60 19	60 17	60 26	60.16
	34	59 60	59 65	59 62	59 56	59.69	59.80
13	07	60 98	60 95	60 99	61 05	61 11	61.13
	10	61 08	61 12	61 13	61 22	61.21	61 18

Table A-XXVI

Mines Development

Blended–Unblended Drum Study

Lot No.	Drum No.	Weighted Drum Averages, per cent U: Unblended(1)	Blended(2)	(1)–(2)
9	31	60.06	60.15	– 0.09
	34	59.85	59.62	+ .23
13	07	60.96	61.00	– .04
	10	61.13	61.14	– .01

Table A-XXVII

Monticello Acid

Auger Position Bias Study – Per Cent Uranium

Drum Size: 30 gal.

		Position					
		1		2		3	
		Analyst		Analyst		Analyst	
Lot No.	Drum No.	A	B	A	B	A	B
Auger Evaluation--Unblended Drums							
54	36	67.48	67 36	67 31	67.18	67.24	67.31
	51	67.08	67.09	66 99	66.99	67 00	67.07
55	12	65.76	65 88	65 83	65 96	66.40	66.38
	60	61 19	61.23	60 74	60.92	60.29	60.45
58	54	60.07	60 14	59 77	59.91	59 68	59 69
	57	59.98	60 02	60 08	59.94	59 94	60.01
61	01	59.51	59 53	59 44	59.43	59.64	59.62
	38	56.83	56.79	56 76	56 83	56 83	56 89
Auger Evaluation--Blended Drums							
54	36	67.10	67.21	67 54	67.41	67 48	67.34
	51	66.84	67.03	67 20	67 16	67.00	67.05
55	12	60.01	60.05	60 00	60 00	60.07	60 18
	60	65.84	65.90	65 98	65.90	65.82	65.93
58	54	59.92	59.88	60.00	60.00	59 87	59.95
	57	60 05	60.03	59 85	59.96	59.75	59.78
61	01	59 59	59 69	59.51	59.45	59.78	59.74
	38	56.92	56 94	56 98	56.97	57.11	57.02

Table A-XXVIII

Monticello Acid

Blended–Unblended Drum Study

Lot No.	Drum No.	Weighted Drum Averages, per cent U Unblended(1)	Blended(2)	(1)–(2)
54	36	67.34	67 27	+ 0.07
	51	67 04	67 03	+ 01
55	12	65 90	65 90	.00
	60	61 00	60 02	+ .98
58	54	59 92	59 94	– 02
	57	60.00	59 97	+ .03
61	01	59 50	59.59	– .09
	38	56 81	56 96	– .15

Table A-XXIX

Naturita

Auger Position Bias Study – Per Cent Uranium

Drum Size: 55 gal.

		Position 1		2		3	
		Analyst		Analyst		Analyst	
Lot No.	Drum No.	A	B	A	B	A	B
Auger Evaluation--Unblended Drums							
342	08	68 29	68 36	68 90	68 88	69.06	69 05
	09	69 20	69 06	68 80	68.91	68 85	68.68
345	21	71 13	71 21	71 06	71 14	71.26	71 39
	27	69 29	69 27	69 13	69.04	69 50	69.40
Auger Evaluation--Blended Drums							
342	08	68.70	68 85	68 60	68 71	68 76	68.70
	09	68.62	68.73	68.53	68 57	68.85	68.91
345	21	71 34	71.21	71.20	71 13	71 07	71 04
	27	69.47	69 55	69 57	69 49	69 37	69.47

Table A-XXX

Naturita

Blended-Unblended Drum Study

Lot No.	Drum No.	Weighted Drum Averages, per cent U Unblended(1)	Blended(2)	(1)–(2)
342	08	68.60	68.73	– 0.13
	09	69.00	68.65	+ .35
345	21	71.16	71.22	– .06
	27	69.22	69.51	– .29

Table A-XXXI

Rare Metals

Auger Position Bias Study – Per Cent Uranium

Drum Size: 30 gal.

