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Manhattan District History

Book II - Gaseous Diffusion [K-25] Project

Vol. 5 - Operation

[redacted]

Department of Energy Declassification Review	
1st Review Date: 6-17-[illegible]	Determination: [Circle Number(s)]
Name: W. Brown, HS-60 Reviewer	1. Classification Retained
Authority: ☐ DC ☒ DD	2. Classification Changed To: ______
Derived From: ______	3. Contains No DOE Classified Info
Declassify On: ______	4. Coordinate With: ______
2nd Review Date: 6/14/13	(5.) Declassified
Name: [illegible], HS-60 Reviewer	6. Classified Info Bracketed
Authority: DD	(7.) Other (Specify) Appendix only, 57 pp.

1325-47

20130006869

[redacted] SECRET

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This document consists of 39 pages
No. 4 of 6 copies, Series a.

[redacted] SECRET
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Per R. W. Cook
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CONTROL SYMBOL
0 461 /SWP

MANHATTAN DISTRICT HISTORY

BOOK II - GASEOUS DIFFUSION (K-25) PROJECT

VOLUME 5 - OPERATION

TOP SECRET APPENDIX

CLASSIFICATION CXXXXXXX
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MANHATTAN DISTRICT HISTORY

BOOK II - GASEOUS DIFFUSION (K-25) PROJECT

VOLUME 5 - OPERATION

TOP SECRET APPENDIX

SPECIAL HAZARDS

1-1. <u>History of Special Hazards Work at K-25.</u> - One of the basic factors influencing design and construction of the K-25 plant was the consideration of special hazards associated with possible solid or liquid U-235 accumulations beyond safe limits. In all cases, equipment was so designed that, not only its prescribed function would be performed, but, at the same time, the possibility of hazardous accumulations of solid or liquid U-235 would be avoided in so far as possible. The Kellex Corporation was guided in its work on plant design by specifications on permissible limits of accumulations given, for the most part, by Dr. E. Teller and his associates at Los Alamos. At the time the plant was designed, a maximum U-235 product concentration of 36.6 per cent was contemplated; all equipment was therefore designed on this basis. Dr. Teller obtained his stated values of maximum permissible accumulations from theoretical consideration of factors affecting chain reactions in fissionable material, and from critical mass experiments performed under conditions more or less relevant to those involved at K-25. Assuredly large, but rather uncertain, safety factors were included in the specifications.

Late in 1945, preliminary experiments relevant to the K-25 plant were performed at X-10 on 25 per cent material, to investigate problems of plant safety. These experiments did not give the final solutions to problems encountered under the various conditions considered, primarily because of the difficulty of realizing actual plant conditions with the material and methods available, particularly with regard to density, fluorine content, and homogenity, i.e., the difficulty of allowing theoretically for the large difference in density and molecular weight between the assemblies for which criticality was measured, and the solid deposits to be anticipated under actual operating conditions. The experiments were restricted because of the limited amounts of enriched material available (40 kilograms of uranium at 25 per cent isotopic concentration), and inadequate time for preparation and performance. The results of the 25 per cent criticality tests were used because they were the best available at the time. However, the actual operating conditions of the plant were approached to give very satisfactory results in later mock-up experiments on 30 per cent, 60 per cent, and 95 per cent materials.

Worthy of special mention because of the major potential hazards offered by the condensation of UF_6, is the wide elimination of cold trapping operations in the plant, which was started in 1945, by use of the alternative (surge for purge) method of process gas recovery. The most important items of plant equipment that could be considered dangerous were thus eliminated (Vol. 5, Par. 4-6).

As the U-235 concentration was raised in the product (Item 2), the need increased for additional information on margins of safety and factors affecting the values of critical accumulations. A series of experiments was conducted in 1946 to determine the values of critical mass under conditions pertinent to the K-25 plant, and to study the effect of various factors. The experiments were undertaken as a joint effort of the K-25, Y-12, and X-10 Projects, under the direction of Dr. C. K. Beck of K-25. Since the Clinton Engineer Works group had not worked previously with critical mass assemblies, arrangements were made for the first series of experiments to be performed at Los Alamos under the supervision of personnel having considerable experience in work of this kind. These experiments achieved the following:

1. Considerable information was established, pertaining to critical masses under conditions of interest to K-25.
2. Experience was gained by the Oak Ridge group, which could then continue with further investigations, as necessary, for the safety of the plants at the Clinton Engineer Works.

The first experiments performed at Los Alamos used 95 per cent material, and the later experiments at Oak Ridge were concerned with critical assemblies at 30 per cent and 60 per cent. All the uranium material was fabricated into cubes for ease in handling, and to facilitate the formation of proper assemblies. In general, the 30 per cent experiments confirmed the earlier theoretical extrapolations of Dr. Teller and his colleagues. The 60 per cent experiments were performed at K-25 by properly stacking 30 per cent cubes with 95 per cent cubes, which were shipped to K-25 from Los Alamos.

In the summer of 1946, an educational program on critical mass problems was conducted within the plant for both technical and non-technical supervisory personnel who needed the information to perform their work safely. As a prerequisite to raising the product purity to its present value of 94 per cent, a review of K-25 operating equipment and procedures from the special hazards viewpoint was made, in July 1946, by a group of K-25 personnel under the direction of Mr. C. E. Beck. The following conclusions were reached:

1. Operation at high purity could be accomplished safely.
2. Several problems required correction before the concentration was increased. These corrective measures were taken.

In order to review and approve all future proposed equipment and procedural changes in Plant II, a body was formed on 29 July 1946, known as the Plant II Special Hazards Committee. Special instruments were placed in service. Instruments were installed to detect excessive accumulations of HF, which is conducive to the formation of a critical condition in case of condensation of both UF_6 and HF. Radiation monitors were installed throughout the plant to indicate a condition that has become barely critical. Instructions were issued to all operation personnel concerning prescribed procedures for evacuating any hazardous area that might develop, and for isolating the area with the aid of radiation detectors. Prior to raising the product purity in K-25, the Bradbury-Felbeck-Keith Committee was appointed by the District Engineer for final recommendations on operating the plant at high purity. The conclusions of this committee may be summarized as follows:

1. The plant appeared safe for high purity production.
2. Safety for future operation depends on a rigorous safety program of continual review of operations by a special hazards group of the operating company, composed of competent personnel, including experienced physicists.
3. Material balances are important in order to follow possible accumulations of U-235.

On 1 November 1946, Mr. C. N. Rucker, Assistant Plant Superintendent, outlined the organization planned to cope with special hazards in the plant. Essentially, it was proposed to continue the operation of the K-25 Special Hazards Committee, the Plant II Special Hazards Committee, and a Radiation Monitoring Group, and to secure the consultant services of several prominent physicists experienced in this field. The Special Hazards Section of the Uranium Control and Inspection Department (Vol. 5, Par. 9-3) was activated on 2 December 1946. Its function was to devote full time to, and coördinate, all critical hazards work at K-25 with the exception of certain experimental work.

PRODUCTION

2-1. <u>General.</u> - This section presents a discussion of the uranium flow to and from the gaseous diffusion plant from the time of initial operation to 31 December 1946. The following paragraphs are intended to serve as a guide for previous plans of operation, and to reflect the major productivity characteristics of the plant. In this connection, the discussions are to be supplemented by reference to the corresponding curves and table presented in Item 5. (Paragraph numbers in this section correspond to graph titles in Item No. 5.) All concentrations named are expressed on the basis of per cent by weight of U-235 in the total uranium metal present.

2-2. <u>Normal Feed to K-25 and K-27 Plants.</u> - The uranium hexafluoride normal feed to the gaseous diffusion cascade, procured from the Harshaw Chemical Company through the Madison Square Area of the Manhattan District, has the universally accepted isotopic concentration of 0.705 weight per cent. This value, for natural occurring uranium ores, was used to calculate the U-235 input to the cascade (Item 3). The quantities of normal material, (U-235 basis) fed to the K-25 and K-27 plants are shown in the graph of Item No. 5, Page 1.

2-3. <u>S-50 Material Fed to K-25 and K-27 Plants.</u> - Early in 1945, it was decided by the Manhattan District that the product of the S-50 Liquid Thermal Diffusion Project, averaging 0.85 per cent U-235, could best be utilised by feeding it to K-25. In September 1945, after the end of the war, the District Production Control Section authorised the termination of S-50 operations, since a study of productivity calculations prepared by the Carbide and Carbon Chemicals Corporation showed that, under various plans of joint operation of the S-50 and K-25 plants, it was no longer desirable, from the point of view of cost economy, to continue operation of S-50 (Book VI). The plant was shut down, and all of the process inventory, of average isotopic concentration 0.703 per cent, and all of the S-50 waste, of average concentration 0.66 per cent, were shipped to K-25. The net kilograms (kg) of U-235 in the S-50 material, over the various concentration ranges as fed to the K-25 plant, are shown on Page 2 of Item No. 5.

2-4. <u>Y-12 Oxide Fed to K-25 and K-27 Plants.</u> - As the Y-12 electromagnetic separation plant (Book V) received product of increasing isotopic concentration from the gaseous diffusion plant, some of the Y-12 inventory of lower isotopic concentration was returned to K-25. Material, in the form of oxide, was returned to K-25 in three concentration ranges: 7.8 per cent, 12.5 per cent, and 23 per cent. The 7.8 per cent and the 12.5 per cent oxide received at K-25 were converted to the hexafluoride, and fed to the plant as shown in Item No. 5, Page 3. The 23 per cent material was returned to K-25 for the purpose of performing special hazards experiments at Clinton Laboratories, X-10 (Book IV), under conditions relevant to the K-25 plant (Item No. 1). The uranium was returned from X-10 to K-25 for subsequent uranium recovery, conversion to UF_6, and feeding to the K-25 cascade.

2-5. <u>K-25 Waste Fed to K-25 and K-27 Plants.</u> - Approval was given by the District to use depleted material, of approximately 0.55 per cent isotopic concentration, as feed to the cascade of cascades, because it increased production without increase in feed material cost, and it provided a stockpile of waste material of approximately the same concentration as the K-25-K-27 waste. A graph showing the K-25 waste, as U-235, fed to the K-25-K-27 plant is shown in Item No. 5, Page 4. No depleted material was fed to the cascade during the month of December 1946; this was a period for determining the productivity of the K-25-K-27 cascade at the 95 per cent product purity level. Based on the results of this test period, the decision was made in the latter part of December to operate the gaseous diffusion plant at 94 per cent product concentration.

2-6. <u>Per Cent U-235 in Product and Waste.</u> - The graph in Item No. 6, Page 5, shows the percentage of U-235 in the product and waste from the plant. The product concentration increased steadily from 1.1 per cent to 23 per cent as more cells became available for separation. The purpose of this increase was to allow K-25 product to be fed directly to the Y-12 Beta tracks, thereby increasing the Manhattan Project overall production rate. The product concentration was subsequently increased to approximately 30 per cent isotopic concentration, the maximum concentration that could be used by Y-12. The product concentration was later raised to the 60 per cent level in order to obtain operating data at high top concentrations, and ultimately increased to the present isotopic concentration of 94 per cent, which is isotopically suitable for shipment to Los Alamos (Book VIII). The top product of the gaseous diffusion plant is currently shipped to Y-12 for further chemical processing only.

2-7. <u>Waste Produced by Cascade.</u> - The waste (depleted material) withdrawn during original separate operation of the K-25 cascade, of average assay 0.65 per cent, was stored at the site, and is now being fed back to the cascade as discussed above. The waste from the cascade of cascades, of approximate assay 0.48 per cent, is being stored at the site in steel drums. Plans have been made to store this material for an indefinite period of time. A graph showing the waste produced during diffusion plant operation is shown in Item No. 5, Page 6.

2-8. <u>Uranium-235 Produced.</u> - A cumulative curve showing the U-235 produced over the various concentration ranges is shown in Item No. 5, Page 7. Since the production capacity of a gaseous diffusion plant decreases as the concentration of the top product is increased, the slope of the curve of cumulative production vs. time would be expected to decrease for higher concentrations. In actual operations, the slope of the curve has remained approximately constant for all ranges of concentration, as a result of the steadily increasing efficiency of plant operations. In raising the product purity from one concentration to a higher level, most of the plans of operation called for a period of total reflux (i.e., no product withdrawal). These periods show on the curve as intervals of horizontal slope. There was only one day of total reflux between the 7 per cent and 10 per cent product concentration periods. Because of the scale used in Item No. 5, Page 7, this period of zero production cannot be seen on the graph. The period labeled 25 per cent refers to material withdrawn from the cascade over the range of concentrations from 22 through 26.8 per cent, while 30 per cent material designates a range from 26.8 through 30 per cent. Since the increase in concentration was gradual from 25 per cent to 30 per cent, a total reflux period was not necessary. Some of the product from the gaseous diffusion cascade was stored and later fed back to the plant during various total reflux periods, in order to raise the concentration from one level to the next higher level. Theoretical calculations showed

	Withdrawn		Re-fed		Kg	Per cent	Concentration Plan	
	From	To	From	To	Uranium	U-235	From	To
First Recycle	20 May 1945	5 June 1945	5 June 1945	9 June 1945	105.0	2.7	1.1 -	7.0
Second Recycle	11 June 1945	30 June 1945	4 July 1945	8 July 1945	92.7	7.14	- -	-
Third Recycle	3 July 1945	1 August 1945	1 August 1945	5 August 1945	250.08	10.	10.	33.
Fourth Recycle	25 May 1946	20 June 1946	12 July 1946	12 July 1946	156.42	30.	20.	6[illegible].
Fifth Recycle	20 July 1946	31 October 1946	4 November 1946	4 November 1946	308.05	80.	[illegible].	[illegible].

that withdrawing a pre-determined amount of U-235, and then feeding it back to the cascade, decreased the required time for zero product withdrawal. The total reflux time then was primarily used to redistribute the U-235 inventory in the cascade so as to obtain the necessary concentration gradient (see below). The tabulation on the opposite page summarizes the past periods of recycle operation. The change from 7 to 10 per cent product concentration was effected without the use of recycle feed during the period of concentration increase. However, the second recycle feed was used shortly thereafter, in order to increase production rate and cascade inventory. The 30 per cent Special Hazards material was withdrawn from the cascade, shipped to Y-12, converted to oxide, and returned to K-25 for subsequent use in critical mass experiments as discussed in Item No. 1.

