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DESIGN STUDY FOR A GRAPHITE-MODERATED GAS-COOLED REACTOR USING PARTIALLY ENRICHED URANIUM

By

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INTRODUCTION

In September 1957 the United States Atomic Energy Commission undertook as part of its Reactor Development Program a serious study of gas-cooled reactors for power production. The purpose of this study was to present to the Congress a specific set of conclusions concerning the possible role of gas-cooled reactors in the United States together with a set of recommendations which would constitute a national program for gas-cooled reactor development.

In order to evaluate the studies which have been made by Kaiser Engineers, General Electric Company-Hanford, and the Oak Ridge National Laboratory, it is necessary, first of all, to understand the historical development of the American attitude on gas-cooled reactors. The very first U. S. studies of gas-cooled reactors were in connection with the original plans for plutonium production at Hanford. In the early days of the Metallurgy Laboratory at Chicago, after the chain reaction has been demonstrated experimentally, the reactor design program was based on the utilization of gas cooling for plutonium production. It was only after the painstaking work of the group under the direction of Dr. Eugene Wigner that it became apparent that natural-uranium, graphite-moderated, plutonium-production reactors could be successfully water cooled. Since it was possible to utilize lower temperatures and conventional materials in a water cooled system, the original plan to build gas-cooled plutonium-production reactors was set aside. It must be emphasized that the gas-cooled reactor design work at Chicago was carried out in a thoroughly responsible fashion and the plans for gas cooling were only laid on the shelf when it became completely clear that water offered a surer route for achieving large scale production of fissionable material. Since 1943 there has been only one other serious study of gas-cooled reactors for power production in the United States, the ill-fated Daniel's Power Pile project

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at Oak Ridge immediately following the war.

Generally speaking, gas-cooled systems have received hardly more than casual attention because the early studies seemed to indicate that it is difficult to achieve sufficiently high power densities in these reactors to be interesting. This notion has remained firmly planted in American nuclear energy thinking up to the present time.

The studies referred to above are the most up-to-date and thorough going studies which gas-cooled reactors have had in the United States during the past twelve years. As a result of the British and French success with gas-cooled systems, a sufficient technology now exists on which to base firm estimates of the present performance and future potential of gas-cooled systems in the United States. In the light of twelve years additional experience we now know that the popular notion of the limitations and economics of gas-cooled reactors are not adequately true in detail to permit rejecting out-of-hand gas-cooled reactors for power production.

It is the purpose of this paper to establish the basis for these general conclusions and to summarize the research and development aspects of the U. S. gas-cooled reactor program. Finally, an attempt will be made to evaluate the future potential of gas-cooled reactors as compared with other reactor types which are presently part of the U. S. reactor development program.

REACTOR DESIGN

The classical argument against gas-cooled reactors has been that gases are such poor heat transfer media, when compared with liquids, that gas-cooled reactors will have very low power densities and hence high unit capital costs. It has always been recognized that natural-uranium-fueled gas-cooled stations have very low fuel and operating charges associated with them as has been borne out by the experience in the British stations. One possible way of achieving a substantial improvement over existing gas-cooled reactor stations is to employ partially enriched uranium as the fuel for such reactors. It is certain that the utilization of enriched fuel will reduce the capital costs of a gas-cooled station, but it is not obvious in advance how the utilization of enriched fuel affects the economics associated with the fuel cycle itself. On the basis of the previously mentioned design studies, the United States has decided to concentrate its entire research and development program in the area of gas-cooled graphite-moderated systems on reactors utilizing partially enriched uranium fuel.

There are three fundamental limitations on any gas-cooled reactor which must be considered in detail in the design of such a power plant.

1. The basic limitation on the reactor itself stems from the ability of the fuel element to perform over its required lifetime under the operating temperatures, pressures, and radiation conditions. It is necessary in undertaking a first reactor design to provide a larger margin of engineering safety than would be required once some specific operating experience has been obtained with a given

reactor system. Further, future development of improved fuel elements will certainly lead to increased confidence in the predictions of fuel element integrity and lifetime under operating conditions.

2. A second important limitation arises from the chemical behavior of the system of gas, coolant and moderator. Of particular interest here is the oxidation of graphite by CO_2 which sets an upper limit on the gas temperature which can be achieved in a CO_2-cooled graphite reactor. It is likely that further research will eventually succeed in increasing our confidence, that the materials presently under consideration can be operated at the required temperatures for sufficiently long times, or that the materials can be altered so as to increase their reliability and improve their performance.

3. Once the materials have been selected the final limitation on reactor performance results from practical considerations of how large a pressure vessel can be field-constructed, stress-relieved and tested. As time goes on, the capability of the fabrication industries to produce larger diameter and thicker walled pressure vessels, assembled at the site, will improve the economic picture of gas-cooled reactors. From the reactor performance point of view, there will always be an incentive to increase the physical size or the pressure level of a given reactor, thus permitting one to extract more power from a single unit. Accordingly, the present capabilities of the pressure vessel fabricators play an important role in the final design of such a system.