Lot No.	Drum No.	Position 1, Analyst A	Position 1, Analyst B	Position 2, Analyst A	Position 2, Analyst B	Position 3, Analyst A	Position 3, Analyst B
Auger Evaluation--Unblended Drums							
10	01	64.26	64.30	65.37	65.33	63.83	64.00
	20	66.43	66.43	66.54	66.48	66.45	66.47
11	29	67.22	67.36	67.25	67.18	67.18	67.20
	34	65.78	65.90	65.94	65.82	65.86	65.84
Auger Evaluation--Blended Drums							
10	01	64.24	64.16	63.76	63.84	63.63	63.71
	20	66.51	66.45	66.53	66.48	66.81	66.66
11	29	65.94	65.88	65.73	65.76	65.91	65.88
	34	67.16	67.13	67.23	67.25	67.15	67.17

Table A-XXXII

Rare Metals

Blended-Unblended Drum Study

Lot No.	Drum No.	Weighted Drum Averages, per cent U Unblended(1)	Blended(2)	(1)–(2)
10	01	64.64	64.01	+ 0.63
	20	66.46	66.51	– .05
11	29	67.25	67.18	+ .07
	34	65.85	65.85	.00

Table A-XXXIII

Anaconda Acid (First Series)

Sampling Plant Evaluation

Lot No	Gross Incoming Wet Weight lb	Tare Weight lb.	Net Incoming Wet Weight lb	Sampling Stage	Number of Drums Sampled	Net Input Wet Weight[a] lb	Per Cent Sample vs. Input	Per Cent Moisture in Lot Sample	Assay, Per Cent Uranium, Dry Basis: Analyst A	Analyst B	Average	Uranium Content lb.
1087	16,856.00	1,781.50	15,074.50	Auger 1	33	14,924.50	0.380	6.38	67.48	67.72	67.60	9,445
				Galigher 1	33	14,863.00	094	6.41	67.56	67.48	67.52	9,431
				Auger 2	32	14,692.75	450	6.41	67.42	67.49	67.46	9,423
				Galigher 2	32	14,626.25	099	6.23	67.39	67.60	67.50	9,447
1103	17,256.00	1,749.75	15,506.25	Auger 1	33	15,433.75	315	5.96	65.30	65.39	65.34	9,483
				Galigher 1	33	15,304.25[b]	097	6.02	65.42	65.54	65.48	9,498
				Auger 2	32	15,278.00	.290	6.36	65.58	65.64	65.61	9,482
				Galigher 2	32	15,225.00	.090	5.87	65.34	65.57	65.46	9,510
1112	16,470.50	1,689.00	14,781.50	Auger 1	33	14,707.00	350	7.46	65.62	65.58	65.60	8,928
				Galigher 1	33	14,658.50	098	7.43	65.67	65.64	65.66	8,939
				Auger 2	32	14,568.50	426	7.56	65.55	65.57	65.56	8,913
				Galigher 2	32	14,503.50	099	7.41	65.66	65.59	65.62	8,935
1117	28,563.00	2,809.75	25,753.25	Auger 1	56	25,622.75	304	6.69	66.00	65.91	65.96	15,770
				Galigher 1	56	25,540.25	.091	6.82	65.92	65.89	65.90	15,734
				Auger 2	48	25,430.75	273	6.95	65.96	65.89	65.92	15,717
				Galigher 2	48	25,352.75	.092	6.79	65.89	65.79	65.84	15,724
1118	17,068.00	1,679.25	15,388.75	Auger 1	33	15,307.25	.376	6.30	66.20	65.96		
									65.89	65.96	66.00	9,466
				Galigher 1	33	15,259.75	.100	6.32	65.82	65.87		
									65.87	65.93	65.87	9,446
				Auger 2	29	16,137.00[c]	.274	6.20	65.92	65.75		
									65.92	65.84	65.86	9,456
				Galigher 2	29	16,090.00	.096	5.95	65.66	65.83		
									65.81	65.78	65.77	9,468

[a] The "Net Input Wet Weight" excludes the weight of the "Sample Reject" from Lucius Pitkin, Inc.

