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UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

AUG 1 3 1980

MEMORANDUM FOR: Commissioner Gilinsky

FROM: Harold R. Denton, Director
Office of Nuclear Reactor Regulation

THRU: (Signed) William J. Dircks
Executive Director for Operations

SUBJECT: SECY-A-80-70 (UNIVERSITY OF CALIFORNIA, BERKELEY, TRIGA REACTOR)

Your memorandum of July 17, 1980, requested a response to an analysis by OPE regarding the Design Basis Accident (DBA) for the University of California, Berkeley, TRIGA Reactor. Enclosed is an assessment of the conservative assumptions present in the NRR evaluation of the DBA, with the conclusion that the limiting dose to the thyroid as originally calculated is likely to be conservative by at least three orders of magnitude. The dose as originally calculated was itself a small fraction of the 10 CFR 100 limit.

Three specific questions were raised in the note enclosed with your memorandum: the NRR response to each question is presented below.

1. Fuel temperature at time of accident

The experiments were performed with the fuel temperature about 400°C. If the earthquake (causing complete core disruption) occurred a few hours after a LOCA, the temperature could be above 700°C. Would this permit a larger fraction of the volatile fission product gases to be released because of increased rate of diffusion of internally generated gases to the fuel-cladding interface? Similarly, if the earthquake occurred at the same time as a reactivity accident (where the estimated fuel temperature might be as high as 800°C), would the release fraction be increased?

Response As discussed in the enclosure, the temperature cited are peak temperatures rather than whole-core temperatures needed for evaluation of whole-core releases. Further, the higher temperature cited (800°C) is itself calculated for accident conditions.

2. Time factor

In the experiment, the fission products were allowed to be released from the fuel surface (the fuel-cladding interface) during a three-hour period. If the period were extended to many hours, e.g., several thousand, would the fraction released be increased? (A low diffusion rate simply means a longer time is required for a given quantity of gas to migrate to the fuel surface).

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Response As the temperature of the assembly is lowered over several thousand hours, the diffusion of gas to the surface, if any had taken place before, would be reduced. All the gas activity was assumed to be released immediately. Any larger total release fraction would be more than balanced by a dose reduction due to meteorological assumptions applicable to releases over several hundred to several thousand hours. It is estimated that reductions of 1 to 2 orders magnitude in calculated dose would be appropriate for extended release duration.

3. Fuel integrity

In the experiment, fresh fuel was used. Would the release fraction be affected by fuel age, i.e., nvt or total heat generated, or by thermal history, i.e., temperature cycling? Would the mechanical properties deteriorate with exposure, so that the fuel might break up into many pieces as a result of earthquake damage?

Response As discussed in the enclosure, deterioration of the fuel was assumed in the calculation of the release fraction of $1.5 \times 10^{-5}$. It is of interest to note that three quarters of the fuel in the first TRIGA, still operating at the General Atomic Company, is original fuel, twenty-three years old. This reactor is located near the Rose Canyon Fault, and has been subject to seismic activity for many years.

It is concluded that the orders of magnitude of conservatism in the limiting dose calculation are sufficient to provide ample assurance of the safety of the University of California, Berkeley, TRIGA. The calculation of dose is consistent with, or more conservative than, NRC accident evaluations for other reactors.

Original Signed By
E. G. Case
Harold R. Denton, Director
Office of Nuclear Reactor Regulation

Enclosure:
DBA Scenario

cc: Chairman Ahearne
Commissioner Hendrie
Commissioner Bradford
S. Chilk, SECY
L. Bickwit, OGC
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DBA SCENARIO FOR THE UNIVERSITY OF CALIFORNIA

AT BERKELEY TRIGA MARK III RESEARCH REACTOR

The scenario assumed was that of a large seismic event, destroying the reactor room walls and ceiling, resulting in a non-mechanistic failure of all 83 fuel elements in the core concomitant with loss of core water.

With respect to fission product release fraction, two experiments performed at General Atomic Company gave two distinct values for this parameter, $9.6x10^{-3}$ and $3x10^{-6}$, respectively, which differed by more than $10^3$ (1960 and 1966 respectively). On June 1, 1971, in a letter from Ralph H. Peters of General Atomic to the Director of the AEC, Division of Reactor Licensing, an error in the 1960 experiment was described. GA found its recalulated release fraction to be between $6.1x10^{-5}$ and $8x10^{-5}$, considered to be in "reasonable agreement" with the 1966 release data.

