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PRELIMINARY REPORT

ON A

HEX PILE

D. E. Hull
F. T. Miles

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THE USE OF URANIUM HEXAFLUORIDE IN PILES

D. E. Hull and F. T. Miles

A very costly part of operation of piles presently in use and under design is the chemical reprocessing, with its attendant losses, which must be carried out on the metal fuel rods with greater or less frequency because of (1) mechanical deterioration of the metal caused by fissions, and (2) accumulation of fission products of high cross-section within the rods. The problem of pile operation would be greatly simplified if the uranium could be used in a form from which the fission products could be extracted without the necessity of performing chemical operations upon the fuel.

Use of the fuel in the form of UF_6 instead of metal offers certain outstanding advantages in these respects.[1] Although the use of UF_6 would present new problems, and would have some disadvantages, yet the possible economies to be effected in the chemical plant from its use are so great that it appears worthwhile to explore this possibility. The engineering problems of handling UF_6 (and F_2) are not a serious drawback, since they have been solved in connection with the U^{235} separation projects.

The great advantage of UF_6 over metallic uranium lies in its fluidity and its unique chemical properties. Its fluidity makes it invulnerable to the mechanical damage caused by fission recoils and simplifies the process of putting it in and taking it out of the pile. Its chemical properties are such that it can be separated from all, or nearly all, the fission products simply by distillation,[2] which may be envisioned as operating as a continuous process. This leads to a very low hold-up compared with present piles and chemical plants.

Suppose that a pile is constructed to operate with liquid or gaseous UF_6 (or UF_6 dissolved in an inert solvent) containing some free fluorine. When a uranium atom undergoes fission in such a mixture, the recoil fragments coming to rest might be expected to react with either the UF_6 of the F_2 to form the highest fluorides of the particular elements. Some of the UF_6 molecules will be disrupted by the recoiling fission fragments, as well as by the radiations in the pile, but it may be assumed that in the presence of excess fluorine, UF_6 will be reformed. Thus, after a time, the pile fuel mixture will consist of the unreacted portion of the uranium, still in the form of UF_6, plus the reaction portion in the form of fission product fluorides.

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Examination of the table of boiling points of these compounds discloses that nearly all of them are widely separated from the volatile UF_6. Therefore, a simple fractionation (distillation or sublimation) will serve to separate the unchanged uranium from all the other elements in the list, with the possible exception of molybdenum. Then, without any further treatment, the decontaminated UF_6 is ready to be returned to the pile. A large decontamination factor is not necessary, since all these operations can be carried on with adequate shielding by remote control.

TABLE I

BOILING POINTS OF FISSION PRODUCT FLUORIDES

Kr	- 153°C
SrF_2	2460
YF_3	High
ZrF_4	850
CbF_5	220
MoF_6	35
RuF_5	270
TeF_6	- 35
IF_7	5
Xe	- 107
CsF	1251
BaF_2	2260
LaF_3	High
CeF_3	1460
UF_6	56 (sublimation temperature)

If the fuel material is enriched 25, it will be necessary periodically to remove the accumulations of 26 and 28. The fact that UF_6 is the process gas in the diffusion plant presents another obvious advantage for its use in piles.

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One can imagine several forms of a pile using UF_6. If the fluid fuel (liquid or gaseous under high pressure) were circulated, continuous removal of the fission products might be accomplished, thus giving the highest possible value of g, a point of considerable interest in breeding. If the use of pure UF_6 is found to lead to too low a specific power, various diluents may be studied, such as HF, DF, CF_4, or other fluorocarbons. If a non-circulating pile were chosen, the removal of fission products might be facilitated by forcing gaseous UF_6, under moderate pressure, into a porous metal fabricated in the form of a fuel rod with a solid jacket, and used in the conventional pile arrangement. The life of such a fuel rod would be limited only by the accumulation of fission products in the surface of the porous metal, and after the UF_6 were pumped out into a fresh metal rod, the used rod could be discarded (or used for the extraction of fission activities).

A number of problems immediately present themselves for solution before serious consideration can be given to the hex pile. The effect of radiation on UF_6 under pile conditions must be studied. This is also the first question in the case of fluorocarbons. The corrosion resistance of pile materials to UF_6 and fluorine at high temperatures and pressures will be very important. Fortunately, a wealth of information on this problem is available from the K-25 development. The thermal stability of UF_6 at high temperatures may be a limiting factor, and hence must be investigated. The phase relations of fission product fluorides and UF_6, and possible diluents must be known throughout the range of temperatures and pressures in any proposed cycle in the circulating pile. The heat transfer properties of UF_6 in its various phases and solutions will require study.

It is proposed to determine the present state of knowledge of some of these questions, and to institute some exploratory experimental work directed at the question of the feasibility of a hex pile.

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REFERENCES

(1) The use of UF_6 as a pile fuel has been suggested by different persons for various reasons at one time or another. For example see

H. L. Anderson and H. S. Brown	CN-362	11-27-42
A. M. Weinberg	CP-964	9-25-43
E. P. Wigner, A. M. Weinberg and G. Young		MUC-EPW-134 12-23-44

(2) This fact forms the basis of the "dry fluoride" process, which was extensively studied as a possible method in the plutonium separation.

See H. S. Brown, O. F. Hill and E. G. Bohlman in CN-696 5-31-43

(3) J. J. Katz CC-1013 11-12-43

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