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Declassified in Part - Sanitized Copy Approved for Release 2012/09/25 : CIA-RDP10-00105R000100740001-4

Nuclear Power and the Maintenance of Combat Readiness

by

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At the present time there is no need to furnish proof of the obviously great importance of electric power engineering in ensuring that our Armed Forces maintain a high level of combat readiness and combat effectiveness. Suffice it to say that most combat complexes and systems and types of military equipment are able to fulfil their combat or support functions only if they have an uninterrupted supply of electric power. The development of the means of armed combat results in an increase in the volume of the power supply to the forces, coupled with a growth in the demands made on sources of electric power. The need is especially serious for reliability and regularity of supply, independence, and the ability to function when isolated from external conditions, when in transit, etc.

Potential power sources that meet all these requirements are nuclear power plants and engineless generating sets with electrochemical generators (fuel elements).

In the article "Certain Problems of Military Electric Power" we have already dwelt briefly on these sources of electric power supply.* The goal of the present article is to evaluate more fully the significance and capabilities of nuclear power plants as one of the components of military electric power engineering and their influence on the combat readiness of weapons and the combat effectiveness of personnel.

Nuclear power engineering is in the forefront of world technical progress. Whereas in the first 20 years of the worldwide development of nuclear power engineering, only slightly more than 85 power reactors of varying capacities and functions were built, in the last 5 to 6 years this figure has nearly doubled, and the total capacity of nuclear power plants increased by a factor of 8 to 10.

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* Collection of Articles of the Journal "Military Thought", 1966, No. 2 (78).

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The development of nuclear power engineering is proceeding in two different directions. On the one hand, the capacity of nuclear power plants is increasing greatly (up to 500 to 1000 MW in one unit), while on the other hand small-capacity power installations are being built, most of which are earmarked for special use. At present, small-capacity nuclear power already plays an important role in ship propulsion units (the nuclear engines of submarines, surface ships, and icebreakers) and is beginning to assume a prominent place in overland military energy, space research, etc.

In the present article,low-yield nuclear power is examined only as a basis for the construction of self-contained overland sources of thermal and electrical energy; in order to impart a more accurate understanding of its significance, we shall first give a military-technical assessment of nuclear power plants by comparing their basic tactical-technical indices with data on power plants operating on conventional organic fuel.

The main advantage of nuclear power plants over all other power plants is that they do not need a continuous supply of fuel. Nuclear power plants, depending on their operating schedule, can already function without a new supply of nuclear fuel for a period of 2 to 4 years, and in the next few years the duration of this period should be increased to 5 to 6 years. Consequently, nuclear power plants can make any installation or group of installations totally self-sufficient in heat and electricity for an extended period of time, since they do not require delivery of large quantities of POL. It should be observed that the longer the period of self-sufficiency of operation, the more appreciable this advantage of nuclear power plants will be.

The lack of dependence of nuclear power plants on supply bases is especially important to military installations, since it makes them independent of sources of fuel and of transportation facilities. In addition, it should be borne in mind that during the very first nuclear strikes, supply and communications bases may be destroyed or damaged and the supply of fuel disrupted, which in the end could render inactive those important combat installations with power plants using conventional thermal engines. When there is mass destruction (and fuel bases are extremely vulnerable to nuclear strikes) and disruption of communication routes and lines of control and communications, the power supply of especially important installations can be quickly restored with the aid of nuclear power plants. Nuclear power plants can be delivered where needed by using the most available transportation under existing circumstances, and

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installed and put into operation within a short time without organizing supply services.

The length of time a nuclear power plant functions continuously (without stopping) is calculated in thousands of hours. There is not a single diesel or gas turbine power plant that can ensure this. The maximum period of uninterrupted work of diesel power plants generally amounts to 150 hours, and only a few models can achieve 240 hours. This illustrates the much greater reliability of nuclear power plants and their superior operational characteristics.