It should be recognized in attempting to judge the development potential of any reactor system, gas-cooled or otherwise, that it is impossible to predict with any degree of certainty how successful a research program will be in providing for improved reactors in the future. The only possible predictions of the success of such research are necessarily based principally on previous experience. With this in mind, the United States indicates its belief that there exist substantial prospects for improving the performance of gas-cooled reactors beyond that predicted in current design studies.

It is most useful to discuss the general properties of such a reactor plant in terms of a specific design. A perspective section through a plant proposed by the Oak Ridge National Laboratory, known as GCR-2, is shown in Fig. 1. Figure 2 gives details of the reactor design.

The site selected for the Oak Ridge National Laboratory study is one which is typical for U. S. power plants, and which meets the nuclear requirement for semi-remoteness, as well as the practical requirements of water transportation, a supporting power network, good construction conditions and an adequate labor force. The most important deviations from standard gas-cooled reactor practice, represented by the design, are as follows:

1. Utilization of stainless steel capsules as the cladding for the fuel (Fig. 3).

2. Utilization of enriched UO_2 as the fuel material (Fig. 4).

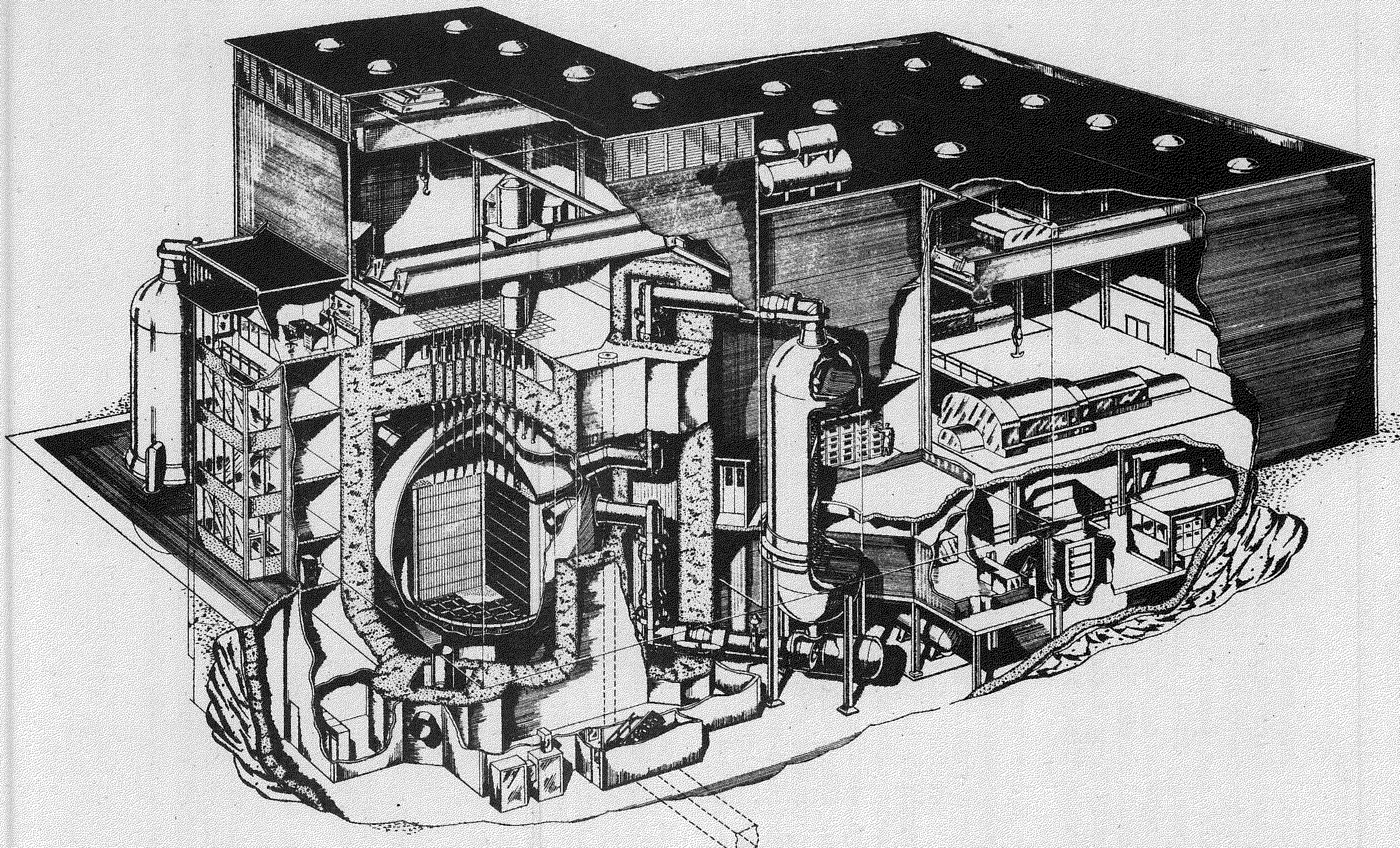

Figure 1. Cutaway Perspective of ORNL Gas-Cooled Reactor Plant (GCR-2).

