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CENTRAL INTELLIGENCE AGENCY
WASHINGTON, D.C. 20505

11 January 1983

MEMORANDUM FOR: Director of Central Intelligence

FROM : Clair George
Acting Deputy Director for Operations

SUBJECT : Soviet Naval Nuclear Reactors

1. The enclosed Intelligence Information Special Report describes Soviet naval nuclear reactors in use and under development, including fuel composition, some aspects of core design and some specifics of reactor performance. The information was acquired from a Soviet with a technical background and good access to the information.

2. Because the source of this report is extra sensitive, this document should be handled on a strict need-to-know basis within recipient agencies.

[redacted]

Clair George

[redacted]

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Intelligence Information Special Report

COUNTRY USSR

[redacted]

DATE OF INFO. Mid-1982

DATE 11 January 1983

SUBJECT

Design and Performance of Soviet Naval Nuclear Reactors

SOURCE [redacted] Soviet source [redacted]

SUMMARY

This report describes some aspects of the Soviet development program for naval nuclear propulsion plants, which makes extensive use of nuclear icebreakers as test-beds for new core designs. The cores described are the VM-14-5/02, the VM-14-5/03 using reprocessed fuel, and the VM-149/M. Brief data are given on the nuclear reactor aboard the KIROV-class guided missile cruiser and the liquid-metal cooled reactor aboard the ALFA-class submarine. A new type of nuclear submarine "with eggs" is reported to be undergoing testing in the Black Sea. The fuel burn-up value is given for a future icebreaker reactor core.

END OF SUMMARY

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1. On the basis of Soviet Government Decree No. 546-177 of 17 June 1977 titled, "Plans for Development of Nuclear Science and Technology until 1990", the Ministry of Medium Machine-Building and the Ministry of the Maritime Fleet issued joint order No. SR 588-80 on 20 March 1980 stipulating that all new reactor core designs intended for nuclear submarines should be tested onboard nuclear icebreakers.

2. There is essentially one reactor design, although power levels may vary; this is the OK-900, which is the "work-horse" of the Soviet Navy. The Soviets are trying to standardize fuel pin design. The KLT-40-01 is essentially the same reactor design as the OK-900, but in an unclassified version to permit the construction of nuclear icebreakers in Finland. The KLT-40-01 uses VM cores. There are currently three VM cores which have been or are being tested. These are the VM-14-5/02, the VM-14-5/03 and the VM-149/M, described below.

The VM-14-5/02 Core

3. There are two kinds of fuel pins in the core; "heavy" pins containing 16 grams of U-235 at 45 percent enrichment and "light" pins containing 12.9 grams of U-235 at 30 percent enrichment. There are about 10,000 heavy pins and about 2,200 light pins, containing a total of 197.5 kilograms of U-235. The fuel pins are assembled into two kinds of fuel element designs, one kind containing 26 light fuel pins and the other kind containing 48 heavy fuel pins. Each pin has an external diameter of 7 mm and an active length of 900 mm. The diameter of the core is 1,500 mm, giving a moderator-to-fuel volume ratio of 3.3. The lattice is triangular. The enriched uranium is embedded in a matrix of N A1 S1 03 (also given as N AI S1 04). The fuel pins are not pre-pressurized with helium.

4. There is an extensive development program on burnable poisons:

a. A gadolineum-mono-aluminate compound has been developed which is in current operation. The burnable poison is apparently manufactured by a co-extrusion method where the poison is drawn together with its canning (also given as compensator wall)--a very thin tube of ZH-844BU-UD (also given as ZHE-844GY-UD) alloy measuring 0.12 mm thickness. The fuel can wall measures 0.3 mm. The total amount of gadolineum in the core is 38 kilograms plus or minus 0.11 kilograms.

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b. Two experimental fuel assemblies containing burnable poison of gadolineum-titano-niobate are installed in this core. The mass of gadolineum in each absorber is 22.57 grams plus or minus 0.87 grams. The specific density of this poison is 3.5 plus 0.17 or minus 0.7 grams per cubic centimeter.

c. Two types of gadolineum-mono-aluminate are under study, one developed by the Kharkov Physico-Technical Institute and one developed by the Moscow POLIMETAL Plant. The latter type is drawn to a higher specific weight.

d. Burnable absorbers of gadolineum-mono-molybdenate and gadolineum-mono-zirconate are also under study. Densities of up to 4.5 grams per cubic centimeter have been achieved. Three experimental fuel assemblies with gadolineum-mono-aluminate are being irradiated. The canning is made of non-deformed steel. Similar burnable poisons with zirconium cladding are also under study.

e. Two rods with zirconium canning (E-110 alloy) are currently being manufactured for the third unit of VM-14-5/02. The detailed distribution of burnable poison in the core is not known, but fuel pins do contain burnable poison in varying amounts.