Nuclear power plants with a steam-turbine cycle generate steam for heating purposes in addition to electric power, which is especially important in the northern areas of the country. It is extremely difficult to bleed heat efficiently for heating purposes from diesel power plants. It is also inadvisable to bleed heat for heating purposes from gas turbine power plants, in view of the fact that the low temperature of the gases produced (180 to 200 degrees C) makes it necessary to employ huge, heavy heat recovery boilers. The use of diesel and gas turbine power plants as a rule entails building auxiliary heating units in the form of separate boiler rooms or even heat and electric power plants. As will be shown below by specific examples, the operation of and supply of fuel to these units in the northern areas of the country entails a large expenditure of material means and of effort on the part of the personnel of military installations.

The restoration of a protected or semi-protected nuclear power plant is greater and simpler than that of any other power plant, since the absence of air ducts and pipelines eliminates the possibility of a shockwave penetrating the installation and causing its usual damage. The aftereffects of the seismic loads that accompany a nuclear burst are approximately the same for nuclear power plants as for other types of power plants.

When nuclear power plants are located in protected and semi-protected buildings it is easy to establish a system of prolonged, complete insulation from the atmosphere. This will decrease and possibly even preclude infiltration of the premises by chemical and bacteriological warfare agents and radioactive particles and their affecting the maintenance personnel. Other types of power plants are unable to do this, since the air necessary for the maintenance of fuel combustion is not

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cleansed of these substances and leakage and rupture of air ducts enables contaminated air to invade the premises of the power plant.

As has already been said, large fuel storage units need not be built for nuclear power plants, whereas conventional power plants must have fuel storage units with a capacity that provides either a month's fuel requirements with the power station working at maximum load, or (in the case of long-distance delivery of fuel) two years' fuel requirements. Under the conditions of the Far North and the Far East, even when power consumption is comparatively low (1 to 3 thousand kilowatts of electric power and about 5 to 10 kilocalories per hour of heat), the necessary fuel reserves are calculated in tens of thousands of tons. The lack of a need for large, protected fuel storage units in nuclear power plants decreases the volume of construction work and the quantity of construction materials and equipment needed, and consequently reduces the cost of construction.

Nuclear power plants have less noise and vibration than diesel power plants. The noise created by diesels as a rule exceeds 110 to 115 decibels. The noise and vibrations penetrate other spaces of the installation and seriously affect working conditions. To avoid this, the engine rooms of diesel power plants are placed some distance away from the working area of personnel, thus reducing the compactness of the installation.

It may be possible to build military nuclear power plants that convert thermal energy directly into electric power. These plants will possess a number of even higher qualities and greater advantages over plants with conventional generators.

Along with these advantages, nuclear power plants have definite shortcomings. First of all, their initial cost is still comparatively high. This can be attributed to insufficient experience in their planning, manufacture, and operation; the lack of special production facilities with well-developed technology for the manufacture of nuclear power plant equipment systems; the necessity of using costly materials, etc. The building of a new-type nuclear power plant involves a substantial amount, not only of designing work, but also, of scientific-research and experimental work. But these factors gradually become less significant with the overall development of nuclear power engineering. Rapid scientific and technological progress in the area of the use of nuclear energy can lead to wider mass production of nuclear and special materials; improvement of the technology of the production of units components, and

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instruments; the standardization of their use; and the accumulation of production and operating experience. The manufacture of a series of small nuclear power plants earmarked for the military may prove especially advantageous. Based on their own experience, the Americans have computed that the initial cost of military nuclear power plants for the US Army, including developmental expenditures, will be 50 percent lower in 1970 than in 1963.

In the second place, nuclear power plants are more complex than diesel and gas turbine power plants. They require more complex and sensitive automatic control and have, as a rule, a greater number of systems in the technological cycle.

In the third place, nuclear power plants require the establishment of special protective measures against the effects of radioactive emissions on people and the surroundings when the power plant is operating, when there is an overloading of the active zone, when storing new heat-generating elements of the reactor and burying waste elements, and when various types of preventive and repair work involving the equipment are being carried out.

In an overall evaluation of nuclear power plants as sources of power for military installations, it should be stated that they have a number of decided advantages over other types of power stations and will be widely employed, primarily in remote areas that are difficult of access. The most important advantages of nuclear power plants are independence from supply bases, total self-sufficiency of operation, and the capability of operating reliably and uninterruptedly for an extended period of time. These are precisely the characteristics that could ensure that weapons and military equipment have a high level of combat readiness without dependence on the operations of certain auxiliary support services.