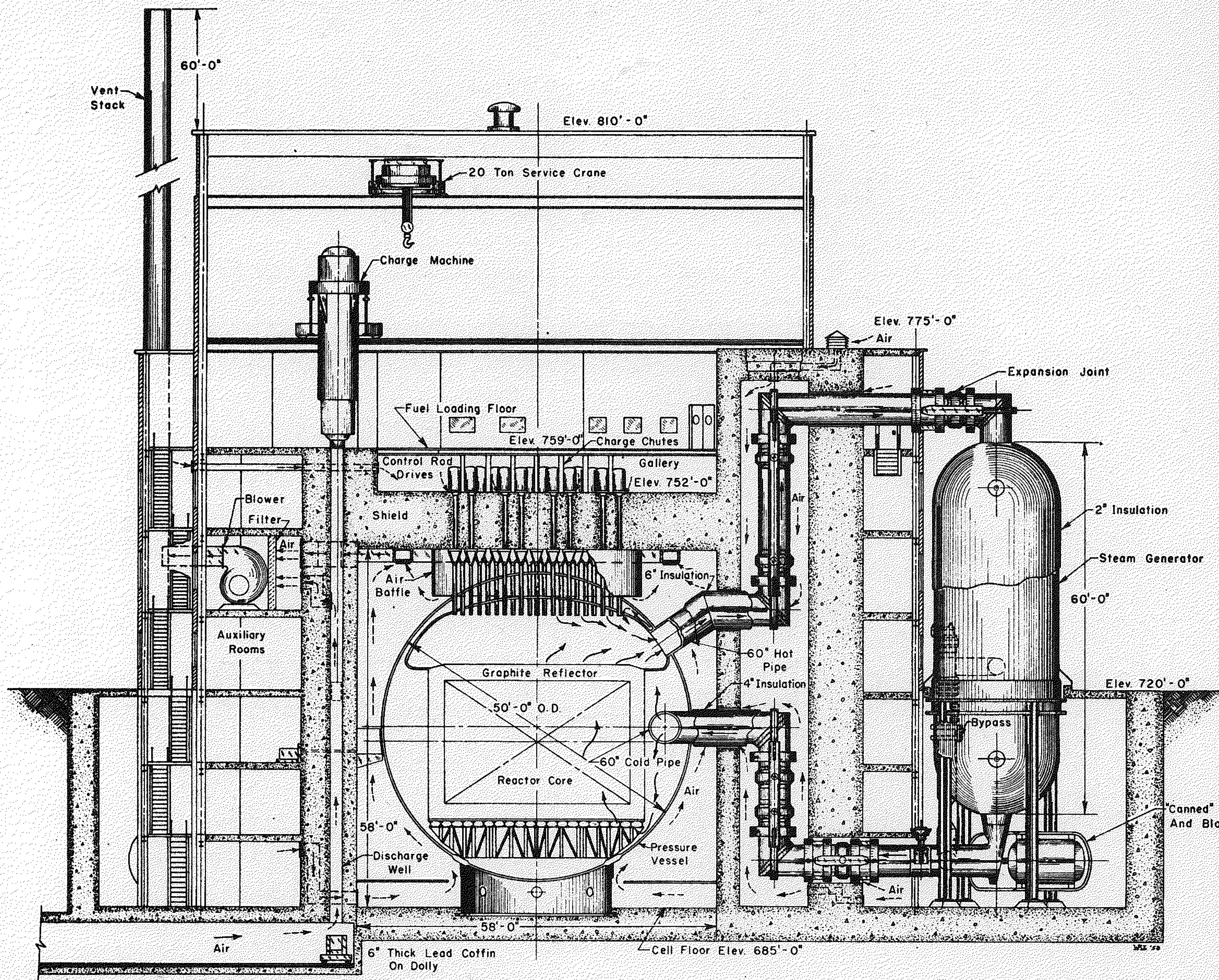

Figure 2. Sectional View Through Reactor and Reactor Bay (ORNL-GCR-2)

