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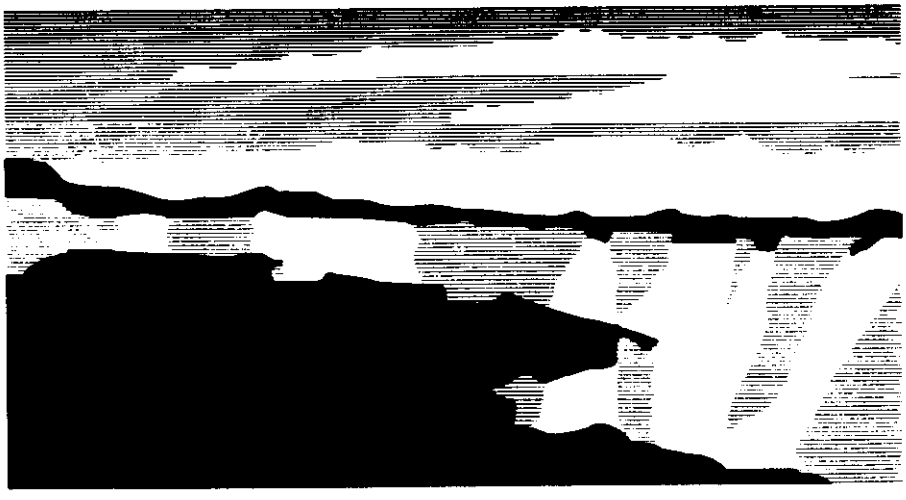

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SUMMARY OF SAFEGUARDS INTERACTIONS BETWEEN LOS ALAMOS AND CHINESE SCIENTISTS

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EXECUTIVE SUMMARY

Los Alamos, under the direction of DOE/NN-40, has been collaborating since 1984 with scientists from the Chinese Institute of Atomic Energy (CIAE) to develop nuclear measurement instrumentation and safeguards systems technologies that will help China support implementation of the nonproliferation treaty (NPT). To date, four Chinese scientists have visited Los Alamos, for periods of six months to two years, where they have studied nondestructive assay instrumentation and learned about safeguards systems and inspection techniques that are used by International Atomic Energy Agency (IAEA) inspectors. Part of this collaboration involves invitations from the CIAE to US personnel to visit China and interact with a larger number of Institute staff and to provide a series of presentations on safeguards to a wider audience. Typically, CIAE scientists, Beijing Institute of Nuclear Engineering (BINE) staff, and officials from the Government Safeguards Office attend the lectures. The BINE has an important role in developing the civilian nuclear power fuel cycle. BINE is designing a reprocessing plant for spent nuclear fuel from Chinese nuclear power reactors.

China signed the nonproliferation treaty in 1992 and is significantly expanding its safeguards expertise and activities. The Chinese are very interested in increased interactions on safeguards with the US and the outside world as they prepare to meet their NPT obligations. Chinese interest in interactions with the US are currently focused on the practical aspects of developing and implementing nondestructive assay (NDA) instrumentation and safeguards systems that will allow China to comply with IAEA inspections.

The CIAE safeguards section is responsible for China's compliance with the NPT and is advising Chinese government officials on topics related to safeguards. China has offered the CIAE and the two Chinese power plants for IAEA inspections. Professor Zhu Rongbao, head of the CIAE safeguards section, has been assigned to the Chinese Mission in Vienna for three years as a technical attaché where he serves as a liaison on China's interactions with the IAEA.

