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PRELIMINARY ENGINEERING PROGRAM FOR
RENOVATION OF THE HORIZONTAL CONTROL ROD
SYSTEM - K REACTORS

April 16, 1963

P. H. Hutton
Reactor Design
Design Engineering
FACILITIES ENGINEERING SECTION

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PRELIMINARY ENGINEERING PROGRAM FOR RENOVATION OF
THE HORIZONTAL CONTROL ROD SYSTEM
K REACTORS

I. INTRODUCTION

The purpose of this document is to describe an engineering program being conducted by Reactor Design, Facilities Engineering Section to provide a solution for current and anticipated problems of binding and inoperative horizontal control rods (HCR's) at the "K" Reactors. Primary emphasis in the program is on alleviating problems at the K Reactors because of the more advanced stage of graphite distortion and hence control rod problems existing at the K Reactors as compared to the other reactors. It is recognized, however, that problems of similar severity can reasonably be anticipated at the other reactors in the near future. With this in mind, design of remedial measures for K will incorporate consideration of adaptability to the other reactor HCR systems.

Also, primary concern of this program is to provide an HCR system which will fulfill functional requirements for safe operation of the reactors at current power levels under conditions of severe HCR channel distortion. Suitability of the system for producing by products such as tritium is considered to be of secondary importance at this time although still a point to be kept in mind in designing the new rod tip and to be studied in detail at a later date.

II. DISCUSSION OF THE PROBLEM

The problem under consideration arises from the phenomena of dimensional changes in graphite which occur when it is exposed to heat and nuclear radiation. No attempt will be made here to discuss this basic phenomena since it is itself the subject of extensive study work being reported by others (References 1, 2, 3 and 4, to mention a few.) The relation between dimensional changes in the graphite moderator stack in HAP0 reactors and the functional integrity of the HCR system is, however, vital to this report. The following discussion relates to the K Reactors.

Nuclear radiation and temperature affects are causing a progressive deformation of the graphite moderator stacks in the Hanford reactors.⁽¹⁾ This condition is more advanced at the K Reactors due to greater total exposure and is manifested by a general subsidence of the central portion of the moderator stack. Study of elevation traverse data from various channels^(5,6,7) through the graphite stack shows that the profile of the subsidence is very similar to the profile of the neutron flux level along the various axes of the reactor.⁽⁸⁾

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The horizontal control rods which are the routine reactor control mechanism are inserted into channels which extend from side to side in the reactor, perpendicular to the process tubes. (See attached drawing H-1-22000). Subsidence of the center of the graphite stack has caused a definite bow in the HCR channels in the vertical plane (See Figure 1) which tends to cause the HCR tip section to bind or stick in operation. Data indicate that cumulative distortion is essentially linear relative to height on the graphite stack thus tending to make the HCR channel bowing most pronounced in the upper channels. Another factor which affects the degree of vertical bowing in a given HCR channel is its position relative to the front and rear of the reactor. Figure II shows the position of the HCR's relative to typical front to rear graphite distortion profiles. Assigning a factor of 1.0 to channel No. 4 (the latest elevation traverse data is from No. 4 KW) and considering the affects of elevation and front to rear position, the index numbers in Table I were calculated to give a relative measure of severity of distortion to be expected in individual HCR channels.

TABLE I

<u>Rod No.</u>	<u>Index No.</u>	<u>Rod No.</u>	<u>Index No.</u>	<u>Rod No.</u>	<u>Index No.</u>
1	1.16	8	0.84	15	0.38
2	0.98	9	0.71	16	0.52
3	0.72	10	0.34	17	0.44
4	1.0	11	0.49	18	0.21
5	0.84	12	0.68	19	0.36
6	0.41	13	0.57	20	0.30
7	0.65	14	0.28		

Figure III shows the HCR pattern. This set of indexes was applied to elevation traverse data taken on No. 4 KW channel on 9-19-62 to establish estimated maximum distortion for each channel as of that date. Finally, predicted annual increase in subsidence of the graphite at various levels (3,8) was used together with the above distortion values to estimate maximum HCR channel vertical displacement five and ten years hence. The results are tabulated in Table II on the following page.

The technique described below was used in an attempt to extrapolate the traverse data taken in No. 1 KW channel on 1-4-62 to predict the maximum value for No. 4 KW on 9-19-62. A comparison of this result with actual traverse data taken in No. 4 KW channel on 9-19-62 indicates that the calculations may be conservative by 15% to 20%.