2-8. <u>U-235 Concentration Gradient in the Enriching Cascade.</u> - In drawing the gradient for the K-25-K-27 combined enriching cascades in Item No. 5, Page 6, the vertical scale was chosen, on the basis of the separation theory, to straighten the curves over the whole range of concentrations covered. Any enriching cascade at zero product rate, or a cascade tapered ideally for a specific product rate, providing that such plants operate at constant barrier conditions throughout, would be represented by a straight line on this graph; the slope of the line would be a measure of the barrier performance and equipment size, and the height would be a measure of the terminal concentrations. On the basis of theoretical calculations, and in order to obtain maximum production, the K-25 cascade feed point was lowered, when 90 per cent production was begun, thereby increasing the size of the enriching cascade.

This is shown on the graph through the use of a different horizontal scale for the 95 per cent curve.

2-10. Cascade Inventory. - During the war year of 1945, the cascade inventory was increased from one concentration to the next higher concentration to produce U-235 in appreciable quantities for shipment to the Y-12 electromagnetic separation plant. Operation of K-25 under optimum conditions was never reached during this period, the primary objective was the combined production of the S-50, K-25, and Y-12 plants, and K-25 operation under optimum conditions had to be sacrificed to meet this requirement. As material, other than normal, became available, it was fed to the cascade to increase either product concentration, production rate, or cascade inventory. In 1946, at 80 per cent and 60 per cent production, the plants operated at optimum inventory requirements. At the present product concentration of approximately 94 per cent, the total U-235 inventory for the entire K-25-K-27 cascade under optimum conditions would be 660 kilograms. Up to 31 December 1946, the optimum inventory for 94 per cent has not yet been accumulated. When the value of 660 kg U-235 for the present K-25-K-27 cascade is reached, the production at the current product concentration will be at a maximum. The optimum U-235 inventory requirement increases rapidly with product concentration, although the total uranium inventory decreases (since lower process pressures are required). However, production rate at a fixed product concentration does not vary very rapidly with the U-235 inventory, when the inventory is near optimum. Prior to 11 June 1945, a method for calculating the cascade inventory was not established; it was not until the plant was producing material at 7 per cent concentration that a suitable inventory calculation was performed.

2-11. <u>Gaseous Diffusion Plant Schedule of Operation and Actual Shipments.</u> - The table presented in Item No. 5, Page 10 ff, compares the product shipment commitment, as approved by the District Engineer, with actual shipments to Y-12 of enriched uranium hexafluoride. It will be observed that some of the earlier proposed plans were not rigidly fixed as to rates or concentrations. This is a reflection of the efforts made during the early periods of operation to obtain maximum production of U-235 from the combined operation of plants whose operation had never previously been tested, and which, therefore, were going through a period of rapid development. The continuous increase in knowledge of operation, together with the construction of additional operating facilities, required that many of the plans be changed before they were completely carried out. (It may be noted here that the production plans have been designated by consecutive numbers solely for tabulation and reference purposes. The plans, as approved by the District Engineer, were never referred to by any particular plan number.)

Colonel K. D. Nichols, District Engineer, in a letter dated 10 March 1945 to Dr. G. T. Felbeck, Vice-President of the Carbide and Carbon Chemicals Corporation, summarized the results of a meeting held on 26 February 1945, to discuss combined operations involving the K-25, S-50, and Y-12 plants. The meeting was attended by representatives of Carbide, Kellex Corporation, Tennessee Eastman Corporation (operator of the Y-12 plant), and respective operations officers. The following is abstracted from this letter to establish the primary objective of combined operations, as set down by the District Engineer. This meeting planned the course of action for many of the operating plans which were to follow:

"As pointed out in the meeting referred to above, it is essential to obtain the maximum cumulative final product through a combination of K-25, S-50, and Y-12 plants.

"Pursuant to understanding reached at such meeting the present prime objective of the K-25 plant is to produce 1.1% material and 20% material for use as feed to the Y-12 plant. Representatives from K-25 stated that material from S-50, both product and waste, were suitable for use as feed to the K-25 plant. However, certain studies in this connection must be made to determine purification necessary before introducing such material to the K-25 plant ...

"Regardless of the method of operation to be used (for K-25) it was the consensus that the maximum amount of 1.1% material should be produced until the output from the lower cases were required to obtain earliest possible production dates for the 20% material. (See Plan I, approved 10 March 1945.)

"Production of the 20% material should begin at the earliest possible date. Initial requirements of material at this concentration will be somewhere in the range of 100 to 200 kilograms of uranium. The Y-12 plant would be capable of consuming the initial requirements of this material at the maximum rate of production by K-25. An accurate determination of initial requirements as well as subsequent daily requirements will be submitted to your office prior to production at this concentration.

"I would like to emphasize that the greatest increase in final production will be realized through combination of the K-25 and Y-12 plants, when 20% feed material can be made available for charge directly to the Y-12 Beta plant.

"Plant operations conditions, both in Y-12 and K-25, must be examined and detailed calculations must be made at such time that 10% or higher production can be anticipated. The feasibility of using 10%, 20%, or some intermediate concentration material as feed to the Y-12 Beta plant can then be determined. It is understood, however, that it is desirable to completely utilize all Y-12 Beta capacity at the earliest possible date."

Changes in production schemes to produce intermediate concentration material were authorized when the plans showed an increase in the District's overall product rate. This is noted in a letter to Dr. Felbeck from Colonel Nichols dated 12 May 1945:

> "Reference is made to my letter of 10 March in which the immediate objective of the K-25 plant was stated to be the production of 1.1% and 20% material for use as feed to the Y-12 plant. The letter pointed out also that the feasibility of using some intermediate concentration material as feed to the Y-12 Beta plant would be investigated as data on actual plant operations at K-25 and Y-12 become available ...
>
> "A production study made on the basis of the above schedule (Plan II, approved 12 May 1945) indicates that it is the most favorable schedule to date ...
>
> "Studies will continue as further data on actual performance of the K-25 and Y-12 plants are collected. Schemes other than the above will be authorized when they can be shown to be more favorable toward meeting our objectives."

The emphasis placed on rapid shipments of enriched material to Y-12 in the early stages of operation is noted in letter to Dr. Felbeck from Colonel Nichols dated 4 June 1945:

> "Isotopic analysis will be made by K-25 and such information will be furnished Y-12, but shipments will not be delayed pending results of such assays.
>
> "In this connection, I wish to emphasize that there must be no delay on the part of K-25 in transferring this material to Y-12 immediately upon withdrawal from the plant."

In the shipment of UF_6 of increasing isotopic concentration to Y-12, certain plans of operation called for the return of Y-12 Beta inventory material when it was replaced with some higher isotopic concentration material from K-25 (Plans III, approved 29 June 1945, and IV, approved 24 July 1945). The proposed schedule for the return of oxide material during Plan III was as follows:

1. That Y-12 return the 7 per cent Beta inventory material as it is replaced by 9 per cent K-25 shipments, and that the returning rate be 80 per cent of the shipment rate

of 9 per cent feed. 75 per cent of the difference between 80 per cent and 100 per cent of the daily rate would be shipped by 24 August 1945, and 25 per cent of that difference would remain at Y-12. The first return material in the form of pure orange oxide, UO_3, was to be received by K-25 not later than five days after initial delivery of 9 per cent material to Y-12, and would have a uranium content not less than 80 per cent. This same requirement applied for the period during which 9 per cent material was being replaced by 15 per cent material.

2. That K-25 be prepared to complete the conversion of all return material not later than 6 August.
3. At all times during the critical period, through 31 July, K-25 can guarantee uninterrupted deliveries of suitable material to Y-12.

As more information was obtained on the K-25 and Y-12 operations, the proposed schedule for the return of oxide from Y-12 was modified from the previous plan, and approved as one of the requirements for Plan IV. The material to be returned from Y-12 fell within the following conditions:

1. Return of approximately 160-180 kg of uranium at approximately 7.0 per cent purity in the form of UO_3 or U_3O_8, or a mixture thereof, at a purity of not less than 95 per cent uranium oxides, not more than 0.02 per cent nitrate radical, and having a moisture content as low as possible, and a density as high as possible. This was to be returned at a rate of not less than 15 kg of uranium per day with the final shipment by 3 August 1945.

2. Return of approximately 160 kg of uranium at approximately 10.5 per cent, meeting the above chemical specifications. This material was to be returned at a minimum rate of 4 kg per day, beginning not more than three days after delivery to Y-12 of the first 21 per cent material.

3. Start delivery to K-25 of Alpha production at a rate of 3 kg of uranium per day at approximately 11 per cent purity meeting the above chemical specifications not later than two days after delivery to Y-12 of first amount of 21 per cent material.

With respect to paragraph 3 above, it was felt that if the Y-12 Alpha I plant was producing material of purity greater than 20 per cent at the time Y-12 began to receive 20 per cent material from K-25, it would be desirable to keep this product at Y-12 for processing through the Beta tracks directly. Furthermore, it was believed possible that, with modified operation, the Alpha II product could be raised to 20 per cent purity by 24 July 1945. In this case, it would also be advisable to retain the Alpha II product for use directly in the Y-12 Beta plant.

The following table shows the different ranges of oxides received from Y-12; the 23 per cent oxide was used in the critical mass experiments at K-10, and the 30 per cent material was used in criticality experiments at K-25, (Item No. 1).

	Dates Received from Y-12	Kg Uranium	Average Concentration
First Oxide	15 July 1945 - 3 August 1945	134.80	7.8
Second Oxide	11 August 1945 - 3 June 1946	292.30	12.3
Third Oxide	4 October 1945 - 14 October 1945	41.69	23.
Fourth Oxide	15 March 1946 - 20 May 1946	170.72	30.

The 7.8 per cent, 12.3 per cent, and 23 per cent material was fed to the K-25 cascade, as shown in Item No. 5, Page 3. The 30 per cent oxide was shipped to Y-12 as UF_6 for feed to the Y-12 Beta tracks as discussed below. Although the 12.3 per cent oxide material was shipped through 5 June 1946, the major part of the oxide was shipped during August, September, and October 1945.

It will be noted that the previous discussion has been concerned with maximum production of U-235 from the combined operation of K-25 and Y-12, prior to and immediately following the dropping of the first atomic bomb on 6 August 1945. The remaining plans and discussions are concerned with subsequent peace-time operation of the combined plants.

In early 1946, approval was received from the District Engineer to withdraw material of 30 per cent isotopic concentration for special hazards criticality experiments which were to be performed at K-25, (Plan VI, approved 11 February 1946). This required that product of two different concentrations be withdrawn. One product at 28.0 per cent, was to be withdrawn as a side stream at a rate of 9.2 kg of uranium per day, and shipped to Y-12 as feed to the Beta tracks. The other product, at 30 per cent, from the top of the cascade, was to be withdrawn at a rate of 1.5 kg of uranium per day, shipped to Y-12 for conversion to an oxide, and later returned to K-25. In Plan VI, Revision IV, approved 18 April 1946, it was decided that the side withdrawal of 28 per cent would be discontinued, and that the entire production of the K-25 plant would be at 30 per cent concentration. This entire output of K-25 was shipped to Y-12, and that amount which was above the daily feed requirement of the Beta tracks was to be returned to K-25 as the oxide for the 30 per cent criticality experiments. The entire K-25 production was to be shipped to Y-12 until approximately 170 kg of uranium at 30 per cent had been returned from Y-12 as shown in the table on Page 11. After the K-25 Special Hazards Material had been accumulated, Plan VII was approved by the District Engineer on 27 May 1946, to supply Y-12 with approximately 10.2 kg of uranium at 30 per cent of feed material as make-up requirements for the Y-12 Beta tracks. The remaining portion s of the K-25 production, approximately 1.8 kg of uranium, was to be stored at K-25 as UF_6, pending decisions to raise the isotopic concentration at K-25 above 30 per cent. Because of the great economic significance involved in operating at higher concentrations, everything possible was done to complete the plan for producing 60 per cent material at the earliest possible date. As a result of experience gained during low pressure operation, after the first plan (Plan VIII, approved 7 June 1946) for 60 per cent operation was discussed, it had been found that pressures closer to optimum could be adopted. This meant that a lower U-235 inventory would be required for producing 60 per cent material, and accordingly would decrease the stockpile and the time required to start production at 60 per cent concentration. The excellent performance of the cascade for the month of June, together with the reduction in stockpile requirement, made it possible to revise the steps in the schedule so that the completion date of the plan would be on or before 6 August 1946 (Plan VIII, Revision I, approved 16 July 1946).

