Selected Works: Development of Nuclear Charges at RFNC-VNIITF (1963–1976) and Explosive Deuterium Energy

B.V. Litvinov et al.

Translated from Russian for www.nukegate.org

Abstract

The Chief Weapons Designer Boris V. Litvinov's useful book, *Selected Works*, published by Russia's 2nd nuclear weapons laboratory, the Russian Federal Nuclear Center RFNC-VNIITF in 2014, contains a chapter titled: *Development of Nuclear Charges at RFNC-VNIITF (1963–1976) and Explosive Deuterium Energy.* The primary focus is the development of nuclear charges at RFNC-VNIITF from 1963 to 1976, a pivotal period marked by the transition to underground testing and advancements in charge design, starting with the highly successful Project 49 double-primary device first tested on February 23, 1958, which its co-designer Yuri Trutnev has stated in openly published Russian news interviews, gave 2.4 times the yield/mass of the single-primary RDS37 design (which declassified Russian design reports showed used a pear-shaped casing to re-radiate x-rays from the primary on to the spherical secondary to ensure its isotropic compression, something not required by the early Teller Sausage design, which had a cylindrical shaped secondary requiring only axial compression; although all British secondaries were spherical, they used a low density filling as an x-ray disperser for isotropic compression of the secondary, rather than case focussing which was only used in Russian and also one experimental American test, namely the 1956 Redwing-Huron test of the Egg design, which had a spherical secondary and used the egg-shaped case to focus x-rays into that spherical secondary isotropically). Litvinov also includes a section on explosive deuterium energy as a potential solution to resource challenges. Translated from Russian, this text covers technical achievements, historical context, and some speculative energy concepts. By itself, it is of limited use, but when combined with other Russian recent technical books on the design and testing of cleaner nuclear weapons for "peaceful use" like canal creation (a dual-use concept, also of use for tactical neutron warhead design), British efforts to design a double-primary device (never tested by Britain in the end) as an alternative to the use of DT booster gas and ABM-vulnerable large single primary fissile cores, photographs of Russian devices in museums including warhead design cut-away illustrations accidentally published, photos of deactivated Russian nuclear warheads in Ukraine with the sides partly cut away to reveal the arrangement of components inside (although primary and secondary have had the hazardous materials removed during de-activation), and of course the quite recently published detailed interviews of Tsar Bomba testing staff and film showing the compact pear-shaped two-stage devices at each side of the central fusion stage (that too was a double-approach weapon, but using two two-stage devices to compress a clean central charge) and also from Yuri

Trutnev, a founder of Project 49, plus some information from pages 155-228 of the English (Hutchinson, London, 1990) edition of Russian nucleat weaponeer Andrei Sakharov's *Memoirs,* plus a VNIITF documentary film of Russian nuclear weapons development to 1980 (published at our site www.nukegate.org, we can get a reasonably complete understanding of the design of Russian nuclear weapons. It appears they have used intuition and trial-and-error of extremely different designs to anything tested in the West, producing far better, cheaper, cleaner nuclear warheads. By using double-primaries rather than foam disperser to compress the secondary, they reduce the time required for compression, meaning a thinner outer case is required, maximising neutron output. Highly efficient isentropic compression (rather than shock compression), first suggested at the April 1946 Super Conference at Los Alamos (ignored by Teller using a fake-no-go theorem against compression!), is used in Russian secondaries, reducing the weight and increasing the efficiency of their fusion burns to such an extent that they have been able in certain designs to eliminate tritium and to use non-radioactive deuterium fusion (DD fusion has a cross-section approximately 100 times smaller than DT fusion, at typical secondary burn temperatures). We have already discussed and illustrated much of this material at www.nukegate.org and in compressed form at https://vixra.org/abs/2312.0155. The full translation of Boris Litvinov's article below may help publicise the facts:

1 *Development of Nuclear Charges at RFNC-VNIITF (1963–1976) and Explosive Deuterium Energy:* Introduction

This review article presents some of the work on the creation of nuclear charges at the Russian Federal Nuclear Center – All-Russian Research Institute of Technical Physics (RFNC-VNIITF) from 1963 to 1976. The choice of this period is determined by two factors. First, it was a highly significant and productive time for the creators of nuclear charges—the core component of any nuclear weapon. Second, the boundaries of this period are tied to both international events and developments within the nuclear weapons complex itself.

