TECHNICAL POLICY WITH RADIOACTIVE WASTES MANAGEMENT.

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I. INTRODUCTION .

The question to be considered is of great importance and has to be discussed from two points of view. The first aspect conserns the perspectives of following development of atomic power. We think that it is difficult to hope for large-scale development of atomic power without satisfactory solution of the problem of high-level radioactive wastes (HLW) of atomic power and industry. The second aspect conserns the necessity of incineration of the HLW stored as a result of activity of the plants of military nuc-lear industry and existing NPP. Our Institute opinion is that the world community is obliged to take efforts to create reliable met-hods of HLW incineration.

It is worthwhile to mention that specialists in nuclear in-dustry have different points of view to the problem of HLW incine-ration. The *specialists* from Great Britain, judging from the mate-rials of the meeting of experts at the IAEA 24-26, Ott.~ 1991 on the problem of nuclear transmutation of the long-lived HLW and partitioning, do not think it is expedient to carry out works on nuclear transmutation. Some specialists of our country think that it is much cheapier to store the HLW in controlled conditions in near the surface storages. For provision of reliability of storing it is necessary to provide periodical secondary sealing of the containers with HLW. Apparently storing of HLW in near the surface storages is possible but the economical gain is not obvious. There is information that the price of one storage for long-time storing of HLW in the Ukka Moutain (Nevada, USA) is 28 billion doll., and of two *storages* - 34 billion doll. It is necessary to bear *in mind* two important factors concerning construction of the near the sur-face storages like the storage in the Ukka Mountain. One of them is that the population of the region where construction of HLW storages is supposed raise objections against the construction. This fact takes place in all the countries possessing NPP. A specific example was given by D-r Hyun-Soo PARK, director of the Spent Fuel Management Division of Korea Atomic Energy Institute at the Soviet-Korean seminar in Moscow 2 - 3 Dec., 1991. He said that "in 1990 they had to abandon the place destined for construction of the storage due to the protests of local authorities. Since that time the problem of choice of a place for burying the radioactive wastes became a complex social problem which is intended to be solved with the aid of a program of social accord". The other condition is connected with moral and ethical problems connected with the necessity to *shift* off the troubles of management of HLW formed due to industrial activity of our generation to the concerns of the next generations. Finally, there is one more aspect being worthwile to be mentioned. If to compare the volumes of radioactive wastes of atomic power and industry with the volumes of the wastes of other branches of industry the great difference is clearly seen. The volume of HLW is tens thousand times less than the volume of the wastes of other industries and this is a favorable feature to create methods of HLW incineration and elaboration of such kind of atomic power industry which would be almost wasteless. It is possible to hope that creation of technology of HLW incineration would be a good example for other branches of industry in rational wastes management.

2. STATE TECHICAL POLICY ON HIGH-LEVEL WASTES MANAGEMENT.

The state technical policy of our country stimulates the necessity of a complex solution of the problem of radioactive wastes management beginning from standards for formation of wastes, collection, registration, counting, temporal storage, technology of preparation for burying, including reliable isolation of the radionuclides and other biologically dangerous components of the radioactive wastes, from thy biosphere under corresponding system of controlling at all the operating, being projected or constructed plants independently of their formal belonging to any ministry.

Technical policy is a system of technical decisions which are obligatory to obey under radioactive wastes management.

The main requirement to the plants or scientific centers where the radioactive wastes are formed, buried, used or reprocessed is provision of radioactive safety of the personel, population and protection of the environment. Technical constructions capable to provide biological protection. to prevent any leakage of the radionuclides outside of the construction and to separate the gaseous blips are thought to be the main barriers preventing distribution of radionuclides and ionizing radiation in the process of collection, reprocessing and temporal storing of the wastes.