Since the electromagnetic plant was unable to handle uranium material of an isotopic concentration greater than 30 per cent, it was required that K-25 blend normal material with the 60 per cent material to produce UF_6 of 30 per cent concentration. All 60 per cent production above the daily commitment to Y-12 was stored at K-25 as UF_6 to be used in the future plans for raising the isotopic concentration to 95 per cent. The feed material at an isotopic concentration of 0.00 per cent was the Y-12 Alpha inventory material, which was converted to UF_6 at an off-area site.

After sufficient data were accumulated to establish the productivity of the K-25-K-27 cascade at higher concentrations, the District Engineer approved the plan for increasing the concentration to 95 per cent (Plan IX, approved 19 October 1946). Effective 2 December 1946, it was necessary that Y-12 be supplied with their daily requirement of 30 per cent material. To avoid withdrawing side stream material at 30 per cent, and thereby disrupting the test performance at 95 per cent, it became necessary to convert the 30 per cent special hazards material to UF_6 at K-25, and to ship this to Y-12 for feed to the Beta tracks. During the total reflux period, which started 6 November 1946, it was discovered that because of the presence of an increased amount of U-234, approximately 2 per cent, at the top of the cascade, the plant was experiencing difficulty in raising the concentration of U-235 to 95 per cent, and was requiring a longer period of total reflux. It then became apparent that the U-234 content at the top of the cascade would have to be reduced in order to reach a U-235 concentration of 95 per cent within a reasonable period. To do this, it was decided to withdraw top product at a definite rate regardless of the effect on the U-235 concentration. It was predicted that the top concentration would fall approximately 1 per cent, but would gradually rise as the U-234 concentration decreased.

This situation made it necessary to extend the limited amount of special hazards material shipped to Y-12 over a longer period of time. (Plan IX, Revisions I, II, III, and IV.)

Since the oxide and recycle feeds have been tabulated above, they are not included in the table on Page 10 of Item 5.

In an early plan of operation (Plan II, approved 12 May 1945) no mention was made of stockpiling any of the production material for increasing concentration from 1 per cent to 7 per cent, and therefore it was not shown in the approved plan. However, the amount of recycle feed withdrawn is noted in the table of Item No. 2, Page 5. In later plans (Plan II, Revision II, 23 June 1945, and Plan IV, 24 July 1945) a schedule was approved for the stockpiling of material to be used in subsequent plans of operation, but, because of the method of keeping inventories in the early period of operation, no separate records were kept of the stockpile, i.e., all the material withdrawn from the cascade was kept in one storage account. The Y-12 material was shipped from this account, and the remainder was considered stockpile. Therefore, it was necessary to report the withdrawal period as the entire period of operation at 7 per cent and 10 per cent (see table in Item No. 2, Page 5).

The various approved feed rates are shown in the table only on the dates they became effective. The feed rates in each case continue until a change in date is noted in the table.

Further discussion of the correlation and coordination of K-25 and Y-12 production schedules is contained in Top Secret Supplement No. 1.

MATERIAL BALANCE

3-1. Uranium Balance. - The following table shows the final material balance on uranium from the beginning of operations through 31 December 1946. The excellent agreement between the input and output is purely coincidental, since the greatest accuracy that can be claimed for certain of the quantities and analyses is plus or minus 2 per cent on the overall balance.

Input	Kilograms Uranium	Output	Kilograms Uranium
Receipts	986,349.63	Shipments	21,226.39
		Product in Storage	2.48
		Stored as Feed:	
		Enriched	[illegible]2,719.21
		Normal	37,704.24
		Depleted	889,836.39
		In Process	16,907.38
		Laboratories and Development	1,703.16
		Recovery Operations	196.09
		Waste and Scrap	10,452.89
		Known Loss	183.72
Total Input	986,349.63	Total Output	981,081.91

3-2. U-235 Balance. - The following table gives the final material balance on Uranium-235 from the beginning of operations through 31 December 1946. Again, the agreement between input and output is coincidental.

[redacted] SECRET

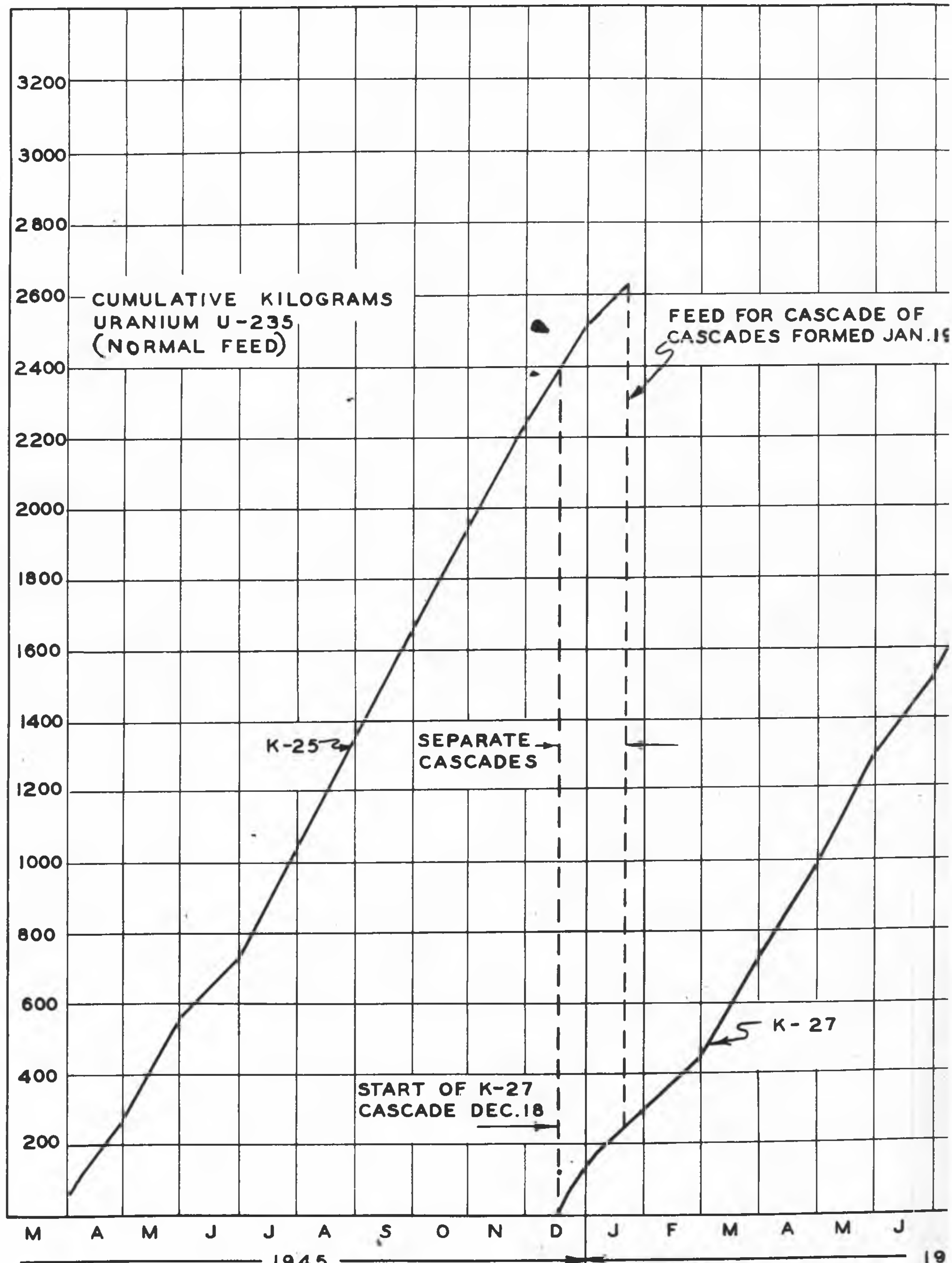
Input		Output	
	Kilograms U-235		Kilograms U-235
Receipts	7,187.49	Shipments	1,540.29
		Product in Storage	2.30
		Stored as Feed:	
		Enriched	83.61
		Normal	266.28
		Depleted	4,445.44
		In Process	611.98
		Laboratory and Development	14.94
		Recovery Operations	3.09
		Waste and Scrap	73.04
		Known Loss	1.30
Total Input	7,187.49	Total Output	7,042.27

3-3. Consumption. - The unknown loss figure (difference between input and output) includes the "consumption " of process material, which is defined as the continuous depositing of uranium material on all surfaces in the process area exposed to process gas. The amount deposited on any unit area is small; approximately 16,300,000 square feet of surface area are exposed to UF_6. The consumption of process material from the beginning of operations through 31 December 1946 has been estimated at 5,455 kilograms of uranium, or 147 kilograms of Uranium-235. Although these figures check closely with the unknown losses of 5,257.72 kilograms of uranium and 145.22 kilograms of Uranium-235, it should be noted that these consumption data are based upon extrapolations and assumptions; precision is plus or minus 40 per cent. The problem of accurate determination of plant consumption is being attacked actively by the Consumption Section of the Uranium Control and Inspection Department (Vol. 5, Par. 9-3).

UNIT COST

4-1. <u>Unit Cost of Product at 94 Per Cent Isotopic Concentration.</u> - Since the Carbide and Carbon Chemicals Corporation monthly operating cost fluctuates over a wide range (Vol. 5, Par. 11-2), and production of 94 per cent material has been carried out during the month of December 1946, only, unit cost has been calculated on the basis of an estimated monthly cost for the six-month period from 1 January 1947 through 30 June 1947. An average figure of $3,361,079 per month, or $108,422 per day is estimated in a Top Secret report dated 31 December 1946, subject "Production Cost Data, P-25 and P-49", from Lt. Colonel R. W. Cook to Mr. W. J. Williams. This figure includes the cost of normal feed, coded chemicals, Government furnished material (helium, telephone, railroad, Government bills of lading, Government purchased material, Government transfers, nitrogen, and T.V.A. electrical power) and direct costs of the operating contractor. It does not include indirect costs (such as operation of the Townsite, or Government overhead), capital cost amortization, or interest on land. Approximately 2.50 kilograms of U-235 at 94 per cent concentration were produced per day during the month of December (Item 5, Page 7). Therefore, the operating cost of producing U-235 at an isotopic concentration of 94 per cent is estimated at approximately $43,369 per kilogram.