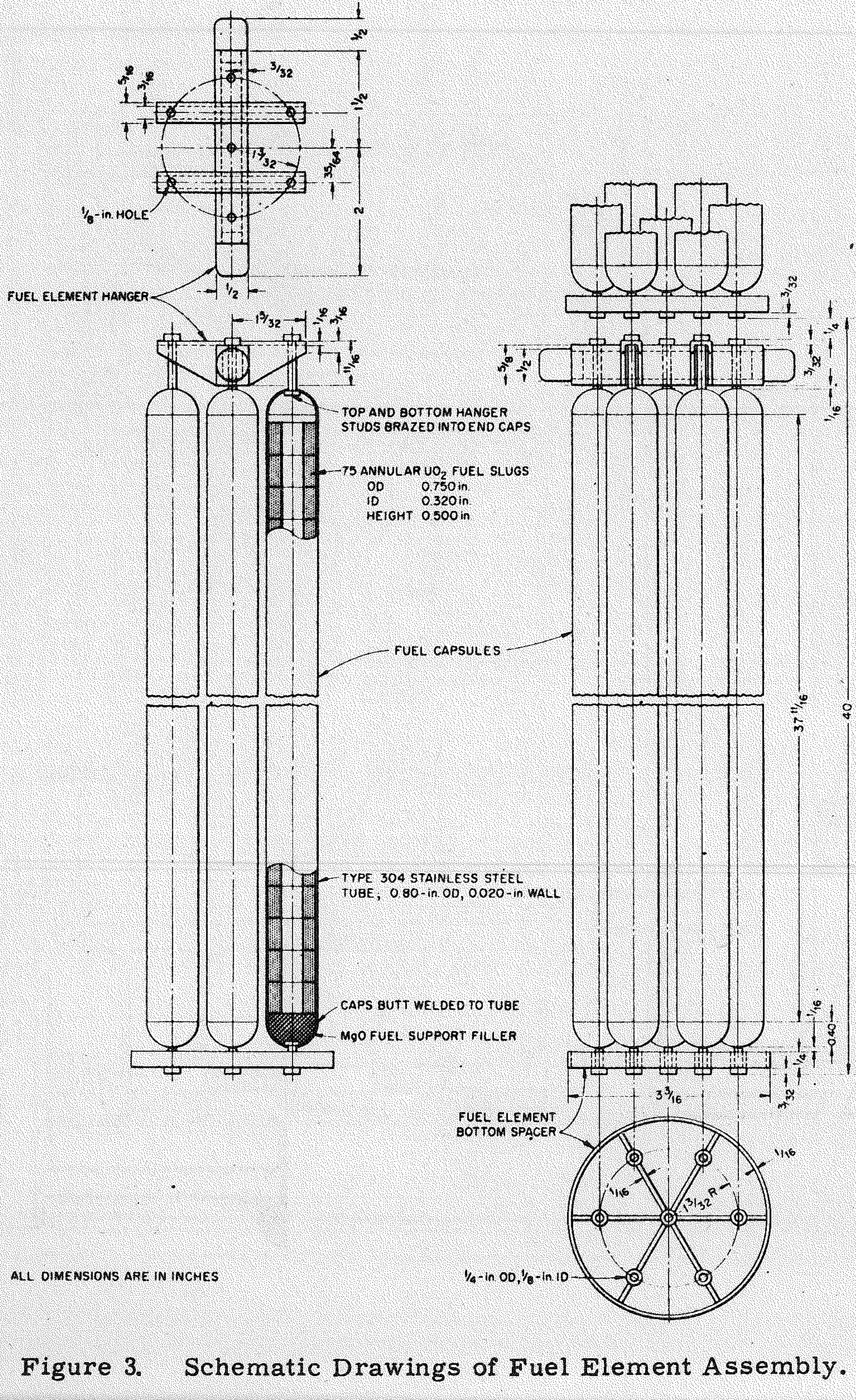

Figure 3. Schematic Drawings of Fuel Element Assembly.

