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NUCLEAR DIVISION
OAK RIDGE Y-12 PLANT**

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NUCLEAR SAFETY CONSIDERATIONS IN FABRI-
CATION OF MASSIVE PARTIALLY ENRICHED
URANIUM-MOLYBDENUM REACTOR PARTS

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INTRODUCTION

BACKGROUND

Metal prompt-burst reactors, in general, have features which naturally lead to significant nuclear safety problems in the manufacture of their components. Such reactors are designed to operate essentially unreflected and may need to have large amounts of excess reactivity to compensate for experimental samples. These requirements demand a large inventory of fissile material. Also, desired operating characteristics, simplicity of design, and economic considerations lead to a design having as few separate core pieces as possible, some of which may in themselves contain large amounts of fissile material. The identification and resolution of nuclear safety problems arising in the manufacture of core components for such a reactor, the Super Kukla prompt burst reactor, at the USAEC Oak Ridge Y-12 Plant are described in this report.

Discussions between the reactor designers, the Lawrence Radiation Laboratory of the University of California, and the Oak Ridge Y-12 Plant regarding the feasibility of manufacturing the Super Kukla core components were begun in late 1961. Over the next approximately two

years the core design was firmed up, with manufacturing nuclear-safety considerations significantly influencing the size of the major components. The last of the Super Kukla components were shipped from Y-12 in July 1964. The reactor has been operating at the USAEC Nevada Test Site since November 1964. ^[1]

REACTOR DESCRIPTION

A brief summary of the features of the core design, significant for the purposes of the present discussion, follows. The main core structural details are shown in Figure 1. The core is in the form of a cylindrical shell with an outer diameter of 76.2 centimeters (30 inches), an inner diameter of 45.7 centimeters (18 inches), and a nominal critical height of 94 centimeters (37 inches). The bottom on the axial cavity is filled with two 45.7-centimeter (18-inch) diameter, 7.6-centimeter (3-inch) thick discs of core material. The core material is a uranium-molybdenum alloy containing 10 weight percent molybdenum. The uranium is enriched to 20 percent in the U-235 isotope. The cylindrical shell is composed of annular rings approximately 5.1 centimeters (2 inches) thick, averaging 240 kilograms each. The discs filling the bottom of the axial cavity weigh approximately 206 kilograms each. Shim rods, burst rods, and bushings range from about 35 kilograms to about 1 kilogram in weight. Two sets of shim and burst rods were fabricated, one from 20 percent enriched unalloyed uranium and one from 40 percent enriched uranium. A photographic montage of four of the components is shown in Figure 2. More complete details of the final design of Super Kukla and its operation can be found elsewhere. ^[2, 3]

NUCLEAR-SAFETY CONSIDERATIONS

NUCLEAR-SAFETY PROCEDURES

General

The manufacturing operations involved in the fabrication of the reactor components ranged from the initial reduction of 20 percent enriched uranium hexafluoride to metallic uranium, to the conversion of salvage from various operations into reusable forms such as uranium oxide. Each of these operations was analyzed in detail and appropriate nuclear-safety limits were prescribed.

Figure 1. SUPER KUKLA REACTOR CORE STRUCTURAL DETAILS.

Figure 2. SUPER KUKLA REACTOR CORE COMPONENTS.

The limits for many of these operations were based on the results of reactor theory-type calculations of critical parameters of 20 percent enriched uranium metal and uranium-molybdenum alloy systems. To assist in establishing the reliability of these calculations, comparisons were made with the results of the most closely related critical experiments.

Problem Analysis Procedures

The general procedures used at Y-12 to perform nuclear-safety analyses are not considered unique. They merely follow what is considered to be a "common sense" approach. Some of the aspects of this approach have been discussed previously.^[4,5] The following generally describes the mechanics of the nuclear-safety procedure.

Any operation which involves fissile material must be analyzed for nuclear safety and approved by nuclear-safety specialists prior to startup. The analysis begins with a determination of the values of the physics parameters which influence criticality (such as mass and form of fissile material, moderation, and reflection) which are characteristic of the operation as planned. The values of these parameters are compared to existing limits, or, if necessary, new values are determined from critical data. Assuming that at this state of the analysis adequate safety is indicated, the operation is analyzed for the controls required to prevent the safe values of the physics parameters from being exceeded. If the values of the parameters are satisfactory and the operations of the controls are such that at least a "double contingency"¹ is required for criticality, the operation may be approved. Otherwise, consultation is held between the specialist and operating personnel to determine how to provide adequate controls, change the characteristics of the operation so that the values of the physics parameters will be more favorable, or both.

