NUCLEAR KNOWLEDGE MANAGEMENT: RUSSIAN LESSONS

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The paper describes the Soviet experience preserved in Russia and related to the strategy of nuclear knowledge preservation in period of fast nuclear energy deployment. This experience includes:

- creation of nuclear science & engineering centers and "science towns" on the base of the "Uranium Project" founder organizations;
- formation of scientific schools headed by eminent scientists on the base of major nuclear power problems, thus establishing creative teams with "natural" nuclear knowledge transfer;
- harmonious nuclear education system, which has a principal achievement of close connection with the country's leading nuclear centers;
- establishment of a regional centers' network for regular retraining of nuclear specialists;
- creation and development of national centers for collecting, processing and evaluating nuclear and other (material, thermal physics, etc.) data relevant for nuclear engineering, as well as algorithms and codes.

The paper discusses the problems of 80-90ies: "gap" between generations, loss of the experimental base, ageing of scientific teams, weakened governmental support, etc.

Obviously resumed positive development of the Russian nuclear energy in the last years, as well as expectation of the "Second Nuclear Era" of large-scale nuclear energy use in the country, has made the elimination of NKM defects and the development of human resources one of the most important and vital prerequisites of the further nuclear development. The paper considers the measures taken in this regard by the Russian nuclear industry, including international cooperation.

This paper was prepared by the representatives of the Russian Research Centre "Kurchatov Institute" and the Central Research Institute of Management, Economics and Information. The latter was established in 1963 and now is the head scientific & methodical center of the Federal Atomic Energy Agency of Russia in the field of management, economic and information activities, including the issue of knowledge preservation. Below we shall return to its role.

As concerns the Kurchatov Institute, established in 1943, it was the first – and, for some time, the only – scientific center of the "Uranium Project", and this should be the "staring point" for discussing the issue in question.

Since the very beginning of the works on practical use of nuclear energy in the Soviet Union, the problem of generation and accumulation of nuclear knowledge, as well as providing human resources to apply this knowledge, have received strong governmental support and have been subject to strict control of the state.

This policy, in spite of the known Russian difficulties related to the lag of computer base and hampered scientific & technical exchange with the West ("Iron Curtain"), as well as to the "internal" barriers for knowledge exchange between military and civil nuclear powers, nevertheless, in the 50-70ies has made it possible both to solve the required defense tasks, and to ensure the development of peaceful nuclear energy applications in the Soviet Union. It should be noted that in a fast-developing system, knowledge accumulation and transfer issues are solved almost "automatically".

Now - after the "quick start" – when the rate of nuclear power development stays slow for a long time, there are already some concerns that "the time is out of joint", and some achievements of the first period were lost irrevocably.

But now it is also the right time to remember, what has been done by the "fathers" of nuclear energy use in the field this Conference considers, which is widely enough understood as accumulating knowledge, processing the information which makes this knowledge accessible, and organizing its transfer to the new generations of nuclear professionals.

These achievements had much in common in the countries, which began to develop nuclear energy – as well as astonishingly similar were many of independently found technical solutions in nuclear designs, when the specialists from West and East received opportunity to compare them. Nevertheless, we would like to remind of some specific Soviet experience. Here it should be noted that the Russian experience was already presented in the IAEA (in 2002), in a detailed report of Prof. E. Adamov [1].

1. SOVIET ACHIEVEMENTS PRESERVED IN RUSSIA

1.1. Nuclear centers and scientific towns

A great, though concomitant, achievement of the first phase of the nuclear program - which our country owes mainly to I. Kurchatov – consisted of creation of a system of national research centers, which went far beyond the frames of pure nuclear weapons' creation task, and was aimed at widely using nuclear energy. Despite the severe post-war conditions, the decision-makers have been persuaded that such nuclear power centers are necessary – and we still enjoy the results of these decisions.