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TABLE II

HCR Channel No.	Estimated Maximum Depression - Inches		
	<u>9-19-62</u>	<u>1-8-68</u>	<u>1-1-73</u>
1	4.2	7.8	10.7
2	3.5	6.4	9.1
3	2.6	4.6	6.8
4	3.64*	6.7	9.5
5	3.1	5.8	8.1
6	1.5	2.8	3.9
7	2.2	3.8	5.75
8	3.06	5.6	8.0
9	2.56	4.5	6.7
10	1.25	2.2	3.25
11	1.78	3.1	4.65
12	2.48	4.4	6.5
13	2.08	3.7	5.4
14	1.02	1.8	2.7
15	1.37	2.3	3.6
16	1.89	3.3	4.9
17	1.59	2.9	4.1
18	.78	1.5	2.0
19	1.31	2.3	3.4
20	1.09	1.9	2.58

* Value from traverse data (5)

Accurate calculation of the limiting channel deflection for use of the existing HCR assembly presents a rather formidable challenge when the number of variables and the very limited data on complete channel profile are considered. No significant effort has been devoted to this aspect simply because a more reliable measure already exists, i.e., significant problems of rod binding are now being experienced with the upper rods at both reactors with 3.5" to 4" maximum channel distortion.(9) In view of this, it is quite reasonable to assume that with a maximum channel distortion of 5.5" to 6", the existing HCR assembly will be essentially inoperable. Looking at Table II with this in mind, it can be conservatively predicted that rods 1, 2, 4, 5 and 8 will be virtually inoperable within five years and that rods 3, 7, 9 and 12 in addition will become inoperable within ten years due to graphite distortion in the vertical plane. Furthermore, the ten year operational integrity of rods 6, 11, 13, 16 and 17 would appear questionable.

Distortion in the horizontal plane does not appear to constitute a major problem in the HCR channels. Very limited data (10) presently available on this aspect indicates that a maximum horizontal distortion of about one-half to three fourths of an inch exists in the HCR channels. Also, distortion in this plane can be overcome to a degree by removal of graphite from the filler blocks forming the sides of the HCR channels.

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Review of the above discussion would indicate that the lower HCR's should be relatively free of functional problems arising from channel conditions during the next ten years. A unique but related problem, however, already exists with the lower HCR's. Shifting of the graphite stack as a result of graphite deformation has opened voids at many locations between the individual blocks. One result of this is that 3X Safety System balls have leaked out of the vertical safety rod channels into the graphite stack and hence into the lower HCR channels. Since there is insufficient channel to rod clearance to accommodate the balls, they jam the rod and break the graphite track blocks when the rod attempts to go over them. They also work their way under the track blocks, displacing them and obstructing the channel. This condition is shown to exist by operating experience. (9) In the past year there have been 20 recorded cases of problems among the lower six rods at the two reactors due to channel conditions directly attributable to 3X System balls. It is possible to withdraw the rod tip during reactor shut-down and scrape the balls and pieces of broken track block out. This, however, provides only a stop-gap remedy for the problem because, in time, more balls leak into the channel. Furthermore, continued efforts to auger balls out of the HCR channels aggravates the broken track block problem because this operation in itself tends to break the track blocks.

Current efforts to maintain the HCR's in operable condition are time consuming and very expensive of personnel radiation exposure. A rough average of 30 manhours and 8 outage hours is required to pull a rod, clean the channel and restore the rod to service if no problems are encountered. Where problems are encountered, this may increase by a factor of 3 or 4. (11) Even with utilization of remote work techniques, personnel exposure levels in the order of 1 to 4 roentgen/hour are experienced during HCR maintenance. (12) To date, this work generally has not been outage controlling, but as the severity of the problem increases, it is inevitable that it could be outage controlling. Evidence indicates that the severity is increasing. During CY 1962, a total of 54 cases of sticking control rods due to channel conditions was recorded at the two reactors. Of the 54 total, 39 occurred in the last six months of the year. (13)

In summary, normal maintenance measures are fast becoming inadequate to maintain a full complement of operable HCR's at the K Reactors.

III. JUSTIFICATION FOR A REMEDIAL PROGRAM

A program to provide a remedy for the HCR problems at the K Reactors is justified to prevent production losses, maintain reactor safety and to gain intangible production and economic benefits.

The justification is presented in detail in the FY 65 budget study for rehabilitation of K Reactor HCR systems. (14) Briefly, in order to operate the reactor safely, production losses ranging from 28,000 grams/year to 280,000 grams/year at each reactor can reasonably be expected to be experienced within the next ten years due to inoperable HCR's if no

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remedial action is taken. This production loss would be incurred by lack of optimum reactor operating control with less than a full complement of operable HCR's available. Poison splines inserted in the process tubes are available to supplement the HCR's but they are not and were never intended as a substitute for HCR's to accomplish routine control of flux transients. They depend on procedural control and are manipulated manually from the front face of the reactor thus making them quite unsuited for control of transient conditions.

One of the criteria for ultimate reactor safety in a catastrophe situation is that all poison material remain in place at least until the fuel has lost its lattice configuration.⁽¹⁵⁾ Although horizontal control rods are not included in calculating total control capability, operable HCR's comprise a significant source of reserve poison material which could be expected to remain in place in a catastrophic situation.

