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The 1999 JNC International Forum on the Peaceful Use of Nuclear Energy

Summary

March,1999

International Cooperation and
Nuclear Material Control Division
JAPAN NUCLEAR CYCLE
DEVELOPMENT INSTITUTE

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Nuclear Nonproliferation Group
International Cooperation and
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ABSTRACT

The 1999 JNC International Forum on the Peaceful Use of Nuclear Energy: the Nuclear Fuel Cycle and Nuclear Non-Proliferation Technology, a continuation of the annual International Forum on Nuclear Non-proliferation sponsored by its predecessor organization PNC (Power Reactor and Nuclear Fuel Development Corporation), was held February 22 - 23, 1999 in Tokyo, Japan. About 380 people from government, industry, and academia involved in nuclear technology and issues attended the forum. A distinguished group of speakers participated in the forum sessions including highly respected technology and policy experts from France, Russia, and the United States. Session themes were: (1) Advanced Nuclear Technology for Peaceful Purposes and Nuclear Non-Proliferation, (2) Transparency Improvements in Nuclear Technology through the Use of Remote Monitoring, and (3) International Cooperation and Technical Issues on the Disposition of Excess Nuclear Weapons Plutonium. This document provides a record of speeches and discussion which have no written documentation and summarizes presented papers as appropriate. Full papers prepared by the presenters can be found in **The Proceedings of the 1999 JNC International Forum on the Peaceful Use of Nuclear Energy.**

The Nuclear Nonproliferation Group has prepared this summary and bears full responsibility for its wording. If you have any questions regarding this summary, please contact the Group.

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Session I 14:10～17:40	**"Advanced Nuclear Technology for Peaceful Purposes and Nuclear Non-Proliferation"** **Chairman** **Dr. Shiro Matsumoto** Professor, Saitama University Speech : **1) "Concept of Advanced Fuel Recycle System"** **Dr. Toshio Wakabayashi** Chief Senior Scientist Executive office for the policy planning and administration, JNC, JAPAN **2) "Nuclear Fuel Recycling for a Self-Consistent Nuclear Energy System"** **Mr. Masao Suzuki** Chief Specialist, Nuclear Plant & System Planning Department, Toshiba Corporation, JAPAN **3) "Actinide Recycle Technology for the Back-end of the Fuel Cycle and the Management of Radioactive Wastes"** **Mr. Massimo Salvatores** Research Director, CEA Cadarache, FRANCE **4) "Fast Reactor and Fuel Technology for the Next Stage"** **Dr. Victor Orlov** Deputy Director, NIKIET, RUSSIA **5) "An Architecture for Nuclear Energy in the 21st Century"** **Dr. Edward Arthur** Deputy Program Director, Civilian and Industrial Technology Program DOE Los Alamos National Laboratory, USA Panel Discussion All above speakers participate in the panel discussion

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Opening Address

Dr. Yasumasa Togo
President, Japan Nuclear Cycle Development Institute, Japan

Dr. Yasumasa Togo, President of the JNC opened the forum by describing JNC's mission, management policy, and commitment to nuclear technology development for peaceful purposes in the context of both global and national needs. JNC, established October 1, 1998 from the reorganized Power Reactor and Nuclear Fuel Development Corporation, has a three-fold mission in accordance with the Atomic Energy Law: development of the fast breeder reactor and its nuclear fuel, development of reprocessing technology, and development of technology for treatment and disposal of high level radioactive waste. JNC's four management principles are: maintenance of safety for all, promotion of transparency by full information disclosure, management of business properly and effectively, and respect for government and people in local municipalities. President Togo emphasized that JNC's nuclear fuel cycle development activities are being conducted exclusively for the purpose of the peaceful use of nuclear energy and stated that research and development in Japan is limited to peaceful purposes by law. He also stated that Japan needed to contribute to both areas of nuclear energy development and nonproliferation and said that without being devoted to peaceful use of nuclear energy, the world will not be able to proceed forward with nuclear development. President Togo concluded his speech by thanking speakers, participants, and various Japanese governmental organizations including the Atomic Energy Commission, the Science and Technology Administration, and the Ministry of Industry and Trade.

Special Speech on A Nuclear Perspective for the Future

Dr. Yoichi Fujiie
Vice Chairman, Atomic Energy Commission, Japan

Dr. Yoichi Fujiie gave a special speech on the future of nuclear energy from Japan's perspective; he spoke about the SCNES (Self-Consistent Nuclear Energy System) concept as a means to address future needs. Dr. Fujiie started by talking about Japan's quandary with nuclear technology – how Japan opposes it because of the atomic bombings in Japan during World War II and how Japan advocates it because of Japan's desire for energy security. He spoke about the benefits that nuclear technology has afforded in power, medical, and food science and followed by posing broad questions that must be answered to deem whether nuclear is a technology worthwhile for the 21st century. He went on to speak about his SCNES concept, where the ultimate goals of SCNES are recycling, i.e., full utilization of resources, and zero-release, i.e., no emissions of harmful wastes. He stated from this viewpoint of self-consistency, the fast reactor development was important and could be justified. He acknowledged that economy must be and has not yet been addressed with SCNES. He stated, however, that SCNES hinders proliferation efforts by recycling together transuranic elements with plutonium. Regarding Japan activities in a global context, Dr. Fujiie said that Japan could contribute to the disposition of weapons plutonium by promoting peaceful nuclear energy use through nuclear fuel recycling and nuclear nonproliferation. Dr. Fujiie emphasized that the fundamental basis of Japan's peaceful use of nuclear energy is grounded in the call for the absolute abolition of nuclear weapons. He stated that Japan must be a nation to contribute to advanced science and technology for the world. He concluded his speech by stating that nuclear science and technology has the capacity to address the future challenges and that the issue is if the nuclear community has the passion and vision to meet the future as well.

Session I

Advanced Nuclear Technology for Peaceful Purposes and Nuclear Non-Proliferation

Chairman: Dr. Shiro Matsumoto

Professor, Saitama University, Japan

Dr. Shiro Matsumoto chaired this session with five presentations – two from Japan and one each from France, Russia, and the United States. The presentations were followed by a panel discussion and questions from the floor.

Concept of Advanced Fuel Recycle System

Dr. Toshio Wakabayashi
Chief Senior Scientist, Executive Office of Policy Planning and Administration
Japan Nuclear Cycle Development Institute, Japan

Dr. Toshio Wakabayashi spoke about the Advanced Fuel Recycle System Concept and the research and development that JNC is conducting, particularly with MA (minor actinide) transmutation, to address the individual technical challenges posed by the system concept. The objectives of the system are to improve economics and the management of radiotoxic waste while strengthening the system's ability to impede proliferation activity.

Dr. Wakabayashi stressed that economics is the most important issue and that radioactive waste issues must be addressed. Dr. Wakabayashi presented the system concept in terms of improving reprocessing and fuel fabrication, achieving actinide recycling, and integrating reprocessing and fabrication to address economics and radioactive waste management. In reprocessing, the system concept calls for, "less decontamination and separation" to improve the economy. With the assumption that fuel fabrication is remotely-operated, there is less of a need for perfect purification, thus reprocessing can be greatly simplified which results in improved economics. This simplified reprocessing improves proliferation resistance as only the minimum necessary Pu (plutonium) separation is conducted. In the assumed remote fuel fabrication, low decontamination reprocessing and dust free fabrication reduces loss to wastes and in process inventory. The gelation technique with sphere packing using a mixed Pu/U (plutonium/uranium) nitrate solution from aqueous reprocessing is thought to be a candidate, as it does not generate dust and it is conducive to remote operation, massive production, and possibly to the addition of MAs. Actinide recycling is another important component in the system concept in terms of minimizing environmental impact with "as less waste possible." The system would recycle all transuranic waste including Pu and MAs. To do so, technology innovations are necessary to recover MAs from the high active waste stream and to recycle them as fuel. Integrating reprocessing based on single-cycle co-extraction and fuel fabrication based on gelation and vibro-packing methods reduces costs, generation of secondary waste, and proliferation risk.

Dr. Wakabayashi spoke about R&D that JNC is conducting to tackle some of the technical challenges of the Advanced Fuel Recycle System: single cycle Pu/U co-extraction including the crystallization process for uranium extraction at the Chemical Reprocessing Facility in Tokai Works; fabrication of MOX (mixed oxide) fuel with MAs by a gelation technique at the Plutonium Fuel Development Facility in Tokai Works; irradiation testing of MOX sphere-packed fuel pins using the Experimental Fast Reactor JOYO in Oarai Engineering Center.

Dr. Wakabayashi reported results of studies on MA transmutation in fast reactors, some of which are as follows: hybrid MA loading method has the potential to achieve maximum transmutation of MA with no special design considerations; use of inert matrices in target subassemblies effectively increases the MA transmutation rate; homogeneous loading of MA and rare earth nuclides has no serious effects on reactor core performance provided that they are less than 5 and 10 wt % respectively; accumulation of Cm (curium) from MA recycling will results in problems in fuel handling and reprocessing because of an increase in decay heat and neutron emission rate; removing Cm from the MA-loaded fuel should be investigated as a trade-off between plant modification and reprocessing; continued accumulation of nuclear measurements for MAs and fission products are necessary. Dr. Wakabayashi also reported results on an analysis predicting overall reduction in MA mass balance if fuel is recycled as opposed to being used once-through; between the year 2030 and 2100, the study predicted an 80 percent reduction in MA mass balance.

Dr. Wakabayashi concluded his presentation by speaking of benefits of the Advanced Fuel Recycle System with regard to non-proliferation: if built and operated under full-scope International Atomic Energy Agency safeguards it would be practically impossible to modify the facility and recover separated Pu in pure form, and not fully purified fuel used in the system would contain fission products which would serve as a radiation barrier and deter theft.

