STANDARD FORM NO. 64

# *Office Memorandum* • UNITED STATES GOVERNMENT

TO : Lyall Johnson

DATE: December 20, 1956

FROM : Clifford K. Beck

SUBJECT: CURTISS-WRIGHT - LICENSE APPLICATION

SYMBOL: CA:HEB:CKB

## PART I - DESCRIPTION OF THE REACTOR

The Curtiss-Wright Corporation has submitted a license application for a reactor to be built and operated on an 80 sq. mile tract of land at Quehanna, Pennsylvania. The proposed reactor is a one megawatt light water moderated and cooled, solid fuel type often referred to as a swimming-pool reactor. Considerations of neutron economy may at times dictate the use of a beryllium oxide reflector. The core is immersed in a 20 ft. wide by 40 ft. long x 26 ft. deep pool with a minimum of 19 ft. of water covering the core. The reinforced concrete pool is separated into two sections, one being a three sided end section penetrated by three beam tubes for experimentation purposes, the other a 20 ft. x 24 ft. section used for bulk shielding studies.

The reactor core will be made of MTR type fuel elements containing a maximum of ten fuel bearing plates per element. Each plate is essentially a sandwich of aluminum-uranium alloy between two layers of aluminum cladding. A fuel element will contain about 170 gms of U-235 enriched to ~ 90%. These elements are supported by a grid plate capable of accommodating a 9 x 6 array or a total of 54 elements. This number of fuel elements would almost certainly not be used, but many flexible arrangements are possible, and present plans do include placing peripheral rows of beryllium oxide elements as reflector around the fuel elements. Previous experience with this type of core places the cold clean critical mass at 2.75 - 2.85 kg U-235 but usually the requirements for available reactivity to override xenon poisoning and experimental needs will increase the critical mass to 3.4 or 3.6 kg.

In this case, the applicant states that the maximum reactivity requirements for prolonged operation at 100 kw and 1000 kw are as follows:

| Source | Reactivity 100 kw | Required at 1000 kw |
|---|---|---|
| Negative Temp. Coefficient | .0006 | .001 |
| Equilibrium Poisons (Xe, Sm, etc.) | .018 | .040 |
| Xe override | .000 | .006* |
| Burnup (1000 days) | .0005 | .005* |
| Adequate rate of change of power level | .003 | .003 |
| Addition of smalles increment of reactivity available | .003 | .003 |
| Totals | .025** | .053** |

* Only one indicated in total

** No allowance made for experimental reactivity requirements

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The reactor control system consists of three (3) safety shim rods and one (1) control rod. The boron carbide safety-shim rods have a reactivity control worth of 2.5% each for a water reflected core and 3.8% each for a beryllium oxide reflected core. The stainless steel control rod under similar conditions will have reactivity worth of 0.6% and 1.2% respectively. The safety-shim rods are magnetically coupled to the drives which are capable of driving the rods at 24 in/min. Upon power failure or receipt of scram signal the rods will fall freely into the core. The control rod drive mechanism is rated at 6 in/min.

When operating at low power, up to 100 kw, convective cooling will be sufficient to cool the core. For operation at power levels in excess of 100 kw, water will be pumped through the core at 700 gpm and recirculated via a holdup tank to allow essentially all of the $N^{16}$ activity to decay.

The reactor is to be housed in a 48' wd. x 120' lg. bay of the Radioactive Materials Laboratory Building. The exterior construction consists of aluminum panels fastened to structural framework. Estimated leakage rate with all doors closed and the ventilator off is estimated to be one air change in 32 hours.

The site selected by Curtiss-Wright for its research facilities comprises 51,175 acres of which 8,579 are owned outright and 42,596 leased from the State of Pennsylvania for 99 years. This tract, approximating a circle of 10 miles diameter, lies in North Central Pennsylvania encompassing portions of Elk, Cameron and Clearfield Counties.

The reactor itself will be located a minimum of 3 miles from the present boundary of the property. The countryside surrounding the site is largely uninhabited with the closest towns of any appreciable size being 10 miles from the reactor. The area within a 25 mile radius has a population density of approximately 28 people/sq. mile.