2 Pivotal Year: 1963

The year 1963 marked a turning point in nuclear weapons development. That year, three nuclear powers—the USSR, the USA, and the UK—signed the Moscow Treaty banning nuclear tests in three environments: the atmosphere, outer space, and underwater. For the designers of nuclear charges in these countries, the era of atmospheric testing ended, and the era of underground nuclear explosions began. The USSR entered this phase having conducted only two underground nuclear tests at the Semipalatinsk Test Site: a calibration test on October 10, 1961 (executed by specialists from KB-11, NII-1011, the Institute of Physics of the Earth of the USSR Academy of Sciences, and certain units of the 12th Main Directorate of the Ministry of Defense), and a physical experiment, FO-10, on February 2, 1962 (executed by NII-1011 specialists). These two tests already demonstrated that, in addition to a sharp reduction in the energy yield of tested charges (from 50 Mt TNT equivalent in atmospheric tests to 4–5 Mt TNT in underground tests, and later even lower), the preparation and execution of underground nuclear tests would be costlier due to new types of work (mining and drilling) and an increased volume of preparatory activities, which became more time-consuming. While atmospheric tests required only three to five days from the delivery of a test device (typically an air-dropped bomb) with a nuclear charge to the explosion, underground tests stretched preparations over months.

3 Challenges of Underground Testing

The preparation for underground nuclear explosions required months. This time was needed to excavate tunnels in rock formations (or drill boreholes of appropriate depth and diameter), place complex physical installations in the tunnels to record shock waves and radiation from the nuclear explosion to determine the charge's parameters—primarily its energy yield and radiation flux intensities. All this, including the methods for detonating nuclear charges, had to be developed essentially from scratch. In the initial underground tests, equipment designed for surface and atmospheric tests was often used, which created its own challenges. It can be unequivocally stated that the transition from atmospheric to underground testing was itself a serious test for nuclear charge developers. This challenge was met with honor by Soviet scientists, engineers from both nuclear centers, and military personnel at both test sites (Semipalatinsk and Novaya Zemlya).

There is reason to believe that the American proposal to ban atmospheric nuclear tests and shift to underground testing was motivated not only by environmental concerns but also by the hope that such tests would slow the USSR's nuclear weapons development. However, this did not happen. Realizing this, the USA and UK proposed a new initiative in 1972: a trilateral treaty limiting the energy yield of underground nuclear explosions to no more than 150 kt TNT equivalent. On July 3, 1974, this treaty was signed in Moscow between the USSR and the USA. It entered into force on March 31, 1976, and was strictly adhered to by its signatories until the complete cessation of nuclear testing in the USSR in October 1990, despite the treaty being ratified by both sides only in 1990. Thus, 1976 can be considered the end of the period of underground nuclear tests with unrestricted energy yields. This required solving new challenges, but those belong to a different period in the history of Soviet nuclear weapons development.

4 New Design Paradigms

The second, equally important reason for marking 1963 as a pivotal year in charge development is the shift, starting that year, to physical schemes and designs of nuclear charges that became the foundation for the subsequent creation of the generation of nuclear charges that still forms the basis of Russia's nuclear arsenal. The year 1976 can be considered the end of this period, as by then, most developed nuclear charges had been mastered in serial production and transferred to the Soviet Army's arsenal.

The shelf life of these nuclear charges has long expired, and they have been dismantled. Production of some, given their excellent combat and operational qualities, was resumed multiple times. Others now exist only as design documentation stored in archives. Unfortunately, most technological documents for their production have been destroyed, as have many of the materials used to make them. Many of the specialists who designed and built these charges from 1963 to 1976 are no longer with us. Only archival documents and the memories of surviving veterans help reconstruct the details of this critical period in RFNC-VNIITF's activities.

Reflecting on the stages and directions of this period's work, one concludes that they were all linked to the realization that nuclear charges with massive energy yields of 50 or 100 Mt TNT equivalent had no future. In 1963, our institute's work plan included creating a nuclear charge with a 100 Mt TNT yield, as the charge tested by KB-11 on October 31, 1961, with such power could only be carried by a specially modified Tu-95 aircraft. We proposed our variant of a charge with the same yield, based on a scheme developed at our institute by L.P. Feoktistov, M.P. Shumaev, E.N. Avrorin, and B.M. Murashkin, successfully tested in atmospheric tests in 1962 with charges of lower yield. Missile design bureaus, particularly the one led by Academician V.N. Chelomey, were developing a heavy rocket capable of carrying over 20 tons of payload specifically for our charge. This seemed to suggest continued military interest in powerful and super-powerful nuclear charges and their delivery systems. However, reports increasingly indicated that the Americans had chosen a different path: creating nuclear charges with yields up to 1 Mt and masses of 300 to 500 kg, requiring far less powerful rockets than those being developed in the USSR. The atmospheric tests by KB-11 and NII-1011 in 1961–1962 in this direction were unsuccessful, causing concern among both the military and the developers. It turned out that creating powerful charges was easier than creating less powerful ones with strict mass constraints.

