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CIASW 87-20011M

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SUBJECT: Soviet Breeder Reactor Program

The attached memorandum addresses the Soviet Union's breeder reactor program, including its development, current status, and future course. Several deficiencies of the program are also noted, and Soviet technical exchanges in this area with France and Japan are reviewed. If you have any questions or comments regarding this paper, please contact

OSWR

Director
Scientific and Weapons Research

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DIRECTORATE OF INTELLIGENCE

6 February 1987

SOVIET BREEDER REACTOR PROGRAM

Summary

The USSR has steadily pursued the development of breeder reactors and today has the most active breeder reactor program in the world. They have three main research and demonstration breeder reactors now operating: the 60 MWe BOR-60 reactor at Dimitrovgrad, the BN-350 reactor plant at Shevchenko, and the BN-600 reactor at Beloyarsk. Their near-term plans call for series production of standardized 800 MWe breeders, the first of which is under construction. Despite their massive commitment to this technology, however, the Soviet program has a number of deficiencies, including lack of experience with mixed-oxide fuel, steam generator design and safety problems, and lack of containment structures for their current breeders. There is little or no evidence of substantial military involvement in the Soviet breeder program, or use of the breeders for weapons material production, though the Soviets may find this option attractive in the future.

The Soviets have had several technical agreements and exchanges with France and Japan in the past, but these have mostly been scientific seminars. We have no evidence that any equipment was transferred. The Soviets probably will continue to seek Western breeder expertise as their program grows, particularly in areas where their program is deficient. Their new emphasis on safety will probably increase their interest in breeder safety and inherently safe liquid-metal reactor concepts.

This memorandum was prepared by [redacted] *OSWR. Comments and questions may be direct to* [redacted] *OSWR*

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Introduction

The Soviets have had an active breeder reactor development effort since the early days of their nuclear power program. The USSR, like other countries, has concentrated its efforts on sodium-cooled breeders. Although the Soviet effort generally has lagged the accomplishments of US and Western Europe breeder programs, the decline of the prospects for breeder reactors in the West in recent times have made the continuing Soviet program the largest, if not the most technically advanced, breeder effort in the world. The Soviets have three major research and demonstration breeder reactors now operating: the 60 MWe BOR-60 reactor at Dimitrovgrad, the BN-350 reactor plant at Shevchenko, and the BN-600 reactor at Beloyarsk. The 600 MWe BN-600 is one of the largest breeder reactors in the world, second only to the 1200 MWe French Superphenix. The USSR's plans for continuing development of breeder reactors far surpasses the projections of the West. A series of standardized 800 MWe BN-800 reactors is planned, the first of which is now under construction at Beloyarsk (Ref 1). Four more BN-800 reactors are projected in the current five-year plan (Ref 2), with an ultimate total of as many as 20 (Ref 3). A larger, 1,600 MWe breeder is on the drawing boards, but no definite date has been set for construction.

Soviet Breeder Technology

The Soviet breeder designs thus far have used fairly conventional liquid-metal fast-breeder reactor (LMFBR) technology. The BOR-60 and BN-350 used a loop-type coolant system layout, but a pool-type configuration was selected for the BN-600, BN-800, and subsequent reactor designs. The BN-350 reactor is unique in that is supplies heat to a desalinization plant for the town of Shevchenko, on the Caspian Sea, as well as generating electricity. The equivalent electrical output of the electrical and desalinization functions of this reactor is 350 MWe.

The most obvious shortcoming of Soviet LMFBR technology is in the area of fuel. Western prototype breeder reactors long have used fuel made of plutonium and uranium oxides (mixed oxide), which is the fuel material of choice for commerical breeder operation. The Soviets, however, have only used enriched uranium oxide in the range of 17 to 33 percent U-235 to fuel their LMFBRs thus far (Ref 4); [redacted]

The apparent lack of progress in mixed oxide fuel development is somewhat puzzling, given the emphasis the Soviets have placed on the LMFBR program in general. Up until the later 1970s, mixed oxide fuel development may have been hindered by the unavailability of plutonium, [redacted] Since the late

1970s, however, the Soviets have been reprocessing civilian light-water-power reactor fuel in quantities sufficient to meet the needs of their breeder program (Ref 6). We do not know the disposition of the civilian reactor-grade plutonium, or why the Soviets have not pursued mixed oxide fuel development more vigorously. The Soviets are planning, however, to use mixed oxide in the BN-800s when they become operational (Ref 4).

Breeder Fuel Reprocessing and Military Implications

Breeder reactor fuel reprocessing is being developed at Dimitrovgrad, the site of the BOR-60. The Soviets have constructed a research laboratory there which has a pilot-scale plant for reprocessing BOR-60 fuel using a fluoride volatility process instead of the more conventional aqueous solvent exchange processes.

Civilian reactor research and design in the Soviet Union is under the State Committee for the Utilization of Atomic Energy (GKAE), which is controlled by the Ministry of Medium Machine Building (MSM), the Soviet nuclear weapons authority. All demonstration and prototype reactors in the Soviet Union, including the LMFBRs, have been under GKAE control (Ref 9).

Plutonium produced in the breeders, especially in the blanket region of the core, would be ideal for nuclear weapons.

(Ref 10).

Strengths and Weaknesses of the Program

The basic strength of the Soviet program is the commitment of the USSR's nuclear leadership to the technology, and its near-term implementation. With the largest number of currently operating liquid-metal reactors and the most ambitious LMFBR construction program in the world, the Soviet Union will soon have an almost insurmountable lead in operating experience with these reactors. A number of serious problems remain in their path, however. In addition to their lack of experience with mixed oxide fuel, addressed above, the Soviets have had a number of problems with sodium steam generator design and safety. For example, a serious incident occurred at the BN-350 in late 1975 when about 800 liters of water leaked into the secondary sodium loop in the steam generators, (Ref 11) resulting in a violent sodium-water reaction that damaged the steam generator. The Soviets have had somewhat better experience, however, with the modular steam generators on their BN-600 reactor. [redacted] A major potential concern in the aftermath of the Chernobyl' accident is the lack of a secondary containment structure of Soviet breeders. A major core disruptive accident in one of these plants could have severe consequences.

Western Cooperation

The Soviets have been relatively open with their LMFBR program in the past, and technical exchanges were conducted in the 1970s with several Western countries, including the US, the UK, and France. These formal exchanges largely ended in the early 1980s as relations between the Soviet Union and the West became more strained and as Western LMFBR research slowed. The Soviets continue to publish some data on their program in technical journals, however, and informal exchanges of information continue. France had a joint research project with the USSR on fluoride-volatility breeder fuel reprocessing in the early 1980s, but the project ended in 1984. (Ref 12) The Soviets also signed an exchange agreement with the French on LMFBR technology in April 1982 which covered a number of areas, including steam generators, fuel reprocessing, and waste handling (Ref 13). A number of exchanges took place, including a tour of the Superphenix by the Soviets (Ref 15). [redacted]

The Soviets probably are interested in acquiring Western LMFBR technologies in the areas of mixed oxide fuel, steam generator design and safety, and containment structures. Computer simulators and nondestructive examination techniques are areas where the Soviets are seeking Western assistance throughout their nuclear program. The Soviets expressed an interest in component fabrication technology to the French (Ref 2), an area of increasing importance as serial production of the BN-800 units begins. Breeder fuel reprocessing technologies probably also will be an increasing Soviet concern as their LMFBR spent fuel inventory grows. The recent emphasis on nuclear power safety may cause the Soviets to become more interested in such areas as safety analysis for liquid-metal reactors and inherently safe liquid-metal reactor concepts.