Nuclear Fuel Recycling for a Self-Consistent Nuclear Energy System

Mr. Masao Suzuki
Chief Specialist, Nuclear Plant and System Planning Department
Toshiba Corporation, Japan

Mr. Masao Suzuki started his presentation by explaining about why he, a Toshiba employee, was talking about a SCNES (Self-Consistent Nuclear Energy System). He stated he worked on the SCNES concept from its early stages at Tokyo Institute of Technology with Dr. Fujiie, the creator of the concept. Mr. Suzuki's presentation was on the scientific feasibility of SCNES and on near term goals for SCNES. His conclusions were that the ultimate goal of SCNES could be achieved given an actinide recycling system with fast reactors, a radioactive FP (fission product) recovery system, an isotope separation system, a system that incinerates long half-life FPs in the fast reactor core, and a storage system for short life FPs, and that SCNES should be pursued together with economic improvement.

Mr. Suzuki declared the need for a SCNES by saying that nuclear energy will be an inevitable necessity for the 21st century and that Japan should lead this effort. He stated that a breakthrough can be achieved that will reactivate nuclear energy development by taking advantage of the essential nature of nuclear energy.

Mr. Suzuki said the SCNES concept of full recycling with no emissions is idealistic, but talked about the features of fast reactors that provide the possibility: parasitic capture of fuel is low and fuel breeding is feasible; TRUs (transuranic elements) and MAs (minor actinides) in spent fuel can be used as fuel; incineration of TRUs can be achieved with a core structure within the same plant. He said that burning of TRUs can be achieved by actinide recycling and that the crucial issue in a feasibility assessment is evaluating whether the target system "ensures FP incineration while maintaining a fuel breeding capability and containing radioactive FPs in the system."

Mr. Suzuki spoke of evaluating the scientific feasibility of SCNES by separately assessing neutron balance, mass balance, and energy balance. The feasibility of SCNES is highly dependent on the ability to conduct isotope separation of FPs. Mr. Suzuki stated that SCNES is feasible from a scientific standpoint, given certain technology advancements, but did not know if the same could be said from an engineering standpoint.

Mr. Suzuki spoke of four near-term goals for SCNES: actinide recycling by fast reactor with a recovery rate of 3 to 4 nines, recovery of I (iodine), Tc (technetium), Cs (cesium), and Sr (strontium) with a recovery rate of 2 to 3 nines, incineration of I, Tc, and Cs by fast reactor, and storage of Sr for decay. He stated it is possible to realize a SCNES that meets near-term goals with an actinide recycling system that does not treat plutonium as a special substance. With such

a SCNES it would be possible to achieve substantial reduction in high-level waste radioactivity and potential toxicity (1/100, 1/1000 after once-through) while generating energy at the same time.

He stated that "the Self-Consistent Nuclear Energy System and economic improvement should be sought together."

Actinide Recycle Technology for the Back-End of the Fuel Cycle and the Management of Radioactive Wastes

Mr. Massimo Salvatores
Research Director, CEA Cadarache, France

Mr. Massimo Salvatores spoke about the challenges and current approaches to actinide recycling for optimizing the fuel cycle back-end. He described new possibilities in addressing technical challenges. Some of his main conclusions were fast breeder reactors are the essential option for managing Pu (plutonium), significant R&D needs to be conducted in the transmutation of MAs (minor actinides) and LLFPs (long lived fission products) and in new technologies, and a final waste repository is needed.

Mr. Salvatores stated that the development of nuclear energy as sustainable option in the future is related to sound strategy in optimal resource utilization and reliable waste management, that economy and public acceptance will play an important role, and that no unique strategy has emerged and basic arguments developed in the 1970's have been questioned. Mr. Salvatores called the combined management of Pu, MAs, and LLFPs "a formidable challenge."

Mr. Salvatores stated that Pu is the major element for radiotoxicity and mass in storage for the open cycle and stated that any back-end fuel cycle strategy should first set options for Pu management. He gave various options for Pu management but concluded that the fast reactor is the only flexible option to manage Pu safely and that added benefit could be envisaged in the transmutation of MAs and some LLFPs.

Mr. Salvatores spoke of MA and LLFP transmutation and about four general ways in which necessary surplus neutrons could be obtained. He described transmutation concepts that have been explored. Salvatores stated that conclusions from these studies are that Np (neptunium) is not a problem, but Am (americium) is, and that Cm (curium) is even more. Mr. Salvatores gave examples of reduction in toxicity with respect to the open cycle for the heterogeneous and homogeneous mode transmutations of Am and Cm. He also spoke about strategies for handling Pu and MAs separately or together.

Mr. Salvatores spoke about using ADSs (accelerator driven systems) to provide neutrons, stated that a relevant question is if it is possible to reduce the number of reactors to support the transmutation process, and spoke about the "double strata" scenario with Np, Am, and Cm transmutation which he estimates would enable a potential reduction in radiotoxicity of a factor of 100 over the open cycle. Mr. Salvatores spoke about fuels for transmutation -- homogeneous mode, heterogeneous mode, and dedicated fuel. He spoke of aqueous reprocessing and how extensions/complements to PUREX (Plutonium Uranium Recovery Extraction) are being

investigated. He also stated that there is renewed interest in pyrochemistry for its potential in transmuting fuel and described anticipated benefits.

Mr. Salvatores conclusions were: fast reactors are necessary for managing Pu; MA and LLFP transmutation must be further investigated and fuel/target issues are crucial; a scientifically based scale needs to be defined to measure performance of waste management techniques; recycling Pu offers a gain factor of 3 to 5 in radiotoxicity reduction and 10 to 20 with Am and Cm management but that the choice of best strategy will be related to the minimization to the consequences on the fuel cycle; innovative technology like ADC and pyrochemistry may play a significant role though significant R&D is required; a final waste repository is needed.

Fast Reactors and Fuel Technology for the Next Stage

Dr. Victor Orlov
Deputy Director, NIKIET, Russia

Dr. Victor Orlov presented a Russian view on nuclear power development for the next stage. Dr. Orlov stated that Russia has long experience in the nuclear field, but currently there is a lack of direction. Russia is searching for a more defined direction to pursue for the next century. Dr. Orlov emphasized that in doing so, scientists must take into account not only the fuel cycle, but reactors. He said the reactor is about 80 percent of the cost of nuclear energy.

Dr. Orlov described the first stage of nuclear energy development as using uranium-235 for military applications. He said this stage is finished and it is necessary to think about the next stage and in thinking about the next stage we can learn from experience gained in the first stage.

Dr. Orlov spoke of Enrico Fermi in 1944. He said that Fermi started talking about civil nuclear power in 1944 and that many problems from that time still remain unsolved. Dr. Orlov presented a tentative scenario of nuclear capacity growth needed to meet the growing needs of society. In the mid-21st century he estimated an increase in energy demand of about 4000 GWe. He stated there is no alternative but fast reactors in meeting this demand and thinks that demands can be met in 10 - 15 years time if technology is appropriately used. Returning to Fermi, Dr. Orlov stated that Fermi viewed the main problems as creating economically efficient reactors, reactor safety, radioactive waste, and nonproliferation. Dr. Orlov presented an example on fuel balance to meet needs. He said that ~10 million tons of cheap U (uranium) consumed by thermal reactors would produce ~10 thousand tons of fissionable Pu (plutonium) and that fast reactors could be used on Pu mixed with LEU (low enriched uranium) to produce ~8000 GWe – enough to meet demands.

Dr. Orlov stated that economics and high safety must be priorities and these problems are simpler than 50 years ago. He spoke of the inherent safety in the design of NPPs (nuclear power plants) though today's reactors have many hazards. The philosophy in building NPPs has been to do so safer and cheaper. He spoke of benefit derived from experience, such as from nuclear submarines and gave examples on technically improving safety.

Dr. Orlov spoke of radioactive waste and nonproliferation. He said the main problem is actinides – Am (americium), Np (neptunium), and Cm (curium) -- and proposed separating Cm in storage. Regarding iodine, he stated that an equilibrium must be reached between the mined U and waste. He did not understand the need for isotope separation and said the main problem is removing actinides from waste and stated that if removal can be achieved to ~10^{-3}, then equilibrium can be

achieved in ~200 years. He said that the ^{14}C (carbon-14) problem is not, as it is only 1% of total radiotoxicity of waste.

With regard to supporting the nonproliferation regime, Dr. Orlov spoke of not separating the Pu from the fuel and having no U blanket. He said the radioactivity of the fuel is good protection. He said the tentative scheme for a closed fuel cycle supports nonproliferation efforts.

Dr. Orlov closed his presentation by speaking about how MINATOM has begun the technical design of a 300 MW fast reactor it will complete next year. He said the plan is to build the reactor in the next century, but that it is difficult to do so financially. He hoped that interested countries would work together with Russia to build this plant and said that working together, the picture of nuclear power growth is not unattainable.

An Architecture for Nuclear Energy in the 21st Century

Dr. Edward Arthur
Deputy Program Director, Civilian and Industrial Technology Program
DOE Los Alamos National Laboratory, USA

Dr. Edward Arthur started his presentation by saying that the timing for this conference is good in terms of talking about nonproliferation. He said that nonproliferation is receiving worldwide interest and in the U.S. in particular. He stated that the President's Committee of Advisors on Science and Technology submitted a report on the increased need to address nonproliferation. He said this report led to the creation of a nuclear energy research committee, and that this is the first time money has been put into nuclear energy research in number of years. Dr. Arthur presented an architecture for nuclear energy to address global energy needs while managing back-end fuel cycle issues.