[b] Spillage of one drum (approx. 80 lbs.) occurred following the first augering.

[c] The sampling of lot 1113 just prior to that of 1118 was discontinued because of malfunction of the star valve below the receiving hopper. A failure to clean out this material from the system is indicated by the gain in "Input Weight."

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Table A-XXXIII (Continued)

Anaconda Acid (Second Series)

Sampling Plant Evaluation

Lot No.	Gross Incoming Wet Weight lb.	Tare Weight lb.	Net Incoming Wet Weight lb.	Sampling Stage	Number of Drums Sampled	Net Input Wet Weight[a] lb.	Per Cent Sample *vs.* Input	Per Cent Moisture in Lot Sample	Assay, Per Cent Uranium, Dry Basis: Analyst A	Analyst B	Average	Uranium Content lb.
1249	14,707.50	1,782.25	12,925.25	Auger 1	33	12,863.25	0.283	6.59	69.17	69.25		
				(Sample 1)					69.28	69.29	69.25	8,321
				Auger 1	33		.298	6.56	69.22	69.21		
				(Sample 2)					69.06[f]	69.19	69.21	8,318
				Galigher 1	33	12,785.75	.091	6.58	68.86	68.85		
									68.70	68.68	68.77	8,264
				Auger 2	36	12,654.25	.266	6.64	69.14	69.19		
									69.09	69.12	69.14	8,303
				Galigher 2	36	12,616.75	.094	6.63	69.13	69.01		
									68.99	69.01	69.04	8,292
1259	13,939.50[d]	1,674.00[e]	12,265.50	Auger 1	33	12,265.50	279	6.45	71.56	71.48		
				(Sample 1)					71.65	71.51	71.55	8.209
				Auger 1	33		.299	6.22	71.43	71.37		
				(Sample 2)					71.42	71.38	71.40	8,212
				Galigher 1	33	12,190.00	.090	6.39	71.41[g]	71.28		
									71.26	71.29	71.28	8,183
1270	15,145.00	1,695.75	13,449.25	Auger 1	33	13,385.25	.271	6.47	68.28	68.24		
				(Sample 1)					68.38	68.20	68.28	8,548
				Auger 1	33		.282	6.62	68.12	68.16		
				(Sample 2)					68.23	68.10	68.15	8,518
				Galigher 1	33	13,307.75	.103	6.35	68.43	68.43		
									68.36	68.37	68.40	8,574
				Auger 2	41	13,240.00	.292	6.42	68.31	68.18		
									68.02	68.19	68.18	8,540
				Galigher 2	41	13,212.00	.108	6.36	68.26	68.48		
									68.39	68.42	68.39	8,572
1275	13,328.50	1,700.75	11,627.75	Auger 1	33	11,570.75	.282	6.93	72.04	72.10		
				(Sample 1)					72.11	72.12	72.09	7,763
				Auger 1	33		.290	6.89	72.09	72.12		
				(Sample 2)					72.17	72.22	72.15	7,773
				Galigher 1	33	11,506.75	.100	6.99	71.95	72.03		
									71.95	71.95	71.97	7,746
				Auger 2	36	11,352.25	.354	7.06	71.99	72.07		
									71.97	72.08	72.03	7,746
				Galigher 2	36	11,303.25	.106	7.05	72.04	72.07		
									72.09	72.08	72.07	7,751