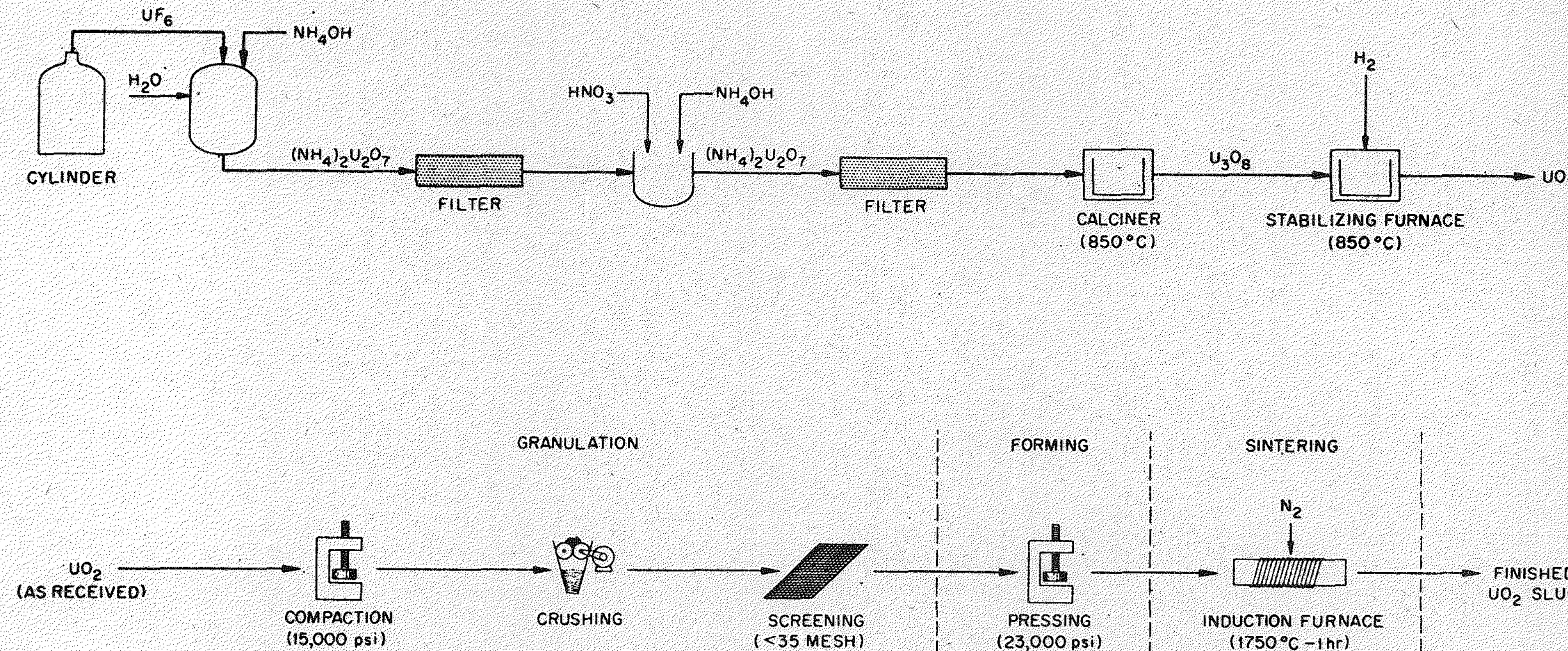

Figure 4. Proposed Flow Sheet for Producing UO_2 from UF_6 for GCR-2 and Fabrication Process Proposed for GCR-2 Fuel.

3. Utilization of helium as the cooling gas.

It is worthwhile to draw specific attention to the effects on reactor performance of the three factors.

1. The principal virtues of stainless steel as a structural material are two in number.

   a. Because of the excellent high-temperature strength of stainless steel, it is possible to raise the temperature of the reactor exit gas, thus improving the over-all heat transfer and thermodynamic performance of the system.

   b. There is no catastrophic oxidation between stainless steel and the important coolants which could initiate a graphite fire.

2. The utilization of enriched fuel is not merely a matter of counteracting the nuclear poisoning effect of stainless steel. Rather the use of enriched fuel has several other important consequences.

   a. The enriched fuel design permits the utilization of UO_2 which is a superior fuel material to natural uranium metal. Uranium dioxide does not suffer the mechanical deformation characteristic of uranium metal in the low-temperature range. At higher temperatures, UO_2 retains most of the fission product gases which are produced without undergoing severe distortion, as does the metal.

   b. By enriching beyond the level required for criticality, it is possible to obtain enough excess reactivity so that the nuclear poisoning effect of the Pu^{240} which is produced can be overcome to the point where Pu^{240} begins to behave as a fertile material through the production of fissionable Pu^{241}. The effect of this over-enrichment is to increase the reactivity lifetime to such an extent that the over-all fuel costs of the enriched gas-cooled reactor become comparable to those of a natural-uranium gas-cooled reactor. In the past the principal argument for building enriched gas-cooled reactors has been to achieve reductions in capital cost. It has always been presumed that the fuel costs associated with enriched systems would be considerably higher than in natural systems. All of the U. S. design studies to date indicate that there is no substantial fuel cost penalty associated with a properly designed enriched reactor system.

   c. The principal economic effect of enrichment is to reduce the over-all capital cost by permitting operation at higher specific power levels. The investment costs/kw fall substantially as the power density of a given sized system is increased, since the capital cost of a large fraction of the over-all power plant is only slightly dependent on power level.

3. It is recognized that the use of stainless steel imposes a severe nuclear penalty on the system which can best be offset by raising

the exit gas temperature of the system. Once the design temperature is substantially higher than the levels in use at Calder Hall and Marcoule, the whole materials system based on CO_2 is suspect, in virtue of the chemical reactions between CO_2 and graphite. In order to circumvent this problem, helium was selected for the coolant in the GCR-2. It is presently planned that the first gas-cooled reactor constructed in the United States will utilize helium as the coolant.

If helium were universally available, it would undoubtedly be the standard coolant for such reactors. The chemical inertness of helium makes catastrophic oxidation of the capsule material, as well as the graphite, almost impossible since only impurities enter into such reactions. Thus, the character of the principal maintenance problem, location and replacement of leaking fuel elements, is greatly simplified.

It is generally felt in the United States that it would be desirable as part of a gas-cooled reactor program to develop a reactor which uses CO_2 as coolant since helium is not available on the world market at the present time. Accordingly a significant part of the over-all research and development programs in support of gas-cooled reactors in the United States is devoted to examining the oxidation reaction between CO_2 and graphite as a function of temperature and radiation exposure. Significant effort is being devoted to the preparation and evaluation of possible coatings for graphite in the hope that the CO_2 graphite materials system can eventually become a sound basis for future high performance gas-cooled reactors.

One of the principal objections to utilization of helium as a reactor coolant is the high cost of helium which imposes an engineering requirement on the design for much-improved leak-tightness over the Calder Hall performance. It is the opinion of Oak Ridge National Laboratory that adequate leak-tightness can be assured by proper design. An over-all system helium-leakage loss of 1% per day, which is more than ten times higher than is achieved in present practice in large gas systems, would result in an increase in net power cost of only 0.05 mills/kwh.