At the initial stage, it was the Kurchatov Institute, which served as an "incubator" for creating new research centers [2]. Today's Nuclear Center in Sarov (VNIIEF) at first was the Kurchatov's department. Then large centers were established in Obninsk, Dubna, Dimitrovgrad, Serpukhov, in parallel with industrial and scientific centers of the Ural and Siberia. The Kurchatov Institute gave birth to the Institute of Nuclear Physics of the Siberian Branch of the Russian Academy of Sciences (RAS), with its unique accelerator base, and the Institute of Molecular Genetics of the RAS. At I. Kurchatov's initiative, research reactors have been built in the physical centers of Russia and Soviet Republics.

Development of large nuclear centers has resulted in establishment (mainly in Russia) of so-called "science towns" – relatively small towns, with scientific research, development and testing of new technique and high-class specialists' training being their main production activities. Over 15 such towns of only nuclear profile exist now in Russia. Their research centers gradually "attract" other scientific organizations of similar profile and educational institutions. Obninsk, which, besides the large "national nuclear laboratory" - the Institute of Physics and Power Engineering (IPPE), also has the Medical Radiological Research Center, large physics & chemistry and meteorological institutes, device manufacturing plant, etc., is a good example of such a town-formation. Also in Obninsk, there is the nuclear technical university with 4000 students, which provides specialists for the most important nuclear activity areas. Naturally, such towns create very favorable atmosphere for creation and transfer of scientific knowledge between generations.

Creation of a wide nuclear science and technology centers' network has ensured not only the real sustainability of new knowledge development and generation, but also the high level of selection and the quality of the selected solutions, thanks to the healthy competition and collaboration between various scientific schools, as well as wide involvement of young people into science and reproduction of the scientific successor generation.

1.2. Scientific schools

Nuclear centers have established the base for formation of nuclear schools around eminent scientists, on the basis of large-scale nuclear energy issues, which formed creative teams with "natural" transfer of nuclear knowledge. Many of such schools are known outside Russia. Let us note the schools headed A.Leipunski (fast reactors), I.Kikoin (isotope separation), A.Bochvar (radiation material science). L.Artsimovich (controlled thermonuclear fusion), and dozens of others. Many of these schools currently live and develop. It should be noted that the process of formation of a scientific school may take decades, and their destruction is, as rule, irreversible.

1.3. Data banks

The system of nuclear centers has become a natural basis for creating and developing national centers for collecting, processing and evaluating nuclear and other data, needed for nuclear technologies (radiation protection, material properties, thermal hydraulics, etc.), as well as algorithms and codes.

As an example, the following Russian nuclear data centers have had a firm place in the international nuclear data service centers' cooperation already in the times of limited contacts between East and West: neutron database (SUD, Obninsk), charged-particle database (CAJAD, Kurchatov Institute), photo-nuclear database (CDFE, Nuclear Physics Institute of the Moscow State University), and some others.

Nuclear industry's database of nuclear reactor and radiation safety calculation algorithms and codes contains about three thousand of verified and validated codes and accompanying documents; moreover, it practically assures the obligatory code certification procedure, prescribed by the regulatory authority (now Gostechnadzor) for nuclear installations' safety evaluation.

An example (which is particularly close to one of the authors) of a successful international collaboration program (which will be described in detail at this meeting) in this key KNM area – preservation and transfer of knowledge and "safety culture" to new generations – could be represented by the Criticality Safety Benchmark Evaluation Project [3], initiated by US DOE in 1992 and realized by Dr. Blair Briggs (INEEL). The basic idea of the new approach consists of collecting, presentation in a standard format, and additional peer review of all the available experimental data on multiplying systems' criticality that meet certain requirements. The project received worldwide recognition, and was transferred into an international project (ICSBEP) performed under the auspices of the Organization for Economic Cooperation and Development – Nuclear Energy Agency (OECD-NEA).

Implementation of this project was aimed, in particular, at preserving the "nuclear legacy" accumulated in the last century, including the results of now disclosed experiments performed in the past for defense purposes and almost inevitably being past recovery after the death of their authors, for the future arising problems.