Use of supplementary poison to compensate for out-of service HCR's represents a cost in production and dollars due to the inflexible and cumbersome aspects and the material costs of this approach. It is very difficult to attach specific numbers to these factors because of the wide range of possible conditions.

IV. PROPOSED SOLUTION TO THE PROBLEM

Reactor Design, Facilities Engineering Section has an engineering program in progress to provide a solution to the problem described above. The following work is proposed as a means of assuring a full complement of routinely operable HCR's at the K Reactors for at least the next ten years.

- A. Remove the existing track blocks from all HCR channels. (See Figure IV, Part A for location and configuration of these blocks.) It is necessary to remove these blocks to make way for subsequent steps in channel renovation.
- B. Insert graphite sleeves in the bottom six channels. The purpose of the sleeves is to keep the 3X System balls out of the channel in which the HCR operates. Channel distortion in these lower channels where infiltration of balls is a major problem, appears to be sufficiently limited to make this a feasible approach to combating the problem. (See Figure IV, Part B and drawing H-1-23952 for details). The existing rod tip (See attached drawing H-1-22069) would continue to be used in these channels.

In proposing this approach to the ball infiltration problem, it is assumed that the vertical safety rod (VSR) channels will be lined to prevent further loss of 3X System balls into the graphite stack.⁽¹⁶⁾ Sleeving the lower HCR channels is considered to be an effective method of preventing the balls already in the stack from migrating into the path of the lower HCR's. Obviously, it would do nothing to alleviate the basic problem of balls escaping from the VSR channel into the stack which is highly undesirable in itself.

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- C. Insert thin ($3/8$ " to $1/2$ " thick) graphite spacer plates in the bottom of the upper fourteen channels. These plates would be keyed into the side blocks and would serve to keep the blocks in place. The channel side blocks are not keyed into the stack in the portion of the channel containing track blocks. At the same time, the plates would provide $3/8$ " to $1/2$ " additional channel clearance in the vertical plane. (See Figure IV, Part C and Figure V for details).
- D. Install a new, relatively flexible tip section on 14 HCR assemblies. The purpose of the flexible tip would be to negotiate grossly distorted HCR channels using the existing rod drive system. As pointed out earlier in this report, five to six inches channel distortion appears to be a limiting condition for use of the present rather stiff rod tip (See drawing H-1-22069) from the standpoint of binding forces. In addition, preliminary calculations indicate that the bending stresses in the rod tip are close to the yield point of the material (6063-T5 aluminum) with 3.5" to 4" channel distortion. With two exceptions it is anticipated that flexible tips would be required on the top 14 rods. Assuming the predictions in Table II are correct, No's 10 and 14 should not require flexible tips but No's. 16 and 17 may. If further study proves this to be true, special sleeves, compatible with a flexible rod tip, would be needed since No's 16 and 17 are in an area where ball infiltration is also a problem.

Design of a flexible rod tip section will also include designing appropriate modifications for the step plug and inner rod room sleeve.

The design criteria for this program are:

1. Maximum graphite temperature: 1100 C (5000 Mw power level)
2. Maximum nuclear strength: Goal - 125% of present rod
Mandatory (17) - 50% of present rod.
3. Maximum channel distortion: Vertical - 12 inches
Horizontal - 1 inch
4. Design life: 10 years minimum.
5. Minimize residual reactivity in the rod tip for maintenance.
6. Flexible rod tip shall be compatible with the existing drive and cooling water systems.
7. Flexible rod tip to be adaptable to use at the other reactors with a minimum of modification.
8. Minimize production model cost for flexible rod tips.
9. Poison material to be in solid form as opposed to powder for protection against poison dispersion in case of rod tip rupture.
10. Compatibility to use for by product manufacture is desirable.

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V. PROGRAM ACTIVITY

This program falls into two rather distinct phases - channel renovation and installation of flexible rod tip sections. Channel renovation is planned as the first phase. It offers immediate relief from both problems - ball infiltration and channel distortion. In the case of channel distortion, the relief would be effective for only about one year, however. The severity of the problem requires some remedial measures at the earliest possible time. In addition, channel renovation is the least complex of the two phase from a design standpoint. As presently planned, installation of flexible rod tips would follow channel renovation by about one year, and is intended to provide long range relief from channel distortion problems.

Briefly, the program for accomplishing the work outlined in Part IV consists of the following parts:

- A. Preliminary work including refinement of problem definition and process and functional requirements, preparation of a budget study and preparation of an engineering program document.
- B. Design and develop channel renovation components and tooling.
- C. Laboratory test channel renovation components and tooling.
- D. Test channel renovation on-reactor.
- E. Design a flexible rod tip section and step plug and inner rod room sleeve modifications.
- F. Procure two prototypic rod tip assemblies one for laboratory testing and one for in-reactor testing.
- G. Laboratory test a prototypic rod tip under projected channel distortion conditions.
- H. Design and provide special tip removal facilities and supplemental shielding as may be required.
- I. Test a prototypic flexible rod tip assembly in-reactor.