CHEMICAL AND FABRICATION METHODS

The processes involved in the manufacture of the Super Kukla reactor core components are indicated in Figure 3. They are grouped to illustrate six major operations which are briefly

¹"Double contingency" is a term signifying the concurrent, independent breakdown of controls on two different parameters affecting criticality.^[6]

Figure 3. SUPER KUKLA REACTOR COMPONENT FABRICATION FLOW SHEET.

summarized in the sections that follow. More extensive details of these and other related process chemical and metallurgical operations are given in a monograph by Patton, Googin, and Griffith.^[7]

Chemical Conversion to Metal

Conversion of UF₆ to UF₄ - Uranium hexafluoride (UF₆) enriched to 20 percent in the U-235 isotope was received from the Oak Ridge Gaseous Diffusion Plant in 12.7-centimeter- (5-inch) diameter cylindrical tanks. The UF₆ was converted to UF₄ using hydrogen reduction with a fluorine gas booster in a cold-wall reactor that is 15.2 centimeters (6 inches) in diameter. In this process, the UF₄ powder collects in the bottom of the reactor and is subsequently removed in batches containing up to 10 kilograms of uranium for further processing.

Reduction of UF₄ to Metal - The 20 percent enriched UF₄ obtained was reduced to metal, utilizing the Los Alamos reduction procedure described by Patton, et al.^[8] Five-kilogram batches of uranium were processed in 15.24-centimeter- (6-inch) diameter by 45.7-centimeter- (18-inch) high reduction reactors. The resulting uranium metal "buttons" were cleaned, sampled for analysis by drilling, and subsequently accumulated into casting charges.

Casting

Casting massive pieces of uranium was accomplished in vacuum induction melting and casting equipment. The uranium metal and molybdenum were alloyed together in batches up to 300 kilograms total weight in a crucible and cast into billets. The alloy billets were used in charges up to 400 kilograms each for casting the reactor components.

Machining

The castings were machined to finished dimensions on horizontal lathes. Burst rod, shim rod, and bolt holes were made by trepanning, followed by drilling. Machine turnings were of particular nuclear-safety concern due to the large bulk generated, the copious use of coolant, and the use of equipment and personnel not normally employed in processing enriched uranium.

Plating

All of the fabricated reactor components were electroplated with nickel. The various steps of the plating process were done in large, geometrically unsafe tanks containing solutions for rinse, etching, stripping, and plating. The immersion of massive castings and oxide loss to the solutions were causes for special nuclear-safety considerations.

Inspection

The reactor components were given dimensional, radiographic, and ultrasonic inspections. Dimensional inspections were performed at the machines. Radiographs were made utilizing 2 Mev X rays. The ultrasonic inspection, used to determine plating faults, generated special problems due to the necessity to submerge the parts in water for testing.

Shipment

The finished components were packaged into containers, each consisting of a 36-inch square metal skid with a Fiberglas lid. The rings and discs were packaged one part per container. The burst and shim rods were packaged two per container. Internal tie downs were provided in each container to hold the components in position.

The shipping requirements for the reactor parts were in accordance with USAEC regulations for Class III shipments, which are for the most part identical to the IAEA regulations.

NUCLEAR-SAFETY ANALYSES OF OPERATIONS

General

A discussion of all the nuclear-safety problems arising in each of the manufacturing operations would be much too involved for this presentation; and so, only those operations which appear to be the most significant will be discussed. Details will be presented for: casting the alloy pieces to be machined into reactor components, machining the pieces, plating the components with nickel, and salvaging the machine turnings.

The nuclear-safety problems fell into two categories. First, there were those which could be resolved satisfactorily through the application of criticality data and established practices for highly enriched (93 percent U-235) uranium.^[6,9] These will not be given detailed consideration in this discussion. The remaining problems were those for which criticality data had to be obtained and practices devised which took into account the actual enrichment and, where applicable, the presence of the molybdenum diluent. These problems will be treated more extensively.

Essentially all of the facilities used for fabricating the Super Kukla reactor core components were designed for work with nonenriched uranium or nonradioactive materials. Accordingly, it was necessary to establish proper nuclear-safety controls and to orient the personnel to think in terms of these controls. Areas and equipment used in the fabrication operations were marked off with signs designating enriched uranium operations only, chain barriers were erected, and some equipment was walled off to prevent intermixing of operations. It also became necessary to modify some existing equipment and to revise certain operating procedures.