Dr. Arthur stated that the idea for the architecture is based on how nuclear energy might progress. He stated that scenarios are uncertain and that there is controversy in the world on what the nuclear fuel cycle should be and that the dominant areas of controversy are tied to nonproliferation and environmental. He stated that the proposed architecture is not an absolute solution, but should be viewed as a catalyst to providing best options. He described the architecture having two major component in (1) technology – nuclear power, interim storage and remote monitoring, and backend materials management and (2) institutions – interim storage, backend materials management, and safeguards and transparency.

Dr Arthur stated that in developing this architecture, a first step was understanding various scenarios for nuclear futures through modeling. The purpose was not to attempt to predict futures but rather to try and understand a range of scenarios. Dr. Arthur spoke about the components of the model – energy demand, energy source, nuclear model, economic model – and provided results from analyses. The model was run using various options such as population growth and carbon taxation affecting the demand. Some general conclusions from the analyses were: nuclear energy demand will grow with a significant upswing possible in latter part of 21st century, demand in nuclear power will shift from developed to developing nations, from a global perspective the penetration of FBR (fast breeder reactors) will be slight until past the middle of the 21st century, and that inventories of Pu (plutonium) in spent fuel will continue to grow even for low-demand nuclear scenarios. Dr Arthur continued by saying that the back end of nuclear fuel cycle is important for any scenario.

Dr. Arthur spoke of the issues surrounding both the open and closed cycle. He stated that the open or once-through cycle implemented in U.S. leads to an increased inventory of spent fuel and that these inventories are sometimes called "plutonium mines"; he commented that

University of California Berkeley has an effort to try and quantify what this means. Regarding the closed cycle he said that reprocessing and recovery of Pu is generally through a complicated PUREX (Plutonium Uranium Recovery Extraction) processes. He characterized the MOX (mixed oxide) being produced as one-use MOX and stated that recycling is not happening at present and added that the number of times it could be recycled is one or two times total. Dr. Arthur stated that breeder reactor implementation has been pushed out in time and there is still the question of what to do with discharged MOX.

Dr. Arthur spoke about the nuclear materials strategy for the architecture. He stated the desire is to enhance proliferation resistance and waste management attributes. He said it makes no sense to attempt to try for a cure as that would bankrupt nuclear energy. He said the desire is to do so with minimum cost, and one example would be to improve LWR (light water reactor) performance.

Dr. Arthur presented a "2050 Architecture", with five components: uranium enrichment, power reactors, interim retrievable secure storage sites for spent fuel, IACS (Integrated Actinide Conversion Systems), and permanent waste disposition. Dr. Arthur also showed via his 2050 Architecture chart the flow of different types of fuel from component to component and spoke about the levels of security and proliferation concern associated with each. For example there would be little proliferation concern with the high level waste flowing from the IACS to permanent waste disposition. He described each of the components and provided possibilities. For example, Dr. Arthur spoke of Urenco, a multinational company, possibly providing enrichment services.

Dr Arthur presented a high level roadmap with objectives associated with each major component: the conversion of separated Pu to MOX would minimize the amount of existing separated Pu, power reactors using uranium fuel and MOX would enable improvement of power reactors for safety and economics; an international spent fuels storage facility like the IMRSS (International Monitored Retrievable Storage System) concept would enable all discharged fuel to be placed in secure and monitored storage; the IACS would enable the consumption of Pu and other minor actinides and would provide no separated Pu and would generate power; and the permanent waste isolation would provide a site to securely and safely dispose of high level wastes.

Dr. Arthur concluded by saying that nuclear nations need to work in concert to better the nuclear energy option, that the U.S. needs to reengage with other countries and that a first step is to implement the IMRSS. He warned that serious discussion on proliferation and materials could increase contention. He provided arguments for starting now: the need to dispose of increased weapons Pu, the forecasted environmental drivers and energy demands, the opportunity for

technology and institutions development when spreading nuclear energy to developing nations, and the low cost of starting the effort.

Panel Discussion and Chairman's Comments

Chairman: Dr. Shiro Matsumoto
Professor, Saitama University, Japan

Dr. Matsumoto asked questions to the panelists and opened the session for questions from the floor.

Question 1: Reprocessing based on plutonium/uranium coextraction and nonproliferation

The first question posed by Dr. Matsumoto was the following. There has been talk about coextraction of Pu (plutonium) and U (uranium) which is a tedious activity. Is the probability for proliferation high?

Mr. Salvatores spoke about France's situation. He said they have been doing this in La Hague and they have had an excellent record, and the activity has had a positive contribution to nonproliferation. He said that economy and waste management must be considered and that the CEA and other places have been carefully planning the future. He stated that the government and utilities are not seen as strong supporters. As for waste management, France is in a unique position because of the 1991 decision by parliament to work until 2006 on the issues of waste management and resource utilization.

Dr. Orlov responded by saying that there are alternative methods for handling radiation waste with Pu. He said from their point of view, if there is development in FBRs (fast breeder reactors), they do not need to conduct this type of coextraction, but that actinides needed to be handled. However if large FBRs are not built he did see why this should not be done.

Dr. Arthur spoke about simplifying the recovery of U and Pu. He stated that the aqueous process described by the first speaker reminded him of concepts proposed several years ago in the U.S. and Europe. He talked about Germany having simplified flow sheets. He stated that these efforts were stopped, but Japan is continuing research. Dr. Arthur commented that this is good for advancing recycling research of materials.

Question 2: Proliferation resistance from dry reprocessing

Dr. Matsumoto posed a second question. He stated that actinide recycling had been viewed in terms of proliferation resistance and France had its own viewpoints on aqueous recycling, but asked "How can we view this from the dry system side?"

Mr. Suzukii answered that there are two types of dry methods and Pu and MAs (minor actinides) have been integrated in the reprocessing. They are dedicated not only to recovery of Pu but to

combined recovery of Pu and MAs. Given this, the activities are enhanced for nonproliferation.

Question 3: France's economic evaluation on radioactive waste disposition and resource utilization

From the floor, Mr. Nomura of JNC Tokai asked the third question. He stated that there is talk about economic value added, and in France's case there is a legislation to evaluate this, i.e., there is legislation until 2006 to evaluate treatment of radioactive waste and resource utilization. Mr. Nomura asked what kind of mix would be applied in the evaluation.

Mr. Salvatores responded that in 2006 they are required to have an economic evaluation done; up to now only a rough evaluation has been made. He stated that a decision is not to be made before 2006. The approach is to provide the government several options including cost estimates. They are now assessing basic scientific feasibility and are trying to obtain a more precise cost estimate. He stated that this cannot be done by an R&D organization alone. He stated that it is difficult to do a cost estimate above ground including implied costs such as dose to workers. He stated that implied costs can make one strategy preferable to another. Mr. Salvatores said the first stage will be complete by 2003 and a final evaluation will be complete in 2006. He said they are doing their preliminary evaluations based on a 20 percent increase in Kwh. He then gave an example of one of the trades by saying "Why don't we extract curium and let it decay?" and replied that the reason they do not is there probably would be a large increase in cost.

Mr. Suzuki stated that he represents industrialists and for nonproliferation whether an institutional or technical issue, there is a need to look at the fundamentals. Mr. Suzuki stated that uranium will be probably be depleted in less than a century and that it is rich energy source that can be utilized by any country. Attaching proliferation resistance influences the system financially and nonproliferation requirements have been imposed from a wider perspective. He said, "What is the proliferation risk? We need to have the numbers."

Dr. Orlov stated that regarding nonproliferation, there is no technical measure to assure this. Uranium enrichment technology exists as does the PUREX (Plutonium-Uranium Recovery and Extraction) process, and any country and any person who wants to have materials for weapons can use these developed technologies to do so. Proliferation is a political problem. We can develop a new technology where we can use Pu in LWRs (light water reactors), produce Pu in LWRs, take spent fuel and produce Pu. We can obtain Pu from storage and from reactors and from fuel cycles in protective conditions. We must deal with these technologies that use Pu.

Dr. Arthur had some comments on nonproliferation. He said that the U.S. has had, for a long period, a level of concern for the civilian use of Pu and proliferation. The concern still continues. He then gave some personal opinions. He stated he agreed with Dr. Orlov – if a nation wants to

proliferate it can. He stated, however, at same time, it is important for civilian community to make sure their concerns about proliferation are addressed in the civilian fuel cycle. He stated that this must be pursued at highest level. He said this is best done as he described conceptually, and that the international community can pursue this through better technology and institutional objectives. He added that international pursuit translates into transparency. He stated that Acheson-Lilienthal Plan, conceived at the beginning of the nuclear age, recognized the importance of addressing these types of issues.

Mr. Salvatores said that aqueous and dry are very different and it is not fair to compare them as such. He stated that Mr. Orlov commented that these were not quantified and he stated that the scale is not quantified. Mr. Salvatores stated that in the development of technology one should not jump quickly to conclusions, as much more work needs to be done. Mr. Salvatores added that he agreed the nonproliferation issue is a political one.

Question 4: Proliferation resistant technology

Dr. Matsumoto stated that Dr. Arthur talked about nonproliferation – institutionalizing the system and implementing a radioactive barrier for proliferation resistance. From a technical viewpoint, there are MAs which are radioactive and Dr. Arthur also spoke about them. Proliferation resistance is a result of some of these technical approaches. He asked for comments.

Dr. Wakabayashi commented on proliferation resistance and actinides from a technical point of view. He said that if facilities are looked at from an institutional point of view the fuel cycle should be resistant. From a technical point of view, however, this was not 100 percent, but he stated safeguards could be added.