The basic design of the reference power plant is predicated on conventional power-station practice insofar as possible. The plant is designed for base-load operation, with the provision of load-following ability. The reactor is designed to produce a gross thermal power output of 687 Mw. The turbine generator plant will produce a gross electrical power of approximately 250,000 kw at a turbine heat rate of 9458 Btu/kwh. With a net efficiency of 32.8%, the net electrical power output of the power plant is 225 Mw.

ECONOMIC COMPARISONS

Optimization studies described in detail elsewhere[1] form the bases for the selection of the nuclear power plant design. Since the convnetional portion of gas-cooled reactor power plants utilizes modern U. S. steam power practice, it should be possible to construct such plants with a smaller contingency factor than is currently in the vogue for stations utilizing other reactor types and less conventional steam power practice. The capital costs of the GCR-2 are summarized in Table 1. The total direct costs are $47,904,700. The indirect charges when added to the direct costs give a total estimated plant cost of $83,627,300. The indirect charges used were specified by the U. S. Atomic Energy Commission and have been applied to each of the several proposed gas-cooled reactor designs in order to achieve direct comparability of the final costs.

The over-all cost of producing power has been divided in conventional fashion into fixed and operating charges.

Fixed charges include:

1. Capital charges against the cost of the power plant, computed at 14% per year.

2. Capital charges against interest on construction funds (interest computed at 6% per year during construction; capital charges computed at 14% per year).

3. Capital charges against fuel fabrication costs for the first core, computed at 14% per year.

4. Interest charge on initial value of in-pile fuel inventory, computed at 4% per year.

Operating charges include:

1. Fuel burn-up cost, less plutonium credit.

2. Cost of recovering fissionable material from spent fuel ($12.40/kg U).

3. Cost of fabricating replacement fuel elements ($30.90/kg U).

4. Interest charge on fuel inventory held up outside reactor.

5. All other operating and maintenance costs.

Among the important assumptions made in the cost analysis are the following:

1. Annual charges against the fixed investment in the plant (exclusive of fuel inventory) are 14% of the investment. This rate includes return to the investors, corporate income tax, amortization of principal, ad valorem taxes, and insurance.

TABLE 1

CAPITAL COSTS ORNL GCR-2 EXCLUDING FUEL ELEMENTS

Land and land rights	$ 450,000
Structures and improvements	7,695,000
Reactor system	19,414,700
Steam system	3,349,000
Turbine generator plant	12,030,000
Accessory electrical equipment	4,091,000
Miscellaneous power plant equipment	875,000
Direct Costs Subtotal	$ 47,904,700
Indirect Costs (15% of Direct Costs)	$ 7,185,700
Subtotal	$ 55,090,400
Escalation at 6%/yr from 1-1-58 to 7-1-60 on direct costs and indirect costs	8,263,600
Subtotal	$ 63,354,000
Contingency (20% of direct costs and indirect costs and escalation)	12,670,800
Design - including contingency (12% direct costs and indirect costs and escalation)	7,602,500
TOTAL COST	$ 83,627,300

2. Annual interest, or rental, charges for the fuel are 4% of the initial value of the fuel. This rate is firmly established by the U. S. Atomic Energy Commission.

   It should be emphasized that this low arbitrary interest rate which has been specified by the U. S. Atomic Energy Commission strongly influences any decision based on the relative economics of gas-cooled reactors. The comparison of large-fuel inventory systems typified by the GCR-2 with the more compact highly enriched systems which have low-fuel inventories is partially dependent on the interest charges assumed to apply to the fuel. If the interest rate were significantly higher than 4% it could influence such comparisons.

3. Plant load factor is 0.80. It is assumed that this plant would be a base-load plant.

4. A value of $12/g is assigned to the plutonium content in spent fuel. This is an approximate value established by the U. S. Atomic Energy Commission as the worth of plutonium as a reactor fuel (without regard to its isotopic composition). It is possible that a lower figure would be more realistic if the value of plutonium is to be determined exclusively for thermal reactors.

5. It is assumed that progress payments which will be necessary as construction proceeds are equally spaced over the construction period, 14% of the appropriate capital cost must then be added to the annual fixed costs of the plant.

6. It has been assumed that construction costs rise 6% per year. For a three-year construction period from 1959 to 1961, an average end escalation date of mid-1960 was chosen, in view of the uniformly spaced progress payments assumed previously.

It is of interest to compare the GCR-2 design with recently constructed United States fossil fuel plants of approximately the same thermal rating. A relative analysis of the GCR-2 and such plants is presented in Table 2. Table 2 lists an escalated cost column for each of the fossil fuel plants which takes account of the increase in construction costs since the date of completion of these plants. Although the GCR-2 is not competitive with these modern steam plants, it should be noted that the GCR-2 is at least as competitive as recent studies have shown the best pressurized-water reactors to be.

FUTURE OF GAS-COOLED REACTORS IN THE UNITED STATES

Although the slightly enriched versions of the gas-cooled reactor which have been described above appear to be strictly competitive with the best pressurized water reactors in the United States, it cannot be conclusively proved at present that they are superior to reactor types which are more fully developed in the United States at the present time. Thus, any argument in favor of undertaking a major program for the development of gas-cooled reactors must rest on the prospect that practical reactor systems of much improved performance appear possible with a reasonable amount of research and development.