The latest version of the International Handbook of Evaluated Criticality Safety Experiments, contains descriptions of more than 3000 critical and subcritical configurations, performed by the specialists from 12 countries. Russian contribution to this world "bank" of benchmark evaluations makes about 40%. CSBEP lives, and the International Handbook is permanently updated.

1.4. Nuclear education

Since the very beginning of the Soviet "Uranium Project", when, in the hardest war conditions not only nuclear physicists, but also school physics teachers have been recalled from fronts, a harmonious system of nuclear education was laid in. A special Russian report will be dedicated to this issue at this meeting, so it will be enough to mention briefly its current state and emphasize one important feature.

Russian nuclear education system, which was created almost simultaneously with the nuclear branch, and which receives organizing and material support from the Ministry of Atomic Energy (currently Federal Agency), today comprises twenty secondary professional education institutions (colleges) with annual number of about 5 thousand graduates, and more than ten higher education institutions (over 80 specialities), including the basic one – Moscow Engineering & Physics Institute (state university). Over 7000 students study only in MEPhI. Every year over 2000 young specialists from about 200 higher educational institutions come to nuclear enterprises.

Close connection between educational institutions and the country's largest nuclear centers is a principal achievement of the Soviet nuclear education system. This provides the possibility of practical training of senior students on the country's best experimental facilities, and in due time places the future specialists in the creative scientific atmosphere – when "the walls (i.e., collective experience) teach".

It is especially important that this method "naturally" solves the issue of knowledge transfer in the "sensitive" nuclear engineering areas, the access to which is restricted by national security considerations.

Since the end of 60ies, a system of regional centers for nuclear specialists' retraining began to develop. Today such centers exist not only in Moscow, Saint-Petersburg, Obninsk, but also in Siberia and the Ural (leaving aside personnel training faculties in educational institutions). They are capable to improve the qualification of about 12-14 thousand specialists per year. It is characteristic that these institutes have also become nuclear public information centers.

2. SOVIET CRISES

The Chernobyl NPP accident of 1986 has not resulted in an immediate stop of the Soviet nuclear power program. From 1985 to 1995, 8 VVER and 2 RBMK units have been commissioned in the former-USSR (Russia, Ukraine, Lithuania). This has also made it possible to perform large-scale cardinal safety enhancement works on reactors of all the existing types.

However, the social consequences of Chernobyl turned out to be incomparably more serious, than the direct losses caused by it. As soon as the population "received the voice" as a result of the political system restructuring in the end of 80ies, it demanded to stop nuclear power development – and this really occurred in the beginning of 90ies.

Almost all nuclear R&D organizations received severe blows. The governmental support, which reduced to the minimum, for obvious reasons has coincided with the mass departure of specialists (mainly the young ones) from the nuclear industry. It should be noted that, in the overwhelming majority of cases, it was not the emigration abroad – as widely discussed on the West, but a departure to "internal" business structures, banks, etc., which were willing to welcome these well-educated nuclear specialists. This was followed by drastic reduction of technical service personnel, moral ageing and physical wearing of the equipment park. For example, in the 90ies the Kurchatov Institute has lost right a half of its staff. Some scientific institutions have simply disappeared.

Similar situation has formed in the education system, where there was almost no competition for nuclear – and all technical – professions, in parallel with great interest of the young generation to economic and, especially, juridical education.

Collapse of the Soviet Union has not added much to the blows received by the Russian nuclear sector (leaving aside the loss of most uranium resources and some sensible production). Nevertheless, the ties with some research centers, important for the whole complex, have been broken or became much weaker. These centers include the Kharkov Physics & Engineering Institute in Ukraine (radiation material science), Belarus nuclear center (original family of fast reactors), Kazakhstan experimental base with a unique pulse reactor, and some others.

On the whole, the crisis decade resulted in the dangerous proximity to the boundary, which could be described by the above-mentioned maxim of the Prince of Denmark: “The time is out of joint”.