Burying of the radioactive wastes into geological formation must be accomplished under condition that the hazardous influence of the wastes would not penetrate beyond the boundaries of the mountain site taking into account the long-time prognosis of ecological, geological, hydrological and constructing requirements to the state of the environment and health of the population. The period of prognosing is defined taking into account the characteristics and quantities of the radionuclides and toxic chemical substances in the wastes to be buried. The main barriers for protection of the biosphere from radionuclides and toxic chemical compositions in the process of burying of radioactive wastes should be geological formations and physical and chemical forms of the wastes. Wrapping means and technical constructions may be used as additional barrier for a limited period of time. The main principle of preparation of the wastes to burying are concentrate on and transfer into stable state under long periods of storing excluding their contact with natural factors.

Choice of the technology of solidification has to be done taking into account following wastes management.

The technology providing production of chemically, thermo and mechanically stable materials (glass, mineral-like materials etc.) is used while reprocessing the wastes of high activity (specific activity is more 1 Cu/l).

The technology of production of chemically stable monolitic materials (glassification, cementation, bitumenation, mixing with polimeric and other materials) taking into account the conditions of transportation and specific features of the plantsis used for preparation for burying of the wastes of medium (activity from 10^{-5} to 1 Cu/l) and low (less 10^{-5} Cu/l) level of activity.

The place and the depth of the wastes, design of an under surface long-term storage is being chosen taking into account geological and seismic conditions, volume, type and form of the wastes. The mountain site for placement of radioactive wastes in geological formations is excluded from civil activity.

It is admittable to create the under surface storages with special equipment of reliable isolation, corresponding control systems, provision of necessary repairs and measures for prevention of accidental situations for solid forms of low and medium active wastes. For stable monolithic solidificated wastes it is admitttable constructing of temporary storages of not deep type in assumption to transfer the wastes from them in deep underground storages in future.

Reprocessing and burying of the radioactive wastes is an integral part of the main technological processes during routine operation of nuclear installations. While considering any questions combined with creation of new plants or modernization of existing technological processes the ways of reprocessing and isolation of the radioactive wastes should be forseen.

Simultaneously a lung-term alternative programe of HLW management is carried out and is now under realization. The necessity of the alternative program arises due-to: first, protests of the population of a raw of regions of the. country; second, the program of scientific-research and R&D works for grounding of the state technical policy in HLW management is not yet completed. The third reason to our opinion is the absence of any garantees excluding leakage of the radioactivity out of the storages after a period of time mare than 1000 years. The absence of garantees means the absence of technical decisions.

Irrespective of all mentioned above ideas, which constitute the point of view of our Institute, the next alternative methods of the wastes management are now under serious consideration:

a) isolation of the wastes in the space,

b) isolation of the HLW in the central part of the Earth kernel due to radioactive self-heating,

c) nuclear transmutation of HLW.

3. SHORT DESCRIPTION OF ALTERNATIVE METHODS OF HLW MANAGEMNT.

3.1. Isolation of the wastes in the space.

Isolation of HLW with the aid of rocket systems in the space is under investigation in our country for several years. Three main technical task are being studied:

a) possibility of creation of rocket system of high reliability excluding disruption of a transportation rocket at the point of launching and in the space in case of collision with some objects, mainly the remnants of the rockets launched earlier;

b) possibility of creation highly durable and hermetical transportation container with HLW to be placed in the rocket;

c) choise of the part of the space to place the containers with HLW.

The first two tasks are now in the state of scientific-research of techical works. As to the third task, the near the Earth space, Sun, some planets of the Sun system and the Galaxy were studied. Two main criteria were taken into account: energy consumption for launching of the rockets and reliability of storages in the space. Some ethical questions of storing the HLW in the space were also discussed. It was noted also the necessity of international cooperation and internationally agreed ways of realization of the cosmic isolation.

3.2. The method of melting through due to self-heating.

Under utilization of this method HLW are placed in a sealed container which will be self-heated due to the heat of radioactive decay. Calculations show that the temperature of the container can reach the melting temperature of the rocks. The container will be sinking in the depth of the earth rocks and this process will lead to self-burying.

3.3. Nuclear transmutation of long-lived HLW.

Conceptual study of the possibilities of nuclear transmutation of the long-lived HLW is being carried out in our country in the next directions with the use of a row of new power nuclear installations:

- thermal nuclear reactors;
- fast reactors;
- accelerators of charged particles (protons and deutrons);
- fusion installations.