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1276	14,165.50	1,701.00	12,464.50	Auger 1	33	12,405.50	.313	6.91	71.40	71.42		
				(Sample 1)					71.36	71.41	71.40	8,245
				Auger 1	33		.313	6.72	71.42	71.49		
				(Sample 2)					71.48	71.50	71.47	8,270
				Galigher 1	33	12,315.00	.104	6.86	71.32	71.42		
									71.34	71.38	71.36	8,245
				Auger 2	41	12,197.75	.327	6.91	71.29	71.40		
									71.32	71.44	71.36	8,241
				Galigher 2	41	12,155.75	.106	6.81	71.34	71.32		
									71.26	71.40	71.33	8,246
1277	14,754.00	1,700.75	13,053.25	Auger 1	33	12,992.25	.286	7.13	71.86	71.85		
				(Sample 1)					71.86	71.88	71.86	8,671
				Auger 1	33		.286	7.16	71.76	71.96		
				(Sample 2)					71.86	71.97	71.89	8,671
				Galigher 1	33	12,912.75	.106	7.16	71.85	71.88		
									71.78	71.92	71.86	8,668
				Auger 2	40	12,864.00	.317	7.24	71.97	71.94		
									71.82	71.92	71.91	8,666
				Galigher 2	40	12,824.50	.106	7.21	71.90	71.88		
									71.83	71.89	71.88	8,666

[d] The "Gross Incoming Wet Wt." excludes the weight of sample reject material.

[e] The tare for the "Sample Reject" drum is excluded.

[f, g] These assays were rejected by statistical tests for the rejection of outlying values.

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Table A-XXXIV

Rifle

Sampling Plant Evaluation

Lot No.	Gross Incoming Wet Weight lb.	Tare Weight lb.	Net Incoming Wet Weight lb	Sampling Stage	Number of Drums Sampled	Net Input Wet Weight[a] lb.	Per Cent Sample vs. Input	Per Cent Moisture in Lot Sample	Assay, Per Cent Uranium, Dry Basis: Analyst A	Analyst B	Average	Uranium Content lb.
35	21,568.00	1,213.00	20,355.00	Auger 1	23	20,197.00	0.515	0.10	70.43	70.40	70.42	14,208
				Galigher 1	23	20,089.00	.113	.15	70.45	70.46	70.46	14,209
				Auger 2	23	20,143.25[b]	.297	.18	70.51	70.54	70.52	14,217
				Galigher 2	23	19,253.25[b]	.102	.16	70.40	70.45	70.42	14,201
38	21,617 00	1,242.50	20,374.50	Auger 1	24	20,374.50	.428	.10	68.62	68.56	68.59	13,961
				Galigher 1	24	20,323.50[c]	.099	.12	68.69	68 70	68.70	13,980
				Auger 2	25	20,286 50	.456	12	68.55	68.65	68.60	13,960
				Galigher 2	25	20,262.00	.100	.11	68.57	68 65	68.61	13,964
40	21,609.00	1,128 50	20,480.50	Auger 1	22	20,480.50	.466	04	66 77	66 67	66 72	13,659
				Galigher 1	22	20,322.50	105	.12	66.92	67.02	66 97	13,699
				Auger 2	21	20,358 75	.325	.13	66.69	66 67	66.68	13,639
				Galigher 2	21	20,200.75	.097	12	66.68	66 71	66.70	13,644
41	22,011 00	1,224 75	20,786.25	Auger 1	23	20,786.25	506	.04	63.00	63 02	63.01	13,092
				Galigher 1	23	20,641.75	.095	02	62.90	63.00	62.95	13,082
				Auger 2	26	20,342.75	424	.06	62.96	63.10	63.03	13,094
				Galigher 2	26	20,252.75	.097	07	62 94	62.98	62.96	13,078
46	14,990.00	877.50	14,112 50	Auger 1	17	14,112.50	.501	.06	70.26	70.11	70.18	9,898
				Galigher 1	17	14,057 00	102	.12	69.85	69.76	69.80	9,839
				Auger 2	17	13,185.00	.258	.17	70.16	70.14	70.15	9,880
				Galigher 2	17	13,152.50	.110	.13	69.81	69.73	69.77	9,834

[a] The "Net Input Wet Weight" excludes the weight of the "Sample Reject" from Lucius Pitkin, Inc.

[b] The difference of 890 lbs.between inputs to Auger and Galigher is partially accounted for by eliminating Drum 22 which spilled.

[c] A gain in weight of 36.5 lb.was apparently due to substitution of clamp-type rings in place of the bolt-type rings with which the drums had been shipped.