3. WHERE ARE WE NOW

Russian nuclear complex has survived a crisis decade. For five years (from 1998 to 2003), nuclear energy production increased with a factor of about 1.5. It may be expected that by the end of 2004 the number of new nuclear power units, designed in Russia and commissioned at the post-Soviet territory in the current century, will grow up to four. Five nuclear units of Russian design are under construction abroad.

This has become possible, because the Russian nuclear branch, unlike other high-technology branches of the FSU, has managed (though with considerable losses) to preserve its organizing unity, science, high technologies and potential. The principles laid in during its establishment, including scientific knowledge management, have proven their high sustainability in crisis conditions.

As noted above, this sustainability is based on a ramified system of nuclear centers, which preserves and develops the support of scientific schools headed by the leading scientists, as well as on state-of-the-art scientific & technical base of nuclear database centers’ network.

Russia has also managed, to a certain extent, to preserve and develop the Soviet achievements in the sphere of nuclear education. Several Russian institutes have their branches at nuclear enterprises, forming joint education & research centers. For example, the Kurchatov Institute has close ties (including branches) with many leading educational institutions: MEPhI, Physics & Engineering Institute, Moscow State University, aviation, energy and other institutes. The education institutes can use the experimental base of scientific enterprises in Moscow, Obninsk, Podolsk, Dubna, St.-Petersburg, Nizhni Novgorod, Ekaterinburg, Krasnoyarsk, Tomsk and some other cities and towns of Russia. Revival of interest to nuclear education in the last 3-4 years is now a fact.

Nevertheless, the situation gives no reasons for much optimism from scientific knowledge preservation and transfer. The recent analysis of the age of nuclear specialists has shown that over a half of the country’s nuclear R&D professionals are older than 50; the rate of young people (up to 30 years old) makes only 10-15% - and this age group has reduced 2-3-fold in the last 15 years, while the group aged over 60 – increased with the same factor. The situation in the Kurchatov Institute is almost similar, though in the last 10 years it was outside the Minatom system. It should be noted that in nuclear industry, where the salaries are considerably higher, the situation is also less critical: the rate of workers over 50 makes 20-30%, and workers younger than 30 – about 20%.

The education system has also suffered from the severe consequences of the crisis decade. Schools and institutes have lost teachers and professors of the most efficient age. Obvious fast progress of Russian computer base and software is only a partial compensation of purely human issues.

4. WHERE ARE WE GOING TO

Russia shares the hopes of the world nuclear community for the “Second Nuclear Era”. Moreover, serious and long-term recognition of the need to develop the nuclear power is a political decision of the Russian leaders. Influencing the solution of issues related to fossil energy resource constraints, crises related to uneven distribution of fossil fuels, and global and regional environmental constraints, use of nuclear energy becomes a factor stabilizing the global economic development and an environmentally acceptable part of the energy choice.

In the same time, “high” and even “medium” nuclear energy development scenarios dictate considerably high rates of technological innovations in the field of nuclear reactors and fuel cycles, which are objectively based on the knowledge and experience accumulated during the first fifty years of nuclear development [4].

In this situation, elimination of defects in the system of preservation of nuclear knowledge, its transfer to the next generation of researchers, and development of the human resources lies on the “crucial way” of nuclear development.

In the last years, understanding of this situation has pushed the nuclear community to look for the ways of resolving it. Leaving aside the financial aspects (salaries, scholarships, etc. – where Russia still differs too much from the West), it could be noted that in this area the ways were intensively searched for – and found - of attracting the young generation to nuclear science and keeping its specialists (both “students” and “teachers”) from leaving, along with the ways of their material and moral support. The latter include dedicated scholarships, grants, competitions of diplomas and works performed by young specialists, governmental support of scientific schools, etc.

A new form of education has been found – establishment of higher educational institutions right in the large scientific centers, that makes it possible already for the students of second or third year to take part in the scientific research (for example, the Institute of Natural Sciences and Ecology at the Kurchatov Centre). Combined with the special physics & mathematics classes for schoolchildren, and with the system of school Olympiads on physics, mathematics and informatics (one of the most popular of which was named after Kurchatov), this undertaking has good prospects.

