APPROACHES TO STRENGTHEN CHINA'S NUCLEAR SECURITY

Hui Zhang*

Project on Managing the Atom
Kennedy School of Government
Harvard University
79 John F. Kennedy Street
Cambridge, MA 02138

ABSTRACT

Establishing modern, well-designed nuclear material protection, control, and accounting (MPC&A) systems to secure nuclear material in China is very important to prevent against nuclear terrorism. At the 2010 Nuclear Security Summit in Washington, DC, Chinese President Hu Jintao made clearly commitments to strengthening nuclear security. This paper will assess China's material protection, control, and accounting approaches, analyze existing regulations and administrative systems, and propose ways of strengthening them.

Weapon-Usable Fissile Materials and Nuclear Facilities in China

Military nuclear stockpile. Since the 1960s, China has established a complete military nuclear fuel cycle for plutonium and HEU production. All its previous military production facilities have been closed, converted, or are being decommissioned.[1]

China has produced HEU for weapons at two facilities: Lanzhou gaseous diffusion plant (GDP), which began operating in January 1964; and Heping GDP, a "Third Line" facility that began operating in1975. The Lanzhou and Heping GDPs stopped production of HEU in 1979 and 1987, respectively. It is estimated that China's military inventory of weapon-grade HEU would be about 16±4 tons of HEU for weapons.

China has produced plutonium for weapons at two nuclear complexes: The first is the Jiuquan Atomic Energy Complex. This site includes China's first plutonium reactor, which began operation in 1966, and the associated reprocessing facilities. The second is the Guangyuan plutonium production complex. The reactor began operation in 1973. Both the Jiuquan and Guangyuan reactors stopped plutonium production in 1984 and 1989 respectively. It is estimated that China's current inventory of weapon-grade plutonium would be 1.8±0.5 tons available for weapons.

---

* The author thanks the Carnegie Corporation of New York and the John D. and Catherine T.MacArthur Foundation for financial support of this work.

Approximately less than half of China's military stocks of fissile materials could be contained in its nuclear warheads. The others could be located at a small number of sites including the Jiuquan and Guangyuan plutonium production complexes which conduct HEU and plutonium processing, warhead component production and weapon assembly, China Academy of Engineering Physics which conducts research, development and design of nuclear weapons, and storage facilities of fissile materials. Chinese non-weapon uses of HEU and plutonium are very limited. Its nuclear-power submarines are fueled with LEU.

Based on a new estimate, China has a total inventory of approximately 170 nuclear warheads including approximately 110 operationally deployed nuclear missiles, and approximately 60 warheads stored for its submarine-launched ballistic missiles (SLBMs), and bombers.[2] It is reported China has a highly centralized storage and handling system of warheads managed by 22 Base under the Second Artillery Corps.[3] Most of Chinese warheads are storage at the 22 Base and a very limited number of warheads are storage at six missile bases. The central storage complex of warheads is nestled deep in secure Taibai Mountain, which could be one of the most secure warhead stockpiles in the world.[4] The 22 Base's physical protection system could use not only "guns, gates, and guards," but also the advanced physical protection system including real time video monitoring, infrared secure system, a computerized warheads accounting system, temperature and humidity controls, fingerprinting and other control, advanced communication.[5]

Civil use of weapon-usable nuclear materials. Civil use of HEU in China is very limited. China's Experimental Fast Reactor (CEFR), which reached criticality in July 2010, has a first loading of almost 240 kg of HEU (64.4% U-235), provided by Russia. The CEFR will use MOX in later loadings, as will China's planned future fast reactors. China has a few HEU-fueled research reactors.[6] Since 2007, several of them have been shut down or converted to LEU. Now the major operational facilities include two Miniature Neutron Source Reactors (MNSR) (approximately 1 kg of 90%U-235), one Zero-Power Fast Critical Reactor (90% U-235, 0.05 kWt), and one PPR Pulsing Reactor (20% U-235, 1MWt). China has decided to shut down its MNSR and build the new ones using LEU. China's use of HEU for research reactors in the future would be insignificant. China stopped HEU production in 1987. China currently operates two centrifuge enrichment plants at Hanzhong and Lanzhou, which produce LEU for civilian use.

China has operated a pilot civilian reprocessing plant at Jiuquan nuclear complex since 2010. This plant has a production capacity of 50-100 tHM/a. After starting up the operation of its pilot reprocessing plant on December 21, 2010, in its annual INFCIRC/549 report of civilian plutonium holdings for 31 December 2010, China declared a stock of 13.8 kg of separated plutonium "in product stores at reprocessing plants."[7] Once the pilot reprocessing plant is fully operational, it will separate 0.5-1 ton of plutonium per year. In recent years, the China National Nuclear Corporation (CNNC) has been negotiating with France's Areva on building a commercial reprocessing plant (800 tHM/a). Recently the CNNC has discussed plans to build a medium-scale commercial reprocessing plant (200 tHM/a) by 2020 and a larger one (800 tHM/a) between 2025 and 2030.[8]

A pilot MOX fuel fabrication plant (with a capacity of 0.5 ton/a) is now under construction near the pilot reprocessing plant. The plutonium for the MOX fuel will come from the pilot reprocessing plant. Moreover, the CNNC signed an agreement in 2009 with Russia with an intention to purchase two Russian 800 MWe BN-800 fast breeder reactors. The CNNC also plans to build a series of commercial FBR by 2032.[9]

By 2011, China had 15 electricity-generating reactors in operation with an aggregate installed capacity of about 12 GWe. In addition, 27 reactors capable of producing a total of 29 GWe are under construction. China officially plans to increase its total nuclear capacity to 40 GWe, as well as have additional reactors with a total capacity of 18 GWe under construction by 2020. The nuclear industry expects up to a 70 GWe capacity by 2020.