A specialized heavy water reactor was considered as a reactor with thermal neutrons. The choice of this reactor was stipulated by the possibility of production of neutron fluxes of rather high density and creation of a large volume for placement of the targets to be irradiated. We considered the existing reactors, the reactors of RBMK type for example, for the Purposes of transmutation. We studied also the possibility of transmutation of ^{99}Tc in modular heavy water reactor MTR-500 designed by us for the purpo - see. of industrial heat production without decrease of output energy; the ^{99}Tc maily will define the activity level of the fission products in 1000 years. The possibility of transmutation in a reactor with lead heat-carrier was also considered.

Investigation of possibilities of fast reactors, serial reactors BN-350, BN-600 which are in routine operation now, BN-800 which is now being projected and of a special fast reactor—burner was carried out. Transmutation of only actinides and even only minor actinides is possible in these reactors.

Accelerators of protons and deutrons for transmutation were studied. The results were presented at the international workshop in Obninsk (1 - 5 July. 1991). ITEP reefers a proton accelerator with energy 1.6 GeV and current 0.3 mA. Some more details on the project of the accelerator will be given in the next paragraph.

A fusion installation designed under leadership of the staff-members of AEI named after Kurchatov academician S.T. Beliaev and prof. B.A. Rusin is being studied as an intensive source of neutrons.

The next scientific centers of our country are working in this direction:

Institute for Theoretical and Experimental Physics - (ITEP, MOSCOW) - heading institute in the country and scientific leader on the problem of nuclear transmutation? simultaneously it carries out theoretical and experimental investigations on heavy water reactors and proton accelerators for transmutation.

Physical—Energy Institute (FEI, Obninsk) - carries out investigations on possibility of utilization fast of reactors for the purposes of transmutation and on grounding of the target for proton accelerator.

Institute of Power Engineering (IPE,Moscow) is the main designer of the target and the blanket of the proton accelerator and also conceptually investigates possibilities of reactors of RBMK type and reactors with lead heat-carrier.

Institute for Nuclear Power (INP, Obninsk) investigates possibilities of deutron accelerators for transmutation.

Scientific-Research Institute of Non—Organic Materials named after

A.A. Bochvar (SRINOM, Moscow) is a leading institute on fuel compositions, construction materials and technology of HLW management, it also works on the technology of radiochemical reprocessing of spent nuclear fuel (SNF).

Scientific-Industial Cooperative Plant = Radium Institute named after V.G. Khlopin (RI, Sanct-Petersburg) carries out works on technologies of radiochemical reprocessing of the SNF and fragmentation of fission products and actinides, investigates the possibilities of ecological safety of nuclear fuel cycle.

Scientific-Industial Cooperative Plant Scientific-Research and Project Institute of Electro-Technology (SRPIET, Sanct-Petersburg designs the plants of nuclear fuel cycle.

Moscow Engineering-Physical Institute (MEPI) carries out theoretical work and calculations of different nuclear power installations for transmutation, mainly on fast reactors.

Moscow Radio-Technical Institute (MRTI) designs the proton accelerator and its technical systems.

Besides, a row of institutes carries out a large complex of experimental works on measurements of cross-sections of interactions and other nuclear data. These works are being carried out in Joint Institute of Nuclear Research (JINR, Dubna), Scientific-Research Institute of Experimental Physics (SRIEP, Arzamas), Kharkov Physical-Technical Institute (KhPTI), MRTI, RI and others.

4. THE MAIN RESULTS OF CONCEPTUAL INVESTIGATIONS OF NUCLEAR TRANSMUTATION OF LONG-LIVED HLW.

The conceptual study allowed to establish that nuclear transmutation of long-lived HLW is a complex of technological processes of multi-purpose directions. Nuclear transmutation combines the next nuclear-physical and chemical processes:

- transformation of long-lived HLW into short-lived or stable nuc - lides:

- partitioning o-f radionuclides in the process of radiochemical processing of the wastes of nuclear technics,

production of useful radionuclides in the process of transformation of long-lived HLW,

- production of powerful fluxes of neutrons for fundamental and applied investigations on radiational materialogy, physics of solids, nuclear physics of low energies, radiational chemistry an so on;

- production of powerful fluxes of gamma-quanta for different industrial utilizations (radiational polimerization, radiational sterilization etc.). So study of nuclear transmutation which is perspective technology of the 21-st century has to be of complex character.