TABLE 2

COMPARISON OF COST AND PERFORMANCE DATA FOR TYPICAL COAL-FIRED POWER PLANTS* WITH CORRESPONDING DATA FOR THE ORNL GCR-2

Plant Designation (ORNL or Electrical World)	GCR-2**	303(218)		304		305	
GENERAL DATA							
Total generator rating - Mw	252	262		275		230	
Date of construction	1958	1954		1955		1954	
Thermal efficiency, over-all	32.8	32.48		37.22		33.98	
Steam pressure, psig	950	900 and 1450		2050		1475 and 1825	
Steam temperature, initial superheater °F	950	950 and 1000		1050		1010	
(Reheat) °F	---	1000		1000		1010	
Plant factor, %	80	80.85		87.7		89.4	
INVESTMENT DATA ($/kw)	(Base)	(Base)	(Escalated)***	(Base)	(Escalated)***	(Base)	(Escalated)***
(310) Land	3.12	0.43	0.43	4.93	4.93	0.49	0.49
(311) Structures and improvements	53.33	35.27	44.70	40.02	47.70	33.56	41.20
(312) Boiler or reactor plant	157.60	60.62	76.70	52.82	63.00	64.72	81.90
(314) Turbine generator plant	83.25	39.24	49.70	38.07	45.40	42.20	53.40
(315) Accessory elect. system	28.32	7.51	9.51	9.75	11.64	12.88	16.31
(316) Miscellaneous plant equipment	6.06	1.53	1.94	1.97	2.35	2.00	2.53
TOTAL	331.68	144.60	182.98	147.56	175.02	155.85	195.83
Total less reactor or boiler	174.08	83.98	106.28	94.74	112.02	91.13	113.93
COST OF ENERGY (mills/net kwh)							
Fixed Charges							
a. Plant costs	7.42	2.93	3.86	3.353	4.43	3.319	4.48
b. Computed at (%)	14.0	13.6	14.0	12.61	14.0	15.0	14.0
c. Fuel inventory at 4%	0.76						
d. Fuel element fab. at 14%	0.38						
TOTAL - Fixed	8.56	2.93	3.86	3.35	4.43	3.32	4.48
OPERATING COSTS (mills/net kwh)							
Wages (including supervision)	0.38	0.25		0.38		0.18	
Water, lubrication, supplies	0.25	0.03		0.15		0.004	
Maintenance	0.26	0.15		0.21		0.066	
Total, operating and maintenance (excluding fuel)	0.89	0.43		0.74		0.25	
Fuel	1.73	2.78		2.73		2.97	
Total operation (including fuel)	2.62	3.21		3.47		3.22	
Total cost of energy	11.18	6.14	7.07	6.82	7.90	6.54	7.70

*Base data for coal-fired plants from "Electrical World," (October 7, 1957).

**All costs except land and operating costs were escalated to a 1958 base at 6% per year compounded semiannually, and fixed charges were computed at 14% for an 80% load factor.

***The GCR-2 data herein differ from those quoted in ORNL-2500, Sections 1 and 11. This resulted from a last-minute change of ground rules for economic evaluation of the various gas-cooled reactor designs. The U. S. Atomic Energy Commission requested these changes in order to achieve comparability between reports.

The approaches that have been suggested for achieving much improved performance are quite numerous. They have in common the difficulty that they all involve more or less substantial extrapolations of existing technology, and that in general the possible disadvantages have been investigated with less care than the possible advantages. Promising possibilities include the following:

1. Fuel elements capable of operating with very high surface temperatures, i.e., 2000°F or higher. Most of the suggestions for improved gas-cooled reactors stem from some variation of this approach. They include a) graphite-clad uranium-oxide fuel elements; b) uranium-carbide-impregnated graphite fuel elements; c) homogeneous cores of graphite, beryllium-oxide, or beryllium impregnated with uranium or one of its compounds, either as a solid block with regular cooling channels, as a bed of small spherical elements, or as a suspension in the coolant; and d) ceramic fuel elements such as silicon carbide or beryllium oxide.

2. Direct power recovery cycles, which eliminate the need for heat-exchange equipment between the heat source and the thermal-electrical converter.

   In a non-condensing system, as would be the case with He, N_2, or CO_2, a direct gas turbine cycle, because of pressure drop in the reactor, intercoolers, etc., will be attractive only if the fluid is heated to at least 1400°F which therefore inherently implies one of the fuel element developments listed under item 1 above. A condensing system such as steam, can be based on materials already at hand. Such a condensing cycle is already under serious study at Nuclear Development Corporation of America.

3. Improved neutron economy, which may result in very long fuel irradiations, or in negligible costs for fuel enrichment; in either case, the objective is to reduce the fuel cycle costs as closely as possible to the minimum set by the cost of raw uranium. These considerations are, of course, at the heart of Canada's approach to nuclear power. They lead quite naturally to consideration of D_2O as a moderator, and perhaps less obviously, to beryllium as a cladding material. Whether gas-cooled D_2O moderated reactors will prove to be superior to D_2O-cooled and moderated reactors, and whether graphite-moderated reactors with Be-cladding and slightly enriched fuel will be equally attractive are questions that cannot yet be answered definitively in the United States.

