ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
UNITED STATES ATOMIC ENERGY COMMISSION
WASHINGTON, D.C. 20545

November 8, 1974

Honorable Dixy Lee Ray
Chairman
U.S. Atomic Energy Commission
1717 H Street, N.W.
Washington, D.C. 20545

Subject: CONCEPTUAL DESIGN FOR PROTOTYPE GAS-COOLED FAST BREEDER REACTOR (GCFBR)

Dear Dr. Ray:

At its 142nd meeting on February 3-5, 1972, its 173rd meeting on September 5-7, 1974, its 174th meeting on October 10-12, 1974, and a special meeting on October 31-November 2, 1974, the Advisory Committee on Reactor Safeguards reviewed a conceptual design and proposed design bases for a prototype 300 MW(e) Gas-Cooled Fast Breeder Reactor (GCFBR). Subcommittee meetings were held on July 21, 1971, in Denver, Colorado, December 1, 1971, in La Jolla, California, September 11-12, 1973, in La Jolla, California, and January 9, February 6, and August 6, 1974, in Washington, D.C. During its review the Committee had the benefit of discussions with representatives of General Atomic Company, the AEC Regulatory Staff and of the documents listed.

The purpose of this review was to acquaint the Committee with the current status of the conceptual design and proposed design bases and to enable it to identify those areas which the Committee believes require further technological development, or which it currently considers unacceptable. The information available, however, was not sufficient to permit the Committee to determine if all areas important to safety have been identified.

The reactor concept utilizes helium cooling of stainless steel clad oxide fuel elements whose design is similar in many respects to those used in liquid metal fast breeder reactors. The reactor core, three primary coolant loops and three auxiliary coolant loops are completely contained in a cylindrical prestressed concrete reactor vessel (PCRV). The core occupies the central cavity. The steam generators, primary helium circulators and the auxiliary coolant circulators and heat exchangers are located in cavities in the PCRV wall. A conventional low-leakage containment building, similar to those used for PWRs and proposed for HTGRs, is provided.

The Committee recognizes that the GCFBR has certain advantageous safety characteristics relative to other types of fast reactors. These include:

(1) The reactivity effect associated with the helium coolant is small;

(2) Potential chemical reactions between the primary coolant and the secondary steam are eliminated because helium is chemically inert;

(3) Maintenance access problems tend to be less severe because the helium coolant is subject to limited radioactivation.

Certain safety disadvantages unique to the GCFBR, as well as some safety problems common to all fast reactors, are discussed below.

A significant problem area, requiring substantial additional study, is the reliability of core cooling capability. Special emphasis needs to be given to partial or total loss of core cooling without depressurization and to a spectrum of loss-of-coolant accidents with various rates of depressurization. Sensitivity studies in these areas are necessary, including coolant compositions ranging from helium alone to helium plus various concentrations of hydrogen, water vapor and air. Because reliability of helium circulators is essential, problems such as common mode failures affecting the primary circulators, auxiliary circulators, or both, must be addressed more extensively. The reliability of valve operation in the primary circuit requires additional careful scrutiny. Further work is required on thermal and mechanical parameters influencing fuel damage within the spectrum of accidents which potentially could lead to some fuel melting to determine the impact of fuel damage on core cooling reliability.

Because the cooling efficiency during a depressurization accident is a function of the back pressure in the containment, various aspects of design relevant both to the containment and to the core cooling system capability in the depressurized condition should be evaluated further. Sensitivity studies should be made covering the spectrum of containment pressure from the assumed maximum to zero gage. Other features affecting containment systems and filter design such as the presence of combustible gases, e.g. hydrogen, the creation and release of plutonium aerosols, and the response to post-accident heat generation, should be investigated more extensively.

Postulated core disruptive accidents should be examined as a potential design basis for the GCFBR. Analyses should be conducted in detail on the GCFBR, as is being done on LFMBRs, taking into account possible reassembly and potential autocatalytic phenomena, to permit a better understanding of PCRV and containment response to such accidents.

Potential sources of these accidents include a loss-of-coolant flow, depressurization, or a rapid reactivity insertion with failure of timely scram.

A desirable approach, for this prototype plant relates to the ability to maintain containment in the unlikely event of melting of fuel.

The Committee recognizes that two independent reactor shutdown systems represent a desirable step toward reducing the probability of an anticipated transient without scram. Efforts should be continued to improve the reliability of these shutdown systems.

While the ACRS recognizes that there are some advantages in a PCRV, the world-wide experience with PCRFs is still too limited to provide meaningful reliability statistics. Because the GCFBR operating pressures are substantially higher than those in most previous PCRVs, additional analytic and experimental studies are needed to establish possible failure mechanisms under a variety of accident conditions.

A critical component of the PCRV is the thermally insulated liner, which is similar to that proposed for HTGRs. While the GCFBR design provides greater accessibility to the insulation and liner for inservice inspection than exists in an HTGR, there are still problems on inspection techniques, the liner response to loss of thermal insulation and the impact of loss of insulation on system operation, fuel, etc. These problems should be investigated further.

The various core internals, including the fuel, are subject to variable loads at temperatures at which creep, stress rupture, and creep-fatigue interactions may be critical. Since the proposed core materials are sensitive to parameters of time, temperature, modes of loading, and environment, it is essential that sufficient engineering data be obtained to permit prediction of component behavior throughout life, including normal, upset, emergency, and faulted conditions.

It is important that the applicant maintain adequate flexibility of design for purposes of modifying or supplementing presently contemplated safety features until the major safety questions and design criteria are resolved.

This is an interim letter for the purpose of aiding in the identification of major problem areas. Other items may prove to be equally significant, requiring extensive evaluation. The Committee will continue its review as viable alternates or acceptable justification of the existing proposed systems are provided.

Sincerely yours,

W. R. Stratton
Chairman

References attached

References

1. General Atomic Company (formerly Gulf General Atomic) "Gas-Cooled Fast Breeder Reactor - Preliminary Safety Information Document" Volumes I and II

2. Supplements 1 through 10 to the Preliminary Safety Information Document" (PSID)

3. Supplements I and II to the PSID

4. Amendments 1 through 6 to the PSID

5. Regulatory Staff, U.S. Atomic Energy Commission, "Preliminary Report to the ACRS - Gas-Cooled Fast Reactor (GCFR)" dated June 14, 1971

6. Regulatory Staff, U.S. Atomic Energy Commission, "Report to the ACRS Gas-Cooled Fast Reactor Conceptual Design Review" dated November 19, 1971

7. Regulatory Staff, U.S. Atomic Energy Commission "Preapplication Safety Evaluation of the Gas-Cooled Fast Breeder Reactor" dated August 1, 1974

8. General Atomic Company letters dated May 23, 1973, regarding the Regulatory Staff's report of a meeting held on March 13-14, 1973, at which accidental positive reactivity insertion mechanisms were discussed; dated October 10, 1974, regarding the definition of the design basis accidents; and dated October 11, 1974, commenting on the Regulatory Staff's Safety Evaluation Report

9. GA-A12934 "Reactivity Insertion Mechanisms in the GCFBR" by Torri and Driscoll, dated April 10, 1974