It is worthwhile to name the next specific scientific tasks which were solved at the stage of conceptual investigation.

1. Definition of summary activity and quantities of the long-lived radionuclides to be transmuted. It is worthwhile to mention some peculiarities characteristic for soviet specialists. A part of soviet specialists is sure that all the fission products without any exceptions including strontium, caesium and actinides should be transmuted. Some other specialists think that the radionuclides with half-life 30 years and less should be stored in controlled storages for approximately 600 years and should not be transmuted. There is a third point of view in accordance with which transmutation has to be applied only to the atomic power plants to be decomissioned and for HLW of the military atomic industry. Apparetly USA scientists may have analogous points o-f view. Following study will allow to get more information for qualified discussion of the question of necessity and expediency of the process of nuclear transmutation with its multipurposal character.

2. The second task is a logical continuation of the first. It consists mainly in definition of optimal ways of transmutation of the HLW and of its energy efficiency. It is worthwhile to mention the importance of energetical acceptability of the process of nuclear transmutation if this process is a constant element of nuclear fuel cycle but not a separate episode in the history of atomic science and technology. Energy consumption for transmutation processes in fission nuclear reactors, charged particle accelerators and fusion reactors were calculated taking into account the above mentioned idea. Fission products were considered first, ^{90}Sr and ^{137}Cs were taken as some kind of a standard. The reactions (n, γ) were taken as the main nuclear reaction. It was found that it is not expedient energetically to transmute ^{90}Sr and ^{137}Cs in existing nuclear reactors having neutron fluxes to 5×10^{15} cm-%-'. Rising of the neutron flux higher than 5×10^{15} $cm^{-2}s^{-1}$, + or ex amp 1 e to $10^{17}cm^{-2}s^{-1}$ in the reactor with rotating core which is under now under designing in IPE energetically is also unacceptable due to large consumption of enriched uranium. As to the energy efficiency of transmutation of actinides it is worthwhile to note that utilization of minor actinides as addition in quantity 3% to MOX-fuel of fast reactors allows to get positive energy balance as most of actinides are fissile in the neutrons with fast spectum. As to transformation of some actinides into the useful ones. f or example ^{237}Np into ^{238}Pu as energy source (a special report was presented at the Obginsk worksh) here we have negative energy balance with additional consumption of neutrons.

In order to choose correctly the priority in designing of charged particles accelerators ITEP scientist, D-r Kazaritskiy estimated consumption of energy necessary for transmutation of ^{137}Cs in the beams of protons, deutrons and electrons. These estimations show that the least consumption of energy are 60 MeV/nucleus in the proton beam with energy 1000 MeV, appr. 100 MeV/nucleus in the beam of deutrons and 4000 MeV/nucleus in the electron beam. Formation of one nucleus of ^{137}Cs in fission nuclear reactor is followed by release of 1000 MeV of energy. More correct estimations will be made at the following stages of designing of the proton acceleratar. These results and other reasons witness of expediency of choosing of the proton accelerator for transmutation of ^{137}Cs.

It *is* worthwhile to note that the processes of transmutation of ^{137}Cs in the flux of neutrons is, first, multistaged, with alteration of nuclear transformation characterized by presence of reaction branches. This peculiarity of the process of nuclear transmutation predetermines the necessity of optimization during the following stages of design of the installation for transmutation. A theory of optimization of the pointed above processes based on the method developed by soviet mathematician Pontriaguin was improved in ITEP under the leadership of the honorary member of the International Academy, prof. A.P. Rudik.