4. High pressure gas, which may make possible heat fluxes and power densities comparable to the best liquid-cooled reactors now in operation. The principal considerations involved in this approach have to do with the reactor pressure vessel, valves, piping steam generator, etc. Studies which have been made to date indicate that to the extent that high pressures imply small cores and relatively small total power outputs, this approach is probably not fruitful. The possibilities of high pressure have not been thoroughly exhausted however, and it may be that longer cores or higher temperature surfaces than those studied so far could lead to very attractive performance.

5. Hydrogen gas as a coolant. This possibility is singled out because, while its superior performance is universally recognized, the unique problems associated with the use of hydrogen as a coolant have led to its rejection in practically all previous studies of gas-cooled reactors. The technical problems associated with the use of hydrogen are admittedly difficult, but they do not appear to defy solution, and the matter undoubtedly warrants further experimental investigation.

A very considerable amount of work has been done on conceptual designs of high performance gas-cooled reactors with particular attention being paid to fuel element design and materials compatibility problems. These results are available elsewhere and accordingly will not be discussed in detail here.

SUMMARY AND CONCLUSIONS

On the basis of the studies described above, the following conclusions have been drawn at the present time.

1. An enriched gas-cooled reactor will produce cheaper power in the United States than a natural uranium gas-cooled reactor. This follows from the large reduction in capital costs achieved by enriching the fuel, combined with the fact that no serious penalty is paid in increased fuel costs as a result of fuel enrichment.

2. Gas-cooled reactors are at the present time technologically competitive with the best available pressurized water reactors. This conclusion is based on our estimate of the degree of advancement which has been achieved in general gas-cooled reactor technology both in the United States and abroad, coupled with the observation that a very large fraction of the cost of a gas-cooled reactor plant is devoted to components which represent current practice in the steam power industry. In this important respect, gas-cooled reactor systems utilize modern power practice more closely than any other reactor.

3. It appears that at the present time gas-cooled reactors are economically competitive with the best available pressurized water reactors in the United States.

4. There exists a continuum of possible reactor types within the framework of gas-cooled reactor technology. There are a large number of ways in which the performance of gas-cooled reactors can be substantially improved beyond that presently predicted for the first enriched gas-cooled reactor in the United States. The principal improvements which can be achieved are in higher gas temperatures, improved fuel element performance, and increased lifetime. The additional possibility exists of constructing high conversion ratio systems which would further improve the fuel economy. This is a most attractive possibility since ultimately the central question of nuclear energy development must rest on our ability to utilize efficiently the raw material sources available to us.

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Abstract

The outstanding British success with large graphite-moderated gas-cooled reactors has raised a question as to the proper place for this type of reactor in the United States. The advantages of such reactors include the possibility of using natural uranium, a high conversion ratio, a low power density, with consequent very modest thermal stress and afterheat problems, and a relatively simple system from a mechanical standpoint. From the hazards standpoint the system seems to be particularly safe. On the other hand the advantages are in part offset by the fact that the low power density inherent in a gas coolant leads to very large equipment and hence a relatively high cost because of the large quantities of material required. Gas cooling also inherently gives a substantially higher pumping power loss than liquid cooling and hence detracts from the over-all thermal efficiency.

The greatest obstacle to the production of low-cost nuclear power is the large capital investment required for the power plant. Hence it is important to examine the basic elements involved in the cost of gas-cooled reactors. The availability of both helium and enriched uranium in the United States gives a number of degrees of design freedom which permits the exploitation of some of the advantages of the gas-cooled reactor in unique ways. Data are presented for the cost of the graphite, pressure shell, shield, and uranium fuel as functions of the principal design parameters. Similarly, cost data are developed for the other major components of the power plant, including ducting, blowers, boilers, instrumentation and control equipment, steam plant, structures, etc. The important advantages of high steam temperatures and pressures, that is, of the order of 900°F and 900 psi, are demonstrated, together with the

importance of high specific power in the reactor and a high temperature difference in the heat exchangers. The effects of fuel enrichment, burnup, and conversion ratio on fuel costs are also shown.

The design problems associated with evolving a minimum-cost power reactor are discussed, including the effects of coolant choice on permissible operating temperature as a function of the various materials available. Various fuel element designs and materials are discussed, together with fabrication techniques and costs, irradiation effects, and related problems. The effects on reactor power density of gas system pressure level, pressure drop through the reactor core, temperature rise in the gas stream passing through the reactor core, and the temperature difference between the gas stream and the fuel element are presented. This information is then related to problems posed by considerations of reactor physics. The effects of various types of canning material on the fuel enrichment required, on the conversion ratio and burnup, and hence on fuel costs are discussed, together with techniques for flux flattening, including variations in lattice pitch and fuel distribution. The selection of a design for minimum-cost power is then discussed and a design selection is made.

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