5 Energy-to-Mass Optimization

Thus began the era of designing nuclear charges with a specified energy-to-mass ratio. Later, by the end of the period—i.e., by 1976—an additional constraint on the shape of nuclear charges emerged, as it became clear that the best characteristics for a strategic missile warhead were achieved by optimizing all its components, primarily the nuclear charge as the main mass component in the warhead. Thus, the period from 1963 to 1976 can be called not only the time of underground nuclear tests with unrestricted yields but also a pivotal period for designing modern nuclear charges.

Starting in 1963, the main requirement for nuclear charges of non-strategic purpose became minimizing the consumption of nuclear materials, especially plutonium and tritium, per unit. Our minister, E.P. Slavsky, issued a special directive obligating both institutes to begin developing economical and efficient nuclear charges. This task could be solved by fully mastering innovations that emerged at KB-11 in the late 1950s. Although these began to be applied in their designs, they were criticized by many authoritative scientists and designers. This criticism was based mainly on some negative results from the 1961–1962 atmospheric tests. Analysis showed that the negative effects cited by critics were due to poor combinations of design elements and not inherent to the new progressive solutions. Meanwhile, designs incorporating these new elements pointed to new possibilities and successful solutions to the newly posed tasks. Ignoring this for the sake of dogmas would have been unacceptable. Thus, NII-1011 proposed creating a charge for tactical and operational-tactical carriers with the weight and dimensions of a charge previously developed at KB-11 but significantly surpassing it in plutonium economy and operational characteristics. The primary nuclear charge for this was tested at the Semipalatinsk Test Site in September 1965, and the full charge was tested there in early 1966. Both tests were successful.

Another important proposal from this set of issues was our suggestion to replace our own charge with a more economical one with better operational qualities. The replaced charge had many modifications, which underwent various full-scale tests in 1961–1962. However, in late 1963, during a temperature regime violation in one military unit, cracks appeared in the high-explosive components.

6 Overcoming Design Flaws

Over a year was spent investigating the causes of these cracks, the possibility of continued operation with them, and the feasibility of creating a more temperature-resistant design. These technical investigations culminated in a proposal to develop an entirely new charge. On the personnel and organizational side, at the insistence of Deputy Minister V.I. Alferov, who demanded punishment for the designers, the chief designer of NII-1011, B.V. Litvinov, and his first deputy, P.A. Yesin, were demoted. By order of Minister E.P. Slavsky on April 24, 1965, A.D. Zacharenkov, previously the chief designer for warhead development, was appointed chief designer of nuclear charges at NII-1011, with B.V. Litvinov as his first deputy. L.F. Klopov was appointed chief designer for development. The change in leadership did not alter the bureau's focus on new developments. The new charge, replacing the defective one, was tested in October 1965. It was an exceptionally simple and successful design, becoming the basis for a series of subsequent designs for various purposes. The main developers of this new generation of charges—A.I. Balamutin, A.D. Zacharenkov, F.F. Zhelobanov, A.I. Zhukov, B.V. Litvinov, V.K. Orlov, P.K. Panov, L.E. Polyansky, V.B. Rozanov, I.V. Sanin, V.A. Stakhanov, and A.A. Chvileva—were awarded the Lenin Prize, underscoring the significance of their work.

Our institute's scientific director, E.I. Zababakhin, placed great importance on miniaturizing nuclear charges, especially primary ones. Clearly, their miniaturization opened possibilities for miniaturizing thermonuclear charges while maintaining energy yield or increasing yield while keeping total mass constant. Zababakhin noted the U.S. tactical missile "Davy Crockett" with a 280 mm diameter. Theorists N.V. Ptitsyna and A.K. Khlebnikov proposed a charge scheme fitting this diameter. It was the first to use a plastic explosive composition developed at our institute under P.K. Panov's leadership to replace the solid explosive used at VNIIEF. The miniaturized charge was sent to the Semipalatinsk Test Site in February 1964 for an underground test to verify its functionality.