Investigations to define the possibilities of deep cleaning and fragmentation of the fission products and actinides were carried out at the conceptual stage. Long-term experience of radiochemicar reprocessing of the wastes of reactors of WWER and also the research works carried out by Radium Institute with really active solutions witness of the possibility of deep fragmentation of specific fission products with cleaning factor of appr. 97% . Al 1 these works are going on now.

An important task at the conceptual and the following stages is achieving of precise nuclear data for the processes of interaction of radionuclides and neutrons. The available data for a *row* of radionuclides are either not sufficient or not enough accurate. There were no practically data on the energy balance in different materials under interaction with protons o-F the required range of the energies. It is worthwhile to note that the experiments on measurements of energy balance in different target materials are carried out; we think that these data are of serious interest + or the LANL specialists.

Theoretical studies and comparisons of the possibilities and safety of fission reactors carried out in ITEP allowed to establish the next peculiarities of the accelerating structure for transmutation.

1. The accelerating facility allows to transmute the fission products and the actinides. The fission reactors. may effectively implement the process of transmutation of only actinides. Transmutation of the fission products except ^{99}Tc is energetically unacceptable. For transmutation of the fission products and actinides in nuclear fission reactors rather large quantity of highly enriched uranium (up to 400 kg per year) will be necessary. Consumption of plutonium in fast reactors will be approximately 1.5 times less.

2. The accelerating facility is of another level of nucl ear safety than the fission reactors as a result of, first, utilization of subcritical blanket and, second, decreased approximately ten times the value of loading of the actinides into the blanket in comparison with fast reactors.

The accelerating facility possesses a row of other advantages in comparison with fission reactors.

5. CONCEPT AND MAIN TECHNICAL CHARACTERISTICS OF THE ACCELERATING FACILITY FOR TRANSMUTATION OF FISSION PRODUCTS AND ACTINIDES.

After conceptual study ITEP has chosen as the priority direction an accelerating complex of a proton accelerator, a target and a heavy water blanket. Technical decisions of LANL specialists of the last 2 years seriously influenced the choice of ITEP. Undoubtedly that the scientific contacts and discussions also had some influence. All *this creates* a good base for collaborative works of lTEP and LANL on designing and experimental grounding of the project of the accelerating facility for transmutation of fission products and actinides. In *what follows the* main technical decisions on the main parts of the accelerator for transmutation are briefly presented.

It is worthwhile to note that ITEP has put a proposal on construction of a prototype of a proton accelerator with energy

100 MeV and current 30 - 50 mA of the dimensions corresponding to the full-scale proton accelerator with energy 1.6 GeV and current 300 mA for consideration of the authorities of the Ministry of Atomic Energy (MAE). Such a decision is stipulated by the necessity to check up the influence of the scale factor in order to come up to higher energy after mastering the densities of proton fluxes corresponding the currents 30 - 50 mA. It is necessary to say that the MAE has positive attitude to this proposal and gave permission to place the accelerator at one of the atomic industry plants. We think that the accelerator for transmutation should be placed in close neighbourhood with a radiochemical plant reprocessing spent nuclear fuel of NPP or possessing HLW of military industry. Now we began to search a site for this prototype-linac. Just at the same time we began to arrange the calendar plan of design and construction.

5.1. Structure of the proton accelerator.

The structure of the accelerator was proposed in the division of linear accelerators headed by prof. Kapchinskij I.M., one of the three soviet authors of space-uniform quadruple focusing RFQ. Some information was already published and here I would like to mark only the next features. The accelerator should be of three stages with consequengt summing of beams. The first part is a structure with space-uniform quadruple focusing; the second - a structure with drift tubes and magnetostatic focusing; the third - one of the structures with high phase velocity of the equivalent accelerating wave. The proposals of LANL and ITEP are prepared on tle base of this concept but seriously differ in details:

1) in the ITEP project the initial part of the accelerate is operating at the frequency four times lower than in the LANL project and this will provide higher current limit and consequently lower rise of emittance and losses;

2) summing of beams in the ITEP project will be implemented at the lower level of energy (3.5 MeV instead of 20 MeV) and this should simplify the equipment of summing and lower losses while summing,

3) a structure with disks and washers (DAW) is used in the

main part of the ITEP project (instead of a sequence of resonators with side coupling cells) which possesses higher shunt-impedance (parasitic modes are suppressed)?

