ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
UNITED STATES ATOMIC ENERGY COMMISSION
WASHINGTON 25, D. C.

August 1, 1963

Honorable Glenn T. Seaborg
Chairman
U. S. Atomic Energy Commission
Washington, D. C.

SUBJECT: REVIEW OF REACTOR SAFETY RESEARCH PROGRAM

Dear Dr. Seaborg:

The Advisory Committee on Reactor Safeguards has continued its review of the program in reactor safety research sponsored by the Division of Reactor Development. Comments by the Committee concerning portions of this program were forwarded to you in letters dated August 30, 1962, and December 31, 1962.

Additional comments, dealing with that portion of the program related to fission product release from fuel elements and subsequent retention in containment barriers, are contained in the attached letter to the General Manager.

Sincerely yours,

/s/

D. B. Hall
Chairman

Attachment:
Ltr. to Gen. Mgr. dtd 8/1/63.

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
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A. R. Luedecke
General Manager
U. S. Atomic Energy Commission
Washington, D. C.

SUBJECT: REVIEW OF REACTOR SAFETY RESEARCH PROGRAM

Dear General Luedecke:

The Advisory Committee on Reactor Safeguards has been reviewing the safety research program of the Atomic Energy Commission for several months. This review, undertaken at the request of the Division of Reactor Development, has been very timely because it has come during a period when engineered safeguards are increasingly used to justify sites that would otherwise be unacceptable. At the outset, the Committee wishes to thank the Division of Reactor Development for the opportunity to hear of the progress being made in reactor safety research and to comment on it. In a previous letter to you, dated December 31, 1962, some views of the Committee on the Spert and STEP projects were transmitted. In this letter additional comments are offered only on those portions of the program designed to provide further information on the release of fission products from fuel elements and the place and extent of their removal in passing through successive spaces and barriers.

The Committee would like to stress that dependence on engineered safeguards to reduce the effects of credible reactor accidents must be supported by confidence that the safeguards would act as expected. There must be assurance that the conditions to which the devices would be exposed are correctly foreseen. The effectiveness of the devices under these conditions must be established.

The safety research program devotes much of its attention to questions about the nature and magnitude of fission product releases by various mechanisms. Most of the research concerns the release of fission products by fuel that has been melted by afterheat. In most instances, the fission product heating is simulated by other means: plasma torches, electrical heating, induction heating. Several kinds of fuel are being investigated. Those being studied and proposed for study include the principal reactor fuels for the converter reactors.

In the spirit of the statement made above, that confidence in performance as planned is essential, the Committee would like to comment on aspects of these fission product release studies. Most of the comments simply reiterate views on which the research has been based, and these are stated again here only for completeness.

The two basic questions to be answered by fission product release studies are: (1) how much of what fission product of significance is released, and (2) in what form are the fission products released? There are no simple answers to these questions, because the answers depend on a variety of environmental conditions. These include: (1) the chemical composition of the fuel (e.g., uranium metal, uranium oxide, uranium carbide, alloying constituents), (2) the physical nature of the fuel (for instance, sintered oxide or vibratory compacted oxide), (3) the degree of burnup, (4) the temperature history of the melt, (5) the kind of cladding, (6) the kind of atmosphere in which the melt takes place (air, steam, air-steam mixture, noble gas). Amplification of the basic questions in the light of the environmental effects leads to such questions as: What fraction of the release of volatile fission products, particularly halogens, is in elemental form? What is the particle size distribution of released nonvolatiles? What is the expected degree of adsorption of volatiles on these particles? What chemical compounds are formed? What is the size distribution of the particles with which these are associated? The answers as functions of the environmental conditions must be known if the behavior of the engineered safeguards is to be assured.

In addition, the Committee would like to draw attention to the presence of large amounts of plutonium and other transuranic species near the end of reactor core life. The possible release of these, the effect of their release, and their effect on fission product release should be studied.

Throughout, care must be taken to assure that the history of significant fission products is followed. In circumstances where halogens are released in easily removable form, the effectiveness of the engineered safeguards will probably depend on other fission products.

It appears that some increase in the Atomic Energy Commission's safety research program will be needed if satisfactory answers to the above questions on fission product release are to be available for interpreting the consequences of integral experiments such as LOFT.

The release of fission products from fast reactor fuels should also receive growong attention. The fission product distribution curve differs somewhat with fission neutron energy. Fission product yields from plutonium fission are somewhat different from those from U^{235} fission. The fuels themselves will differ from those used in thermal converter reactors.

Before leaving the subject of fission product release research, the Committee would like to comment on the proposed studies of fission product release by methods other than simple fuel melting. The releases associated with nuclear excursions or chemical reactions (such as those between water and metals) will differ from the ones discussed above. The series of Spert destructive tests will shed some early light on the nature of such releases as well as on other questions. But the basic physical understanding of the releases will depend on research such as is projected for the Power Burst Facility. The Committee wishes to emphasize the need for the PBF, and to support its early construction and use.