The attached performance schedule shows the program in greater detail and in the planned sequence.

Design and testing of channel sleeving is essentially complete. A test installation of a sleeve assembly (See drawing H-1-23952) was made at KE Reactor in No. 17 channel in late August, 1962.⁽¹⁸⁾ Borescope inspection of this assembly on February 6, 1963 showed it to be in sound condition except for some wear marks in the top of the sleeves from rod movement. According to record, the rod has operated satisfactorily during this five month period. The final question to be resolved on sleeving is whether to use regular reactor grade graphite as was

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done in the above test and accept the wear or whether to pay a higher cost for a more wear resistant type of graphite. Another inspection of this channel is being planned for May in an effort to determine magnitude of wear. The above question will then be resolved on the basis of functional and economic judgment.

Track block removal tools were developed as a necessary part of the sleeving work. Some refinement of this tooling will be desirable prior to full scale track block removal, however tooling is available which has been proven capable of removing the track blocks from an HCR channel. Manufacturing has initiated and approved Design Change No. 702 authorizing HCR channel sleeving in the lower half of the HCR pattern. Present plans are to sleeve a total of five of the most troublesome channels between the two reactors.

Mechanical Development Operation has in progress development of tooling for installation of spacer plates. This includes 1) a tool to cut a keyway at each side of the bottom of the channel, 2) a tool to notch one side of the channel in the first 12" to 14" (See Figure V) and 3) a tool to insert the plates. A channel mockup is also being fabricated for testing this tooling. The mockup is designed such that it can be expanded for testing flexible rod tips if other facilities such as the N Reactor mockup are not available.

Goal for completion of the tooling development and testing is July, 1962. Thus a test installation of plates in one channel could be accomplished during the zirconium tube outage presently scheduled for August 1963. Tentative plans at this time are to install these plates in No. 1 or 4 KE. Severe binding problems are being experienced with both of these rods.

In order to make the side block spacer plates significantly thinner than the existing track blocks (0.375" vs. 0.860") for added channel clearance, a material with superior strength and abrasion resistance is needed. A graphite material is desirable because of its inherent lubricating properties for rod movement and its nuclear compatibility. Two materials are currently being considered - National Carbon Co. ZTA graphite and polycrystalline graphite impregnated with pyrolytic graphite. The main deterrent with both of these materials is cost. The cost is in the order of five times that for reactor grade polycrystalline graphite however, they provide 25% to 50% greater mechanical strength. Continued effort is being made to find a suitable material at a lower cost.

Preliminary design of a cooled flexible rod tip has been prepared (See drawing SK-1-5678). A 10 ft. long section of this rod is being fabricated for the purpose of testing it in bending. Fabrication and shop scheduling problems have delayed completion of this section. Present schedule shows completion of this work by the end of April, 1963.

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Purchase requisitions have been issued for material to fabricate a full size prototype. These have served to establish cost and availability of the parts. The sheath is the only part presenting a problem of availability. This is primarily due to the size and shape rather than material. It appears that this problem can be circumvented by relatively minor modifications to the purchase specifications. One vendor has indicated informally that he can definitely provide the sheath under a modified specification.

This design concept has the necessary cross section for a flexible rod (a shallow section and relatively low moment of inertia). Calculations indicate that it has a maximum control strength about 125% that of the existing rod and that it has adequate cooling capacity. It also adapts directly to the existing drive and cooling water systems. The high temperature metal sheath is desirable to avoid loss of mechanical strength in service. Although the technique of hydraulically expanding the cooling tubes within the assembly is unproven, it appears to have considerable merit for improved heat transfer.

There are, however, significant problems inherent in this specific design. The sharp return bends in the cooling tubes have proven difficult to make and significant thinning of the tube wall on the outside of the bend is inevitable. In light of the well substantiated problem of corrosion of aluminum by reactor process water at elevated temperatures, this wall thinning is highly undesirable. Bid information on component parts for prototype rods indicates that this rod might be quite expensive. One major influence on cost appears to be the large number of individual poison pieces. Titanium as a sheath material has the disadvantage of high material cost, relatively high residual reactivity and a potential for embrittlement by nitrogen or hydrogen atmosphere at elevated temperatures. Inconel is being considered as an alternate for sheath material. It has good high temperature properties, it is a less exotic and costly material and is not affected by nitrogen or hydrogen atmosphere. The residual reactivity appears to be somewhat less than that of titanium. Inconel has been used extensively in nuclear and general industrial applications with no gross deficiencies evidenced.

Design of a flexible rod requires considerable further effort in the area of analyses of component thermal expansion, cooling tube stresses, flexibility, bending endurance and force required to drive it through a distorted channel.

Current plans are to revise the cooled rod design to incorporate a plenum cooling water return section, fewer individual poison pieces and an Inconel instead of titanium sheath. Off-site fabrication of rod prototypes is also being considered. This has the advantage of providing a known source of supply at the time a rod concept is proven.