From the floor, Mr. Kurihara, Senior Executive Director of the Nuclear Material Control Center, provided some observations. He stated that nonproliferation is a global concern and nonproliferation is a political objective. He said to pursue this objective we need to rely on various regimes. He stated that as Mr. Suzuki said, we need to determine how to suppress others' motivations to go nuclear; we need to determine what incentives to provide. Mr. Kurihara spoke about North Korea's incentive with Korean Peninsula Energy Development Organization (KEDO) and about Iraq's incentive with the threat of punishment. He said there are international agreements and activities such as Brazilian-Argentine Agency for Accounting and Control of Nuclear Materials and International Atomic Energy Agency, but that technical solutions are important. From that point of view it was important to know who's intention it might be to proliferate nuclear weapons. Mr. Kurihara stated that nuclear safeguards are in place to prevent State diversion. Physical protection is in place for diversion by non-state entities and sub-national bodies. He said there is a lot of technology to discourage proliferation by non-

governmental diverters who are much less technically and financially capable. He said that Iraq and North Korea can easily obtain proliferation materials even if the materials contain minor actinides. Mr. Kurihara said that increasing proliferation resistance is important and technology needs to be pursued.

Dr. Arthur commented that diversion for nuclear weapons can take two forms – plutonium or highly enriched uranium. He also spoke of minor actinides, particularly neptunium, gaining international attention because they are fissionable. Regarding enrichment, Dr. Arthur said that there are good safeguards in place for civilian enrichment plant operation. He spoke of a way of conducting enrichment that appealed to him personally – the use of a multinational operation like Urenco. He stated that from a civilian and declared facilities standpoint, preventing diversion of enriched materials was covered. He said, however, as time goes on, more attention needs to be paid on technologies for covert enrichment processes.

Dr. Wakabayashi commented. Regarding neptunium, it is extracted together with plutonium based on single-cycle co-extraction method. In this way it does not lose its nonproliferation characteristics.

Dr. Orlov stated that the critical mass of neptunium is about 100 kg. He stated it is better material compared with 20 percent enriched uranium. He stated that the better way to deal with neptunium is a to bury it; extract it then bury it in the earth.

Mr. Suzukii said neptunium had a secondary effect. Pu-238 will be generated when it is treated. The possibility for proliferation will decrease if plutonium and neptunium are treated together.

Question 5: Viewing nonproliferation from the boundary condition of total nuclear disarmament

From the floor, Mr. Richard Hooper, Former Director, International Atomic Energy Agency asked the panel about considering nuclear futures given the boundary condition of total nuclear disarmament.

Dr. Arthur asked for clarification about the role of nuclear weapons disarmament and nuclear futures in energy. He wanted to know that if without nuclear weapons, the outlook for nuclear futures in energy would be brighter.

Mr. Hooper stated his question deals with political environment of nonproliferation. With complete disarmament, there will be a change public acceptance about the use of nuclear technology.

Dr. Arthur replied that there is an element in going to low number of nuclear weapons. This condition may increase attention on civil use of nuclear energy. Dr. Arthur stated that the energy model did not have an input for public acceptance and that the model did not distinguish between fossil energy and nuclear energy.

Dr. Uematsu of JNC spoke from the floor. He stated he remembered ideas mentioned 20 years ago – fuel radioisotope doping, plutonium storage, interim storage. He asked Dr. Arthur if international evaluation was necessary for this initiative started in the U.S..

Dr. Arthur answered that the study provided a complete technology listing which does not need to be repeated. There are some common starting points from which to move forward for the future nuclear fuel cycle. Regarding the disposition of weapons Pu, there is a larger international cooperative effort addressing the disposition of excess weapons Pu. He stated that Professor Suzuki, the chairman of the last session, has devised an innovative proposal for the regionalization or internationalization of monitorable retrievable waste. We need to go forward.

Chairman's Closing Comments

Dr. Matsumoto made closing comments. He said that the purpose for the nuclear fuel cycle is to obtain a large quantity of energy in a politically-wise and economically secure manner. In carrying forth the nuclear fuel cycle, social and environmental impacts must be addressed. Though there may be some commonality with the situation 20 years ago, there have been a lot of changes since. The nuclear fuel cycle must address impacts to the environment. Back then, one issue that was being pursued was high decontamination technology and at one time it was desirable to scale up the effort, but recently as the environment is considered, the dominant concern is how to dispose of waste. Dr. Matsumoto said that it is important to look at not only wet, but dry processing. The nuclear fuel cycle needs to be viewed from a nonproliferation perspective. Considering nonproliferation together with waste management new technology needs to be pursued. As for nonproliferation, Dr. Matsumoto stated that technology alone is not enough. He said like Dr. Arthur stated, an international and political framework needs to be established. The nuclear fuel cycle will become a recycle system in the 21st century. How this is managed will be an issue. The issues faced will be similar to what other industries have to face. He stated that maybe this is an ideal and closed by reiterating that nonproliferation issues must be addressed.

Session II

Transparency Improvements in Nuclear Technology through the Use of Remote Monitoring

Chairman: Mr. Hiroshi Tani

Executive Director, Japan Atomic Energy Research Institute, Japan

Mr. Hiroshi Tani chaired the forum's second session on remote monitoring technology. Three presentations were given at this session – two from the United States and one from Japan. At the end of this session, Chairman Tani provided a summary of the session and facilitated a brief question and answer session formed by questions from the floor.

The session was preceeded by a demonstration of a remote monitoring system.

Demonstration of the Joyo Remote Monitoring System used at the Experimental Reactor Joyo

Mr. Richard Lucero

International Fellow, Japan Nuclear Cycle Development Institute, Japan

Mr. Richard Lucero provided a live demonstration of the Joyo Remote Monitoring System which was installed at a spent fuel pond at JNC Oarai Engineering Center in July 1996. The purpose for this JNC/SNL (Sandia National Laboratories) collaborative project is to promote nuclear transparency. Mr. Lucero downloaded and displayed data from the day of the demonstration and accessed historical data. Data is accessed via modem using standard telephone lines and is displayed via password protected web site; remote access is currently being conducted at the spent fuel facility, JNC Headquarters, and SNL's CMC (Cooperative Monitoring Center). The remote monitoring system, which incorporates a motion triggered image capture system, gamma sensors, and neutron sensors that feed a data acquisition system and data information retrieval system, will be expanded to conduct fresh fuel storage monitoring.

The Present Status of the Technological Development of Remote Monitoring Systems

Dr. John C. Matter
Manager, Cooperative Monitoring Systems Department
DOE Sandia National Laboratories, USA

Dr. John Matter started his presentation with general comments on transparency and remote monitoring technology, provided examples of newly deployed remote monitoring technology and technology under development, then spoke of some application examples.

Dr. Matter stated that the concept of remote monitoring systems is consistent with the world of nuclear transparency and a said a more complete name is "remotely accessed unattended monitoring systems". Dr. Matter spoke of three functions of a remote monitoring system: sensing, communication, and information management.

In setting the stage for current technology examples, Dr. Matter spoke about the history of remote monitoring which he characterized as both "long and brief". Examples exist from more than 20 years ago, but the technology was unacceptable at the time, as benefits did not outweigh costs. Within the last three to five years there has been renewed interest from both a political perspective to address issues brought about by the end of the cold war, and a technical perspective given the revolution in communication and computer technology. Dr. Matter stated that efficiency and effectiveness must still be proven, but a number of evaluations are proceeding.

Dr. Matter spoke of four significant system engineering issues – intelligibility, surety, architecture, and cost – that must be carefully addressed to ultimately determine success. He then went on to the main body of his presentation – technology and application examples of remote monitoring. Dr. Matter provided technology examples in the areas of sensors, communications, and information management. The sensor examples were Smart Bolt, Integrated Nuclear Materials Monitor, Ntvision, μChemLab; the communication example was Intelligent Logal Node; the information management examples were Recodable Locking Device and Knowledge Generation. For applications, Dr. Matter spoke about various examples in four areas: the environmental monitoring examples were Neighborhood Environmental Watch Network and Remote Monitoring of Automated Air Sampling; the nuclear material trafficking detection example was the Radiation Inspection System; the nuclear materials shipment tracking example was Authenticated Tracking and Monitoring System; the nuclear materials storage monitoring examples were U.S./Russia Storage Monitoring Collaboration and the Integrated Review System.

Dr. Matter concluded by stating: technology is adequate for nuclear transparency and the next

generation is under development; some remote monitoring systems are already in use in demonstrations, evaluations, and field trials; key system engineering issues are being addressed in knowledge generation, data surety, system architecture and life cycle cost.

Remote Monitoring Technology at the Experimental Reactor Joyo

Mr. Yu Hashimoto
Senior Engineer, Irradiation and Administration Section, Irradiation Center,
Oarai Engineering Center, Japan Nuclear Cycle Development Institute, Japan

Mr. Yu Hashimoto spoke about both the current remote monitoring system at the Experimental Fast Reactor JOYO and the planned expansion of this system.

Mr. Hashimoto stated that this remote monitoring work being conducted jointly with SNL (Sandia National Laboratories) began four years ago under the auspices of a JNC/DOE (Japan Nuclear Cycle Development Institute/U.S. Department of Energy) nonproliferation agreement. The current system, which utilizes motion sensors, gamma and neutron radiation sensors, a digital video system called ICAM (Image Compression and Authentication Module), a DAS (Data Acquisition System), a DIRS (Data and Image Review System), and an Echelon LON (Local Operating Network), is being used in JOYO's SFSF (Spent Fuel Storage Facility). An uninterrupted power supply provides backup in case of power failure. In the SFSF, there are four sets of microwave motion sensors, a laser breakbeam, an ICAM, two gamma detectors near the hatch door, and a neutron detector in the pond. The DAS located in the Control Room acquires the data from these sensors. Transmission to external locations is done via telephone line and data is being distributed to the Oarai Engineering Center, JNC Headquarters, and SNL's Cooperative Monitoring Center.