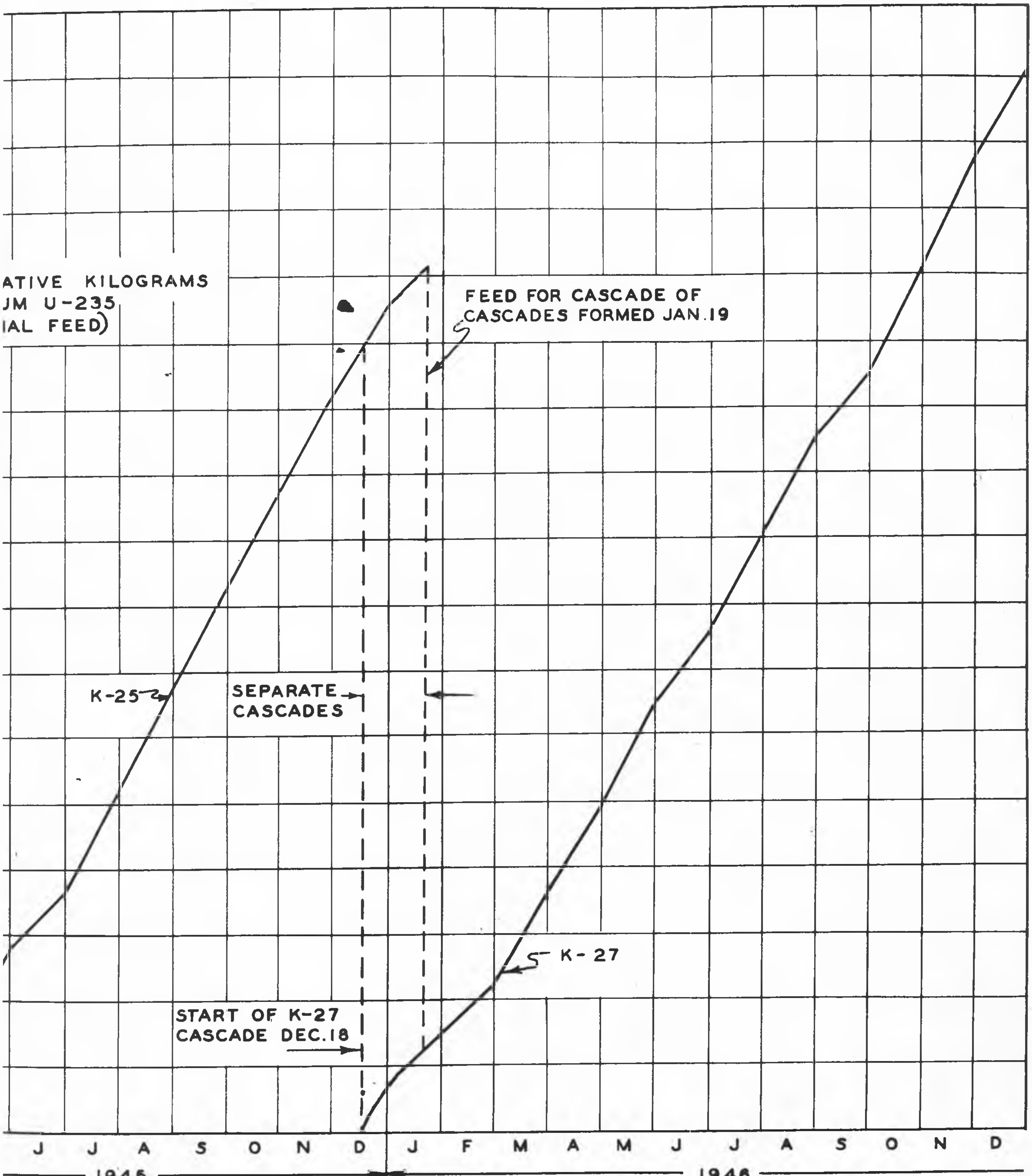
NORMAL FEED TO K-25 AND K-27 PL



[redacted] SECRET

52

NORMAL FEED TO K-25 AND K-27 PLANTS



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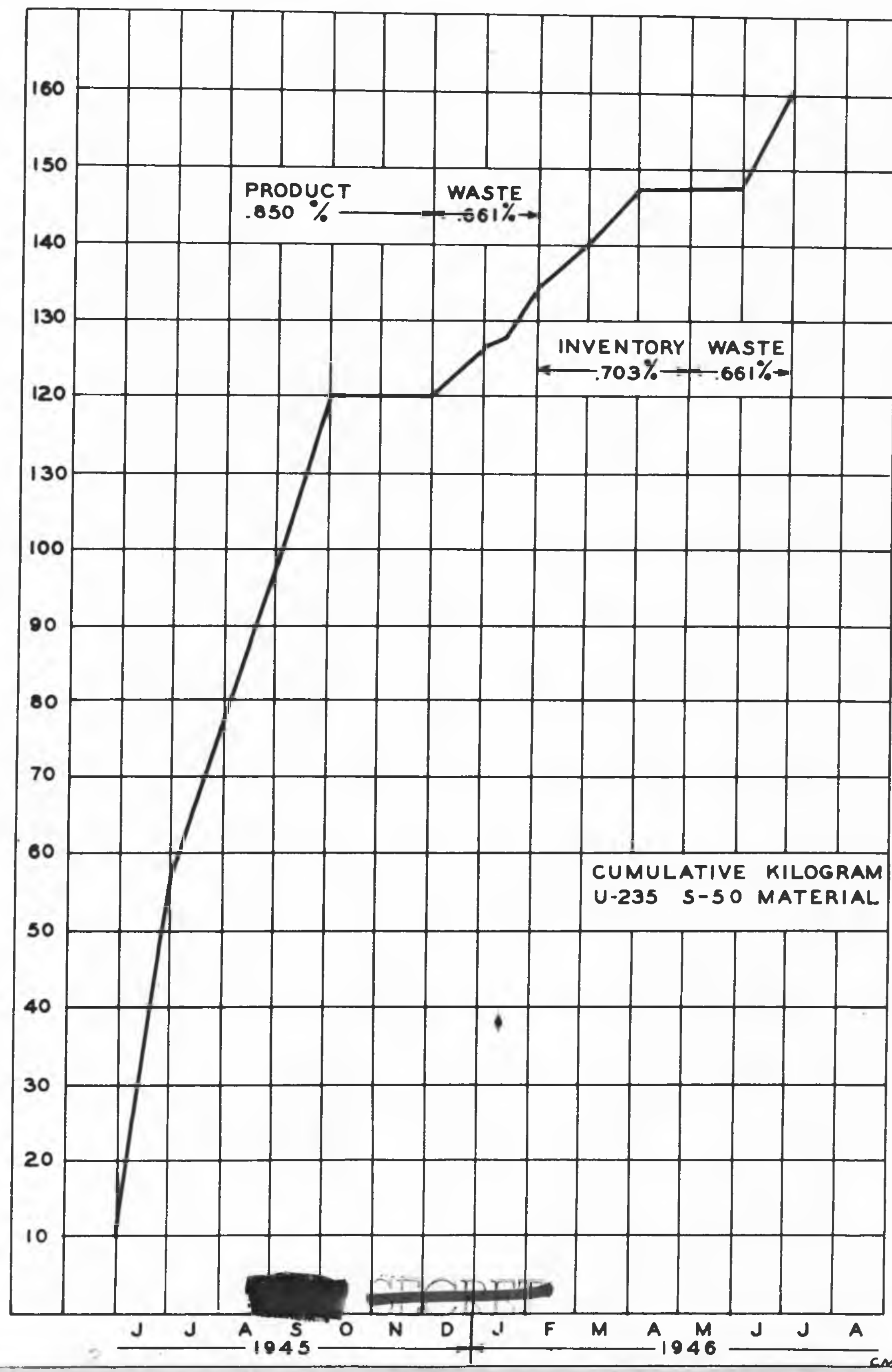
No. 5

[redacted] SECRET

S-50 MATERIAL FED TO K-25 AND K-27 PLANTS



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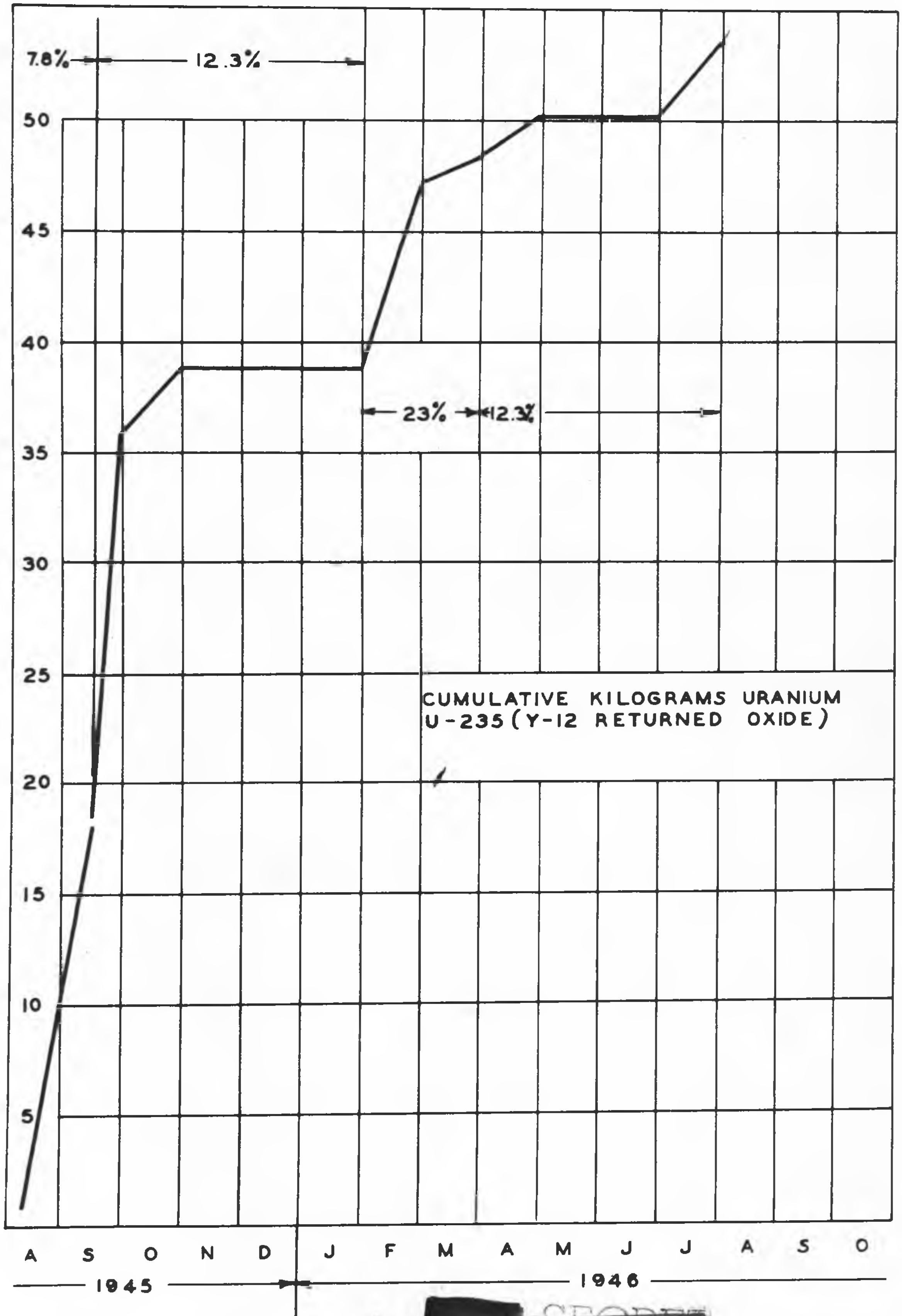
CMD