Because of this variation in release fraction, the 1960 experiment was repeated in 1971, and yielded a normalized release fraction of $.5x10^{-5}$. A new 1971 experiment gave a normalized release fraction of $.8x10^{-5}$. From all of these experiments, the staff concluded that an appropriate release fraction was $1.5x10^{-5}$. The Appeal Board on the Columbia University TRIGA case agreed with the staff, with respect to the conclusion of GEES (predecessor of GA) report number A 10801, that the experiments performed had provided reasonably consistent release fraction data. The Board concluded that the release fraction of $1.5x10^{-5}$ was an appropriately conservative figure for use in evaluating results of a postulated accident involving a TRIGA reactor of the type under consideration. (Decision of ASLAB in the Matter of the Trustees of Columbia University in the City of New York, May 18, 1972).

In the analysis of the Berkeley reactor, it was assumed, therefore, even though very conservatively, that iodine as well as the noble gas fission products are released from the core to the environment with a release fraction of $1.5 \times 10^{-5}$. Involved in the determination of this release fraction was the conservative assumption by General Atomic of fuel fragments of one cubic centimeter volume within the clad. Actually, fragments of volume less than about 10 cubic centimeters have never been observed in TRIGA fuel, even after it has been pulsed thousands of times. Therefore the $1.5 \times 10^{-5}$ release fraction is highly conservative from an available fuel surface leakage point of view. Furthermore, the value of $1.5 \times 10^{-5}$ is highly conservative from a species-dependent release point of view. Recent experiments at Oak Ridge National Laboratory (NUREG/CR-0722, R. A. Lorenz et al) for oxide fuel indicate substantial differences between iodine and noble gas release. At 500°C, ORNL found that the iodine versus noble gas release ratio was at least as small as .03:1.

The release fraction of $1.5 \times 10^{-5}$ is based, as has been discussed, on conservative analysis of the above mentioned experimental results. The temperature of the 1971 experiments was 400°C. Two other temperatures are quoted for accident conditions in the 1964 Safety Analysis, namely 700°C for LOCA after long-term steady state power operation and 800°C after a reactivity accident. However, it was concluded that the temperature of the 1971 experiments, 400°C, was applicable to the present calculation rather than either of the other two, because they contain factors of conservatism itemized below that are not appropriate where whole core destruction and release are assumed.

First, the two temperatures cited are peak temperatures, corresponding to the axially central portion of the innermost ring of rods. Factors of 1.3 and 1.55 were applied in both cases to account for axial and radial peaking. The whole core average temperature needed for the present calculation would be significantly less. For the case of the LOCA, curves in the 1964 Safety Analysis indicate that the temperature would be reduced to 550°C if axial peaking only is taken into account. Second, the pulse which constitutes the reactivity accident is assumed to be initiated from 1.4 MW, in violation of the Technical Specification which limits the power to 1 MW. Further, the peak temperature after a pulse decays quickly, with a "half life of the order of minutes," and the time, therefore, when an earthquake-induced LOCA could coincide with a peak temperature is substantially reduced.

Finally, two hour exposure was assumed under the above stated highly conservative exposure conditions for the closest members of the general population, yielding a 7.5 Rem thyroid dose, although evacuation/removal of any members of the very "close-in" population could be accomplished quickly.

Additionally, other conservatisms were used in the evaluation. No iodine plateout or removal was assumed, even though the vast bulk of released iodine would plate out on rubble covering the reactor and/or very nearby metallic or concrete surfaces. Additionally, a very large X/Q factor (relative concentration), $5 \times 10^{-2}$ sec/$m^3$, was employed. This X/Q value is larger by about a factor of 10 than the largest value observed in field testing at close-in distances ($6 \times 10^{-3}$ sec/$m^3$ at 10 meters; Sagendorf et al, Proceedings of Fourth Symposium on Turbulence, Diffusion, and Air Pollution, January 15-18, 1979, page 596). A semi-infinite cloud assumption was made in spite of the proximity of the closest member of the general population to the reactor (the outside of the reactor room wall) at the time of the seismic event. Actually, a finite cloud assumption would have been justifed, which would have resulted in offsite exposures substantially lower than those in the safety evaluation.

In conclusion, the design basis accident consisting of cladding failure of the entire core and loss of coolant, both caused by an earthquake which additionally destroys the reactor building, has been conservatively evaluated. The limiting offsite radiolc ical consequence (7.5 Rem thyroid dose), which is itself a small fraction of the 10 CFR 100 limit, is conservative by at least three orders of magnitude, due to species dependent release, plateout and meteorological assumptions.