I. DOE SUPPORT FOR US AND CHINESE INTERACTIONS ON SAFEGUARDS

Interactions to foster improved relations between the United States and China were begun in 1984. The Department of Energy (DOE)/NN-40 has supported activities that enable

1. Participation of Chinese officials and scientists in the DOE State Systems of Accounting and Control (SSAC) course. This course is funded by DOE/NN-40 and taught every two years. The Department of State provides half the airfare and full per diem for the Chinese during their participation in this course;

2. Visits (1 to 2 weeks) by US safeguards personnel to China. Lectures and discussions on nuclear materials control and accountability (MC&A), NDA safeguards instrumentation, and IAEA safeguards have been provided by US personnel during these visits;

3. Extended visits (1 to 2 years) by Chinese safeguards scientists to DOE laboratories. The majority of extended visits have been at Los Alamos in the safeguards assay (NIS-5) and the safeguards systems (NIS-7) groups in the Nonproliferation and International Security Division. Professor Zhu, the first Chinese visitor on safeguards to the US, spent time at both Brookhaven National Laboratory and Los Alamos. DOE/NN-40 provides funds for

housing and per diem for visiting Chinese scientists and also pays for their participation in appropriate technical events such as annual meetings of the Institute of Nuclear Materials Management (INMM) and the SSAC course as deemed appropriate by the sponsor.

II. CHINESE SAFEGUARDS

In the early 1980s, Prof. Sun Zuxun, director of the CIAE, decided that safeguards was becoming an important technical area for China. He encouraged Professor Zhu and his group at CIAE to develop safeguards expertise and he provided institutional support for this activity.

Chinese interactions on safeguards were initiated with the US through participation in the SSAC training course and by exchange visits between scientists and safeguards officials in both countries. Chinese scientists, after returning from extended technical visits on safeguards at US national laboratories, are forming the foundation of a safeguards program at CIAE for China. These scientists are the dominant safeguards experts in the entire country.

In 1991 the CIAE established a safeguards group headed by Prof. Zhu following his return from an extended (18 months) assignment in the US where he studied safeguards technology. China signed the NPT in 1992. The CIAE safeguards group has been expanded to a section, is responsible for China's compliance with the NPT, and is advising Chinese government officials on safeguards topics.

The CIAE safeguards section is also responsible for developing the nuclear material accountability plans for their two nuclear power plants (the Qinshan plant near Hanzhou and the Daya-Bay nuclear power plant) and for development of safeguards instrumentation and an MC&A system for a 50 MT/yr reprocessing plant under construction.

China has offered the CIAE and the two power plants for IAEA inspections. Prof. Zhu has been assigned to the Chinese Mission in Vienna on a three-year assignment as a technical attaché. Prof. Zhu serves as a liaison on China's interactions with the IAEA.

III. IMPACTS OF US-CHINA SAFEGUARDS INTERACTIONS

Los Alamos, under the direction of DOE/NN-40, is working with CIAE scientists to develop NDA instrumentation technology and provide safeguards systems studies that will help China support implementation of the NPT. Chinese scientists have visited the US for periods of six months to two years to study and collaborate on NDA and systems techniques that are used by IAEA inspectors. Part of this collaboration involves CIAE invitations to US personnel to visit China, interact with a larger number of Institute staff, and to provide a series of presentations on safeguards to a wider audience. Typically, CIAE scientists, BINE staff, and officials from the Government Safeguards Office attend the lectures. The BINE has an important role in developing the civilian nuclear power fuel cycle. BINE is designing a reprocessing plant to reprocess spent nuclear fuel from the two Chinese nuclear power reactors.

Dr. Hakkila, Los Alamos safeguards systems scientist, on his first visit to China, provided lectures and participated in discussions on the requirements of a State System for Accounting and Control to place the Qinshan nuclear power station under IAEA safeguards. Since then, a number of Los Alamos staff lecturing in China have updated and expanded this information.