Uranium Enrichment Control

To obtain full benefit of the relatively large mass limits possible (if it could be assured that the isotopic enrichment involved in these operations did not exceed the 20 and 40 percent U-235 specified) the following controls were established: (a) enrichment determinations were made on the UF₆ received, on the components for alloy blending, and on parts casting charge components which were not readily identifiable from their size or shape; (b) two enrichment checks were made on the charge components, one of which was made in the casting area itself; (c) additional control against crossover of materials from other operations was provided by segregating the Super Kukla operations.

Consequently, it was considered incredible that any but a nominal enrichment error could occur in any operation for which control of enrichment was of primary nuclear-safety concern.

Casting

General - Two separate casting operations were required for fabricating the uranium-molybdenum components. To meet design requirements, assurance of homogeneous alloying of

the uranium and molybdenum was necessary; therefore, the alloy blending was performed as a separate operation. The other operation was the actual casting of the reactor core discs and rings.

Since the furnace available for these operations had water-cooled induction heating coils, the potential of flooding in event of a cooling coil break during the blending and casting operations was of particular nuclear-safety concern. The nuclear-safety analysis of such an occurrence indicated that uranium mass limits would have to be so small that reactor design requirements could not be satisfied. For this reason, the water-cooled coils were replaced with forced air-cooled coils.

Alloy Blending - The alloy-blending operation consisted of melting a maximum of 275 kilograms of 20 percent enriched uranium metal buttons (of about 5 kilograms mass each) together with a proportional mass of molybdenum metal powder. The molten alloy was then cast into cylindrical billets for use in casting the core components.

The crucible and mold for this operation were fabricated from solid pieces of graphite in cylindrical geometry. The crucible had an inside diameter of 50.8 centimeters (20 inches) and a depth of 43.2 centimeters (17 inches). The mold had an inside diameter of 40.6 centimeters (16 inches) and was 17.8 centimeters (7 inches) deep. The average wall thickness for both was 3.8 centimeters (1.5 inches). The crucible and mold setup used is illustrated in Figure 4. Specially formed pieces of various refractory materials were used to position this setup in the furnace, as shown in Figure 5. When the crucible and mold were in position in the furnace, the furnace insulating materials (consisting of precast refractory firebrick, granulated refractory material, and micarta) formed a reflector about them. The total amount of reflection, including that provided by the vessel walls, was considered to be slightly less effective than that which would be provided by thick (> 6 inches) water in contact with the vessel walls. Considering geometry, material density, and reflection present, it was concluded from analysis of the entire alloy blending operation that, under normal conditions, the minimum critical mass configuration was that of the mold as positioned in the furnace.

Since flooding had been precluded and enrichment error was considered incredible, the only abnormal conditions of concern were the possibilities of mass excess, use of a more optimum geometry crucible or mold, or a break in the crucible or mold while the metal was molten.

Figure 4. CRUCIBLE AND MOLD SET UP FOR SUPER KUKLA ALLOY BLEND-
ING AND BILLET CASTING.

Figure 5. CASTING SETUP FOR SUPER KUKLA REACTOR PARTS

All controls established to guard against mass excess or use of incorrect fixtures were administrative. The crucibles and molds for this operation were kept isolated, and the supervisor preselected the charge material, the crucible, and the mold to be used for each casting. During the charge-loading operation, the crucible was placed on a calibrated scale. Actual loading of the crucible was also checked by supervisory personnel. The loaded crucible and selected mold were transferred to the air-cooled furnace along a specially designated route which was marked off with colored paint striping. These administrative controls were considered adequate to prevent the use of an incorrect fixture and to prevent other than a nominal mass excess.

As is evident from Figure 5, the only void space of significant size into which molten metal could run in event of crucible or mold failure was the 12.7-centimeter-(5-inch) thick void space between the crucible-mold setup and the protective insulation of the furnace shell. Since this void space was annular it was concluded that crucible or mold breakage could not lead to a lower critical-mass geometry than that of the mold itself under normal conditions.

The critical mass in mold geometry was taken to be 355 kilograms of uranium, the amount calculated for a fully water-reflected, 20 percent enriched uranium metal cylinder 40.6 centimeters (16 inches) in diameter. No allowance was taken for dilution by molybdenum because of the inhomogeneity in the makeup of the crucible loading and the lack of positive assurance that the materials would mix homogeneously upon melting. Therefore, on the basis of these considerations, the uranium mass limit of 275 kilograms was considered to provide an adequately large safety margin against any credible abnormality which might arise in the operation.