## PART II - HAZARDS ANALYSIS

### 1. General Considerations

There is an extensive body of relevant knowledge and successful operating experience for reactors of the type under consideration. Pool-type reactors using fuel elements and having core arrangements generally similar to those proposed for this reactor have been safely and successfully operated for several years. The power levels of these reactors are in the 10 - 100 kilowatt range for the Geneva demonstration reactor and the Penn State Reactors, the few megawatt range for the Oak Ridge Reactors and the many megawatt range MTR.

While it is true that none of these previously built and operated units are exactly duplicated in the design of the proposed reactor, and while there are certain features proposed for this reactor such as the greater flexibility occasioned by the large number of available fuel positions (54) which will require special attention prior to the issuance of operational approval, the stability and predictability of pool-type reactors, which has been demonstrated by the extensive successful operation of these reactors, leaves no reason to doubt that an adequately engineered and carefully constructed reactor of the type proposed by the applicant should be capable of safe operation.

One feature of importance in these considerations is the characteristic of negative temperature coefficient shared by this reactor in common with others of this type. The negative temperature coefficient contributes to both the static stability and the dynamic stability of the reactor. A reactor possesses static stability in changing temperatures if it decreases in reactivity with an increase in temperature (negative temperature coefficient), i.e., if for any cause there is a rise of temperature within the reactor, the effective multiplication factor, or its ability to sustain a chain reaction, will then tend to decrease. Consequently, the rate of heat production or power level will also decrease, tending to offset the rise in temperature. Conversely, if the temperature coefficient were positive, the reactor would be unstable to temperature changes. (AMF has presented results of calculations which indicate that) The proposed Curtiss-Wright reactor possesses a relatively strong negative temperature coefficient of reactivity, which tends to insure stability in the event of probable types of power excursions. (These results are consistent with values measured in existing MTR type reactors).

The extent of density changes in the coolant or moderator brought about by changes in temperature have a strong influence on the sign and magnitude of the overall temperature coefficient. However, such density changes do not result instantaneously from temperature variations in the fuel elements, and as a result oscillations may develop in the neutron flux and reactor power. If such oscillations are rapidly damped out because of the inherent features of the reactor, the reactor is said to have good dynamic stability. Although this phenomenon has not been completely analyzed with respect to the proposed reactor, its general aspects should not be significantly different from satisfactory observations of this characteristic made in existing reactors having similar nuclear characteristics.

## 2. Radiations

Realistic appraisal of the maximum accidents considered credible for this reactor has not been made. This will be done at a later time. In lieu thereof the applicant presents results of calculations on the consequences of total release of all fission products in the most unfavorable physical state and under various meterological conditions, including the most pessimistic ones. Even under these conditions, which may be conceded to be unrealistic, the maximum radiation dose at the nearest site boundaries does not greatly exceed what is considered a non-injurious, permissible emergency does: 100R of external gamma radiation and 4000 rem exposure of the thyroid due to iodine inhalation. While these numbers are higher than would be desired, they are not in the lethal range, and realistic doses which could be expected from more credible accidents and dispersal conditions would be many times lower.

## 3. Conclusions

Based on the above considerations, but without attempting at this time to ascertain what credible accident might actually occur in this reactor (though there would certainly be less than the maximum situation assumed above) or examining closely those details of the reactor design, the proposed instrumentation system, or the plan of operating procedures, which have been presented thus far by Curtiss-Wright in its application for license, it is concluded that there is reasonable assurance that a reactor of this general type to be operated at the power level proposed, can be designed, constructed and operated at the proposed site without undue risk to the health and safety of the public.

This conclusion is reached with the understanding that, prior to the time when the reactor, as built, is allowed to go critical, a final evaluation of the hazard aspects of the completed reactor, the operating and supervisory procedures, and the emergency plans, must show that there is reasonable assurance that the reactor, whose detailed design is then known, can be operated as proposed without undue risk to the health and safety of the public.

Lyall Johnson

December 20, 1956

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cc: F.K. Pittman

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