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Table A-XXXV

Uranium Reduction

Sampling Plant Evaluation

Lot No.	Gross Incoming Wet Weight lb.	Tare Weight lb.	Net Incoming Wet Weight lb.	Sampling Stage	Number of Drums Sampled	Net Input Wet Weight[a] lb.	Per Cent Sample vs. Input	Per Cent Moisture in Lot Sample	Assay, Per Cent Uranium, Dry Basis: Analyst A	Analyst B	Average	Uranium Content lb.
298	20,887.00	1,583.75	19,303.25	Auger 1	30	19,204.75	0.397	1.45	62.70	62.80	62.75	11,876
				Galigher 1	30	19,188.75[b]	.095	1.53	62.66	62.63	62.64	11,846
				Auger 2	42	19,677.25[c]	.228	1.61	62.64	62.76	62.70	11,848
				Galigher 2	42	19,639.25	.096	1.56	62.76	62.78	62.77	11,867
299	20,603.00	1,584.00	19,019.00	Auger 1	30	18,920.50	.303	1.58	62.39	62.43	62.41	11,622
				Galigher 1	30	18,927.00[b]	.096	1.62	62.19	62.06	62.12	11,563
				Auger 2	41	18,801.25	.437	1.47	62.16	62.10	62.13	11,582
				Galigher 2	41	18,736.25	.097	1.56	62.06	62.05	62.06	11,559
304	20,277.50	1,670.25	18,607.25	Auger 1	30	18,417.25	.359	0.828	64.68	64.69	64.68	11,814
				Galigher 1	30	18,351.75	.090	0.818	64.80	64.66		
									64.48	64.67	64.65	11,809
				Auger 2	37	18,299.00	.450	0.900	64.56	64.61	64.58	11,787
				Galigher 2	37	18,217.50	.091	0.974	64.51	64.78		
									64.50	64.22	64.50	11,764
305	19,455.00	1,663.50	17,791.50	Auger 1	30	17,697.00	.436	0.695	69.94	69.96	69.95	12,293
				Galigher 1	30	17,549.00	.093	0.807	69.30	69.35	69.32	12,170
				Auger 2	38	17,616.50	.468	0.852	69.73	69.70		
									69.69	69.52[d]	69.71	12,232
				Galigher 2	38	17,532.50	.090	0.858	69.70	69.57		
									69.60	69.42	69.57	12,207
307	21,424.50	1,676.00	19,748.50	Auger 1	30	19,652.50	.348	1.03	67.16	67.23	67.20	13,070
				Galigher 1	30	19,586.00	.091	1.11	67.25	67.26	67.26	13,072
				Auger 2	38	19,170.50	.229	1.11	67.12	67.19	67.16	13,052
				Galigher 2	38	19,116.00	.090	1.05	67.20	67.15	67.18	13,064

[a] The "Net Input Wet Weight" excludes the weight of the "Sample Reject" from Lucius Pitkin, Inc.

[b] Weight increases may be due to weighing-in with bolt-type rings and weighing-out with clamp-type rings.

[c] This increase in weight is attributed to failure to clean out material from lot 292 which was unsuccessful due to mechanical failure.

[d] This result was rejected statistically.