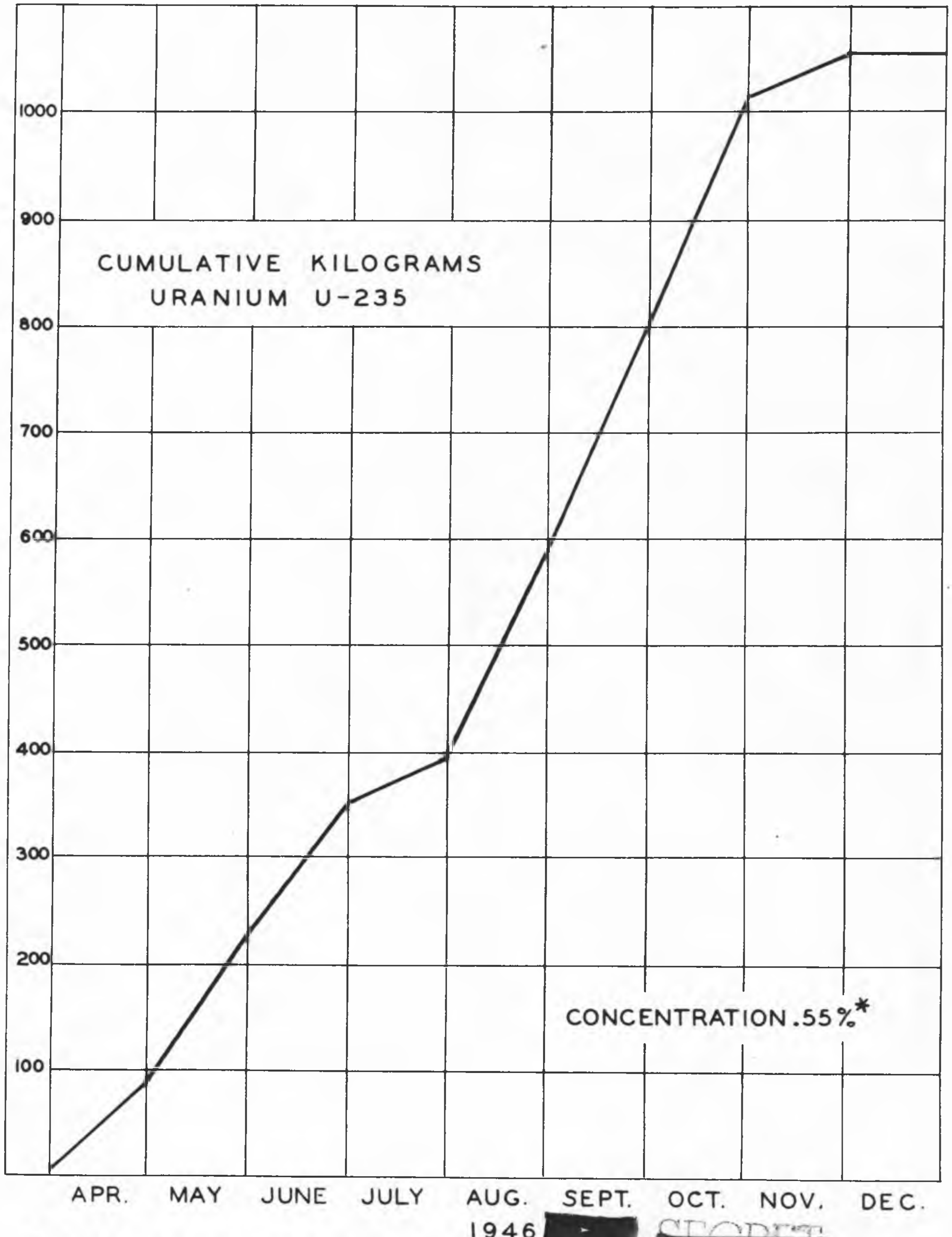
Y-12 OXIDE FED TO K-25 AND K-27 PLANTS



CMD

[redacted] SECRET

K-25 WASTE FED TO K-25 AND K-27 PLANTS



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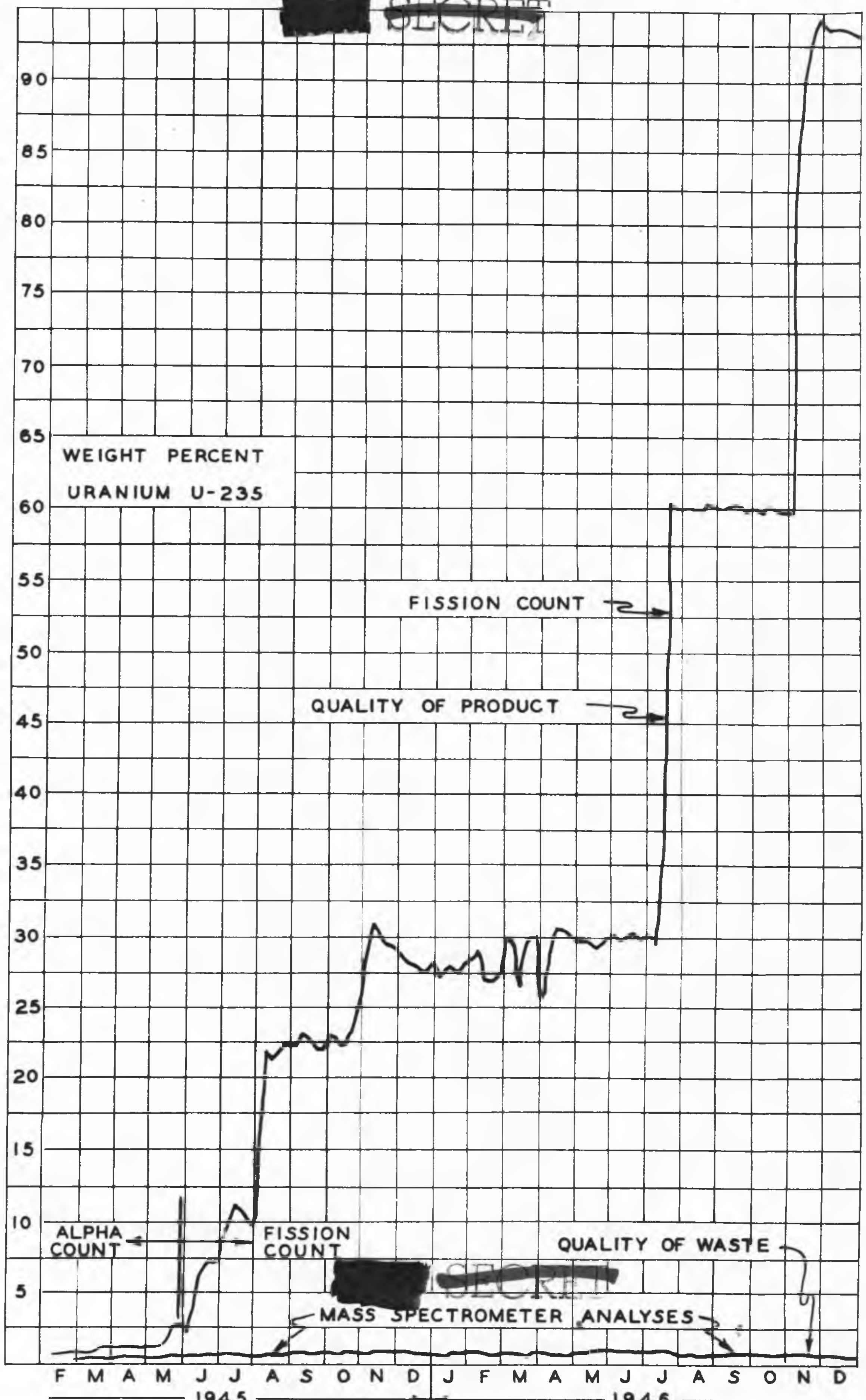
*NOTE: THIS PARTIALLY DEPLETED MATERIAL WAS WITHDRAWN AS WASTE FROM K-25 BEFORE COMBINED OPERATIONS.

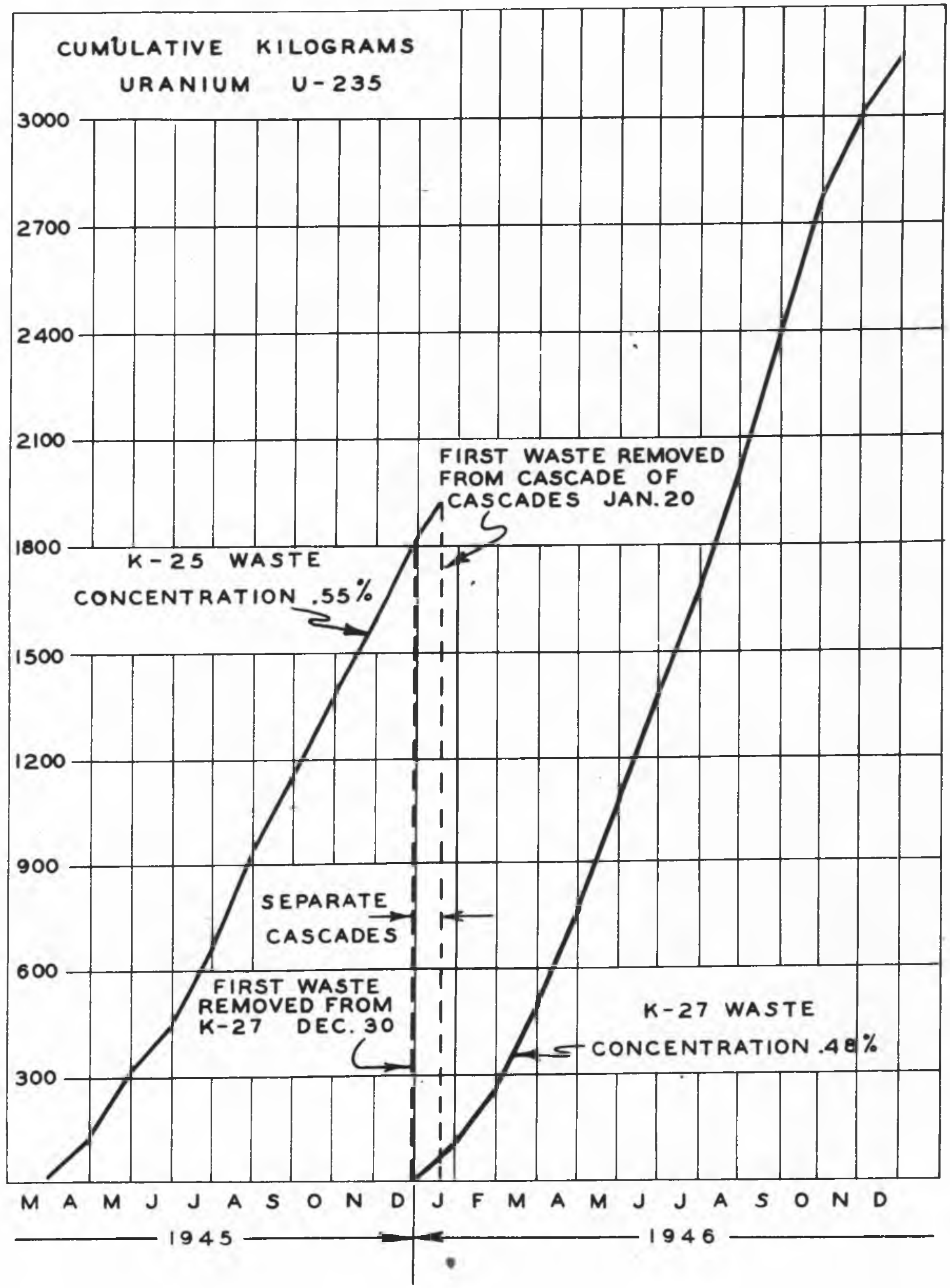
CMO

PERCENT U-235 IN PRODUCT AND WASTE



CMC

WASTE PRODUCED BY CASCADE



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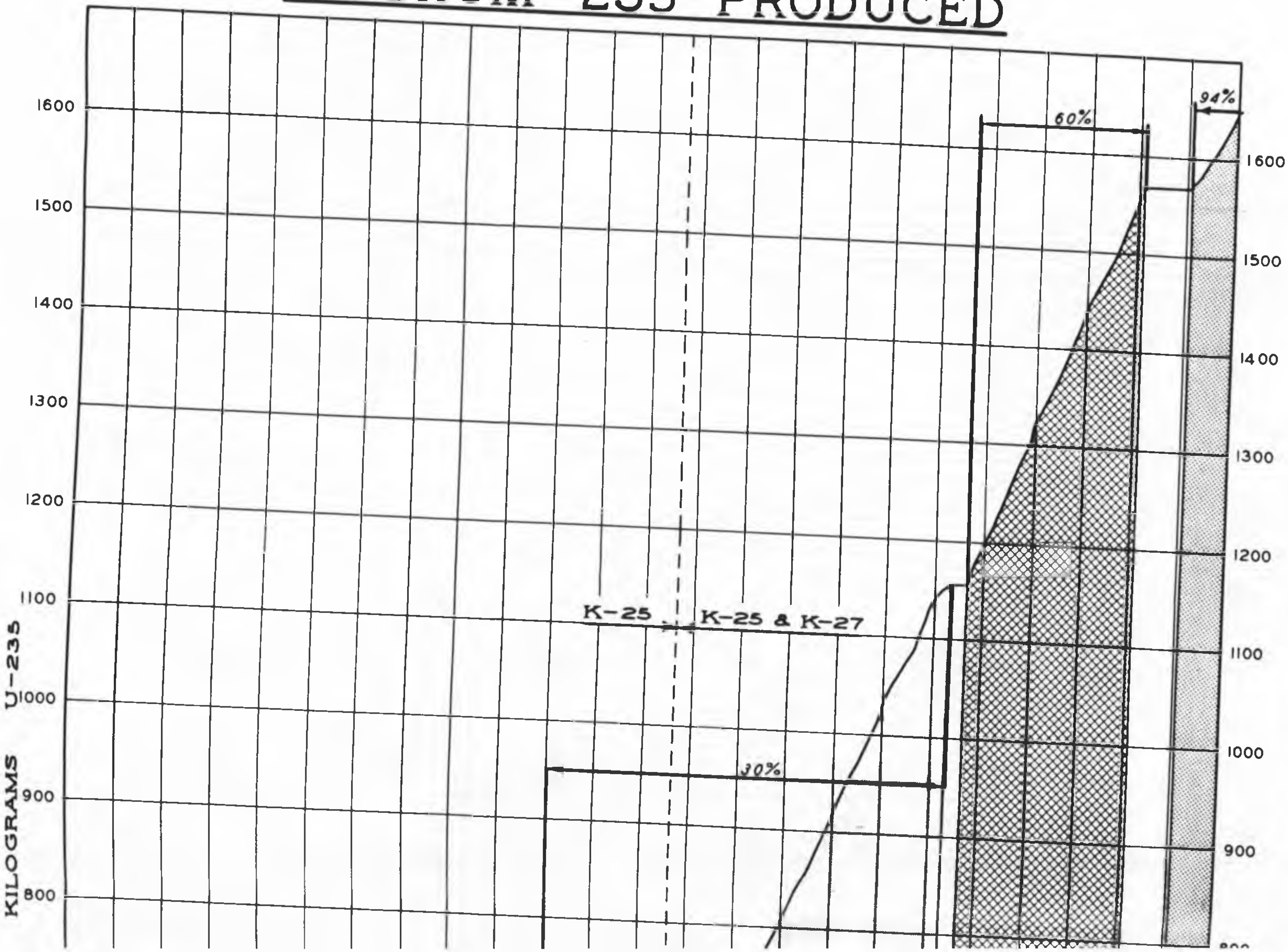
SECRET