The retention of released fission products on the inner walls and internals of the reactor vessel will reduce the magnitude of the release by an amount that is so far unpredictable. This reduction factor will depend on complicated circumstances: The geometry and composition of the surfaces, the form of the fission products (gaseous, elemental, particulate), the temperatures of surfaces, the size of the reactor vessel or pipe rupture, and the atmosphere in the reactor vessel. It will be necessary to identify the cause of the reduction, to establish the dependability of results. The Nuclear Safety Pilot Plant should help to answer a number of the questions influencing the expected retention of fission products in the reactor vessel, but it may be that the complication of structural members and fuel element surfaces will only lead to a lower limit on the advantage to be gained from vessel retention. The need for careful control in these experiments is stressed. It is noted that a plasma torch will be used to melt the fuel. This torch will be located in a separate chamber outside the simulated reactor vessel. Attention has been given to assuring that the release into the simulated vessel resembles that from an after-heat meltdown: this must be assured. The variable nature of the release as influences by features of the melting, discussed earlier, should be taken into account. The course of the deposition in the vessel should become well enough understood on purely physical and chemical grounds to permit mathematical justification of vessel retention factors that might be assumed in reactor plants.

Beyond the escape from the vessel, released fission products to be a major hazard must still escape whatever containment or confinement is provided. The tests of retention by containment or confinement, and the effectiveness of air cleanup devices under actual conditions, are planned for the LOFT facility. Releated test facilities have also been proposed: the Pressure Suppression Facility, and more recently, Spert-II.

It is difficult to specify the features important in finding the degree of retention in the containment or confinement building except by reiterating the need to justify whatever retention factors may be claimed in the future. This justification must rest on a foundation of physical and chemical understanding. The same sources of complication as pertain to vessel retention factors will also apply here.

In view of the recent finding of almost total release of several significant fission products, transport effects assume very great importance. The various engineered safeguards that have been proposed to reduce further the extent of final release should be tested under conditions under which they must be expected to perform. These engineered safeguards include spray washdown systems in the vessel and in the reactor building, building air recirculation systems, and final air cleanup systems. The variability of possible fission product releases will affect the performance of all of these. The temperature and steam content of the atmosphere will affect the performance of recirculating and final air cleanup systems. The possibility of saturation of air cleanup systems should be investigated. The rate of re-evaporation of halogens washed down by spray systems should be known.

The pressure suppression scheme that has been designed for some reactors bears further testing over a somewhat larger range of variables. In relation to the fission product retention problem, however, it would be useful to establish experimentally to what degree this scheme can be relied on for reduction of fission product escape.

The proposed Pressure Suppression Facility seems to be the one device that has been proposed for systematic study of the effectiveness of engineered safeguards such as building spray systems, air recirculation cleanup systems, and pressure suppression. The Committee wishes to encourage further development of this proposal, with emphasis on the

goal of physical justification of the reduction factors to be assigned such engineered safeguards.

The Committee views the LOFT experiments as being in the nature of necessary full system tests. These would establish whether the more specific research on the individual and successive aspects of the core meltdown and fission product release have made it possible to predict accurately the complete sequence of events, and whether any effects of importance have been overlooked. As corollaries to this view, the Committee believes that the research that is to be correlated on a full system basis must be at an adequate stage for this test when it is performed, and that the LOFT experiment must be well instrumented to establish quantitatively the physical and chemical nature of the release from the fuel, the vessel, and the building, and the environmental features influencing the release. It is doubtful that a single LOFT meltdown will be adequate to provide the confidence in predictability of the magnitude and kind of fission product releases after core meltdown.

The proposed use of Spert-II to provide some information prior to the LOFT experiments would be of questionable value. Because the basic experiments needed for interpretation would almost surely not be finished in the two years before a Spert-II meltdown can be done, this test could not be considered as a systems test of the nature of LOFT. Without the physical understanding of the more elementary processes, any results achieved could not be depended on as guides to predicting fission product releases following meltdown of other reactors. It seems that at best a Spert-II meltdown might give some further guidance to the conduct of the later LOFT tests.

The Committee has been favorably impressed by the emphasis that the Division of Reactor Development gives to research on nuclear reactor safety. This research should be of real value in helping to ease the problems of reactor siting and the assured performance of engineered safeguards.

The Committee will forward further comments on research aimed at reducing or clarifying the possibility of serious accidents when the review of these portions of the research program has been finished.

It is clear that some facets of reactor safety are more important than others, and the degree of urgency in attaining useful results varies.

In the near future, the Committee will forward to you their views on the coverage of these facets, on the general scope of the program, and the relative emphasis that should be placed on various aspects of the program. This critique will be based on our opinion of the relative importance of safety problems being faced in the siting, design and construction of large power and test reactors.

Sincerely yours,

/s/

D. B. Hall
Chairman