Visits by US safeguards personnel and the extended technical assignments of Chinese scientists to study safeguards at US national laboratories have had a significant impact on technical directions of the CIAE safeguards program. Currently, the Chinese have expressed interest in increased interactions with the US on safeguards developments. Safeguards methods, systems

analysis, and NDA instrumentation that the Chinese are developing are based on the training they received while in the US. Examples of NDA instruments being developed by the Chinese include

1. **Neutron Coincidence Counter**, which can be used to measure plutonium metals and oxides;

2. **Active Neutron Coincidence Collar**, which is used to measure fresh light-water reactor (LWR) and mixed oxide (MOX) fuel subassemblies;

3. **Segmented Gamma Scanner**, which is used to measure plutonium and uranium;

4. **Delayed Neutron Shuffler**, which is used to provide active neutron measurements to assay uranium; and

5. **Hybrid Densitometer**, which is used to accurately assay combined solutions of plutonium and uranium.

With the signing of the NPT, China is rapidly expanding its activities. The CIAE safeguards budget has seen a significant increase (~3-fold) in the last several years and the staff has more than doubled. The Chinese are very interested in increased interactions on safeguards with the US and the outside world as they prepare to meet the NPT obligations. Chinese interest in interactions with the US are currently focused on the practical aspects of development and implementation of NDA instrumentation and safeguards systems that will permit them to comply with IAEA inspections.

IV. POSSIBLE FUTURE SAFEGUARDS INTERACTIONS

Discussions with Chinese safeguards personnel indicate they are interested in continuing interactions with the US and would welcome closer collaborations on the development of instrumentation and systems for safeguards. Potential areas that could be explored for future interactions consist of the following:

1. Safeguards instruments and systems for Chinese power reactors,

2. Safeguards instruments and systems for Chinese research reactors, and

3. Safeguards at bulk processing facilities such as reprocessing plants.

A. Power and Research Reactors

China is currently providing research reactors to other countries such as Pakistan and Iran. Reactor safeguards collaborations could involve the development of fresh and spent fuel measurement systems, power reactor monitors and radiation surveillance systems that can be applied to research, LWR, and MOX reactors.

B. Chinese Commercial Reprocessing

In 1990 the Chinese announced that they will build a 50 MT/yr reprocessing plant in Gansu province. China is planning on commercial reprocessing for the international market as well as for their Chinese reactors. They plan to build a larger reprocessing plant early in the 21st century.

CIAE is responsible for safeguards systems and hardware design for the prototype reprocessing plant and presumably for the larger plant in the future. Reprocessing plant collaborations could be suggested on MC&A systems, variance propagation methods to provide near real time accountability of nuclear materials, and NDA instrumentation for safeguards measurements at key points in the reprocessing facility. Continued interactions between CIAE safeguards scientists in the areas of design, development, and implementation of safeguards systems could be effective in helping the Chinese meet IAEA safeguards requirements of the reprocessing facility.

APPENDIX

TABLE I: Extended Chinese Assignments to Los Alamos for Safeguards Interactions			
Chinese Scientist	**Technical Interest**	**Dates of Visit**	**Topics of Visit**
Prof. Zhu Rongbao	Nuclear Physics	3/88 to 9/88	Safeguards R&D Spent Fuel Measurements HLNC Data Evaluation Hybrid K-edge Development
Prof. Qiao Shengzheng	Applied Physics	5/89 to 6/91	Fresh Reactor Fuel Assay Delayed Neutron Shuffler Waste Measurements
Mr. Jiang Jincai	Applied Physics	5/91 to 4/92	Safeguards Systems Studies
Mr. Yang Liucheng	Applied Physics	1/93 to 7/94	Gamma-ray Spectroscopy Neutron Coincidence Assay

TABLE II: Los Alamos Staff Visits to China for Safeguards Interactions			
Los Alamos Scientist	**China Destination**	**Dates of Visit**	**Topics of Visit**
A. Hakkila	China Institute of Atomic Energy (CIAE)		Conference and lectures on safeguards
H. O. Menlove	CIAE	10/22/89 to 11/25/89	IAEA Expert to China Safeguards Training Course
S. T. Hsue	CIAE	5/31/92 to 6/14/92	Lectures on safeguards and NDA instrumentation physics
T. K Li	CIAE	9/7/87 to 9/16/87	Conference and lectures on safeguards
R. A. Augustson	CIAE	11/91	Lectures on Safeguards NDA instrumentation
A. Hakkila	CIAE		Program Development
G. W. Eccleston	CIAE	6/4/94 to 6/18/94	Program Development