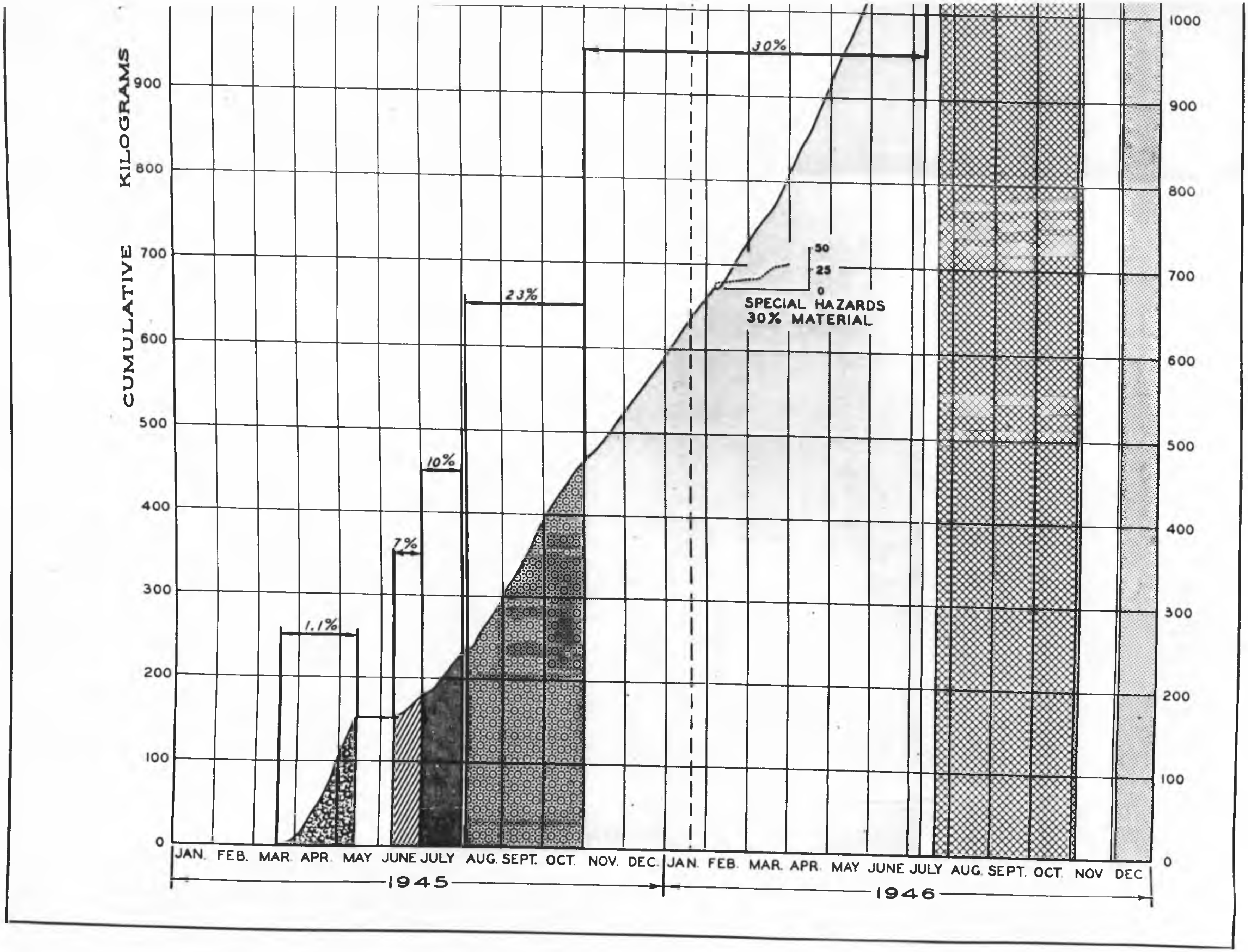
URANIUM 235 PRODUCED



[redacted]
SECRET

17-2

17-1

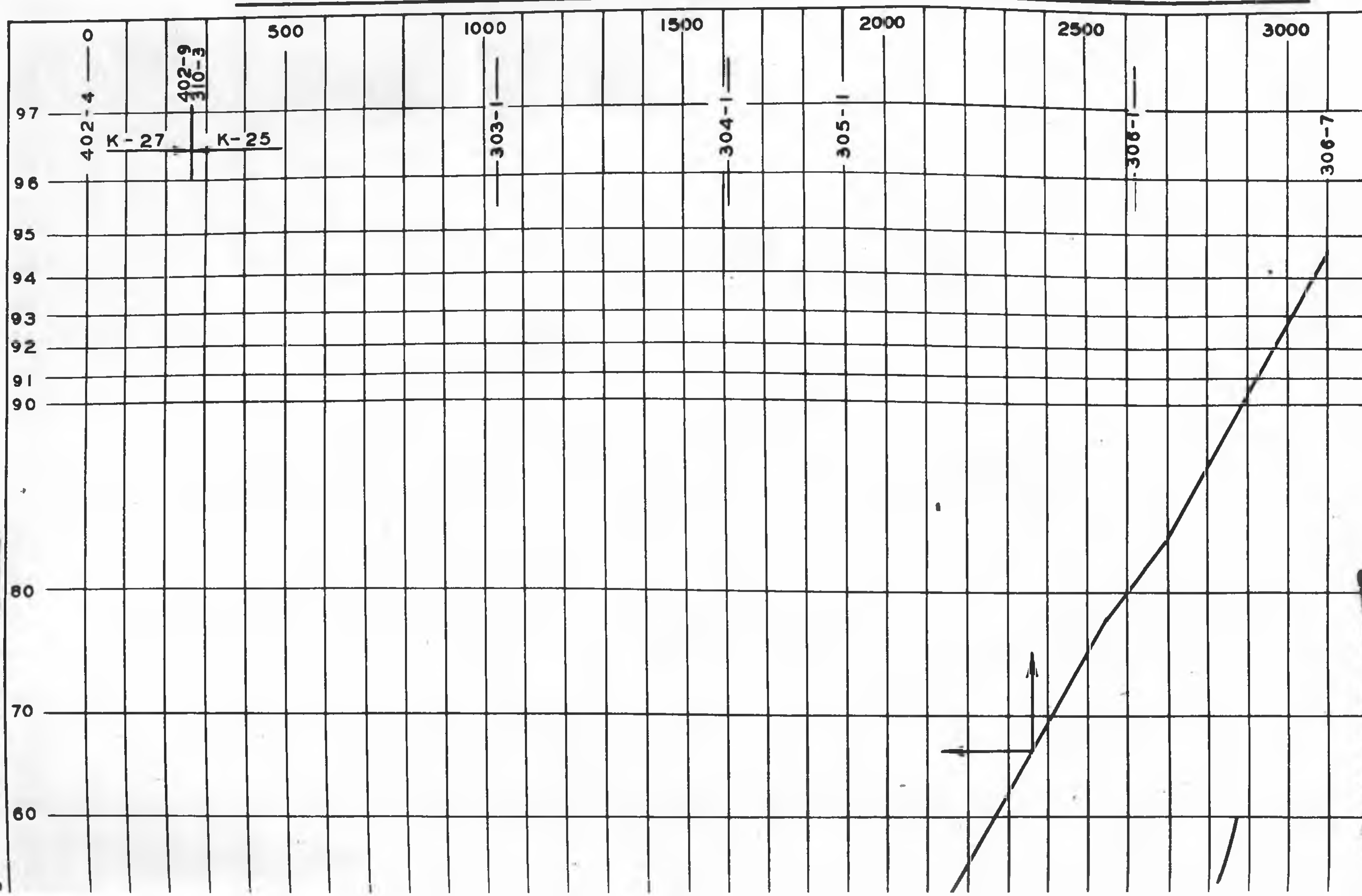


CUMULATIVE KILOGRAMS
0
100
200
300
400
500
600
700
800
900
1000
1.1%
7%
10%
23%
30%
50
25
0
SPECIAL HAZARDS
30% MATERIAL
JAN. FEB. MAR. APR. MAY JUNE JULY AUG. SEPT. OCT. NOV. DEC.
1945
JAN. FEB. MAR. APR. MAY JUNE JULY AUG. SEPT. OCT. NOV DEC
1946

17-1

~~TOP SECRET~~

U-235 CONCENTRATION GRADIENT IN THE ENRICHING CASCADE



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SECRET

[redacted]

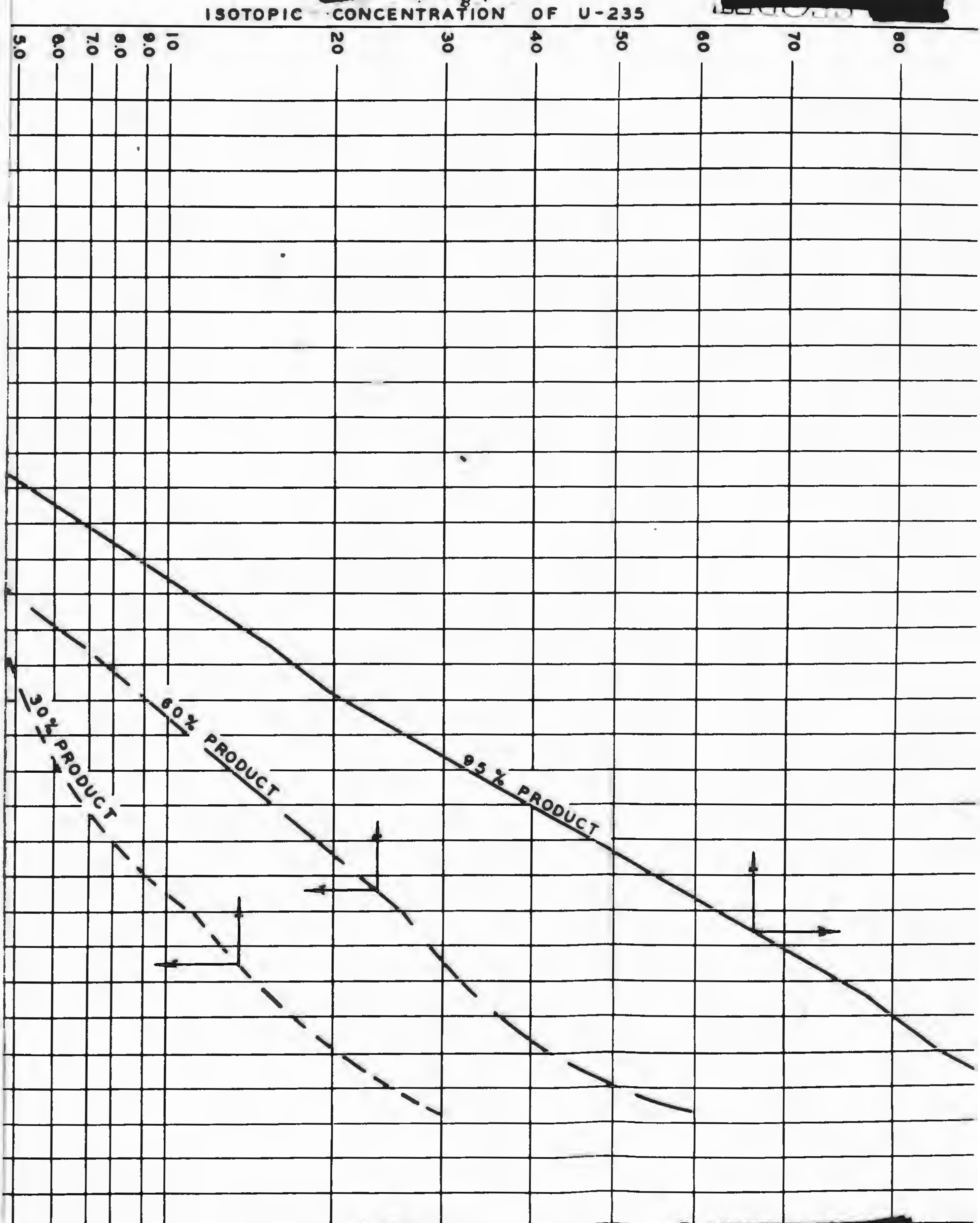
SECRET

1-8

5

[redacted]

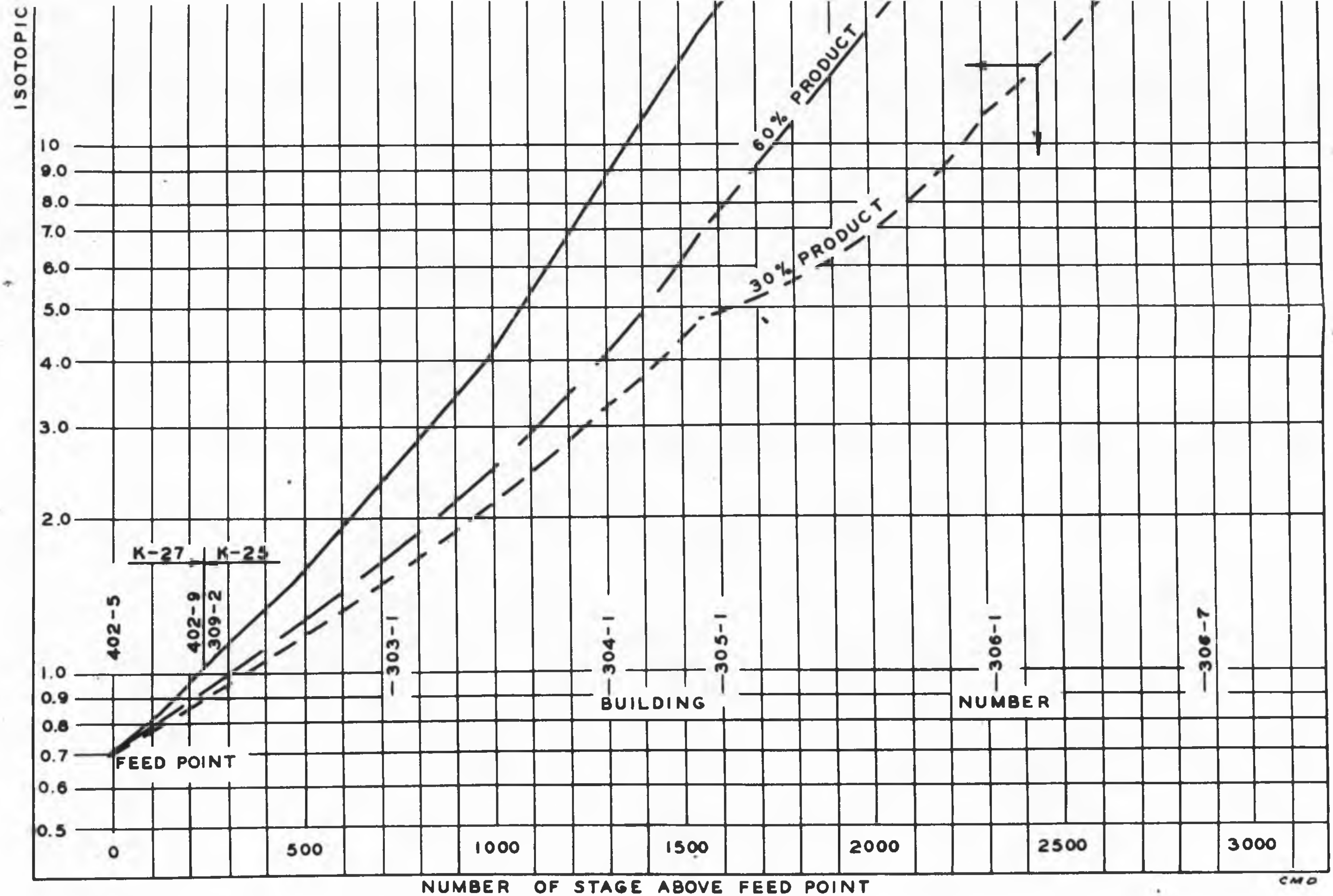
[redacted]