5. Beryllium oxide serves as a neutron source, using the gamma-neutron reaction. The core contains 32 kilograms of BeO.

6. The power level is 180 megawatts.

7. The control rods are neither crosses nor "finger" elements. There are two kinds: The emergency rods, consisting of four groups of four rods each, for a total of 16, and the compensators of reactivity, consisting of about 400 rods in five groups. The emergency rods are equal to the core height of 900 mm and contain boron. The compensators of reactivity have a length of about 500 mm and contain europeum and gadolineum.

The VM-14-5/03 Core

8. The dimensions of this core are the same as for the VM-14-5/02, but the number of fuel pins and the enrichments are different. There are 597 light pins containing a total of 112.95 kilograms of U-235 at 55.6 percent enrichment, and 6,732 heavy pins containing a total of 157.53 kilograms of U-235 at 68.6 percent enrichment, for a total of 270.465 (sic) kilograms of U-235. The "wall" is steel.

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9. The core contains 29.2 kilograms of gadolineum and 325 grams plus or minus 5 grams of boron. The neutron source is 6.2 kilograms of beryllium oxide. The bottom parts of the scram rods consist of europeum oxide.

10. This is the first core to use regenerative fuel. [Comment: This presumably means reprocessed fuel.] This is by joint order No. 624-81 of the Ministry of Medium Machine-Building and the Ministry of the Maritime Fleet.

11. The design burn-up level for this core is 2.6 X 10^6 megawatt-hours. The power level is 171 megawatts. Power cycling has been studied extensively. A core has been cycled 20,000 times in the range of 20-100 percent of full power with a rate of change of one percent per second. The amplitude of each cycle was plus or minus 25 percent. The system of reactivity control makes it possible to change the power from 10^{-6} to 10^{-2} percent using neutron flux meters and from 10^{-4} to 20 percent using neutron current flux meters.

The VM-149M Core

12. This is a low-enriched uranium dioxide core to be designed. [Comment: Apparently in the early stages of design.] It is 912 mm high with a diameter of 1212 mm. The fuel pins have a diameter of 9.1 mm. The canning material is zirconium. This core has heavy pins containing 23 grams plus or minus 0.8 grams of U-235 at 6.5 percent enrichment and light pins containing 17.7 grams plus or minus 0.7 grams of U-235 at 5 percent enrichment. It has a total of 109.45 kilograms plus or minus 1.9 kilograms of U-235, 5 kilograms of gadolineum and 10 kilograms plus or minus 0.2 kilograms of beryllium. The power level is 100 megawatts. The design burn-up level is 10^6 megawatt-hours.

The KIROV-Class CGN

13. The KIROV-class guided missile cruiser KIROV has a VM-14-5/03 reactor core modified so that the fuel pin length is 1,100 mm instead of 900 mm. Its power level is slightly higher than that of the OK-900. During sea trials the KIROV showed a design speed of 40 knots at 83 percent of fuel power.

Performance of Submarine Reactors

14. Reactor cores now being operated in submarines have a fuel burn-up design value of 600,000 megawatt-hours, but in fact have worked only up to 2,000 (sic) megawatt-hours.

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15. The "golden fishes" with liquid metal cooled power plants are still in operation. A lead-bismuth-eutectic is used. Current performance is not known but ten years ago it was poor. [Comment: "Golden fish" is the Soviet nickname for the ALFA-class submarine.]

16. The new type of nuclear submarine "with eggs" is currently undergoing testing in the Black Sea.

17. The future core KLT-40-01 will have a fuel burn-up value of 3.2×10^6 megawatt-hours.

Radiation Tolerances

18. Operational control of naval reactors is maintained through a combination of the use of control rods and of water flow in the primary circuit. Fuel pin failures are tolerated up to a threshold level of radioactivity of the primary coolant of 10^{-2} Curies per liter. If this level is exceeded the core is removed. The normal radiation dose tolerated for crew members is 5 rem per year. The emergency tolerated radiation dose is 25 rem.