7 Miniaturization Efforts

At the same time, our institute was preparing a physical experiment there to study the effects of nuclear explosion radiation on materials. Both experiments were led by N.I. Pavlov (head of the main directorate overseeing both institutes in our ministry). Many observers and leaders attended the physical experiment, including VNIIEF's chief designer, E.A. Negin. Upon learning that our charge used a plastic explosive composition, Negin, as chairman of the ministry's explosives commission, stated that the commission had not reviewed such a composition and could not approve its use. Pavlov ordered the charge returned to the institute. Despite our efforts—both mine and Zababakhin's—to persuade him, Pavlov was adamant. We left the test site empty-handed.

This decision did not halt the development of such charges, only delayed it by a year. In March 1965, the USSR tested its smallest-caliber atomic charge for the first time. Its energy yield was modest, but it was a nuclear charge, functioned as calculated, and was nuclear-explosion-safe.

Undoubtedly, one of the outstanding events in creating new nuclear charges was the physical experiment in February 1965 and the test in May 1965 of a special initiating device (abbreviated SINIUS), proposed by our institute's eminent theoretical physicist, Yu.S. Vakhrameev.

In another physical experiment from those years, proposed by E.I. Zababakhin, L.P. Feoktistov, E.N. Avrorin, and A.A. Bunatyan, and rightly considered pivotal, it was likely the first time in human history that significant quantities of gaseous deuterium were ignited. In this experiment, the combustion of a deuterium-tritium (DT) mixture placed outside the initiating nuclear charge was achieved for the first time, and an attempt was made to ignite a chain of elements filled with the same mixture. This opened the door to many applied uses, including the creation of nuclear explosive devices for applications like ground excavation. Beyond its applied significance, the experiment had fundamental importance, providing reference data on several physical processes in high-energy-density physics. The successful SINIUS test and the proof of the feasibility of deuterium-based thermonuclear reactions enabled...

8 Low-Fission Thermonuclear Designs

NII-1011 (VNIITF from 1967) to pursue work on creating a primary nuclear charge with low fission activity, a transitional device from such a charge to powerful secondary thermonuclear charges operating solely on gaseous deuterium, and a radiating nuclear explosive device for various physical experiments.

The development of these ideas led to 17 underground tests from 1965 to 1972 of various nuclear explosive device designs intended exclusively for industrial, not military, applications. Not all tests were successful, but negative results were also valuable, as they helped define the operational range of these devices. Some key practical results from RFNC-VNIITF include:

First, the joint creation with VNIIEF of the "cleanest" thermonuclear explosive device for excavation nuclear explosions, tested in December 1972. With an energy yield exceeding 100 kt TNT equivalent, its fission activity was only a few tens of grams—ten times less than the fission activity of the industrial nuclear explosion for the Chagan reservoir, conducted by KB-11 in January 1965. This marked significant progress in excavation devices over eight years. Unfortunately, the Soviet-American Treaty on Peaceful Nuclear Explosions (1974) banned nuclear explosions with ground ejection.

Second, the creation at our institute of special nuclear explosive devices for physical experiments studying the effects of nuclear explosion radiation on materials and military equipment.

Third, the development at VNIITF of a special nuclear explosive device with low fission activity for underground ore and mineral crushing. In September 1972, this device was used to crush apatite at the Kuzlypor deposit in the Khibiny Mountains. The extracted apatite was radiologically clean and immediately processed into fertilizer.

The development of nuclear charges for industrial applications also included devices for contained (camouflet) explosions. From 1965 to 1968, our institute created and applied a nuclear explosive device to seal gas leaks from lower horizons to the surface.

9 Industrial Applications

This device was designed for use in technological wells lined with 299 mm pipes, with bottom-hole temperatures up to 105°C and pressures up to 500 atm. Later, another device was created for similar wells, more economical in fissile material use but limited to a maximum temperature of 80°C. These two devices effectively addressed all tasks for industrial contained explosions.