Casting Rings and Discs - The setup for casting core rings and discs was identical to that used for alloy blending except for mold geometry. Consequently, the major difference in the nuclear-safety analysis was that it was considered possible to assume that all the uranium used in this operation was homogeneously alloyed with molybdenum. This assumption was possible because of two controls: (1) laboratory samples were taken from each alloy billet and analyzed for molybdenum content, and (2) the process records for the alloy-blending operation were checked to ascertain whether the proper amount of molybdenum had been added. Material being recycled through the casting operations, such as pieces of defective castings and machine turnings, was also analyzed for molybdenum content if it was not visually apparent that the material was actually alloy.

The mold for casting the annular rings had a solid core 44.4 centimeters (17.5 inches) in diameter, an inside diameter of 77.5 centimeters (30.5 inches), and a depth of 17.8 centimeters (7 inches). The mold for casting the discs was of cylindrical geometry with an inside diameter of 47 centimeters (18.5 inches) and a depth of 11.4 centimeters (4.5 inches). Both molds were made of graphite with average wall thicknesses of 3.8 centimeters (1.5 inches).

From a nuclear-safety analysis similar to that performed for the alloy-blending operation it was concluded that the minimum critical-mass geometry was that of the 18.5-inch inside-diameter disc casting mold as positioned in the furnace.

The critical mass in disc-mold geometry was taken to be 475 kilograms of alloy, the critical mass derived for a fully water-reflected uranium-molybdenum alloy cylinder 47 centimeters (18.5 inches) in diameter. The assumption of full water reflection may be slightly conservative. Therefore, the alloy mass limit for the operation of 400 kilograms was considered to provide an adequately large safety margin against any credible abnormality which might arise in the operation.

Machining Operations

General - While extensive machining of all the core component castings was required, the lathe operations on the ring and disc castings presented the greatest nuclear-safety problem because of the large masses both of the individual castings and the machine turnings generated in the operations. Since the castings themselves were adequately safe before machining (even if fully water reflected) and analysis indicated that no more effective reflection would be encountered in the machining operations, attention is centered on the handling of the machine turnings, both in conjunction with the pieces being machined and separately.

It had been estimated that approximately 100 kilograms of machine turnings would be generated in the machining of a single disc or ring. Existing practices in the machining area which had been set up for machining nonenriched uranium included use of a water-base coolant, accumulation of machine turnings on the lathes, and collection of machine turnings in ~200-liter (55-gallon) drums. Also, mounted on the floor under each lathe was a self-contained horizontal coolant storage tank 22.9 centimeters (9 inches) deep. Experiments in which 93.4 percent enriched uranium machine turnings were dispersed in water had shown

that the associated critical masses and volumes were no more than 10 percent greater than those for homogeneous solutions of enriched uranium under equivalent conditions of moderation and reflection.^[10] To eliminate the obvious potential for accumulating a critical mass of machine turnings on the lathe, in the coolant tank, or in collection containers, several changes were made in the equipment and procedures. First, the water-base coolant was replaced by a chlorinated organic coolant composed of tetrachloroethylene (sold under the trade names Perclene or Perk) and a chlorinated biphenyl (sold under the trade name Arclor 1248), on the basis of experiments that had demonstrated the strong neutron-absorbing properties of such materials.^[10] The machine operators were instructed to remove the turnings as they were generated and to place them in specially constructed collection containers. Each collection container consisted of a 14-centimeter- (5.5-inch) diameter by 102-centimeter- (40-inch) long perforated cylinder positioned in a 15.2-centimeter- (6-inch) diameter by 107-centimeter- (42-inch) long steel cylinder fastened to a dolly having a 61 (24-inch) by 61-centimeter (24-inch) base. Also, the large coolant storage tanks under the lathes were covered with a steel plate to prevent machine turnings from becoming submerged in them. With the implementation of these equipment and procedural changes, it was considered that the handling of machine turnings could be performed safely.

Plating

Existing facilities for electroplating large nonuranium metal parts were utilized to nickel plate the finished core components. The available tanks for the process of preparation and plating had capacities of thousands of liters and were not of geometrically safe construction for enriched uranium solution operations. Although individually machined components would be adequately subcritical with the reflection provided by the homogeneous process solutions, small amounts of uranium would gradually become dissolved or suspended in the solutions under normal conditions, and there would be the potential for much greater losses to the solutions under abnormal conditions. On the basis of an analysis of experiments on a 93 percent enriched uranium metal slab immersed in uranium solutions of various different concentrations,^[11] it was concluded that a loss to the solution in a single process tank of 700 grams of the 20 percent enriched uranium could safely be allowed before the solution would need to be replaced.