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Feasibility of an uncooled metal sheathed or solid metal rod is being investigated, also. Several new materials developed in aero-space and jet engine work offer some promise for this application. Design Analysis, NRD is currently analyzing the temperatures that such a rod would experience. If feasible, an uncooled rod offers considerable incentive from the standpoint of simplicity of design, low cost, functional integrity and mechanical flexibility.

This program will include provisions for any special HCR tip removal facilities and supplemental shielding which may be necessitated by higher residual reactivity of the new rod tip compared to the existing rod tip.

Arrangements have been made to obtain additional on-pile data to supplement the meager information available to describe existing HCR channel profile in both vertical and horizontal planes. VSR channels No. 29 and 63 have been traversed at both reactors and the field data is being compiled. It appears that a maximum bowing of about 3/4 inch exists in the HCR channels in the front to rear direction. Elevation traverses of the No. 1, 3 and 4 "B" or "C" test holes is planned at KE in May. This information will provide a more accurate picture of the near to far stack distortion profile in the vertical plane.

A budget study (14) for FY 1965 for HCR system rehabilitation has been prepared and issued.

Attached is a summary performance schedule for HCR system rehabilitation at the K Reactors. The chart shows a summary of the estimated performance schedule for the entire program through full scale installation. This schedule calls for completion of preliminary engineering and testing for channel renovation by 11-1-63 and for a flexible rod tip by 8-1-64. A study of the work involved shows that this is an extremely stringent schedule, however, the seriousness of the problem warrants a concerted effort to meet such a schedule.

VI. PRELIMINARY ENGINEERING COSTS

Estimated preliminary engineering costs are:

Development of tooling	\$ 15,000
Test Facility	10,000
Testing	10,000
Work Orders (Shop)	4,000
Work Orders (Craft)	6,000
Procurement (3 rod tips and 1 step plug and 1 set spacer plates)	26,000
Drafting	4,000
Engineering Design (1.25 man-years)	20,000
Travel and Living Expense	2,000
Consultation	4,000
	<hr/>
Sub-Total	\$101,000
Contingency	9,000
	<hr/>
TOTAL	\$110,000

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Of this total, approximately \$30,000 has already been committed. An additional expenditure of \$10,000 in FY 1963, \$60,000 in FY 1964 and the balance of \$10,000 in 1965 is anticipated.

VII. ACKNOWLEDGMENTS

The general climate of willing cooperation on the part of Operations, Research and Engineering and fellow Facilities Engineering personnel in supporting this program is gratefully acknowledged. The preliminary work done by the late E. Hollister, Reactor Design, FEO has been a valuable assistance in formulating this program.

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Reactor Design

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VERTICAL BOWING MEASUREMENTS
KW REACTOR
VERTICAL DISPLACEMENT
VS.
DISTANCE FROM FACE

DRAWN ON: 4-9-63

DRAWN BY: D.M. FRIELING

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GRAPHITE
PACKING

CHANNEL TRACK BLOCK

END OF HCR
CHANNEL

RAVERSE ON NO. 1 HCR
CORDED ON 1-4-62

RAVERSE ON NO. 4 HCR
CORDED ON 9-18-62

20 22 24 26 28 30 32 34 36 38 40 42 44 46

FROM REACTOR FACE
SIDE [FEET]
1/2 INCH

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FIGURE III

"A"

"B"

"C"

FIGURE IV
HCR CHANNEL SECTIONS
K REACTION

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to avoid interference problems at the thermal shield, later will be inserted in a diagonal position until they are aligned with the side of the block. The shield will then be drawn to a horizontal position on the bottom of the channel and secured into the levers. The last plate will lock the block in place against the rear end of the lever and side block notch.

HCR CHANNEL MODIFICATIONS FOR
GRAPHITE PLATES IN REFLECTORS.

REF 4-12-53

V. INNER & OUTER ROD ROOM

[illegible]

GENERAL NOTES
1. ROD LOCATIONS SHOWN ARE NOMINAL, FOR CONSTRUCTION
LOCATION SEE H-1-21,408.

AS-BUILT DRAWING
ENGINEERING DEPARTMENT
DATE: 10/1/82
BY: [Signature]

[illegible]

U. S. ATOMIC ENERGY COMMISSION
HANFORD WORKS
GENERAL ELECTRIC

HORIZONTAL ROD OPERATING DIAGRAM

PROJECT TITLE	100K REACTOR FACILITIES
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BLOG. NO.	105 K	DWG. NO.	H-1-22.000	SHEET NO.		INCHES	
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EQUIP. PC. NO 105K-160