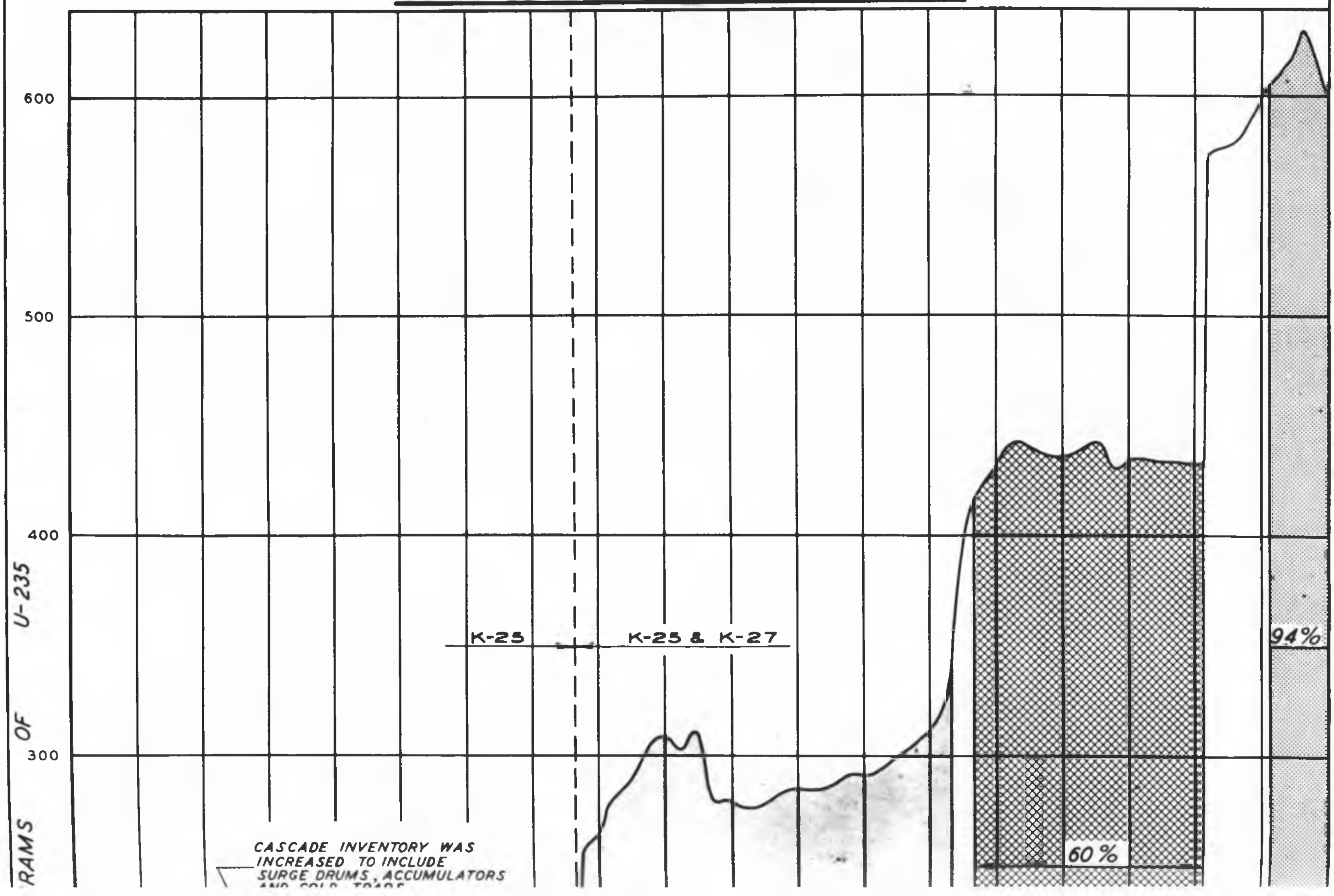
[redacted]

[redacted]

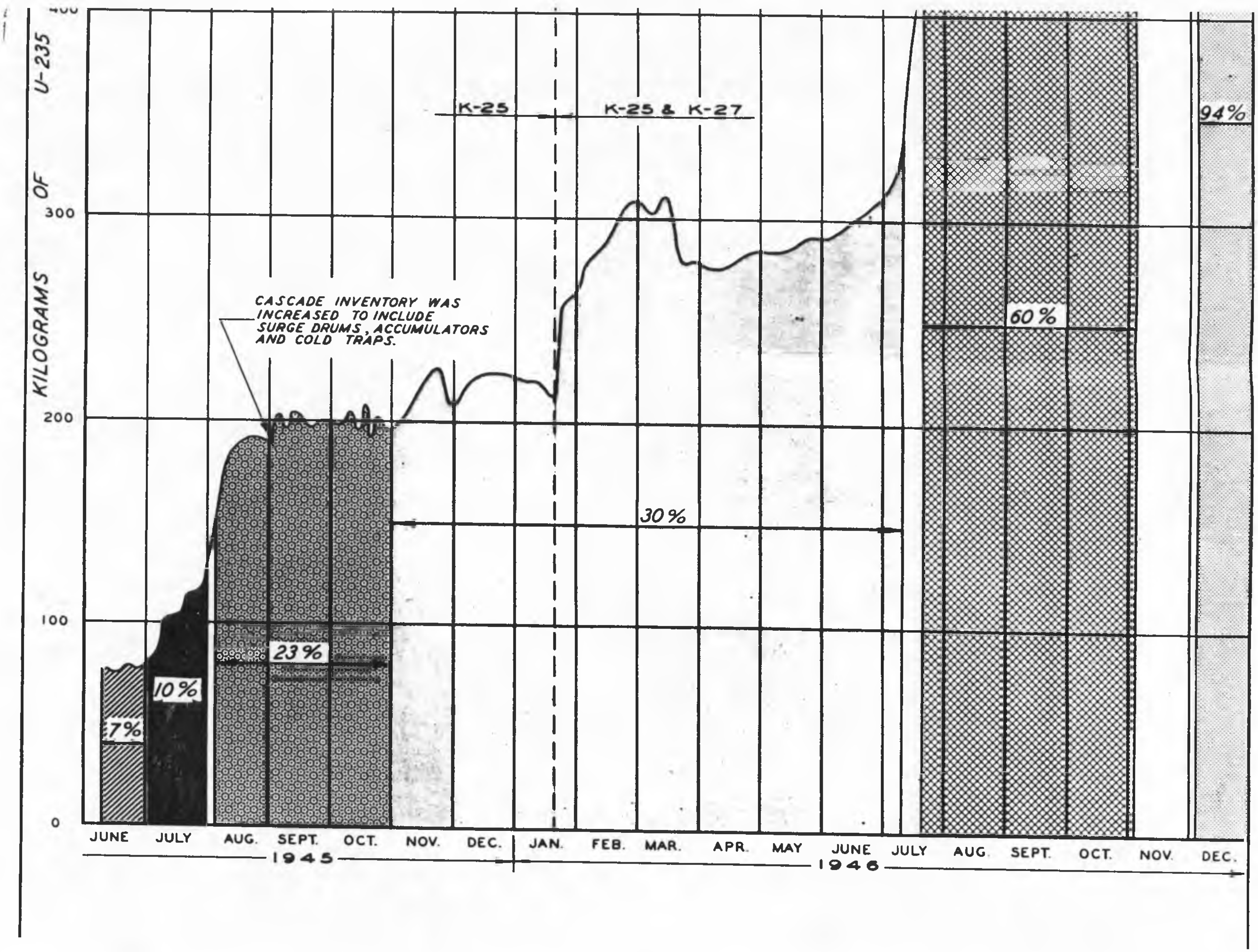
C-8


ISOTOPIC
10
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.9
0.8
0.7
0.6
0.5
60% PRODUCT
30% PRODUCT
K-27
K-25
402-5
402-9
309-2
303-1
304-1
305-1
306-1
306-7
BUILDING
NUMBER
FEED POINT
0
500
1000
1500
2000
2500
3000
NUMBER OF STAGE ABOVE FEED POINT
CMD

CASCADE INVENTORY



[redacted]


KILOGRAMS OF U-235
0
100
200
300
400
CASCADE INVENTORY WAS INCREASED TO INCLUDE SURGE DRUMS, ACCUMULATORS AND COLD TRAPS.
K-25
K-25 & K-27
7%
10%
23%
30%
60%
94%
JUNE
JULY
AUG.
SEPT.
OCT.
NOV.
DEC.
JAN.
FEB.
MAR.
APR.
MAY
JUNE
JULY
AUG.
SEPT.
OCT.
NOV.
DEC.
1945
1946

9-2

APPROVED SCHEDULE OF OPERATION

PRODUCTION PLAN DATE OF APPROVAL	DATE START	DATE END	KG URANIUM TO BE PRODUCED PER DAY	CONCEN[TRATION] WEIGHT[...]
I	1 April	17 May	280	1.
10 March 1945	18 May	Until 30,000 kg Uranium is produced	430	1.
II	12 May	9 June	No shipment	-
12 May 1945	10 June	15 June	27.0	7.
	16 June	4 August	3.7	7 ris[...]
	5 August	29 August	3.7	14 ris[...]
	30 August	31 December	3.7	20 ris[...]
II (Rev. I) 4 June 1945	10 June	Date Y-12 requires only make-up	11	7.
	Date Y-12 requires only make-up	No date specified	3.7	Highest[...] tratio[n]
II (Rev. II)	23 June	30 June	3.7	7.
23 June 1945	24 June	30 June	Difference between maximum production and 3.7 stored at K-25 1/	7.
	1 July	31 July	3.7	Highest[...] tratio[n]
III	28 June	2 July	3.7	7
29 June 1945	3 July	24 July	10	9
	25 July	12 August	3.7	9
	13 August	3 September	10	15
	4 September	No date specified	3.7	Not le[ss] 15

GASEOUS DIFFUSION PLANT SCHEDULE OF OPERATION

…E …AY	CONCENTRATION RANGE WEIGHT PER CENT	KG U-235 TO BE PRODUCED PER DAY	DAILY NORMAL FEED RATE - KG URANIUM	MISCELLANEOUS DAILY FEED RATE KG URANIUM - WEIGHT PER C…
	1.1	3.08	659	S-50 Material:
	1.1	4.73		75 - 90 to maximum 140 0.90 375 - 400 to maximum 700 0.67
	-	-	Start 1 June	On 24 May it was decided that S-50 product should be fed to the cascade in an amount comparable to the production of the S-50 plant. Schedule of S-50 Production:
	7.0	1.89	1226	
	7 rise to 14	0.26 rise to 0.52		
	14 rise to 20	0.52 rise to 0.76		
	20 rise to 30	0.76 rise to 1.11		
				May 2283 0.85 June 1340 0.85 July 2062 0.85
	7.0	0.77		
	Highest concentration obtainable	-		
	7.0	0.259		
…ncen …tion … at	7.0			
	Highest concentration obtainable			
	7	0.259	Start 1 September	
	9	0.9	1533	
	9	0.333		
	15	1.50		
	Not less than 15	Not less than 0.555		

SECRET

10-3

E OF OPERATION AND ACTUAL SHIPMENTS

CUS RATE - WEIGHT PER CENT	ACTUAL SHIPMENTS TO Y-12 DATE START	DATE END	AVERAGE KG URANIUM SHIPPED PER DAY	CONCENTRATION RANGE WEIGHT PER CENT	AVERA SHIPP
ial: 0.90 0 to 0.67 0	31 March	24 May	253.00	1.10	
it was decided product should the cascade in comparable to tion of the . Schedule of ctions: 0.85 0.85 0.85	25 May	10 June	No shipment	-	
	11 June	22 June	16.85	7.04	

23 June	30 June	5.40	7.06
1 July	-	No shipments	-
2 July	19 July	14.92	10.95

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…TION RANGE …R CENT	AVERAGE KG U-235 SHIPPED PER DAY	DAILY NORMAL FEED RATE - KG URANIUM	MISCELLANEOUS DAILY FEED RATE KG URANIUM - WEIGHT PER CENT
[illegible]	2.78	1242.8	9 May thru 14 May 143.9 0.85
	-	1099.5	
	1.19	64.30	8 June thru 22 June 1308.3 0.85
	0.388	808.3	23 June thru 30 June 138.68 0.85
	- 1.58	969.2 1318.0	1 July thru 9 July 148.25 0.85

APPROVED SCHEDULE OF OPERATION

PRODUCTION PLAN DATE OF APPROVAL	DATE START	DATE END	KG URANIUM TO BE PRODUCED PER DAY	CONCENTRATI[ON] WEIGHT PER
IV 24 July 1945	20 July	2 August	Total produced stored at K-25 1/	Not less t[h] 11
	3 August	9 August	3.7	Not less t[h] 11
	10 August	24 August	10	21
	25 August	24 September	10	23
	25 September	No date specified	6	Not less t 23
IV (Rev. I) 12 October 1945	12 October	1 December	7	Rise to 25
	1 December	No date specified	8.5	25-26
IV (Rev. II) 15 November 1945	15 November	30 November	7.0	29-31
	1 December	15 January	8.5	24-26
IV (Rev. III) 16 January 1946	16 January	No date specified	8.5	24-26
V 25 January 1946 1[illegible] February	24 January	5 February	8.5	Rise to 31
	6 February	12 February	No shipments	-
	13 February	4 March	6.5	34.5
	4 March	No date specified	8.5	34.5 rise
VI 11 February 1946	6 February	7 February	No shipments	-
	8 February	9 February	8	30
	10 February	15 March	(9.2 (1.5	(28 (30
	16 March	3 May	(9.2 (1.5 - 1.6	(28 (30
VI (Rev. I) 5 March 1946	1 March	3 March	11.6	26.8
	4 March	20 May	(9.2 (1.5	(26.8 (30.0
	21 May	4 June	9.2	30 rise t
	5 June	31 August	9.2	32 rise t
	1 September	31 October	9.2	34.5 rise
VI (Rev. II) 31 March 1946	19 March	20 May	(10.2 (1.5	(26.8 (30.0