4) HF power losses in the project of ITEP are higher than in the LANL's due to higher value of E_o; this only slightly influenced the efficiency (68% instead of 79%) due to larger consumption of energy by the beam, but allowed to shorten substantially the length of the machine (from 2100 m to 1000 m) and to make less ex- the building and all technological systems less expensive.

Though the concept of creation of a powerful linear accelerator for transmutation exists but there are some difficulties for the modern technics which must be overcome- The main of them are:

- powerful continuous ion source of high brightness (current 200 - 300 mA, phase density to 10 A/cm.mrad);
- HF generators of high unit power (to 5 MW);
- heat removal and absence of local overheating; electric strenth in continuous way of operation:
- decrease of particle losses to the values admitting the maintenance of the accelerator? radiational stability of materials:
- matching structures at the inputs and outputs of the sections with RFQ;
- structures of summing the beams with conservation of emittances and currents;
  maximumal utilization of beam from the ion source;
  matching of the beams while doubling the frequency;
  remote replacing of drift tubes in cases of failure;
- the systems of continuous high power beams diagnosis.

ITEP has rich experience in construction of proton linear accelerators. ITEP was the head in calculations of beam dynamics, construction, adjusting and commissioning of accelerators in ITEP and IHEP. The accelerator ISTRA-56 is now under construct on and partially is already operating. A row of problems are being solved now; these problems consern the RFQ structure, matching channels, doubling of the frequency- utilization of the beam of the ion source, the problem of the rise of emittance, designs connected with remote controlled change of drift tubes.

It is necessary to pay serious attention to transportation of the beam from the accelerator to the target and to the device of connection of the accelerating channel and the target. Preliminary considerations show that this device will be a complicated structure. It should be noted that we began to study this problem in 1983, in the period of investigations of possibilities of electronuclear reactors for production of secondary nuclear fuel. At this time we came to the decision of the necessity to bend the proton beam by 90° from the horizontal direction. This means that the connecting device has to be supplied with bending magnets with reliable cooled coils. Further, as the vacuum volume of the accelerator, connecting device and the target is common continuous oilless vacuum pumping out and the traps for metal vapours and spallation products including noble gases from the target must be envisaged. At the following stages of the work under the accelerator it will be necessary to make a decision on the admissible level of beam power per one target. In order to get the maximum number of neutrons from the target it is expedient by out' opinion to consider 2 versions: 1) with separation of the beam into several less intensive; 2) without separation of the proton beam. The problem of heat removal from the target arises in the last version. One of the possible decisions might be scanning of the surface of the target of special shape by the proton beam. Investigations carried out in ITEP witness of technical possibility of organization of such kind of scannig though some problems of provision of necessary reliability arise. It is also necessary to solve the problem of protection of the magnetic systems of the connecting device from the intensive flux of damaging radiation. Of course there is a row of some other technical tasks.

5.2. Possible designs of the target.

Investigation of possible designes of the target of the accelerating facility carried out in LANL, BNL, JAERY and ITEP witness of the complexity of arising technical tasks. As it is known, utilization of liquid lead, eutectic of lead and bismuth and solid tungsten was considered. The final choice is not yet made as we think in any of the scientific center. ITEP prefers the eutectic of lead and bismuth as it is well studied as a coolant in transportational nuclear power installations. More detailed information should be carried at one of the joint scientific seminars with participation of specialists from Physical Power Institute experienced with Pb-Bi eutectic.

I would like to discuss one technical possibility concerning the design of the target. It is known that in accordance with calculations the number of primary neutrons per one proton is approximately 55. It is also known that utilization of enpovered uranium as target material increases the quantity of primary neutrons. So perhaps it is expedient to add some enpovered uranium in the liquid lead or in Pb-Bi eutectic. An original design of a target made of Pb-Bi with fuel elements of spherical shape of enpovered uranium hydraulically suspended in the near-surface layer of the target was studied in ITEP in 1980 - 1985. This design was patented and it is expedient to continue joint consideration of this design.