NAME

QTY.	REV.	DESCRIPTION	MATERIAL	DWG. NO. OR CAT. NO.
X	1	ASSEMBLY		
1	2	SPRING GUIDE		H-1-23952 P-2
1	3	SPRING SEAT		H-1-23952 P-3
1	4	COMP. SPRING		H-1-23952 P-4
2	5	ROLL PIN # 59-277-375-2500 C STL		H-1-23952 P-5
2	6			
3	7	PIN $\frac{3}{8}$ DIA	SST 300 SERIES	H-1-23952 P-6
1	8	SLEEVE		H-1-23952 P-7
29	9	SLEEVE		H-1-23952 P-8
1	10	SPACER PLATE		H-1-23952 P-9
1	11	PLUG		H-1-23952 P-10

NOTES

1. END SPACER PLATE IN EXISTING STEP PLUG IS TO BE REPLACED WITH NEW END PLATE AS CALLED FOR ON THIS DWG
2. REMOVE ALL BURRS & BREAK ALL SHARP EDGES

SECTION C-C'

H-1-23952 2

SECTION C-C

9 H-1-33119 HCR SLEEVE PLUG							CHECKED	DATE	12/1/64	SCALE	NONE	APPROVED FOR CONST.	DATE	12/1/64	U. S. ATOMIC ENERGY COMMISSION	
8 H-1-23952 HCR GRAPHITE SLEEVE UET							DATE	12/1/64	SCALE	NONE	APPROVED FOR PURCHASE	DATE	12/1/64	LANFORD ATOMIC PRODUCTS OPERATION		
7 H-1-27070 HOR ROD TIP SECTION ASSY DET							DATE	12/1/64	SCALE	NONE	APPROVED FOR DESIGN	DATE	12/1/64	GENERAL ELECTRIC		
6 H-1-21403 BASIC PROCESS AREA DIMS							DATE	12/1/64	SCALE	NONE	APPROVED FOR CONST.	DATE	12/1/64			
5 H-1-21702 THERM SHIELD CL SIDE ARRET							DATE	12/1/64	SCALE	NONE	APPROVED FOR PURCHASE	DATE	12/1/64			
4 H-1-21411 R. SIDE PACKING BLOCK EL							DATE	12/1/64	SCALE	NONE	APPROVED FOR DESIGN	DATE	12/1/64			
3 H-1-21444 Y. PACKING BLOCK ARRET PLAN							DATE	12/1/64	SCALE	NONE	APPROVED FOR CONST.	DATE	12/1/64			
2 H-1-21770 THERM CY BLOCK S-30							DATE	12/1/64	SCALE	NONE	APPROVED FOR PURCHASE	DATE	12/1/64			
1 H-1-22010 H-R STEP PLUG ASSY							DATE	12/1/64	SCALE	NONE	APPROVED FOR DESIGN	DATE	12/1/64			
REV. NO.							DRAWING TITLE							HCR GRAPHITE SLEEVE & COMPRESSION ASSEMBLY		
REV. DATE							DRAWN							195 RE 1900		
APP'D BY							CHECKED							H-1-23952		
POB							DATE							12/1/64		
DATE							SCALE							NONE		
NEXT USED ON							DATE							12/1/64		

NO.	DESCRIPTION	REV.	DATE	APP'D BY	POB	DATE	REFERENCE DRAWINGS	DATE	REV.	DATE	REV.	DATE
2	Q) DELETED NOTE 2 B11 B) CHGD PT. 7 ZALL A) DELETED DIMS 2 1/8" & 2 1/4" PART NR 11 PARTS NR 8 & 9 (b) ADD (b) REMOVE "HOLD" FROM	1	12/1/64	12/1/64	12/1/64	12/1/64	H-1-33119 HCR SLEEVE PLUG H-1-23952 HCR GRAPHITE SLEEVE UET H-1-27070 HOR ROD TIP SECTION ASSY DET H-1-21403 BASIC PROCESS AREA DIMS H-1-21702 THERM SHIELD CL SIDE ARRET H-1-21411 R. SIDE PACKING BLOCK EL H-1-21444 Y. PACKING BLOCK ARRET PLAN H-1-21770 THERM CY BLOCK S-30 H-1-22010 H-R STEP PLUG ASSY	12/1/64	1	12/1/64	12/1/64	12/1/64
1	Q) DELETED NOTE 2 B11 B) CHGD PT. 7 ZALL A) DELETED DIMS 2 1/8" & 2 1/4" PART NR 11 PARTS NR 8 & 9 (b) ADD (b) REMOVE "HOLD" FROM	1	12/1/64	12/1/64	12/1/64	12/1/64	H-1-33119 HCR SLEEVE PLUG H-1-23952 HCR GRAPHITE SLEEVE UET H-1-27070 HOR ROD TIP SECTION ASSY DET H-1-21403 BASIC PROCESS AREA DIMS H-1-21702 THERM SHIELD CL SIDE ARRET H-1-21411 R. SIDE PACKING BLOCK EL H-1-21444 Y. PACKING BLOCK ARRET PLAN H-1-21770 THERM CY BLOCK S-30 H-1-22010 H-R STEP PLUG ASSY	12/1/64	1	12/1/64	12/1/64	12/1/64

SUPPLEMENTARY SCOPE INFORMATION:

