May 17, 1999

The Honorable Shirley Ann Jackson
Chairman
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001

Dear Chairman Jackson:

SUBJECT: USE OF MIXED OXIDE FUEL IN COMMERCIAL NUCLEAR POWER PLANTS

During the 462nd meeting of the Advisory Committee on Reactor Safeguards, May 5-8, 1999, we completed our response to the Commission request, included in the March 5, 1999 Staff Requirements Memorandum, that the ACRS consider the impact on the revised source term if high burnup or mixed oxide fuel (MOX) were used in place of conventional uranium fuel in commercial nuclear power plants. We had the benefit of the documents referenced.

The U.S. Department of Energy is proposing to dispose of some fraction of the Nation's excess weapons-grade plutonium by converting this plutonium into MOX for use in commercial nuclear power plants. There is, however, rather limited operational or regulatory experience with the use of MOX in the U.S. Even the experience in other countries is not extensive.

We have not had the opportunity to review analyses by the U.S. Department of Energy on the safety of the use of MOX in commercial nuclear power plants, nor have we had the benefit of hearing NRC staff views on this subject. There are technical issues that will merit consideration in evaluating the safety of using MOX. We think there are policy issues that the Commission may want to consider in the evaluation of applications for the use of MOX.

Because current regulations are predicated on the use of low-enrichment uranium oxide fuel rather than MOX, applications for the use of MOX may be burdened by needs to propose amendments to numerous prescriptive regulations. To facilitate the evaluation of applications to use MOX, the Commission may want to encourage the use of the risk-informed approach delineated in Regulatory Guide 1.174, "An Approach for Using Probabilistic Risk Assessment in Risk-Informed Decisions on Plant-Specific Changes to the Licensing Basis," to amend licenses of currently operating nuclear plants. For similar reasons, the Commission may want to consider requiring that such applications adapt the revised accident source term described in NUREG-1465 for deterministic safety evaluations.

Technical issues that arise in the analysis of risk at plants using MOX focus on the vulnerability of fuel to neutronically induced core disruption and the different inventory of radionuclides available for release from the fuel during accidents. The differences in neutronics and coupling between neutronics and thermal hydraulics result in different responses of MOX and conventional fuel to reactivity transients. The differences in responses are consequences of changes in Doppler and moderator reactivity feedback, and decrease in delayed neutron fraction, which decreases the response time of MOX to reactivity transients. These dynamic characteristics of MOX pose both safety and control issues that will require the staff to conduct careful review of the neutronics analysis of reactor cores with MOX. Most experts believe now that the number of MOX fuel assemblies and the percentage of plutonium in MOX should be limited to reduce the vulnerability of the core to these neutronic effects. We are aware that the Office of Nuclear Regulatory Research (RES) is in the process of upgrading the tools available for the analysis of coupled neutronics and thermal hydraulics. As part of this work, RES is assessing uncertainties in the neutronics analyses, including uncertainties in the effective delayed neutron fraction for fuels rich in plutonium. We encourage this work so that improved analytic tools wil

l be available to the staff when
the
time comes to evaluate an application to use MOX.

We are aware of experimental studies that show there to be enhanced re
lease of fission gases to the
fuel-
cladding gap during reactor operations with MOX relative to convention
al fuels. This may simply be an
effect caused by fuel temperature. We are also aware of anecdotal acc
ounts of the results of
VERCOURS tests in France dealing with the release of volatile radionuc
lides such as cesium from MOX
under severe accident conditions. Results of these tests revealed tha
t during the early stages of core
degradation, releases of volatile radionuclides from MOX are more exte
nsive than from conventional
fuels at similar levels of burnup. At higher temperatures at which ex
tensive degradation and melting of
fuel take place, integral releases of the volatile radionuclides are s
imilar in the two types of fuel.
The
higher releases of volatile radionuclides at low temperatures (<2000 K
) are consistent with the peculiar
nature of porosity that develops in MOX during burnup and are, apparen
tly, sensitive to the
heterogeneity
of the plutonium oxide distribution in the fuel. Whether these higher
 releases of volatile
radionuclides
are adequately estimated for safety analyses using the release prescri
ptions provided in NUREG-1465 will
not be known until further data and analyses become available.

We are aware of a test of the vulnerability of MOX rods to reactivity
insertion. The safety
significance
of the results of this test could be interpreted more confidently once
 results of the ongoing NRC
research
program on reactivity insertion in high burnup fuels become available.

Public attention has been drawn to the higher actinide inventories ava
ilable for release from MOX than
from conventional fuels. Significant releases of actinides during rea
ctor accidents would dominate the
accident consequences. Models of actinide release now available to th
e NRC staff indicate very small

releases of actinides from conventional fuels under severe accident conditions. There is substantial uncertainty in these predictions. The staff is attempting to validate the predictions of actinide releases through its participation in the PHEBUS-FP program of experimental studies of radionuclide release and transport. There is some hope that the PHEBUS-FP program or a follow-on program will include tests of MOX degradation and fission product release. We encourage the NRC participation in this international collaborative research and hope that definitive results will be available for evaluating the applications to use MOX.

Comparisons are sometimes drawn between the inventories of actinides in MOX and the releases of actinides observed in the accident at the Chernobyl nuclear plant. Such comparisons are not valid in light of the peculiar nature of the accident at Chernobyl and the fact that radionuclide releases are strongly dependent on the details of accident phenomena. It is noteworthy that the releases of actinides during the Chernobyl accident were due almost entirely to fuel dispersal rather than vaporization. It will be important to ensure that fuel dispersal events such as steam explosions and high pressure melt ejection are of acceptably low probability at plants that propose to use MOX.

Our Subcommittee on Reactor Fuels will continue to follow progress in both the use of high burnup fuel and the use of MOX at commercial nuclear power plants. We are participating in a Quadripartite Working Group with our counterparts in France, Germany, and Japan that deals with these topics. We plan to report our observations and conclusions to you, as appropriate.

Sincerely,

/s/

Dana A. Powers

Chairman

References:

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7. Oak Ridge National Laboratory, ORNL/TM-13424, R.T. Primm, III, J.C. Ryman, S.B. Ludwig, "Storage of Assemblies Containing Mixed Oxide Fuel." April 1997.
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