CONCENTRATION RANGE WEIGHT PER CENT	KG U-235 TO BE PRODUCED PER DAY	DAILY NORMAL FEED RATE - KG URANIUM	MISCELLANEOUS DAILY FEED RATE KG URANIUM - WEIGHT PER CENT	I
Not less than: 11				1
Not less than:	Not less than:			
11	0.407			
21	2.1	Start 1 September	4 September: District authorized standby of S-50. All uranium shipped to K-25.	
23	2.3	1533		1
Not less than: 23	1.38			
Rise to 25-26	1.35 - 1.82	Start 24 October		1
25-26	2.13 - 2.21	1300		
29-31	2.03 - 2.17			1
24-26	2.04 - 2.21			
24-26	2.04 - 2.21			1
Rise to 31	Rise to 2.64			2
-	-			
34.5	2.93			
34.5 rise to 37.0	2.93 rise to 3.15			
-	-			
30	2.4 2/			
(28	(2.58			
(30	(0.45 2/			1
(28	(2.58			
(30	(0.45 - 0.48 2/			
26.8	3.11			
(26.8	(2.47			
(30.0	(0.450 2/			
30 rise to 32	2.76 rise to 2.94			
32 rise to 34.5	2.94 rise to 3.17			
34.5 rise to 35	3.17 rise to 3.23			
(26.8	(2.72		Start 19 March:	1:
(30.0	(0.45 2/		500 0.55	

ACTUAL SHIPMENTS TO Y-12

PER CENT

ict
of

DATE START	DATE END	AVERAGE KG URANIUM SHIPPED PER DAY	CONCENTRATION RANGE WEIGHT PER CENT	AVERAGE KG U-235 SHIPPED PER DAY
20 July	4 August	No shipments	-	-
5 August	23 August	10.51	22.74	2.39
24 August	11 October	12.53	23.30	2.92
12 October	14 November	7.77	25.61	1.99
15 November	30 November	7.32	29.78	2.18
1 December	15 January	8.23	28.20	2.32
16 January	23 January	7.61	27.86	2.12
24 January	6 February	7.09	28.07	1.99
7 February		No shipment	-	-
8 February		5.10	30.28	1.54 2/
9 February		No shipment	-	-
10 February	3 March	(9.3	(27.10	(2.52
		(1.34	(30.00	(0.402 2/
4 March	18 March	(9.28	(27.00	(2.51
		(2.62	(30.08	(.785 2/
19 March	29 March	(11.0	(27.00	(2.97
		(1.45	(29.93	(0.434 2/

11-4

...ION RANGE ...CENT	AVERAGE KG U-235 SHIPPED PER DAY	DAILY NORMAL FEED RATE - KG URANIUM	MISCELLANEOUS DAILY FEED RATE KG URANIUM - WEIGHT PER CENT
	-	1474.88	20 July thru 25 July 17.74 0.85
	2.39	1505.58	7 August thru 21 September 105.40 0.86
	2.32	1374.9	
	1.99	1350.1	
	2.18	1322.56	18 December thru 4 January 69.03 0.67
	2.32	1404.11	13 January thru 15 January 44.12 0.73
	2.12	1423.36	16 January thru 23 January 70.41 0.73
	1.99	1286.90	24 January thru 6 February 53.20 0.73
	-	2245.2	27 February thru 3 March 81.54 0.73
	1.54 2/	1218.7	
	-	1218.7	
	(2.52 (0.402 2/	1286.9	
	(2.51 (.786 2/	1251.5	4 March thru 8 March 81.69 0.712 6 March thru 18 March 358.00 0.56
	(2.97 (0.434 2/	1212.5	19 March thru 29 March 596.96 0.56

APPROVED SCHEDULE OF OPERATION

PRODUCTION PLAN DATE OF APPROVAL	DATE START	DATE END	KG URANIUM TO BE PRODUCED PER DAY	CONCENTRA WEIGHT PE
VI (Rev. III)	30 March	5 April	10.2	26.6
6 April 1946	4 April	15 April	10.2	27 rise t
	16 April	15 May	(10.2	(30
			(1.6	(30
VI (Rev. IV)	12 April	15 April	12.00	30
15 April 1946	16 April	15 May	(10.02	(30
			(1.8	(30
	15 May	No date Specified	12.00	30
VII	22 May	26 May	(10.2	(30
27 May 1946			(1.8	(30
	27 May	No date Specified	(8.5	(30
			(3.5	(30
VIII	11 June	14 June	(7.50	(30
7 June 1946			(4.50	(30
	15 June	1 August	(7.50	(30
			(5.90	(30
	2 August	6 September	(7.50	(30
			(4.50	(30
	7 September	12 September	9.50	30
	13 September	4 October	(5.33	(60
			(10.67	(30 (bl
VIII (Rev. I)	12 June	22 June	(7.50	(30
16 July 1946			(4.50	(30
	23 June	8 July	(7.50	(30
			(6.60	(30
	9 July	17 July	No shipment	-
	18 July	6 August	(9.5	(30 (bl
			(0.72	(60
VIII (Rev. II)	5 August	24 October	(9.5	(30 (bl
5 August 1946			(0.72	(60

ES AY	CONCENTRATION RANGE WEIGHT PER CENT	KG U-235 TO BE PRODUCED PER DAY	DAILY NORMAL FEED RATE - KG URANIUM	MISCELLANEOUS DAILY FEED RATE KG URANIUM - WEIGHT PER CENT
	26.8	2.75		
	27 rise to 30	2.75 rise to 3.06		
	(30	(3.06		
	(30	(0.54 3/		
	30	3.60		
	(30	(3.06		
	(30	(0.54 3/		
	30	3.6		
	(30	(3.06		
	(30	(.54 4/		
	(30	(2.55		
	(30	(1.08 4/		
	(30	(2.25		Start 11 June:
	(30	(1.35 4/		600 0.55
	(30	(2.25		15 June thru 1 August
	(30	(1.77 4/		353 0.90
	(30	(2.25		
	(30	(1.35 4/		
	30	2.85 5/		
	(60	(3.8		
	(30 (blend)	(3.2 6/		
	(30	(2.25		Start 13 June:
	(30	(1.35 4/		600 0.55
	(30	(2.25		
	(30	(1.98 4/		
	-	-		23 June thru 30 July
				500 0.90
	(30 (blend)	(2.85 7/		
	(60	(0.43 4/		
	(30 (blend)	(2.85 7/	Start 12 September	
	(60	(0.43 4/	1288	

12-3

ACTUAL SHIPMENTS TO Y-12

DATE START	DATE END	AVERAGE KG URANIUM SHIPPED PER DAY	CONCENTRATION RAGOR WEIGHT PER CENT	AVERAGE KG U-235 SHIPPED PER DAY	DAILY RATE
30 March	3 April	17.17	28.97	4.85	1
4 April	11 April	9.57	27 to 30	2.88	1
12 April	15 December	11.53	30.01	3.46	1
16 April	21 May	12.14	29.08	3.53	1
22 May	26 May	10.43	30.01	3.13	1
24 May	26 May	2.98	29.83	0.88 4/	
27 May	11 June	(9.40	(30.00	(2.82	1
		(2.79	(30.11	(0.84 4/	

The operation of the plant proceeded as noted in Step I, Plan VIII, pending decision Plan VIII, Rev. I - Verbally approved 2 July and approved by letter on

DATE START	DATE END	AVERAGE KG URANIUM SHIPPED PER DAY	CONCENTRATION RAGOR WEIGHT PER CENT	AVERAGE KG U-235 SHIPPED PER DAY	DAILY RATE
12 June	9 July	7.19	29.90	2.15	1
12 June	22 June	4.36	30.04	1.31 4/	
23 June	30 June	4.57	29.97	1.37 4/	1
10 July	19 July	No shipment	-	-	
20 July	4 August	8.97	30.10	2.70 7/	1
20 July	4 August	0.60	60.00	0.36 4/	
5 August	24 October	(9.63	(30.40	2.89 7/	1
		(1.97	(59.89	1.18 4/	

...ATION RANGE ...ER CENT	AVERAGE KG U-235 SHIPPED PER DAY	DAILY NORMAL FEED RATE - KG URANIUM	MISCELLANEOUS DAILY FEED RATE KG URANIUM - WEIGHT PER CENT
7	4.63	1329.96	30 March thru 3 April
0	2.63	1298.3	223.29 0.55
			502.92 0.55
1	3.46	1347	16 December thru 21 May
6	3.53	1297.56	733.86 0.55
1	3.13	1339.7	22 May thru 26 May
3	0.88 4/		826.83 0.55
0	(2.82	1398.01	25 May thru 11 June
1	(0.84 4/		632.41 0.55

d as noted in Step I, Plan VIII, pending submission and
proved 2 July and approved by letter on 16 July 1946.

0	2.15	1294.8	12 June thru 4 July
4	1.31 4/		692.43 0.55
7	1.37 4/	1297.20	25 June thru 9 July
			822.35 0.90
0	2.70 7/	1295.49	16 July thru 17 July
			348.70 0.55
0	0.36 4/		10 July thru 19 July
			589.31 0.90
			20 July thru 22 July
			809.73 0.90
			23 July thru 4 August
			876.54 0.55
0	2.59 7/	1292.28	5 August thru 24 October
9	1.18 4/		1302.71 0.55

[redacted]

APPROVED SCHEDULE OF OPERATION

PRODUCTION PLAN DATE OF APPROVAL	DATE START	DATE END	KG URANIUM TO BE PRODUCED PER DAY	CONCENTRA WEIGHT PE
IX	25 August	6 November	Maximum production	60
19 October 1946	26 October	1 December	No shipment	-
	2 December	15 December	12.0	30
	19 November	15 December	Total production	95
IX (Rev. I)	2 December	28 December	5.67	30
2 December 1946	2 December	28 December	Total production	95
IX (Rev. II)	2 December	28 December	6.67	30
9 December 1946	2 December	28 December	Total production	Not less 94
IX (Rev. III)	6 December	27 December	6.67	30
9 December 1946	6 December	28 December	2.75	Not less 93
IX (Rev. IV) 10 December 1946	10 December	15 January	2.75	Not less 93 9/

NOTES:
1/ Stockpile discussed in Item 2-11.
2/ Special Hazards Material.
3/ Special Hazards Material Shipped with Y-12 Beta feed (see Item 2-11).
4/ Stored at K-25.
5/ Feed to Y-12 from accumulated 30 per cent stockpile.
6/ Entire 60 per cent production of 3.2 kg of U-235 per day was to be blen
7/ 30 per cent material produced by blending 2.85 kg of U-235 at 60 per ce
8/ Material recovered from 30 per cent special hazards experiments.
9/ Concentration was fixed at 94 plus or minus 1 per cent in letter dated

[redacted]

13-2

[redacted] SECRET

DAY	CONCENTRATION RANGE WEIGHT PER CENT	KG U-235 TO BE PRODUCED PER DAY	DAILY NORMAL FEED RATE - KG URANIUM	MISCELLANEOUS DAILY FEED RATE KG URANIUM - WEIGHT PER
uction	60 - 30	Maximum production 4/ - 3.6 5/		
tion	95 - 30	2.00 5/		
tion	95 - 30	- 2.00 5/		
tion	Not less than 34 - 30	2.00 5/		
	Not less than 93	2.56		
	Not less than 93 9/	2.56		

see Item 2-11).

ay was to be blended to 30 per cent.
-235 at 60 per cent.
periments.
in letter dated 30 December 1946 from Lt. Col. W. R. Smith, Jr., Chief, Plant Operations Group

[redacted] SECRET

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ACTUAL SHIPMENTS TO Y-12

PER CENT

DATE START	DATE END	AVERAGE KG URANIUM SHIPPED PER DAY	CONCENTRATION RANGE WEIGHT PER CENT	AVERAGE KG U-23 SHIPPED PER DAY
25 October	30 October	6.41	60.06	3.85 4/
25 October	1 December	No shipment	-	-

The operation of the plant proceeded with shipment of 30 per cent mat
decision by the District Engineer to product UF_6 at a top concentration le

DATE START	DATE END	AVERAGE KG URANIUM SHIPPED PER DAY	CONCENTRATION RANGE WEIGHT PER CENT	AVERAGE KG U-23 SHIPPED PER DAY
2 December	5 December	9.71	30.07	2.92 8/
3 December	5 December	1.70	94.12	1.60
6 December	27 December	5.62	29.89	1.68 8/
6 December	9 December	0.698	93.55	0.653
10 December	31 December	2.83	93.29	2.68

Group.

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13-4

...TION RANGE ...R CENT	AVERAGE KG U-235 SHIPPED PER DAY	DAILY NORMAL FEED RATE - KG URANIUM	MISCELLANEOUS DAILY FEED RATE KG URANIUM - WEIGHT PER CENT
	3.85 4/		
	-	1279.86	25 October thru 3 November 1449.69 9.55

...shipment of 30 per cent material as noted in Plan II, Rev. I., pending ...F_6 at a top concentration less than 95 per cent. (Approved in Plan II, Rev. II)

	2.92 3/ 1.60	1287.74	
	1.68 3/ 0.653	1325.31	
	2.68	1295.15	