Table A-XXXVI

Uravan

Sampling Plant Evaluation

Lot No.	Gross Incoming Wet Weight lb.	Tare Weight lb.	Net Incoming Wet Weight lb.	Sampling Stage	Number of Drums Sampled	Net Input Wet Weight[a] lb.	Per Cent Sample vs. Input	Per Cent Moisture in Lot Sample	Assay, Per Cent Uranium, Dry Basis – Analyst A	Analyst B	Average	Uranium Content lb.
643	16,698.50	1,333.75	15,364.75	Auger 1	26	15,264.25	0.441	0.465	65.66	65.56	65.61	9,968
				Galigher 1	26	15,231.25	.097	.469	65.68	65.66	65.67	9,977
				Auger 2	25	14,928.25	.337	.373	65.73	65.70	65.72	9,994
				Galigher 2	25	14,881.75	.104	405	65.70	65.56	65.63	9,977
645[b]	17,183.00	1,374.75	15,808.25	Auger 1	27	15,688.25	.412	.245				
				Galigher 1	27	15,594.75	.100	.288	64.76	64.52	64.64	10,112
				Auger 2	26	15,111.75	.395	.362	64 84	64.77	64.80	10,129
				Galigher 2	26	15,047.75	.112	.372	64.64	64.76	64.70	10,113
646	16,221.50	1,275 50	14,946.00	Auger 1	25	14,835.00	.395	.191	65.19	65.02		
									62.83[c]	65.08	65.10	9,639
				Galigher 1	25	14,807.00	.106	092	64.73	64.61	64.67	9,585
				Auger 2	24	14,709.25	.373	132	64.94	64.89	64.92	9,618
				Galigher 2	24	14,650.75	118	.108	64.96	64 89	64.92	9,620
650	16,531 00	1,292.25	15,238 75	Auger 1	25	15,113.75	.453	104	64.40	64.35		
									64.71[c]	64.35	64.37	9,719
				Galigher 1	25	15,079.75	.089	.000	64.38	64.32	64.35	9,726
				Auger 2	21	14,551.25	.364	.058	64.46	64.50	64.48	9,739
				Galigher 2	21	14,640.25	.082	046	64 63	64.47	64.55	9,750
651	15,994 50	1,199 25	14,795.25	Auger 1	23	14,695.25	454	.018	63.08	63.18	63.13	9,275
				Galigher 1	23	14,625.25	.092	.024	63.07	62.94	63.00	9,256
				Auger 2	20	14,527 75	.397	.010	63 06	63 04	63.05	9,266
				Galigher 2	20	14,470.75	085	.000	63.06	63.12	63.09	9,272
652	16,679.50	1,369 25	15,310.25	Auger 1	26	15,206.50	.450	222	63.89	63.80	63.84	9,686
				Galigher 1	26	15,160.00	.090	.145	63.84	63.80	63.82	9,691
				Auger 2	23	15,070.75	.352	.098	63.69	63.54	63.62	9,665
				Galigher 2	23	15,019.25	.105	147	63.84	63.72	63.78	9,684

[a] The "Net Input Wet Weight" excludes the weight of the "Sample Reject" from Lucius Pitkin, Inc.

[b] The sample from Auger 1 on lot 645 was lost during preparation in the laboratory. Only partial results were used in statistical analysis of the data.

[c] These assays were excluded from the average by means of statistical tests for the rejection of outlying values.

Table A-XXXVII

Anaconda Carbonate

Sampling Plant Evaluation

Lot No.	Gross Incoming Wet Weight lb.	Tare Weight lb.	Net Incoming Wet Weight lb.	Sampling Stage	Number of Drums Sampled	Net Input Wet Weight[a] lb.	Per Cent Sample vs. Input	Per Cent Moisture in Lot Sample	Assay, Per Cent Uranium, Dry Basis: Analyst A	Analyst B	Average	Uranium Content lb.
1187	23,834.00	1,768.75	22,065.25	Auger 1	34	22,065.25	0.324	2.02	65.08	64.99	65.04	14,061
				Galigher 1	34	21,823.75[b]	.099	1.90	65.06	65.01	65.04	14,078
				Auger 2	46	22,086.00[c]	.252	1.87	65.03	65.01	65.02	14,078
				Galigher 2	46	22,034.00	.106	1.88	65.04	65.09	65.06	14,086
1190	24,810.00	1,745.75	23,064.25	Auger 1	34	23,064.25	.290	2.00	65.37	65.35		
									65.42	65.13[d]	65.38	14,778
				Galigher 1	34	22,990.75	.103	2.49	65.42	65.31	65.36	14,700
				Auger 2	45	22,339.50	.275	2.16	65.43	65.49		
									65.48	65.32	65.43	14,763
				Galigher 2	45	22,282.00	.100	2.14	65.34	65.36	65.35	14,749
1196	23,495.50	1,746.75	21,748.75	Auger 1	34	21,748.75	.342	2.13	63.85	63.84	63.84	13,589
				Galigher 1	34	21,666.75	.104	2.41	64.07	64.01	64.04	13,592
				Auger 2	46	22,054.00	.283	2.32	63.97	63.93	63.95	13,586
				Galigher 2	46	21,958.50	.099	2.26	63.90	63.87	63.88	13,579
1202	23,826.50	1,754.50	22,072.00	Auger 1	34	22,072.00	.302	1.98	64.71	64.68	64.70	13,998
				Galigher 1	34	22,000.00	.099	2.16	64.82	64.76	64.79	13,992
				Auger 2	47	22,259.75	.266	2.17	64.77	64.73	64.75	13,981
				Galigher 2	47	22,203.75	.107	2.20	64.84	64.80		
									64.49	64.74	64.72	13,970
1208	24,070.00	1,699.00	22,371.00	Auger 1	34	22,371.00	.264	1.88	65.65	65.64	65.64	14,408
				Galigher 1	34	22,394.00[e]	.101	1.90	65.52	65.63	65.58	14,392
				Auger 2	46	21,187.75	.229	1.97	65.50	65.55	65.52	14,370
				Galigher 2	46	21,136.75	.101	1.95	65.66	65.62		
									65.29	65.53	65.52	14,373