Mr. Hashimoto showed photos of various sensors. One of the photos was a comparative photo of the ICAMS and the IAEA MIVS (Modular Integrated Video System). Mr. Hashimoto showed how at first glance the cameras appear quite similar, however unlike MIVS, the ICAMS is a digital system. Mr. Hashimoto, using photos and data, showed how the remote monitoring system operated during the transfer of a cask and explained how various actions triggered sensors.

Mr. Hashimoto explained that new remote monitoring technologies will be incorporated in the expanded system extending to the fresh fuel storage facility; assembly of the devices will be conducted at SNL. A Neumann DCM-14 digital camera module which is IAEA approved and commercially available will be used instead of ICAMS. The commercially available, Los Alamos National Laboratory developed Ntvision digital video camera system will be used as a stand-alone sensor; its performance is currently being evaluated at JOYO. The SNL developed RF (radio-frequency) seal "T1", a 2-way transceiver which has internal sensors for temperature, motion, total dose radiation, and light will also be incorporated. The use of a fiber-optic based neutron detector developed in Japan is also planned. The Sandia developed MMS (Material Monitoring System) will serve as the architecture to acquire, store, and disseminate data; data

dissemination is done via password protected Internet access. Mr. Hashimoto explained the functions of the various component modules of the MMS.

Mr. Hashimoto concluded by stating that remote monitoring systems may be helpful to the IAEA in the future. IAEA inspections occur monthly in JOYO and maybe the number of visits could be reduced if system data are reviewed by inspectors. He also thought this technology may be useful in streamlining the audit process. With regard to transparency, Mr. Hashimoto stated that remote monitoring systems can help promote trust by showing that activities are being conducted for peaceful purposes. Mr. Hashimoto stated there is a need to promote and implement new technology to realize the benefits of remote monitoring.

Remote Monitoring as Part of a Broader Strategy for Increased Transparency

Mr. Richard Hooper
Former Director, Conceptual Planning Division of Safeguards Department, International Atomic Energy Agency, USA

Mr. Richard Hooper prefaced his presentation by saying that though he may sound like he is speaking for the IAEA (International Atomic Energy Agency), he is not, as he works for Wind River Consulting. He said his views were speculation, though knowledgeable speculation based on years of IAEA experience. Mr. Hooper gave a history of remote monitoring for IAEA safeguards, spoke about it as part of a broad strategy for increased cooperation with SSACs (State System of Accounting for and Control of Nuclear Materials) and nuclear transparency, and provided examples of its application to IAEA safeguards. Mr. Hooper's and Dr. Matter's presentations were complementary in several areas.

Mr. Hooper spoke about the meaning of remote monitoring to the IAEA. He said that it was implemented from safeguards' beginning, for example photo surveillance, but unsuccessfully. He mentioned Elmo, COSMOS (Compact Surveillance and Monitoring System), and MIVS (Modular Integrated Video System), said they had poor reliability, but that digital technology offered promise. He said bundle counters have been in place for 25 years. These systems, however still require inspectors to retrieve data and service equipment. Mr. Hooper described remote monitoring as "long a dream of safeguards implementers" and spoke of efficiency and effectiveness gains and reduced radiation exposure.

Regarding early efforts, Mr. Hooper spoke about RECOVER (Remote Continual Verification) program; it had some success with SOH (State-Of-Health) data transmission and later with alpha-numeric data, but benefits did not outweigh costs. The IAEA started a follow-on program called Son of RECOVER, and now there is the IRMP (International Remote Monitoring Project). Mr. Hooper characterized early efforts as having some technical success, but problematic in cost, reliability, and political issues. He stated that political issues were the greatest impediment.

Mr. Hooper spoke of circumstances changing in the last four to five year. There is increased political support for efficient and effective safeguards and nuclear transparency. With the 93+2 Program, IAEA's access to advanced technology and modern communication has improved. Remote monitoring experience is increasing in various countries. Cost however remains an issue.

Mr. Hooper spoke about the three levels of information identified by the IAEA which may be transmitted: SOH, summary data, and detailed data such as surveillance imagery. He said that

the last has the greatest potential.

Mr. Hooper spoke of remote monitoring improving IAEA safeguards efficiency and effectiveness when combined with unannounced inspections and additional information on material transfers and facility operations. An important aspect of implementation is making full use of State's systems; some legal basis exists, such as from INFCIRC/153 and INFCIRC/540, but increased cooperation with States is necessary. Mr. Hooper also spoke of independent verification and increasing cooperation with the States to achieve the boundary condition.

Mr. Hooper concluded by giving examples of how remote monitoring might be applied for IAEA safeguards in LWRs (light water reactors), LWRs with fresh MOX (mixed oxide) stores, static or semi-static stores of direct use material, and low enriched uranium fabrication facilities. Common to all examples was using remote monitoring in combination with random unannounced inspections to reduce the total number of inspections.

Chairman Summary and Questions from the Floor

Chairman: Mr. Hiroshi Tani
Executive Director, Japan Atomic Energy Research Institute, Japan

Chairman Tani provided time for a few questions to be asked from the floor before giving his chairman's summary of the session.

Question 1: Paying Costs of New Technology
Mr. Nakano, Japan International Science and Technology Exchange Center asked the first question about paying the costs of new technology and new devices; he directed the question to Mr. Hooper first.

Mr. Hooper replied that the IAEA (International Atomic Energy Agency) is poor and development has largely been carried out under auspices of support member states. He did not see any change. Where the IAEA has been directly involved, investment has been very modest. He stated that the more the cost in capital outlay, the more the cost must be written off in facility inspection. He stated that cost benefit is important. He said the IAEA could benefit if it linked technology development to the large infrastructure being put in place for the Comprehensive Test Ban Treaty Organization. He cautioned that in absence of joint efforts, applications may not be as cost efficient.

Dr. Matter agreed with Mr. Hooper's comments and continued with two more points. He stated he did not think there is a need for every organization and every state to repeat research and development; that much can be shared between different programs. For instance, even entities not involved in the U.S. support program can benefit. There is R&D not linked to IAEA safeguards such as handling of excess weapons that may be applicable. Dr. Matter said he agrees that the final answer is not in for cost benefit and in the U.S. there is a great deal of interest in cost benefit. He gave an example that if visits are reduced from 12 to 8 or 9, that may not be useful.

Mr. Hashimoto stated that R&D is costly and implementation even more so. He stated that costs can be lowered by using commercial available items. He said that if technologies are to be developed, and in his opinion they should be, a determination needs to be made about who will do the development and who will pay for the development. He spoke of best utilizing technologies already available and deriving new technologies cost effectively. He also added that information disclosure is costly, but that there is motivation to do so.

Question 2: Japan, under full scope safeguards, doing more to promote transparency
Mr. Naito, STA (Science and Technology Administration) Director-General for the Nuclear Safety Commission asked the second question. He stated that remote monitoring is being used

to enhance efficiency and effectiveness for international safeguards, but is also being used to enhance transparency and provided the JOYO system as an example. His question was the following: As Japan already conducts its nuclear activities under full scope safeguards, is it necessary to further efforts in promoting transparency through the use of remote monitoring and other methods? He asked about data security as well.

Mr. Hashimoto stated that the Internet is being used to disclose information and is being used to enhance transparency. He stated that it is up operators and government organizations to implement this.

Dr. Matter said it is important to tie the questions back to cost. He stated that thinking from the perspective of transparency is new compared to IAEA safeguards. Transparency suggests the voluntary provision of information to others, but it is not widely done and there is not much precedence for it. He stated there is no information on what will be released and will be required by neighboring states and that more discussion is required. He postulated that in the future, if there is widespread nuclear transparency, there may be less of a requirement for formal treaties and agreements; he then commented that that is probably too idealistic. As for data security he said that there are technical solutions such as separating the data distribution system from the remote monitoring system, i.e., the sensor suite and data acquisition system. As for data security over the Internet, he said there are technically feasible solutions and additional layers of security can always be added.

Chairman's Summary

Mr. Tani summarized the session. He said that Dr. Matter talked about historical, current, and future developments and made far-reaching comments; a decade ago Cecil Sonnier talked with him about various technology developments. Mr. Tani stated that the demonstration system Mr. Hashimoto described is evidence that a certain level of results can be attained. Mr. Tani spoke of seeing at a General Assembly Meeting of the IAEA, then U.S. DOE (Department of Energy) Secretary Hazel O'Leary conduct a remote monitoring demonstration. He said that this represented results of endeavor and brought earned remote monitoring respect. He thanked JNC and DOE for their joint work in remote monitoring.

Mr. Tani stated that Mr. Hooper used to be the former director of conceptual planning at the IAEA and described him as a world authority. He said that Mr. Hooper highlighted safeguards technology in the IAEA regime and described how it will evolve in the next generation. Mr. Tani provided an explanation about the implementation of the 93+2 Program, which covers undeclared facilities and activities, and spoke about the review conference for the NPT (Non-proliferation Treaty) in 1995 prior to the Iraq and North Korea incidents which tested the validation of IAEA safeguards. The incidents triggered the research initiative Mr. Hooper

managed. Mr. Tani spoke about how the process has been enhanced by additional protocol. He said that the Japanese have submitted a revision of the Atomic Energy Implementation Act. Mr. Tani stated that the addition protocol will enhance IAEA safeguards with remote monitoring, and this is worthwhile as budgeting will not allow an increase in headcount of inspectors or staff.