Understanding the urgency of the situation with the youth in science, the government has even adopted such a dramatic measure, as the deferment from the army service (Russia has the law on the general military service), which was received by several thousand of young nuclear specialists in the last four years.

On the social level, the Nuclear Society of Russia (before 1991 – of the USSR), which was established 15 years ago, should consider creation of its Young Generation Department as one of its main achievements. The YGD has managed to launch wide propaganda activities, aimed at attracting young people to nuclear science and industry and at increasing the prestige of nuclear professions. By the way, it successfully used the possibilities of international cooperation in this regard.

Preservation of experience of the old generation (today it consists of people, which were taught directly by the “fathers” of nuclear energy use) represents another side of the problem. This is the experience of people, which have developed their ability to make rational decisions in conditions of usually limited knowledge, with account of all the past mistakes. The recipes that have been found, though not very original, have turned out to be quite efficient. These are: “historical” conferences of high scientific level, for example: International Symposium “Science and Society. History of the Soviet Atomic Project” (1996), International Scientific Conference “Nuclear Age. Science and Humanity” (2003), and many others. Scientific organizations also understood that to order their leading specialists to write books, summing the accumulated experience of achievements and losses, would be an efficient investment of their limited funds, and a good way of knowledge preservation. Among these books, we would like to note five-volumes of the “History of Atomic Energy of the Society Union and Russia” by V. Sidorenko, Member of the RAS, and the “Nuclear Power. Assessments of the Past, Realities of the Present, Expectations of the Future” by V. Asmolov et al. In the last years, dozens of books related to various nuclear technology areas have been published.

All these – and many other – initiatives (often coming “from below”) had sooner or later to be “gathered into a system”. In Russia in such cases concepts and programs are usually developed. The corresponding decisions were adopted in 2002-2003, and concerned both knowledge preservation in nuclear science and engineering, and the development of a united Minatom’s educational system for training qualified personnel. These documents provide for the period till 2010. The hope that they will not have the fate of many other acts, which have been adopted but not realized, is based, first, on understanding of their necessity, and, second, on the authority and qualification of organizations - “carriers” of these programs. In the educational area this is the above-mentioned Engineering & Physics Institute, and in the part of knowledge management preservation – the Central Research Institute of Management, Economics & Information.

Leaving aside the technological issues of knowledge preservation, which will be presented at this Conference by the specialists from this Institute, let us briefly list the primary tasks to be solved in this area, taking the specific Russian situation into account:

- identification of “critical” knowledge and their carriers, as well as knowledge transfer technologies in nuclear area;
- knowledge preservation criteria;
- development of knowledge preservation technologies;
- reliability and trustworthiness, processing of knowledge;
- legal aspects of databases and knowledge;
- market mechanisms and principles of knowledge transfer in the field of nuclear science and engineering.

The nuclear knowledge management concept develop in the nuclear branch is already being realized. As an example, the information & reference system on nuclear materials’ production created by the Institute of Information for the country’s leading material science center – All-Russian Institute of Inorganic Materials – could be indicated.

Certainly, the area of knowledge preservation and transfer is a real field for international cooperation - this is confirmed by many years of collaboration with the IAEA (INIS, etc.) and by such new undertakings in this area as WNU, in which Russia participates actively enough.

However, the main problems and difficulties have quite an “internal” character. For instance, another new restructuring of the Russian nuclear branch would most probably result not in the expected development of corporate ties, but in the growing autonomy – economical independence of nuclear scientific & research organizations, which will create new difficulties on the way of the problem in question.

Nevertheless, the current “Renaissance” in the Russian nuclear power, and “great expectations” for the future, are able to make the decision-makers return to such attitude to the issue of Nuclear Knowledge Management, which it has already received in the past and which it undoubtedly deserves.

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