[a] The "Net Input Wet Weight" includes the weight of "Sample Reject" from Lucius Pitkin, Inc.

[b] Spillage estimated at 175.0 lbs from 2 drums occurred following the Auger 1 stage. The material was not returned to the lot.

[c] The weight increase was apparently holdup material from lot 1182C, run unsuccessfully the previous day.

[d] This assay was excluded from the average by means of statistical tests for the rejection of outlying values.

[e] The weight increase may be due to weighing-in with bolt-type rings and weighing-out with clamp-type rings.

Table A-XXXVIII

Texas-Zinc

Sampling Plant Evaluation

Lot No	Gross Incoming Wet Weight lb	Tare Weight lb	Net Incoming Wet Weight lb	Sampling Stage	Number of Drums Sampled	Net Input Wet Weight[a] lb	Per Cent Sample *vs.* Input	Per Cent Moisture in Lot Sample	Assay, Per Cent Uranium, Dry Basis: Analyst A	Analyst B	Average	Uranium Content lb.
12	12,309 50	945 25	11,364 25	Auger 1	18	11,311.25	0 386	2 60	66 86	66.98	66 92	7,373
				Galigher 1	18	11,304.75[b]	087	2 48	66 74	66.80	66 77	7,365
				Auger 2	22	11,098 50	303	2.78	66 85	66.90	66.88	7,355
				Galigher 2	22	11,064 50	.088	2.59	66.77	66.81	66.79	7,359
13	13,140 00	936 25	12,203 75	Auger 1	18	12,148.75	391	1 97	67.55	67.69	67.62	8,053
				Galigher 1	18	12,094.75	090	2 01	67.60	67 61	67 60	8,048
				Auger 2	23	11,935.50	318	2 10	67.64	67 64	67 64	8,045
				Galigher 2	23	11,897 50	085	2 13	67 50	67 58	67 54	8,031
14	12,716 50	942 25	11,774.25	Auger 1	18	11,720 25[b]	361	2 15	67 44	67 56		
									68 16	67 57	67 52	7,743
				Galigher 1	18	11,703 75	088	2.19	67 43	67 57		
									68 04	67 69	67 68	7,758
				Auger 2	24	11,809 25	290	2 26	67 54	67 61		
									68 55[c]	67.69	67 61	7,745
				Galigher 2	24	11,773 25	086	2 12	67 53	67 64		
									68 02	67 65	67 71	7,768
15	12,635.00	897 75	11,737 25	Auger 1	17	11,681 75	422	2 15	68 65	68.52	68 58	7,839
				Galigher 1	17	11,636 75	087	2 10	68 47	68 38	68 42	7,825
				Auger 2	22	11,460 25	410	2 31	68.38	68 39	68.38	7,804
				Galigher 2	22	11,407 75	.082	2 18	68 51	68.51	68 51	7,828
16	13,319 50	1,044 50	12,275 00	Auger 1	20	12,216.50	398	3 07	66 55	66.64		
									66.72	67.19	66.78	7,908
				Galigher 1	20	12,169 00	091	3 09	66 76	66.78	66.77	7,905
				Auger 2	28	12,030.75	.318	3 20	66.62	66 69		
									66.68	66 39[c]	66.66	7,883
				Galigher 2	28	11,989 25	095	2 95	66.62	66.67	66.64	7,901