Mr. Tani stated that Japan's culture is pro-safety. He said that Mr. Nakano raised the issue of funding. Mr. Tani continued by saying that when he was working for the STA, he found that highly efficient inspections were conducted at the JNC plutonium facility and is confident that efficiency has improved. Mr. Tani stated that the INMM (Institute of Nuclear Material Management) has presented JNC a safety award and that there is world consensus that JNC has been instrumental in increasing the transparency in inspections. Mr. Tani said that the question posed by Mr. Naito brought forth a challenging issue. Mr. Tani stated that physical protection often prevents the disclosure of information and said that the INMM Japan Chapter has discussed different levels of disclosure to the public and that there may be various levels for transparency. He stated that it was important to think about transparency particularly to build the confidence of other countries in Japan's nuclear activities and that remote monitoring technology was applicable.

Mr. Tani closed his summary by saying that Japan is the only atomic bomb victim and that Japan will be last country to possess an atomic bomb. He said there is a need to address question for transparency building and said that the session elaborated on technologies important to transparency.

Session III

International Cooperation and Technical Issues on the Disposition of Excess Nuclear Weapons Plutonium

Chairman: Dr. Atsuyuki Suzuki

Professor, University of Tokyo, Japan

Dr. Atsuyuki stated that this session titled **International Cooperation and Technical Issues on the Disposition of Excess Nuclear Weapons Plutonium** pertained to issues centered around START I and START II (the Strategic Arms Reduction Treaties I and II); the U.S. and Russia have engaged in nuclear disarmament and the world would like to see this happen smoothly. It is an important issue and this issue is not limited to domestic matters, but must be viewed from an international perspective. He stated that there would be four presentations given in the session – two from Japanese speakers, one from the U.S., and one from Russia.

Japanese Cooperative Initiative for the Disposition of Excess Weapons Plutonium

Mr. Tsutomu Imamura
Deputy Director-General, Minister's Secretariat
Science and Technology Agency, Japan

Mr. Tsutomu Imamura stated he would talk about Japan's involvement in excess weapons Pu (plutonium) disposition in terms of the Science and Technology Administration's approach and from personal observations.

Mr. Imamura said it is needless to say that from Japan's viewpoint, it is a country dedicated to realizing the nuclear fuel cycle and promoting peaceful use of nuclear energy. He said it was important to gain trust of country and that Japan's Atomic Energy Law sets policy that nuclear development must be limited to peaceful purposes. He said Japan is working faithfully and steadily toward this and is actively contributing to the nonproliferation regime.

Regarding international agreements, Mr. Imamura stated that the Additional Protocol and bill for implementation were submitted to the Diet in September. He said that Japan ratified the Comprehensive Test Ban Treaty in July 1997 as the 1st of 44 countries needed to ratify for the treaty to go in effect. He spoke of Japan's contribution to Korean Peninsula Energy Development Organization and its cooperation with Russia. He stated that Japan is taking proactive approaches to nuclear materials management.

Mr. Imamura said the end of the Cold War and collapse of the Former Soviet Union has had effect and spoke of the ratification of START I and II (Strategic Arms Reduction Treaties I and II). He said to welcome in world peace, we should ensure that excess weapons Pu generated in the U.S. and Russia are properly managed and disposed. He spoke about a result of the April 1996 Moscow Summit – excess weapons grade Pu should be transferred in a form where it cannot be used as weapons and other countries could assist. In an International Expert Panel Meeting held October 1996, the MOX (mixed oxide) option was recognized as a means of disposition of surplus weapons Pu. MOX fuel has been used in nuclear power generation in Europe and Japan.

Next, he touched upon the international approach to the issue. There is a U.S.-Russia joint verification effort, a U.S./Russia/IAEA discussion on the verification surplus Pu, a joint France/Germany/Russia initiative to construct a MOX fuel fabrication plant in Russia, and a project in which MOX fuel fabricated in Russia would be burned in CANDU reactors in Canada.

He spoke of Japan's contribution and spoke of STA and JNC working together in three areas: a reactor physics experiment on the burning of MOX in converted Russian BN-600 reactors, irradiation testing in the BN-600 of MOX fuel made from surplus weapons Pu using vibro-pack technology and post irradiation testing of spent fuel from FUGEN to study burning of Russian MOX fuel in CANDU reactors. The STA hopes to contribute so that Russia can utilize the BN-600 to burn excess weapons Pu. He said there are three steps to take - fabricating MOX with excess weapons Pu, burning the MOX in BN-600 with a hybrid core and conversion of the BN-600 to a full MOX core - and Japan can help.

Mr. Imamura closed his presentation by saying that Japan is hoping to contribute positively not only to disposition but to nonproliferation and to weapons disarmament.

The Present Status of International Cooperation Pertaining to Russian Excess Weapons Plutonium Disposition by Japan Nuclear Cycle Development Institute (JNC)

Dr. Aiji Yamato

Executive Director, Japan Nuclear Cycle Development Institute, Japan

Dr. Aiji Yamato stated he would report on JNC's status in and focus on the technical aspects of the disposition of WP (weapons plutonium). He said JNC would help prepare the backbone.

Dr. Yamato stated that the Moscow Summit and Paris meetings in 1996 were the start to Japan considering cooperation in Russian WP disposition. He stated that at the first trilateral meeting there was discussion on BN-600 use.

Dr. Yamato stated that JNC is planning to be proactive in the development of fast reactors and in WP disposition. He spoke of JNC's technical capabilities in MOX (mixed oxide) fuel and vitrification. He spoke of capabilities resident at various JNC facilities: FUGEN fuel can be used for CANDU fuel development; JOYO and FUGEN can be used for evaluating burning and management of MOX; JOYO, MONJU, and FUGEN can be used for fuel fabrication evaluation. JNC has experience in fuel transport, storage, and handling. It has experience with International Atomic Energy Agency inspections. It is developing security and safety options and working in the area of transparency. JNC is working on Pu (plutonium) fabrication.

Dr. Yamato spoke of two cooperative efforts – the Fast Reactor Option and the CANDU MOX Option. In the former, JNC determined it could most effectively contribute by joining the U.S.-Russia Study. In this option there will be a core conversion of the BN-600 from UO_2 to MOX. A hybrid (20 - 30 % total) MOX core will burn ~0.3 tons Pu per year and a full MOX core will burn ~1.3 tons of Pu per year. The objective will be for the BN-600 to burn 20 tons WP by 2020 assuming a life extension for BN-600 from 2010 to 2020.

Dr. Yamato spoke of activities with the Fast Reactor Option. Experimentation is needed to evaluate changes that will result when replacing the UO_2 blanket with a stainless steel reflector in BN-600 and will be conducted at BFS-2 in Obninsk. First there will be simulation experiments and then a demonstration of MOX fuel fabrication and irradiation testing. The five year experimental program will conduct critical experiments using BFS-2; an analysis of the experiments will be conducted by Institute of Physics and Power Engineering and JNC, and an evaluation of core characteristics for the hybrid and full MOX will occur. JNC and RIAR (Russian Federation Research Institute of Atomic Reactors) have a collaborative program which will demonstrate irradiation testing by the BN-600 of three MOX vibro-packed fuel assemblies which will be fabricated by RIAR. Dr. Yamato stated that 20 kg of WP will be disposed of in

the demonstration. He characterized this as a small but significant amount.

Regarding the CANDU MOX option, Dr. Yamato stated that JNC has experience fabricating and using MOX fuel with ATR FUGEN. JNC will conduct post irradiation experiments of FUGEN high-burnup test fuels and will provide results. He said details will be discussed soon.

Dr. Yamato concluded by saying in 1992 prior to the Moscow Summit, Dr. Uematsu talked about Japan's proactive contribution to world peace. Dr. Yamato stated that its now time that Japan contributed positively and he believes that Japan can contribute to world peace and also to nuclear cycle development.

USA's Cooperative Program for the Disposition of Excess Weapons Plutonium in Russia and the USA

Mr. John J. Taylor

Vice President Emeritus, Electric Power Research Institute, USA

Mr. John Taylor started his presentation by stating that the U.S. has made a strong commitment to cooperate with Russia and the International Atomic Energy Agency on disposition of nuclear weapons.

Mr. Taylor said risks need to be minimized. The U.S. DOE (Department of Energy) reported 1350 MT (metric tons) of weapons fissionable material in the Former Soviet Union: 700 MT in highly secure weapons, but 650 MT in metals, oxides, solutions and scrap which are not highly secure. This amount is enough to produce 40,000 bombs. Mr. Taylor also stated that the U.S. also has excess weapons material and though highly secure, the growing amount of excess has led the U.S. to increase investment in securing excess material. This increased investment is reflected in the DOE Materials Protection, Control and Accounting budget which grew from $3M in FY93 to $137M in FY98 and is estimated will have total expenditure of $800M by 2002. Mr. Taylor said that progress is being made on centralized safe storage. He said it is urgent to dispose of materials such that they will never again be returned to nuclear weapons; doing so will provide high proliferation resistance and will establish a pattern of irreversibility.

Mr. Taylor spoke of DOE's 1997 Record of Decision which states that the U.S. will follow a dual track approach in weapons material disposition – utilizing it as MOX (mixed oxide) fuel in existing power reactor and immobilizing it. DOE schedules and cost estimates show this task is major and will take a long time to accomplish. Mr. Taylor stated that the recommendation that existing reactors be used was made because doing so will enable this urgent job to be done in the most rapid and least costly way; he said Russia is planning to use the BN-600 and VVERs to burn plutonium.

Mr. Taylor stated that the U.S.-Russian Independent Scientific Commission made recommendations consistent with the DOE's Record of Decision - to use existing reactors to burn plutonium, to separate weapons disposition from nuclear power development, and to expand research on nuclear energy options. He said however that formal U.S.-Russian agreements have yet to be reached.

Mr. Taylor stated that progress is being made in cooperative R&D between the U.S. and Russia. The U.S. and Russia are sharing their results on dry and wet conversion processing. The PDCF (Plutonium Pit Disassembly and Conversion Facility) will be located at Savannah River where it will be co-located with immobilization production and MOX fabrication facilities. The U.S.