TABLE III: Chronology of Visits and Highlights of Activities between Los Alamos and Chinese Scientists	
Sept. 1984	G. R. Keepin visited China as a member of an INMM delegation. Chinese expressed interest in participating in a DOE-SSAC training course.
June 1985	H. Zhuang and Jiang Jincai were the first PRC attendees at the SSAC course held in Santa Fe, NM, and San Clement, CA.
Sept. 1986	As a result of SSAC attendance, Arnie Hakkila presented an invited lecture on destructive analysis for safeguards at the International Conference on Nuclear Radiochemistry in Bejing, China.
Fall 1987	Prof. Sun Zuxun, President of the Institute of Atomic Energy, visits Los Alamos. As part of the visit, Prof. Sun discussed technical exchanges on safeguards between Los Alamos and CIAE. (In 1983, Prof. Sun had previously spent a year in Los Alamos as a visiting scientist at Los Alamos Meson Physics Facility.)
April 1987	Prof. Zhu Rongbao, Z. Q. Luo, and W. Want attend the DOE SSAC course in Santa Fe, Los Alamos, and Richland, WA.
Sept. 1987	Dr. T. K. Li and Mr. W. Kirk from Los Alamos participated in the 6th Pacific Basin Conference on Nuclear Energy in Beijing, China. During the visit Dr. Li presented lectures on safeguards NDA to CIAE scientists. He also visited the Chinese Academy of Sciences in Beijing to discuss application of nuclear detection techniques.
Sept. 1987 to March 1988	Prof. Zhu spent 18 months in the US, first visiting Brookhaven and then Los Alamos. At LANL, Zhu concentrated on NDA physics for safeguards. Prof. Zhu established an NDA safeguards group on his return to the CIAE.
May 1989	Mr. L. Yang and Mr. D. Yang participated in the DOE SSAC course in Santa Fe, Los Alamos, and Richland, WA.
May 1989 to June 1991	Prof. Qiao visited Los Alamos for two years to learn safeguards NDA technology. He became the deputy group leader for safeguards NDA when he returned to the CIAE.
Nov. 1989 to Dec. 1989	Dr. Howard Menlove, Los Alamos Fellow, visited CIAE for six weeks as an IAEA Fellow to provide lectures and to assist the Chinese in safeguards NDA instrumentation development.
Nov. 1990	Dr. Hakkila lectured on safeguards systems design and safeguards for reprocessing plants. He visited Qinshan nuclear power plant and discussed the implications of IAEA safeguards on the power station.
May 1991	Mr. Jiang Zhu, Q. Liu, and H. Wang participate in the DOE SSAC course in Santa Fe, Los Alamos, and Richland, WA.
Nov. 1991	Dr. R. Augustson visited China as an invited lecturer on the design and application of NDA instrumentation to safeguards.
May 1991 to Jan. 1992	Mr. Jiang Jincai visited Los Alamos to learn safeguards systems design methodology. The Los Alamos MAWST code for statistical evaluation of safeguards data was provided to the CIAE as part of this visit. Mr. Jiang returned to the US in 1992 as a student at Texas A&M working toward a Ph. D. in nuclear engineering.
May 1992	Dr. Hsue from Los Alamos attended the Pacific Basin Conference on Nuclear Energy in Beijing China. Following the conference he visited the CIAE and presented lecturers on safeguards and NDA instrumentation.
Jan. 1993 to Present	Mr. Yang was the 4th Chinese scientist at Los Alamos studying NDA methods for safeguards applications.
June 1994	Dr. Eccleston will visit CIAE with John Rooney, DOE/NN-40, to provide a series of lectures on safeguards and NDA instrumentation.