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To: Mr. J. W. Larson

From: P. I. Perry

Subject: Problems Associated With The Design
And Development Of The Lithium Cooled
Reactor For The 1 Mwe Space Powerplant

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CHLM-3682, Suppl. 1

Date: June 21, 1961

cc: Messrs.

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SPECIAL REREVIEW FINAL DETERMINATION	Reviewers	Class.	Date
	KAW	U	10-28-81
Class: U	HFC	U	11-24-81

In general, many of the problems associated with a compact, high temperature, lithium cooled reactor have been solved under the ANP Research and Development Program at CANEL. Other problems in this area are being investigated under the current ABC contract at CANEL which is directed toward the design, construction and operation of a compact 10 Mw reactor with a 2000F lithium coolant temperature and a one year life. The major reactor problem areas not covered under the current ABC at CANEL are those associated with operation in the environment of space.

A discussion of the reactor problem areas follows.

I. REACTOR MATERIALS

A. Structural Material - Columbiu-1 Zirconium Alloy

1) Creep Properties for 10,000 Hours

The creep properties of the structural material are not known for 10,000 hours. Available data extend to approximately 10,000 hours and the validity of extrapolating these data to 10,000 hours is questionable. It is anticipated that creep data for 10,000 hours will be obtained at CANEL under the current ABC contract.

2) Corrosion of the Structural Material

The corrosion resistance of the structural material for 10,000 hours in lithium is not known. Existing data show negligible attack by lithium at approximately 1,000 hours. It is anticipated that 10,000

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hour corrosion tests will be run under the current AEC contract at CANEL.

3) **Radiation Embrittlement of the Structural Material**

The extent of radiation induced embrittlement of the structural material for 10,000 hours of operation is not known. Experience to date is confined to inpile irradiation of fuel specimens and has not indicated any radiation induced embrittlement. Additional information is anticipated from the current AEC contract at CANEL.

B. **Fuel Material - Uranium Monocarbide**

1) **Stability of Fuel Material**

The stability of the fuel material to cracking and dimensional changes at high burnups has not been established. Preliminary results of capsule experiments at CANEL and other organizations are promising. The development and irradiation of uranium carbide fuel is continuing at CANEL under the current AEC contract. Other fuel materials containing uranium dioxide or uranium nitride could be used with an increase in core size being incurred.

2) **Retention of Gaseous Fission Products in the Fuel**

The extent that gaseous fission products are retained in the uranium carbide fuel matrix has not been determined. However, preliminary results indicate that the retention properties of uranium carbide are greater than those of uranium dioxide and hence the 10 percent release used in the design calculations appears conservative. The released gaseous fission products create a pressure buildup in the fuel pin which is accommodated by thickening the cladding or providing a gas accumulation space at the ends of the fuel pins. It is anticipated that more accurate release fractions will be obtained from current work at CANEL.

II. **FABRICATION OF COMPONENTS**

The experience gained from the ANP program at CANEL in the fabrication of fuel elements, reflectors and structural members is directly applicable to this reactor.

III. **INSTRUMENTATION**

A. **Thermocouples**

The development of thermocouples for reliable operation at 2000F for 10,000 hours is a problem. Thermocouple development was performed under the ANP program and is continuing under the current AEC contract at CANEL. It is anticipated that a usable thermocouple will be developed.

To: Mr. J. W. Larson

-3-

CHM-3682, Suppl. 1
Date: June 21, 1961**B. Flux Sensors**

The flux sensors must operate for 10,000 hours in the environment of space. Shielding from meteoroids must be provided and the effects of radiation such as solar flares, Van Allen radiation, etc., on readings must be determined.

IV. OPERATION OF GEARS AND BEARINGS IN SPACE

The bearings and gears of the control mechanisms must operate in the essentially vacuum environment of space. The seal problems associated with a lubricated system appear formidable, hence a nonlubricated system is preferred. The problems of nonlubricated gears and bearings operating in a vacuum should be studied to aid in the selection of materials and coatings.

V. COOLING OF CONTROL MOTORS

The cooling of the electrical control motors has not been examined thoroughly; however, a problem is anticipated in dissipating the heat generated in the windings by thermal radiation. The heat produced in the windings must be radiated to the outer case and in turn radiated from the case to space.

VI. REMOVAL OF HEAT FROM THE MOVABLE EXTERNAL REFLECTOR

A movable reflector located external to the pressure vessel is used to provide reactor control. The heat generated in the external reflector is dissipated to space or the vehicle shell by thermal radiation. The problems associated with this method of heat removal are the effect of this radiant heat flux impinging on other structures such as the radiator, and the inability to accurately calculate the heat generation into this region. This method of reactor control and reflector cooling was selected in an attempt to preclude the presence of moving reactor parts in a lithium environment.

An alternate scheme is being pursued in which control is achieved by moving an annular region of poison material in the side reflector. The side reflector is located external to the pressure vessel and is cooled by tubes containing flowing lithium. The heat generated in the annular poison region is radiated from both the inner and outer surfaces to the side reflector. This system also precludes moving reactor parts in lithium.

VII. EXTENDING REACTOR LIFE

The reactor is designed for a 10,000 hour life at a 10 Mw. Significant changes would be required to extend the life by a factor of two or more. Although the structural modifications would be relatively minor, the changes required to provide additional reactivity control would be major. The fuel burnup would be increased as life is increased, thereby requiring greater control. Certain modifications of the control system can be made; however, the gains from these changes are limited. It may be necessary to incorporate burnable poisons into the active core to obtain major extensions of reactor life.

P. E. Perry