National Laboratories are working on the immobilization option; the prime candidate is the "can-in-canister" and there has been major attention in the design of the can for military use. Russia is not working on immobilization. Russia and the U.S. are cooperating in various areas favorable to both.

Mr. Taylor spoke of how the pace of the program is too slow and not commensurate with the urgency indicated by the U.S. National Academy of a "clear and present danger". The Center for Security and International Studies called for accelerated actions on the joint U.S.-Russian disposition work plan, IAEA verification, pit conversion to unclassified forms, licensing reviews, and identifying and acting on financing mechanisms.

Mr. Taylor said that Japan's assistance in the use of Russian VVERs would be a good addition. He spoke of how the utilization of European facilities is being considered. He talked about the ideas of regional interim storage facilities, and stated that a key feature of the proposals by Dr. Suzuki of University of Tokyo and Dr. Cochran of the Natural Resources Defense Council is that their proposals have a financial component.

Mr. Taylor spoke about the need to develop consensus. He said that the public has been complacent on the dangers of nuclear weapons since the end of the Cold War and that complacency has led the public to believe that burning excess weapons materials is a great danger rather than a safe way of converting "swords to plowshares". He spoke about the contention over burning of MOX and told of how it was eliminated in a National Academy study by the acceptance of a principle in a report by the U.S.-Russian Independent Commission to Presidents Clinton and Yeltsin. The statement was: "the mission of disposition of excess weapons plutonium can and should be implemented without the United States having to support steps that would contribute to additional reprocessing and recycling of plutonium, and without Russia or the other participating states having to agree to permanently foreclose reprocessing and recycle".

Lastly, Mr. Taylor spoke about a role for industry. He said that industry can take part in the assessment of various options to find the most fruitful. He said that ongoing developments are not enough and that industry leadership will assure practicality and economy and help rid the world of nuclear weapons.

Management of Ex-Weapons Plutonium in Russia

Dr. Anatoli V. Zrodnikov
Director, Institute of Physics and Power Engineering, Russia

Dr. Anatoli Zrodnikov started his presentation by talking about Russia views and needs for nuclear power. He stated from the first stages of nuclear power development in the FSU (Former Soviet Union), the closed nuclear fuel cycle was considered the main priority and that Russia's long term views have not undergone any essential change. Further, the disintegration of the FSU resulted in principle U (uranium) sources to be located outside of Russia and that Russia's existing uranium resources are not adequate for development, not even to the level of 50 GW(e) – about half the level of the U.S.. He stated that Pu (plutonium) in Russian policy is considered a valuable fuel for electricity production and in connection with this, large scale reprocessing of spent fuel is supposed to be conducted with Pu separation for further use in MOX (mixed oxide).

Dr. Zrodnikov stated that the closed fuel cycle is good for the environment, nuclear power development, and the nonproliferation regime and said that the release of enormous amounts of Pu from the defense program does not carry any new problems in nuclear power energy. WP (weapons plutonium) will be used like other Pu.

Dr. Zrodnikov spoke about the basic principles of Pu disposition. He said that weapons Pu logically does not go beyond closed concept framework and said that in an official document released by MINATOM the two main theses of the concept of Pu disposition were: in short term – arrangement of reliable and controllable interim storage, investigation of utilization possibilities, and selection of optimum technologies, in long term – realization of Pu power through its utilization of a fuel for power reactors.

Dr. Zrodnikov spoke about storage in Russia. He said Russia is building a modern temporary storage facility at PA MAYAK which will provide storage for 50,000 containers of weapons grade material and will be trilaterally controlled by Russia, U.S., and IAEA.

Dr. Zrodnikov stated that Russia is not ready to use weapons and civil Pu on a wide scale. He said that two types of reactors are being considered for Pu conversion – sodium cooled fast reactors (BN) and pressurized water reactors (VVER). He said that one BN-600 is using HEU (highly enriched uranium) and that seven VVER-1000 reactors are in operation. Of the seven, only four will potentially be capable of introducing MOX. He spoke of Russia's experience with fast reactors with the BR-1, BR-2, BR-10, and BOR-60 experimental reactors as well as the BN-350 and BN-600 pilot industrial fast reactors. He directed people to his paper for more information on BN reactors.

Dr. Zrodnikov gave some significant points about the BN reactors: more than 5000 MOX fuel rods have been irradiated and post irradiation tests have shown high efficiency and safety; spent fuel reprocessed using pyrochemical technology and new fuel from vibrocompaction technology can significantly reduce Pu containing waste; fast reactor technology is ready for Pu utilization; the closed cycle is realized with the BOR-60; the advanced design of the BN-800, designed for using MOX, is available. Dr. Zrodnikov spoke of the BN-600 having the capacity to annually consume about 300 kg of Pu with a hybrid core and about 1.3 MT (metric tons) of Pu with a full core. He spoke about the BN-800 being able to consume 2.3 MT of Pu per year and stated that with an operating lifetime of 30 year it could utilize about 50 MT of weapons Pu.

Dr. Zrodnikov stated there were problems with the VVER reactors. He said there were seven in Russia, eleven in Ukraine, and two in Bulgaria. Given adequate financing, in 2003, three additional units will be commissioned in Russia and two additional in Ukraine. Of the seven in Russia only four will be capable of introducing MOX. Dr. Zrodnikov spoke of various technical issues surrounding the use of VVERs, but said that it may be possible for one unit to consume 250 kg to 280 kg annually. This could lead to the possibility of utilizing 50 MT of weapons Pu over the course of 25 to 30 years. He also said that is adequate funding would allow Russia to start testing three MOX fuel subassemblies before 2000.

Dr. Zrodnikov spoke about nonproliferation issues. He said that though both Pu and enriched uranium can be used for making weapons, they were very different as far as nonproliferation aspects. Dr. Zrodnikov stated that HEU can be diluted and converted to LEU (low enriched uranium) which cannot be used for weapons. To enrich the resulting LEU would be complicated and expensive. He said it is much easier to master Pu extraction as opposed to U enrichment technology. He spoke of various measures required for nonproliferation in terms of storage and management of Pu and in terms of transformation into spent fuel.

Dr. Zrodnikov spoke of the creation of a closed nuclear center concept in Russia. He said one would help solve nuclear power system problems, while being viable to ecology, economics, and health, and while adhering to the nonproliferation regime. He also spoke briefly about various cooperative effort Russia has had with different countries.

Dr. Zroknikov had the following three conclusions: Russia will be able to consume 50 MT of weapons Pu by 2020 using a combination of the BN-600, four VVER-1000, and the to-be-built BN-800 reactors; the closed nuclear centers are the best way to solve nonproliferation efforts; wide-scale international cooperation for weapons Pu utilization is welcome by Russia.

Panel Discussion and Chairman's Comments

Chairman: Dr. Atsuyuki Suzuki
Professor, University of Tokyo, Japan

Question 1: Collaboration on fast reactors by the U.S.

Dr. Suzuki stated that the three speakers stressed the importance of international cooperation and spoke of the role Japan can have. Japan and Russia presented the fast reactor as one area for cooperation. For the U.S., this is beyond its scope of vision domestically. Given this, Dr. Suzuki asked Mr. Taylor to talk about U.S. opinions on the possibility for collaboration on fast reactors.

Mr. Taylor replied that there is no R&D funding for fast reactors in the U.S. today and that meaningful cooperation requires funding. Mr. Taylor stated he did think that would always remain the case. Last year, the U.S. government was supplying no money for nuclear energy, and this year as result of a report submitted by the President's Committee of Advisors on Science and Technology, 30 million dollars has been provided for utilizing energy from excess nuclear weapons. This is in comparison with 500 million dollars for renewable sources. He said that present plans are to cut funding for coal development from 300 to 150 million dollars. He said he thought this state of affairs could not last because it defies realities. Continued major contributions could not be supplied by the LWR (light water reactor), but must be supplied by high conversion. Mr. Taylor said that the time will come when funding is had. He said that the U.S. has put in scope its needs and is doing a clean slate evaluation. He said there is a seed for cooperation between those doing good work and the U.S.. He said there is consistency with what was said yesterday about JNC's initial work in light of the whole picture today. He said there is a little seed to start breeder work. He stated he had no argument that Russia should use the fast reactor, though he did have problem with spending too much money or too much time.

Dr. Suzuki commented on Mr. Taylor's reply. Some argue that the U.S. policy is to urge other countries to follow course. Looking at course of discussion internationally, respective countries should define planning on their policy and should be equally respected. The approach presented by Mr. Taylor was right on the mark in his understanding.

Dr. Zrodnikov commented. Having said the fast reactor is an option, how it functions depends upon what course is taken. 50 MT (metric tons) is a temporary figure. The VVER-1000 will be up in 2007; it is a LWR, and among the existing 7 units only 4 will be operational, so the BN-600 has priority. And from 2010, the BN-800 reactors will be available. This is the best option for Russia.

Question 2: Using only four of seven VVER reactors

Mr. Taylor asked questions about the VVERs based upon Dr. Zrodnikov's comment. Why is it that only 4 units among 7 units will be capable? Why will they only be operational from 2007? And regarding the BN-800 reactors, what are the plans? Mr. Taylor said that the issue is moving the program ahead as fast as possible. The U.S. and Russians are putting it in form that will do this.

Dr. Zrodnikov replied that the reactors are an old type and many changes are required to adopt the reactors for MOX (mixed oxide) fuel consumption with acceptable safety conditions. He said they were made for a short lifetime and that was 20 or 30 years ago. The lifetimes have been exceeded which is why only 4 reactors will be ready to consume MOX.