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In view of the fact that the principal argument of those who oppose the use of nuclear power plants for military purposes concerns the large initial capital investments required for their construction, a separate appraisal of the economic advisability of using nuclear power plants in the armed forces is of interest.

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First a few remarks.

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When deciding whether or not to use nuclear power plants in military installations, economic expenditures are indisputably of great importance, but nevertheless they should not predetermine the fate of these plants. It is the tactical and military-technological advantages of nuclear power plants that are to be considered above all other factors. In fact, if as a result of using nuclear power plants the reliability and survivability of a military installation increase, if a complex or military unit has a higher level of combat readiness and combat effectiveness, and if vulnerability is decreased, for example, in the event of a sharp reduction in fuel supplies, etc., then economic factors, in our opinion, should take second place to these important combat aspects. Economic indices may become decisive only when the power factors and other tactical-technological data of the various types of power plants and power installations are being compared.

In order to arrive at a technical-economic evaluation of nuclear power plants, the technical-economic characteristics of mobile and component-transportable nuclear power plants was compared with those of diesel, gas turbine, and steam turbine power plants. The calculation was based on statistical data obtained in planning and operating small-capacity power plants. Attention was focused primarily on the use of mobile power plants, which constitute the most numerous group in the armed forces.

On the basis of a study of the requirements of the armed forces for power units, and taking into consideration the existing scales of capacities, a series of mobile power plants was selected with rated capacities of 500, 800, 1000, and 1500 kilowatts. The efficiency of a given capacity was ascertained for various periods of usage, specifically: 1500, 3000, 5000, and 7000 hours per year, and with organic fuel costs of 7 to 90 rubles per ton of conventional fuel. The calculated annual expenditures and the cost of the power produced were used as criteria of comparative efficiency.

Analysis of the calculations made shows that mobile nuclear power plants are inferior to conventional power plants when used less than 3000 hours per year and when the cost of conventional fuel is less than 80 rubles per ton, if the nuclear fuel is not regenerated. When the nuclear fuel is regenerated, nuclear power plants become profitable when the cost of conventional fuel is as low as 71 to 72 rubles per ton. The higher the cost of organic fuel and the longer the period of time per year that nuclear power plants are used, the more appreciable their economic superiority over conventional power plants.

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Moreover, calculations show that it is extremely advantageous to operate nuclear power plants in conjunction with diesel power plants. When so doing, the nuclear power plant should operate as the main basic power plant at the rated load, while the diesel power plant is used only to maintain peak loads and as a reserve. Substantial savings result when a nuclear power plant and a diesel power plant are combined in this manner. Thus, when a component-transportable nuclear power plant with a 3000-kilowatt capacity is operating as a main plant, the cost of the power produced is only 2.6 kopecks per kilowatt-hour without fuel regeneration, and 2.31 kopecks per kilowatt-hour with fuel regeneration. This compares with 3.14 kopecks per kilowatt-hour when the same plant is operating on an independent basis.

At the present time, in a number of remote areas of the country, there are military installations that are in need of a reliable power supply. Their basic sources of electric power are low-capacity diesel and steam turbine generators, with heat obtained from a large number of separate boiler rooms. Large amounts of diesel fuel, fuel oil, coal, and lubricating oils are needed to keep these units working. The distance involved, the difficulty and the seasonal nature of deliveries, the frequency of transshipment of fuel, and the impossibility and inadvisability of a return shipment of containers increase costs substantially.

Whereas, for example, the cost per ton of diesel fuel for the central areas of the country is 34 to 36 rubles, according to the data of the Lenaeroproyekt Institute, in the Amderma settlement (Nenetskiy National Okrug) it would be as high as 84.3 rubles; on Kamchatka--134.8 rubles; in the Tiksi settlement--139.6 rubles; in Kresty Kolymskiye--194.7 rubles; and in the Chokurdakh settlement (Chukotka)--214.9 rubles. This does not include the cost of delivering the fuel to consumers from the main bases. In view of the rigorous climatic conditions, the poor roads, and the difficulties involved in making local shipments, one must assume that the above indices of the cost of organic fuel may increase even when it is only shipped over short distances.