The main task in military nuclear charge development was creating compact, highly efficient nuclear charges enabling high energy-to-mass ratios for warheads. As atmospheric tests showed, this could not be achieved with old methods. New ideas were needed for both primary nuclear devices and secondary devices. These efforts dominated our institute's charge developers throughout the period. It was a challenging path, but ultimately, we created nuclear charges that enabled unique combat capabilities for warheads of strategic missile systems across all basing types. According to the 1982 Soviet Ministry of Defense publication *Whence the Threat to Peace*, the USSR was never the initiator in any type of nuclear weapon (see Table 1).

Table 1: Initiation of Nuclear Armament Developments

Armament	USA	USSR
Nuclear weapons	Mid-1945 (approx. August)	Late 1940s
Intercontinental strategic bombers	Mid-1950s	Late 1950s
Nuclear submarines	Mid-1950s	Late 1950s
Separable individually guided warheads	Late 1960s	Mid-1970s

10 Arms Race Dynamics

This table shows that the USSR was not the initiator of nuclear weapons or their new variants but responded worthily to U.S. challenges, ensuring parity through equally advanced designs.

The most complex competition was in creating separable individually guided warheads, not only against U.S. developers but also against colleagues and competitors at KB-11 (VNIIEF).

I recall the origin of the separable warhead idea. I first heard it from missile designer Academician V.N. Chelomey.[1] Work began in 1962 but did not progress at the time. About three years later, it became known that similar work had started in the USA. At that time, the U.S. was pursuing a powerful missile defense system, "Safeguard," against Soviet high-yield intercontinental warheads. Soon after announcing this defense, U.S. opinions emerged[2] suggesting that such a defense could be countered by a missile system with a warhead that separates in flight, before entering the missile defense zone,

[1]See the article "Atmospheric Nuclear Tests of 1961–1962" in B.V. Litvinov, *Nuclear Energy Not Only for Military Purposes*, Yekaterinburg, 2002, p. 130.

[2]Most cogently presented in an article by American physicists Hans Bethe and Garvin, published in *Scientific American*, March 1968.

into multiple smaller-caliber, lower-mass warheads. Additionally, the separable warhead could include lightweight decoys or decoys matching warhead mass. This complex target set would overwhelm the missile defense's guidance and targeting systems, as timely and reliable target designation for interceptor missiles became impossible. After debating for a year or two, the Americans scaled back their missile defense efforts but intensified work on separable warheads for intercontinental ballistic missiles. The first such warheads entered U.S. service in the late 1960s. Their warheads, after release from the dispersal platform, were not guided to specific targets but distributed randomly over the target area, earning the name "passive guidance warheads." By the 1970s, the U.S. had warheads targeted to specific objectives, called "individually guided warheads."

11 Separable Warheads

Naturally, American successes in separable warheads (which they did not conceal) could not go unnoticed, and by the mid-1970s, our institute delivered a passive guidance warhead for a separable warhead on a sea-based strategic ballistic missile.

This was made possible by implementing a new principle for primary nuclear charge design, proposed by L.P. Feoktistov in 1966, and by efforts to miniaturize primary nuclear charges, initiated by E.I. Zababakhin. It's also worth noting that by this time, work on powerful explosive compositions based on octogen began yielding results. These efforts, too, were launched at Zababakhin's initiative.

Once, returning from Moscow, he told me and E.A. Feoktistova about Alfred Yanovich Apin, a renowned explosives researcher at the Institute of Chemical Physics in Moscow. Apin showed him a remarkably large, pure, and beautiful octogen crystal and described its excellent properties. Synthesized in Germany in the 1930s, this explosive had strangely lacked practical application for a long time. Apin's account deeply impressed Zababakhin, who asked us to pursue creating a powerful explosive based on it. E.A. Feoktistova introduced the idea to our plant director, Nikolai Alexandrovich Smirnov, who was equally enthusiastic. By then, I was chairman of our ministry's explosives commission, through which we organized work in several institutes in Moscow, Leningrad, and Dzerzhinsk. The fastest solution came from the nitro-compounds department at Leningrad Technological Institute, led by Lev Ilich Bagal, an outstanding chemist and founder of a remarkable school of explosives researchers. The explosive composition they proposed in mid-1965 was used in our 280 mm caliber charge, tested in October 1966. This test showed the charge's energy yield more than doubled compared to the old explosive. However, the new explosive's path to other nuclear charges was initially marred by its unexpectedly low chemical stability. Intensive studies identified parameters to control, making the composition chemically stable.

