To: Distribution

From: Dunlap Scott

Subject: List of Reports Concerning Fission Product Behavior in Molten-Salt Reactors

Distribution

J. L. Anderson
C. F. Baes
M. J. Bell
E. S. Bettis
F. F. Blankenship
R. Blumberg
E. G. Bohlmann
G. E. Boyd
R. B. Briggs
S. Cantor
W. L. Carter
E. L. Compere
W. H. Cook
J. L. Crowley
F. L. Culler
J. R. Distefano
S. J. Ditto
W. P. Eatherly
D. E. Ferguson
L. M. Ferris
W. K. Furlong
C. H. Gabbard
W. R. Grimes--G. M. Watson
A. G. Grindell
R. H. Guymon
P. N. Haubenreich
R. J. Kedl

J. J. Keyes
S. S. Kirslis
R. E. Korsmeyer
M. I. Lundin
H. G. MacPherson
R. E. MacPherson
A. P. Malinskas
H. E. McCoy
H. A. McLain
B. McNabb
L. E. McNeese
J. R. McWherter
R. L. Moore
E. L. Nicholson
A. M. Perry--J. R. Engel
R. C. Robertson
M. W. Rosenthal (3)
Dunlap Scott
J. H. Shaffer
A. N. Smith
J. R. Tallackson
R. E. Thoma
D. B. Trauger
J. R. Weir
M. E. Whatley
J. C. White--A. S. Meyer
R. P. Wichner
L. V. Wilson
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9. R. B. Briggs and R. B. Korsmeyer, Distribution of Tritium in a 1000-Mw(e) MSBR, ORNL CF-70-3-3 (March 18, 1970).


15. A. Houtzeel, R. Blumberg, and F. F. Dyer, Gamma-Spectrometric Studies of Fission Products in the MSRE, ORNL-TM in final draft form.

17. R. C. Steffy, J. R. Engel, R. J. Kedl, Xenon Behavior in the MSRE, ORNL-TM (in draft form).

18. R. J. Kedl, Migration of Noble Metals and Gases in the MSRE, ORNL-TM (being written).