Several types of controls were established to prevent the limit from being exceeded. First, a mass-loss record was maintained for each component, and routine sampling of the process solutions for uranium concentration established. The mass-loss records and sampling results were carefully checked by supervision as the operation progressed. The components were positioned in the process tanks by a fixture attached to an electrically operated overhead crane. To provide protection against excessive losses of uranium to the solution which might occur if a power failure to the crane prevented removal of the component from the tank, or if the fixture failed and the component was dropped into the tank, a backup system to remove the component from the tank was provided. This system consisted of a metal frame basket attached to a separate, manually operated crane. The basket was positioned in the tank so that the component would fall into the basket if a fixture failed, or both the component and fixture could be lifted out of the tank if a power failure occurred. To be sure that the direction of the electroplating current was correct before a component was put in the electroplating tank, a small sample was inserted in the tank. The component itself was not lowered into the tank until after it was determined that plating was actually taking place. These controls were considered to be adequate for maintaining safe operations throughout the plating operation.

Salvage

Uranium and alloy salvage operations were performed on crucibles, molds, machine turnings, machine coolants, and contaminated combustibles such as absorbent paper which were used or generated in the manufacturing operations. The small quantity of uranium in the materials other than the machine turnings was recovered using procedures devised for recovering 93 percent enrichment uranium. The quantities of machine turnings produced were sufficiently large to warrant a separate salvage operation that would allow the material to be returned to the casting operation.

The operation devised for salvaging the machine turnings consisted of ultrasonically cleaning the turnings in a 1200-liter tank and then pressing them into briquettes containing 2.5 to 8 kilograms of alloy each. Since it was considered that a critical amount of small fragments of the turnings could become suspended in the normal water-based cleaning fluid during the cleaning operation, this normal solution was replaced with the strongly neutron-absorbing tetrachloroethylene^[10] to provide the necessary nuclear safety.

BASES FOR NUCLEAR-SAFETY LIMITS

General

The majority of the nuclear-safety limits applied to the operations discussed in this paper were derived from a combination of reactor theory-type calculations and integral experimental data. Preliminary estimates of critical parameters were made using available criticality data^[12] and nuclear-safety recommendations.^[9] Subsequently, calculations were made on an IBM 7090 computer using the S_n -type multigroup transport theory machine programs, DSN^[13] and DTK,² with Hansen-Roach 6 and 16-group cross sections.^[15] Corrections for resonance self-shielding^[15] were used in calculations for reflected systems; ie, when the 16-group cross sections were used.

The results of the machine program-calculated critical dimensions which were used directly to establish limits are given in Table I. To use these calculated dimensions to establish the required nuclear-safety limits, it was necessary to investigate the reliability of the calculations.

Table I
DSN AND DTK CALCULATED CRITICAL DIMENSIONS USED
IN SUPER KUKLA ANALYSIS

Material	Geometry	Water Reflector	Critical Radius	Critical Mass of Material (kgs)	Critical Mass of U-235 (kgs)
U(20) ^a	Sphere	30.5 centimeters (12 inches)	16.1 centimeters (6.35 inches)	329	65.7
U(20)-10 Mo ^b	Sphere	30.5 centimeters (12 inches)	19.0 centimeters (7.48 inches)	496	89.4

^aU(20) signifies uranium metal at an enrichment of 20 percent in the U-235 isotope.

^bU(20)-10 Mo signifies uranium-molybdenum alloy containing 10 percent by weight molybdenum.

No convenient experimental check points for the necessary calculations existed, so the reliability of the calculations could be checked indirectly only. The primary check was to compare the experimentally derived critical masses of bare, water-reflected, and natural uranium-reflected uranium metal spheres. DSN and DTK calculations were made of the critical radii of water-reflected uranium metal spheres at several different U-235 enrichments.

²DTK is an improved version of DSN generated by the Los Alamos Scientific Laboratory.^[14]

The U-235 critical masses of the spheres, obtained using these calculated radii, were used to draw the smooth curve of Figure 6. Experimental values are plotted in Figure 6 as discrete points. A smooth curve drawn using calculated U-235 critical masses of water-reflected uranium-molybdenum alloy spheres is also shown.