Other figures relating to the transportation of fuel oil are both interesting and extremely indicative. When the temperature of the ambient air is low, the transfer of fuel oil can be accomplished only if it is first preheated. Occasionally, prior to its use in boiler rooms, the fuel oil must be transferred two to three times, and consequently must be preheated two to three times. When this occurs, for each ton of fuel oil

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transferred 0.6 to 0.9 tons of the very fuel oil being transferred must be spent on preheating alone. These losses impede the use of fuel oil even though this fuel is cheaper than diesel fuel and not in as short supply.

It must also be pointed out that the use of separate, inefficient, and low-powered conventional power sources greatly impairs the combat readiness and combat effectiveness of installations, since the power supplied is of low quality. Breakdowns of machinery and other equipment frequently occur, and a large number of personnel must be diverted to the service and repair of the machinery and apparatus of the power plants and boiler rooms.

Let us turn to some concrete examples.

In one of the remote garrisons, seven separate boiler rooms and four diesel power plants are used to supply heat and power to the garrison and the combat complexes. The delivery of coal and diesel fuel is by expedition--once every 12 to 18 months. Coal, the consumption of which exceeds 10 thousand tons per year, is stored in piles in the open air and, to prevent it from being scattered by the wind, it is flooded with water, frozen, and covered with snow. As a result, when the time comes to extract it for the second time, it is necessary to resort to various means, including even blasting operations. Seventy privates and NCO are assigned to service the boiler rooms alone, and they have to be completely excused from combat training.

Another example. Thirty-six boiler rooms and several independent diesel power plants with an overall installed capacity of approximately 2000 kilowatts are needed to supply heat and power to one military cantonment. Coal is delivered to the boiler rooms by 10 ZIL dump trucks during the winter period, and it is often necessary to resort to the use of bulldozers. Here a whole company--120 persons--is engaged daily in the servicing of the power stations and boiler rooms. The expenditure of motor vehicle capacity is also very great. With a yearly consumption of 25,000 tons of coal and approximately 8000 tons of liquid fuel, annual expenditures expressed in monetary terms amount to more than 1,300,000 rubles. This is approximately the cost of two two-year loads of nuclear fuel for a nuclear power plant with a 3000-kilowatt capacity, and which is capable also of furnishing 7 to 10 giga calories per hour of heat. A plant such as this could successfully replace all the abovementioned sources of electric power for this installation.

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And, finally, one more example. The military cantonments of a certain garrison have 5 group and 13 individual boiler rooms and 9 power units with a total capacity of 2085 kilowatts. Coal is sent by sea and then transshipped by motor transport. The yearly consumption of coal is more than 18,000 tons. Here 77 privates and NCO are assigned daily to service the boiler rooms, and the equivalent of one million rubles per year is spent on fuel.

One must also bear in mind that the above installations have been forced by circumstances to obtain their supply of power and heat from small-capacity power plants and boilers of the most diverse types: Shkoda GS-350 diesel generators, turbo-generators produced in the US, our own generating sets such as models AD-50, DES-30, DES-40, etc. The following model boilers are installed there: Universal, Iskitim, MM3, MG-2, VNIISTO, E5-D1, etc. Many of these units have a high rate of depreciation, and consequently their operating reliability is low and the incidence of breakdowns is correspondingly high.

Naturally all this has an extremely negative effect on the combat readiness and combat effectiveness of the units deployed in the above garrisons.

We have cited only three examples to demonstrate the urgent need to solve the power supply problems of these and similar military installations and garrisons by different, more rational and economical methods. We believe this can be done with the aid of small-capacity military nuclear power engineering.

The use of nuclear power plants makes it possible to centralize the supply of heat and power to military cantonments, combat complexes, and other important installations; free a substantial number of personnel for combat training and the servicing of combat equipment; substantially increase the quality and reliability of the power supply; improve the living conditions of servicemen and their families; and on the whole increase the combat readiness and combat effectiveness of units.