[a] The "Net Input Wet Weight" excludes the weight of the "Sample Reject" from Lucius Pitkin, Inc

[b] Weight increases on auger stages may have been caused by weighing-out from the auger with clamp-type rings instead of the bolt-type rings with which the drums were shipped

[c] These assays were excluded from the average by statistical tests for the rejection of outlying values.

Table A-XXXIX

Western Nuclear

Sampling Plant Evaluation

Lot No.	Gross Incoming Wet Weight lb.	Tare Weight lb.	Net Incoming Wet Weight lb.	Sampling Stage	Number of Drums Sampled	Net Input Wet Weight[a] lb.	Per Cent Sample vs. Input	Per Cent Moisture in Lot Sample	Assay, Per Cent Uranium, Dry Basis: Analyst A	Analyst B	Average	Uranium Content lb.
24	19,835.50	2,879.75	16,955.75	Auger 1	55	16,635.75	0.267	7.75	69.06	69.00		
									69.02	69.26[d]	69.03	10,594
				Galigher 1	55	16,617.75	.110	7.74	68.85	68.93	68.89	10,573
				Auger 2[b]	83	15,435.50	.289	7.28	68.85	68.99	68.92	10,626
				Galigher 2[b]	83	15,381.00	.095	7.47	68,86	68.93	68.90	10,604
27	26,533.50	2,616.75	23,916.75	Auger 1	52	23,721.75	.327	1.44	65.10	65.09	65.10	15,220
				Galigher 1	52	23,650.25	.094	1.49	64.99	65.03	65.01	15,192
				Auger 2	73	23,605.00	.282	1.43	65.01	65.09	65.05	15,210
				Galigher 2	73	23,527.50	.094	1.68	64.92	65.07	65.00	15,160
28	25,198.50	2,292.75	22,905.75	Auger 1	45	22,701.25	.352	1.77	65.06	65.07	65.06	14,508
				Galigher 1	45	22,604.25	.072	2.47	64.90	64.98	64.94	14,379
				Auger 2	66	22,220.75	.346	1.70	64.87	65.00	64.94	14,490
				Galigher 2	66	22,163.75	.103	1.77	64.95	64.97	64.96	14,484
30	27,656.00	2,599.75	25,056.25	Auger 1	50	24,928.25	.371	1.02	64.47	64.62	64.54	15,924
				Galigher 1	50	24,782.75	.116	1.40	64.80	64.80	64.80	15,927
				Auger 2	73	24,815.50	.393	0.84	64.42	64.42		
									64.42	64.61	64.47	15,936
				Galigher 2	73	24,739.00	.098	1.01	64.41	64.56	64.48	15,912
33[c]	31,460.50	3,863.00	27,597.50	Auger 1	75	27,464.00	.352	1.49	64.23	64.15	64.19	17,367
34[c]	32,846.50	3,906.75	28,939.75	Auger 1	76	28,807.50	.332	2.13	63.97	63.91	63.94	18,027

[a] The "Net Input Wet Weight" excludes the Lucius Pitkin, Inc. "Sample Reject."

[b] The data for Auger 2 and Galigher 2, lot 24, was excluded from statistical evaluation because of the excessive holdup in the first mechanical run (1200 lbs.).

[c] Lots 33 and 34 were not mechanically sampled because the material was not amenable to flow through the ducts, conveying equipment, and rotary values in the mechanical system.

[d] This assay value was rejected statistically.