5.3. Possible designs of the blanket.

Construction of the blaket envisages solution of the next main technical questions:

1) Choice of the type of the blanket - heterogeneous of homogenous.

2) Choice of coolant and moderator for the blanket.

3) Choice of the composition and the type of chemical composition for the fission products and actinides to be transmuted.

As a main version we have chosen a heavy water blanket. The main reasons of this choice are: utilization of heavy water provides the best possibilities of moderation the neutrons from the target that allows to have a large volume for the targets to be irradiated and rich experience of utilization of heavy water in nuclear reactors ITEP has. Now we are studying the possibility of utilization of solid target compositions and mel ted salt mixed with fission products and actinides. Besides, we began to study the possibility of dissilution of the salts of target materials in the heavy water. The final choice of the blanket design will be done at the following stages of the work.

5.4 Experimental program for grounding the designs the target and the blanket.

A wide program of experiments is going on in ITEP and other scientific centers for grounding of the construction the target and the blanket. Experiments on measurement of energy balance in different target materials and definition of the radionuclide composition of the targets under interaction with protons were being carried out for several last years in ITEP for example. The achieved data will be taken into account while designing the target and the blanket. The preparatory work on organization of the next experiment is going on now:

- definition of the energy spectrum of the primary neutrons under interection of the target nuclei with protons; a time-flight spectrometer will be used in these measurements
- neutrons interaction with nuclei of fission products and actiniales,
- measurements of the speeds of reactions of neutron interaction with nuclei of target materials at the ful-scale critical pile"MAKET" (ITEP),
- modelling of a heavy water blanket with the use of neutron generator with intensity of neutron flux 10^{12} $cm^{-2}s^{-1}$.

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Intensive works on improvement of technology of partitionning of fission products arid actinides with the purpose of achieving of clean factor 99% an more are and will be going on in Radium Institute named after Khlopin V.G. and in the Institute of nonorganic materials.

Other experimental works are implementing in our centers al-50.

All above said witness of the identity of approaches of LANL and ITEP to the ways of solution of the problem of nuclear transmutation of long-lived HLW with the use of high current accelerators. Taking into account the complexity of the problem as a whole it is expedient to combine efforts and experience of the specialists of LANL, JAERI, ITEP and other European scientific centers for grounding and implementation of the project of the accelerator facility for transmutation of long-lived HLW.

In the concluding part of my report I would like to share with you our ideas on organization of our collaboration. The main part of our collaboration is joint design of the project of the accelerator facility with the target and blanket for transmutation of HLW. Combining of the efforts of the specialists of our scientific renters is necessary in connection with serious complexity of some technical tasks. T have to say that the authorities of the Ministry of Atomic Power gave us the commission to prepare the program of the work of creation of the accelerator with the target and blanket to be built at one of the chemical plants. I think that it will be expedient to discuss and to define the directions of collaboration where the main work will be conducted by one of the centers with enlisting of the specialists of the other center.

Apparently it is expedient to organize the joint operating groups of specialists which could work in each of the scientific centers responsible for given element or technology. The project of the program of collaboration envisages corresponding work: on organization of such groups. At the beginning I would like to put a proposal on organization of the next operating groups:

l-5t group - proton accelerator
2-rid group - target-convertor,
3-d group – heavy water convertor
4-th group – constructional materials,
5-th group - chemical technology of fragmentation.

It is expedient to organize the pointed operating groups earlier as possible, in 1992. It is expedient to envisage organization of an administrative group and to nominate the coordinators from each of the scientific centers for coordination of the activity of implementation of the program of collaboration. My Institute and the Ministry of Atomic Energy of Russian Federation are ready to propose qualified candidatures for work in those groups and if the scientific society is ready to support my proposal I

promise to organize in Moscow some kind of preliminary group which could begin the work on voluntary basis, without remuneration at the firts, of course, time.