Allowance for Reduced Enrichment

Using straight-line extrapolations of the experimental data to 20 percent enrichment,^[16] it is found that the extrapolated critical masses at 20 percent enrichment are a factor of three greater than the measured critical masses at about 93.5 percent enrichment for both the bare and the uranium-reflected spheres. The same factor is found for the calculated water-reflected critical masses. Since the calculated critical mass at 93.5 percent is about 5 percent lower than that measured, the critical mass at 20 percent enrichment may therefore be somewhat greater than that calculated. However, since relatively long extrapolations are involved in this comparison (even though these extrapolations may be conservative), it was considered prudent for the purpose of establishing operational nuclear safety limits to assume that the critical mass at 20 percent enrichment could be as much as 10 percent less than calculated.

Allowance for Dilution with Molybdenum

The effect on critical mass of a 10 percent by weight (17 percent by volume) dilution of a water-reflected uranium metal sphere with molybdenum is calculated to be a 20 percent increase at 93.5 percent enrichment and a 34 percent increase at 20 percent enrichment. The magnitude of the calculated effect at 93.5 percent enrichment was considered consistent with the 18 percent increase calculated for the natural uranium-reflected, 94 percent-enriched Topsy reactor using the expression given by Engle, Hansen, and Paxton.^[17] The magnitude of the calculated effect at 20 percent enrichment was considered to be about 15 percent larger than could be justified readily on the basis of comparison with calculated and measured effects of dilution at higher enrichments. It was therefore considered prudent, for the purpose of establishing operational safety limits, to assume that the critical mass of the uranium-molybdenum alloy at 20 percent uranium enrichment could be as much as 25 percent less than calculated. The additional 10 percent reduction was included to be consistent with the previous analysis for pure uranium metal spheres.

Figure 6. CALCULATED AND EXPERIMENTAL CRITICAL MASSES OF URANIUM METAL (U METAL) AND URANIUM-10 WEIGHT PERCENT MOLYBDENUM ALLOY (U-10 Mo) SPHERES.

Conversion to Cylindrical Geometry

Using the reduced critical-mass values established in the last two paragraphs for the water-reflected spheres of Table I, final estimates were made of the critical masses in the cylindrical geometries most closely related to geometries occurring in the manufacturing operations. Spherical-to-cylindrical critical-mass conversion factors were obtained from a curve fitted to experimental data on solid uranium metal reactors with 8 to 9-inch-thick reflectors of various materials. [18]

The reduced values of the spherical critical masses from Table I and the cylindrical critical masses derived from them are listed in Table II.

Table II
CRITICAL MASSES DERIVED FROM CALCULATED VALUES OF TABLE I
(All Values for Reflection by 12 Inches of Water)

Material	Geometry	Critical Mass of Material ^a (kgs)	Critical Mass of U-235 ^b (kgs)
U(20) ^c	Sphere	300	60
U(20)	Cylinder 40.6-centimeter (16-inch) Diameter	355	71
U(20)	Cylinder 50.8-centimeter (20-inch) Diameter	425	85
U(20)-10 Mo ^d	Sphere	395	71
U(20)-10 Mo	Cylinder 47.0-centimeter (18.5-inch) Diameter	475	86
U(20)-10 Mo	Cylinder 50.8-centimeter (20-inch) Diameter	505	91

^aRounded off to the nearest 5 kilograms.

^bRounded off to the nearest kilogram.

^cU(20) signifies uranium metal at an enrichment of 20 percent in the U-235 isotope.

^dU(20)-10 Mo signifies uranium-molybdenum alloy containing 10 percent by weight molybdenum.

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SUMMARY

Uranium, enriched to 20% in U-235, has been chemically converted from UF_6 to the metal, alloyed with 10% molybdenum, and cast into massive core components for a prompt burst reactor, Super Kukla. In those areas for which direct criticality data were sparse or lacking, reactor theory-type calculations were made using S_n -type multigroup transport theory machine programs DSN and DTK. Adjustments were made to ensure conservatism in the application of calculations to the resolution of nuclear-safety problems.

Using the results of these calculations, the available criticality data, and applying double-contingency analyses to operations, core components weighing up to 400 kgs of U-10 (Mo) alloy were cast and safely manufactured into finished parts.

³Reactor Division, Oak Ridge National Laboratory; formerly of the Oak Ridge Y-12 Plant.

⁴Oak Ridge Gaseous Diffusion Plant.

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