1 ASSEMBLY 2 24" BORON CARBIDE 3 24" BORON CARBIDE 4 24" BORON CARBIDE 5 24" BORON CARBIDE 6 24" BORON CARBIDE 7 24" BORON CARBIDE 8 24" BORON CARBIDE 9 24" BORON CARBIDE 10 24" BORON CARBIDE 11 24" BORON CARBIDE 12 24" BORON CARBIDE 13 24" BORON CARBIDE 14 24" BORON CARBIDE 15 24" BORON CARBIDE 16 24" BORON CARBIDE 17 24" BORON CARBIDE 18 24" BORON CARBIDE 19 24" BORON CARBIDE 20 24" BORON CARBIDE 21 24" BORON CARBIDE 22 24" BORON CARBIDE 23 24" BORON CARBIDE 24 24" BORON CARBIDE 25 24" BORON CARBIDE 26 24" BORON CARBIDE 27 24" BORON CARBIDE 28 24" BORON CARBIDE 29 24" BORON CARBIDE 30 24" BORON CARBIDE 31 24" BORON CARBIDE 32 24" BORON CARBIDE 33 24" BORON CARBIDE 34 24" BORON CARBIDE 35 24" BORON CARBIDE 36 24" BORON CARBIDE 37 24" BORON CARBIDE 38 24" BORON CARBIDE 39 24" BORON CARBIDE 40 24" BORON CARBIDE 41 24" BORON CARBIDE 42 24" BORON CARBIDE 43 24" BORON CARBIDE 44 24" BORON CARBIDE 45 24" BORON CARBIDE 46 24" BORON CARBIDE 47 24" BORON CARBIDE 48 24" BORON CARBIDE 49 24" BORON CARBIDE 50 24" BORON CARBIDE 51 24" BORON CARBIDE 52 24" BORON CARBIDE 53 24" BORON CARBIDE 54 24" BORON CARBIDE 55 24" BORON CARBIDE 56 24" BORON CARBIDE 57 24" BORON CARBIDE 58 24" BORON CARBIDE 59 24" BORON CARBIDE 60 24" BORON CARBIDE 61 24" BORON CARBIDE 62 24" BORON CARBIDE 63 24" BORON CARBIDE 64 24" BORON CARBIDE 65 24" BORON CARBIDE 66 24" BORON CARBIDE 67 24" BORON CARBIDE 68 24" BORON CARBIDE 69 24" BORON CARBIDE 70 24" BORON CARBIDE 71 24" BORON CARBIDE 72 24" BORON CARBIDE 73 24" BORON CARBIDE 74 24" BORON CARBIDE 75 24" BORON CARBIDE 76 24" BORON CARBIDE 77 24" BORON CARBIDE 78 24" BORON CARBIDE 79 24" BORON CARBIDE 80 24" BORON CARBIDE 81 24" BORON CARBIDE 82 24" BORON CARBIDE 83 24" BORON CARBIDE 84 24" BORON CARBIDE 85 24" BORON CARBIDE 86 24" BORON CARBIDE 87 24" BORON CARBIDE 88 24" BORON CARBIDE 89 24" BORON CARBIDE 90 24" BORON CARBIDE 91 24" BORON CARBIDE 92 24" BORON CARBIDE 93 24" BORON CARBIDE 94 24" BORON CARBIDE 95 24" BORON CARBIDE 96 24" BORON CARBIDE 97 24" BORON CARBIDE 98 24" BORON CARBIDE 99 24" BORON CARBIDE 100 24" BORON CARBIDE

DECLASSIFIED

Page 24

DECLASSIFIED

SECTION 'G-G'

SECTION A-A'
BELY (1) AS SHOWN

SECTION D.D.

SECTION E-E'

AS-BUILT DRAWING
 GENERAL ELECTRIC COMPANY
 ENGINEERING DEPARTMENT
 PROJECT 100-100000 DATE 10/1/60
 DESIGN _____ DATE _____
 CERTIFIED-REV NO. 6

B. Where Long 3-5-53
C. [illegible] 3-1-53
[illegible] 3-5-53
R. [illegible] 3-5-53

AS-BUILT DRAWING
 GENERAL ENGINEERING COMPANY
 ENGINEERING DEPARTMENT
 PROJECT _____ DATE _____
 DESIGN _____ DATE _____
 CERTIFIED-REV NO. 5 KM

ALL PROFITS ARE THE PROPERTY
OF THE UNITED STATES GOVERN-
MENT AND IT IS IMPERATIVE THAT
THEY BE RETURNED.

A circular stamp with the text "FOR CONSTRUCTION" at the top and "FOR G.E." at the bottom. In the center, it says "APPROVED" followed by a handwritten signature and the date "Apr 4 5/12/54".