Question 3: Futures visions

Dr. Suzuki directed the next question to Dr. Yamato. Russia, Germany, and France have a pilot plan to process MOX fuel and to construct a pilot MOX fabrication facility. A preliminary design is to put this in place. As for the VVER-1000, the assumption is that 7 units are to be used. As for the BN-800, there is still the question on whether it is an appropriate option or not, though for Russia, it is a strong option. The cost to construct a new reactor will require new investment in a new facility. There is a Japanese proposal to use the BN600 and buy back the fuel from Russia. There are possibilities for the future. Dr. Suzuki asked Dr. Yamato to give some future perspectives.

Dr. Yamato stated he would try and respond from a wider perspective. Regarding VVER or LWR usage, from a perspective of time, they should be used as soon as possible and process as much as possible. The usage of LWRs should actually be put into place. The U.S. will also have to bring forward their position on LWRs. The fast reactors, as Dr. Zrodnikov mentioned, such as the BN-600, can consume the largest amount. The BN-600 using MOX should also be put in place as soon as possible. For the BFS-2 criticality experiments and post irradiation examinations – they are currently in a preparatory stage. In the next stage, the fuel assembly will be placed in a fuel assembly line for a hybrid core. The Phase 1 activity, as Dr. Zrodnikov mentioned, will use 20 percent MOX in the hybrid core, which will amount to 40 to 50 fuel assemblies per year or 0.3 MT of Pu (plutonium) per year. With this the blanket must be replaced with a reflector; storage of the blanket must also be considered at the same time. At this point the BN-600 will be converted to full core MOX and consumption of 1.3 MT of weapons Pu will be achievable. With the extended BN-600 lifetime, what is said to be possible in 2010 would be possible in Phase 2. Dr. Yamato posed the question, "What will be program that Russia and Japan will put in place?" He stated that he believes that FBRs (fast breeder reactors), specifically technology development associated with FBRs, will actively affect such a program.

Mr. Taylor commented that the issues regarding full utilization of VVERs and BNs need to be rectified or funding not be forthcoming. He said that 200 million dollars cannot go into the pipeline because of this imbalance. He stated that Dr. Yamato was correct and he hoped Dr. Zrodnikov would follow course.

Dr. Zrodnikov commented. If the VVER type of reactor is used to dispose of weapons Pu, 1/3 will burn the weapons Pu, and the other 2/3 will produce civil Pu, so the total will increase. Thus, the BN reactor is the only fast reactor for burnig weapons Pu. And second, from a nonproliferation perspective, Russia reactors are located in different places thus reliable and safe transportation systems are crucial. The concept of a closed nuclear center to dispose of and manage weapons grade Pu will solve this problem. The BN type reactor can operate as burner or breeder by replacing the uranium blanket with a stainless steel blanket.

Question 4: LWR producing more Pu

Dr. Suzuki directed the next question to Mr. Taylor. LWRs will produce more Pu, how will this be handled?

Mr. Taylor replied that he was on a governmental panel for which an evaluation of almost every reactor type was conducted by the national laboratories. There is a wide variety on the amount of Pu that can be destroyed and produced. He stated that the important issue is to get it in a form in which it is like spent fuel; to bring it to the risk level of current spent fuel.

Dr. Suzuki replied that Mr. Taylor is absolutely right. But he commented that the spent fuel standard may be open to discussion as to a quantitative basis.

Question 5: JNC contribution to the U.S.

Dr. Uematsu from the floor directed the following question to Mr. Taylor. He stated that JNC may have to address disposition by LWR in its program as well. JNC is working out many programs with Russia. Is there anything JNC can contribute to the U.S.?

Mr. Taylor replied yes, the U.S. would like help from Japan. Japan has knowledge, experience, and outstanding capabilities. Japan can provide it. The U.S. would welcome Japan's help.

Dr. Suzuki commented that the financial contribution is what may be expected of Japan, but technological assistance has not been requested. He hoped this would be considered.

Question 6: Quantification on spent fuel standard and fate of Pu after irradiation

Dr. Ed Arthur posed the next question to the panel. He stated that Mr. Taylor spoke of the standard on spent fuel and that this is a standard on LWR spent fuel. He asked for quantification

on discharged fuel and he also asked about the fate of Pu containing fuel after irradiation.

Mr. Taylor replied that the spent fuel standard was devised by the National Academy Study. Excess Pu is amenable to diversion. The objective is to get to a point in which it is not any more amenable to diversion than what is discharged from a regular reactor. He stated that it is necessary to quantify this and that the Academy is trying to develop something more quantitative.

Dr. Zrodnikov stated that the spent fuel standard is a complicated issue and presented a what-if scenario. He said assume that one has a fresh assembly with weapons Pu MOX, irradiates it for 2 – 3 weeks, but because of failure, must remove it from core. What will be done with this assembly? He said this is a difficult question.

Mr. Taylor asked how hard is would be to steal and asked what would be done with it after putting it through a reactor. He said it would be stored in a spent fuel repository, maybe an interim storage facility. This issue was studied in the Academy Study and the evaluation indicated that this should not be the major factor. Is there a greater chance for criticality for thousands of years – judgement – no. It is not a problem, it goes into repository.

Dr. Zrodnikov commented that there is U.S./Russian cooperation and the Joint Committee. He stated that work is being carried out in four main directions and results show that spent fuel from a BN reactor is even better than from VVER reactors.

Dr. Yamato commented that the burnup in the BN-600 is higher than the VVER, but that the 11 atomic percent quoted for the BN-600 is in terms of peak value. He asked "What role will the BN-600 play in this issue?" He answered that it was necessary to operate this for a certain period of time. The BN-600 has a role to supply electricity. More information is needed but peak ratios in the spent fuel standard are quantitative. Fuel failure is not something that is assumed to take place often, but maybe these risks must be taken into account.

Question 7: New nuclear energy options in the U.S.

Dr. Suzuki directed this next question to Mr. Taylor. The U.S. is using existing reactors, but a new nuclear energy option includes the fast gas reactor. What is the reason for taking these new options?

Mr. Taylor answered that there are two issues here. The first deals with disposition of excess weapons Pu. The U.S. wants to do this as fast as possible using existing reactors. There is no more reprocessing. There are strict rules that this disposition program does not become a reprocessing program. The second issue deals with nuclear energy futures. This is an initiative

directed toward the future and recommendations are from the President's Committee. The initiative calls for getting new ideas and being innovative. The first addresses nonproliferation and is longer term. The second is directed toward U.S. energy needs in the future. The idea is to look at things anew and bring forth new ideas.

Question 8: The 20kg of Pu

Dr. Uematsu asked the next questions. He stated that Dr. Yamato mentioned in his presentation that the amount of ex-weapons Pu to be burned in the BN-600 is 20 kg. He asked if this was truly excess weapons Pu. He also stated that there has been some recent talk about redoing the FFTF (Fast Flux Test Facility) and asked about the purpose.

Dr. Zrodnikov replied that the 20kg is weapons grade or weapons quality Pu.

Mr. Taylor replied to the second question. He stated that FFTF was shutdown after operating perfectly for some years . He stated that he was involved in this program so it was particularly disappointing to him. However the decision was made to mothball FFTF and not dismantle it. Recently there has been discussion about restarting FFTF. One use would be radioisotope generation, while the other would be to make tritium.

Dr. Suzuki commented on the first question and said that 20 kg of weapons grade Pu utilized for the first time is very symbolic. In order to proceed with cooperation with Russia, one of challenges is transparency or disclosure of information. Roughly 50 MT is the only figure given. To proceed with a program in international cooperation, it would be appreciated if additional information and a clear picture on accountability could be provided. This would contribute to closer cooperation.

Dr. Zrodnikov stated that he will give a response.

Question 9: BN-600 demonstration experiment purpose

Mr. Salvatores directed this question to Dr. Yamato and Dr. Zrodnikov. He asked about the aim for the BN-600 demonstration experiment and stated that given certain assumptions, the 1.3 MT per year is rather theoretical than practical.

Dr. Zrodnikov replied that some confusion exists. Three subassemblies is plenty to be installed in a reactor. The experiment is to demonstrate that the BN-600 has the capability to consume this weapons plutonium. There is no experience with the VVER and mixed oxide. So there are plans with the VVER with the aim to demonstrate the possibility of using MOX in VVER reactors. By now, more than 5000 MOX fuel rods have been irradiated, but not one rod has been irradiated in VVER reactors.

Dr. Yamato replied that the BN-600 full MOX core requires reconfiguration of the reactor and this will also be required for the hybrid core. The BN-600 is characterized by fast reactor capabilities. Replacing fuel with MOX is not enough, a study must be conducted on how to use blankets and reflectors. As Dr. Zrodnikov said, a safety evaluation is needed as well as assurance. Dr. Yamato stated that it will be necessary to analyze the criticality of the experiment as well as the fuel. The BN-600 experiment will need to be well directed.

Dr. Suzuki asked that the French experience be utilized.

Chairman Summary

Dr. Suzuki spoke of the panel discussing the disposition of excess weapons plutonium using fast reactors. He stated weapons disposition is limited in scope, but the option of using the FBR made the position of the FBR much clearer. He said that there are 50 MT in Russia and 50 MT in U.S. of excess weapons Pu, and there is a lot more Pu that should be regarded as excess. The fast reactor is favorable in Russia. For the U.S. other options have to be taken into consideration in reactors or in LWRs. Dr. Suzuki stated that the disposition of excess weapons Pu should be conducted as soon as possible without any extra work. There is a great deal of potential here and new technologies can be developed, and this is a shared opinion amongst the panelists. In Russia, fast technology can be reevaluated for disposition, and as Mr. Taylor said its useful to go back to the drawing board. Dr. Fujiie stated that peaceful use can also be applicable to nuclear disarmament. And, even though the amount of disposition for the experiment will be 20kg, this act between Russia and Japan will be of great significance.