12 Explosive Innovations

By late 1966, two samples of a new nuclear explosive device were prepared for testing at the Semipalatinsk Test Site and tested in January 1967. These tests launched a highly fruitful direction in nuclear charge design, enabling VNIITF to create uniquely compact and efficient nuclear charges used in many nuclear weapon types. The full story of this work, with its sometimes dramatic moments when VNIIEF's view that our efforts were futile or even harmful seemed poised to prevail, cannot yet be told. Fortunately, that did not happen.

My account would be incomplete without naming the main participants in this heroic work. Theorists: N.V. Ptitsyna, B.M. Murashkin, Yu.I. Kuznetsov, V.I. Muzhitsky. Gas dynamicists: I.V. Sanin, V.V. Danilenko, B.G. Loboiko, I.V. Kotko, E.F. Novoselov, L.E. Polyansky, S.V. Samylov, I.G. Kabin, A.A. Chvileva, V.P. Krupnikova, L.L. Lebedev, Yu.P. Lyvov. Designers: P.I. Koblov, N.V. Bronnikov, Yu.A. Ivanov, Yu.K. Chernyshev, Yu.N. Emelev, V.A. Usoltsev, I.S. Karpov, S.V. Krylov, Yu.V. Starovoytov, V.I. Strebkov, A.S. Krasavin, A.L. Glazkov, N.N. Kriulkin, A.I. Balamutin, A.A. Isupov, V.V. Starikov, V.E. Sinyavin, G.P. Dubrovin. Technologists and manufacturers: F.K. Yakubov, Yu.P. Grinev, A.E. Khupovets, A.A. Gornovoy, B.I. Belyaev, E.A. Dedov, N.A. Smirnov. Testers and physicists: E.I. Parfenov, V.I. Zhuchikhin, V.A. Vernikovsky, Yu.F. Grigorich, G.P. Zyryanov, N.G. Kostetsky, E.I. Vinogradov, A.I. Saukov, B.A. Predeni, L.P. Volkov, A.S. Ganeev, K.K. Krupnikov, N.G. and V.G. Rukavishnikovs. This list is undoubtedly incomplete, and I apologize in advance to those omitted—my memory is not what it was.

13 Artillery and Mortar Charges

No less successfully, our institute pursued mortar and artillery themes, which began at KB-11. Through the efforts of a VNIIEF developer group led by Academician M.A. Lavrentyev and engineer V.M. Nekrutkin from 1953 to 1958, nuclear charges were created for a 16-inch gun and a 240 mm mortar. Later, it was found that these charges lacked nuclear explosion safety, rendering years of effort by a large VNIIEF team futile. After overcoming the country's misguided attitude toward artillery under N.S. Khrushchev, our institute became the USSR's sole developer of nuclear charges and munitions for artillery and mortar systems. Nuclear charges meeting military specifications were created for standard artillery and mortar systems, a task successfully solved at our institute during this period. Samples of 152 mm and 203 mm shells and a 240 mm mortar mine, displayed in our nuclear weapons museum, were created at VNIITF and served in the Soviet Army's arsenal for their designated time.

14 (next chapter extract:) Explosive Deuterium Energy: Preventing a Resource Catastrophe

G.A. Ivanov, N.P. Voloshin, A.S. Ganeev, B.V. Litvinov

Non-homogeneity, estimated availability, currently—140 TW. The article justifies achieving this figure through explosive deuterium energy (EDE).

Proposals to use nuclear explosions for energy date back to the late 1940s. In the 1960s, they were seen as cumbersome compared to anticipated successes in controlled thermonuclear fusion (CTF) and breeding fission energy (BFE). In the 1970s, under the leadership of Academicians E.I. Zababakhin, E.N. Avrorin, and B.V. Litvinov at RFNC-VNIITF, deuterium-based nuclear explosive devices (NEDs) were created, costing less than the energy they released. These were not "demonstration experiments" but real devices—products of advanced technology—burning hundreds of grams of deuterium, though requiring "taming" of energy in tens of kilotons TNT equivalent.

A.D. Sakharov proposed discussing explosive energy “without dogmas or prejudices” [?]. Western history on such proposals can be judged from [?]. By the 1970s, it was clear that even “grams” of thermonuclear fuel burned with “loss of compactness” [?]. RFNC-VNIITF experiments showed that igniting milligrams was unfeasible even with a nuclear explosion’s energy [?], though igniting larger masses allowed “corrections” for smaller ones. [...]