GENERAL NOTES:

- REMAINDER 85% MAGNESIA CEMENT.
- GENERAL NOTES:
1. UNLESS OTHERWISE SPECIFIED:
- TOLERANCES ON FRACTIONAL DIMENSIONS ARE $\pm \frac{1}{16}$
- TOLERANCES ON DECIMAL DIMENSIONS ARE $\pm .003$
- TOLERANCES ON ANGULARITY $\pm$
- FINISHES SHALL BE IN ACCORDANCE WITH SPEC. 8-46.1-1983
2. STRAIGHTNESS TOLERANCE .020 IN 4" NON-ACCUMULATIVE.
3. 250 P.S.I. HYDROSTATIC PRESSURE TEST FOR 1 HR., NO LEAKAGE ALLOWABLE.
4. ALL WELDING TO BE INERT GAS SHIELDED ARC.
5. FILLER ROD TO BE 405 ALUMINUM.
6. PARTS (2/4/5) TO BE CONCENTRICALLY ALIGNED WITHIN .010 T.I.R.
7. UNLESS OTHERWISE NOTED, APPLY MOLYKOTE TYPE "2" TO ALL MATE THREADS.
8. A13.1: TYPE 16, ACCORDS TO ASTM (A13.1-91) HEAT TREAT TO 950/925 °F. MIN. ELEVATION 15'
9. INTERIOR OF ROD MUST BE THOROUGHLY DRIED IMMEDIATELY AFTER PRESSURE TEST. SUGGEST METHOD OF DRYING WITH ACETONE AND PURGE AIR TO 400 °F.
- EQUIP. DC NUT 105X-

AS BUILT

[illegible]

FOR CONTINUATION OF
ROD SEE H-1-22,069 SHEET 2

5	CHG'D FOR ALJURY FOR KTW. 1975 WAS LOCK WASH/STC-2046	APR 11-25-59	Byrd	De	
4	BYRONA BUS 10 (1014 RUMBLE) BA1163 (4) WAS 1180 CLEANUP R-3259	10/12/13	PHC DSD	Byrd De	
3	BY ST P 34 B-2700 P-30, P-30 FERRALIN APPROX P-11 18 30" A-3205	2004-04-21	PHC DSD	Byrd De	
2	BY ST P 34 APPROX P-11 18 30" A-3205	11/16/13	PHC DSD	Byrd De	

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[illegible]

U. S. ATOMIC ENERGY COMMISSION
HANFORD WORKS
1900 GENERAL ELECTRIC 2

HORIZONTAL ROD ASSEMBLY.

PROJECT TITLE			
100K REACTOR FACILITIES			
SHEET NO.	DWG. NO.	SHEET NO.	
NO. 105K	NO. H-1-22,069

- MATERIALS**
- ALL MATERIALS TO BE SUITABLE FOR USE IN A NUCLEAR REACTOR.
1. TITANIUM - COMMERCIAL PURE GRADE 55,000 P.S.I. YIELD (MIN)
 2. BORON BUTTONS ARE A SINTERED BRIQUETTED COMPOSITION OF B_4C AND 25 ALUMINUM.
 3. ALUMINUM BUTTONS.
 4. ALUMINUM TUBING IS UNBROKEN LENGTH OF GRADE 1100.

- ASSEMBLY PROC**
1. FORM AND SEAM WELD TITANIUM SHELL.
 2. WELD TIP TO SHELL.
 3. ASSEMBLE ALUMINUM COOLING TUBES ROLL EXPANDING.
 4. ASSEMBLE ITEM 3 WITH ALUMINUM TIP ALUMINUM BUTTONS INTO ITEM 2.
 5. WELD SHELL TO TITANIUM BLOCK.
 6. INSTALL ALUMINUM PLATE WITH BOLTS TUBES AND GAS VENT.
 7. PRESSURIZE HYDROSTATICALLY WITH SHELL SECTION.
 8. INSTALL ALUMINUM BAFFLE, AND SEAL WELD.
 9. INSTALL SLEEVE AND WELD TO PLATE.
 10. INSTALL COLD MANIFOLD TUBE AND GAS VENT WELD, SLIDE TRANSITION SHELL OVER.
 11. WELD COLD MANIFOLD TUBE AND GAS VENT SHELL TO BAFFLE AND WELD TO BAF.
 12. PURGE TIP SECTION WITH HELIUM.

6	7	8	9	10	11	12
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QTY.	UNIT	DESCRIPTION
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ON BB

SECTION C-C
FULL SCALE

REDUCE
L.
TO TITANIUM BLOCK BY
BLOCK, BORON BUTTONS AND
S AND SEAL WELD COOLING
TURE TO EXPAND TUBES IN
D TO COOLING TUBES AND GAS VENT.
AND BAFFLE.
T IN CONNECTOR BLOCK, SEAL
CONNECTOR BLOCK.
TO BAFFLE, SLIDE TRANSITION
E AND CONNECTOR BLOCK.
ND SEAL VENT HOLE IN TIP

SK-I-5678 10

SCOPE

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DATE

FILMED

7/27/94

END