Practice of China's Nuclear Material Protection, Control and Accounting

Since it became an IAEA member in 1984, China has established material control and accounting (MC&A) systems in accordance with IAEA safeguard guidelines (INFCIRC/153) and physical protection system based on INFCIRC/225 recommendations. China has signed a number of international agreements related to nuclear safeguards and security. In 1988, China signed an agreement (INFCIRC/369) with the IAEA to voluntary place some of its facilities under IAEA safeguards. China joined the NPT in 1992 and signed the Additional Protocol with the IAEA in 1998 , which entered into force in 2002. In 1998, China signed the Guidelines for the Management of Plutonium, which establishes requirements for the management and disposition of civil plutonium and other plutonium no longer necessary for defense. In 1989, China acceded to the 1980 Convention on the Physical Protection of Nuclear Material. In October 2008, China ratified the 2005 Amendment to the Convention on the Physical Protection of Nuclear Material. In August 2010, the country ratified the International Convention for the Suppression of Acts of Nuclear Terrorism. China has implemented its obligations under relevant UNSC resolutions, including Resolution 1540 and Resolution 1887.

Since September 11, China has significantly improved its MPC&A system, with a focus switching from the traditional "guns, gates, guards" approach to an effective mixed approach, combining personnel with modern techniques. Based on a new report about the progress China has made on improving nuclear security since the Washington Nuclear Security Summit, China has made significant progress in enhancing national nuclear security capabilities including the improvement of relevant regulations and standards, and upgrades of the level of nuclear security management.[10]

Legal and regulatory system. In 1987 China approved and issued the "Regulations for Control of Nuclear Materials of the People's Republic of China" (1987 "Regulations").[11] In order to facilitate the implementation of the "Regulations", in 1990 China approved and issued the "Rules for Implementation of the Regulations on Nuclear Materials Control of the People's Republic of China"(1990 "Rules"). [12]The National Office of the Nuclear Materials Control (ONC) under the China Atomic Energy Authority (CAEA) is in effect responsible for nuclear material control.

The ONC has adopted a licensing system for the control of nuclear material. As required, the operator of the nuclear material facilities must apply a "nuclear material license," if the facility holds more than 10 effective grams of U-235 or any quantity of plutonium. To get the license, the operator must establish MPC&A systems met with the regulation guidelines provided by

CAEA. After the ONC accepts the license application, it offers reviewer comments and the license is issued after being reviewed.

Based on the 1987 Regulations, Rules on Inspection of Nuclear Materials Control was issued in 1997. The ONC is responsible to organize professional experts to inspect nuclear facilities to ensure that effective security and accounting measures for weapons usable materials are in place. Inspection activities include verifying the integrity of accounting records, the physical inventory change, measurement and quality control systems, material balance, and effectiveness and reliability of physical protection measures. If a facility is found in violation of these regulations, it would be punished by warning, penalty, or revoking the license-- depending on the seriousness of the violation.

However, the CIAE nuclear experts noted in 2007 that the regulatory basis for conducting domestic inspections in China was not as mature as that in the United States.[13] For example, the related Regulations and Rules do not specifically address federal responsibilities for conducting routine inspections of licensee operations. Thus, the legal basis for conducting civil nuclear MPC&A inspections in China needs to be strengthened.

All those related regulations and rules were issued at least a decade ago and while the government states that they have been improved and updated, the new regulations and rules have not been issued yet.

Nuclear Material Control and Accounting. Based on the 1990 Rules, the licensee is required to establish a facility-level MC&A system with separate material balance areas in accordance with their respective feature. Each balance area shall have a complete accounting system and perform the independent material balance. The calculated MUF should be two times less than its standard error. China has made improvements in its MC&A approach over the last decade by using modern technologies.[14]

The licensee must also establish nuclear material physical inventory procedures with requirements including conducting a complete and strict physical inventory at least once a year and conducting physical inventory for such material as Pu-239, U-233 and HEU at least twice a year. The licensee is also required to establish a record and reporting system, which requires that the record of nuclear material accounting must be clear, accurate, systematic, and complete, and must be maintained at least for five years.

Physical Protection Measures. China's management of nuclear security and physical protection is mainly based on the 1990 "Rules" and the IAEA related recommendations (INFCIRC/225 Rev.4). The facility operators are required to establish a facility level organization in charge of the security of facilities and nuclear materials.

Similar to the IAEA recommendations on physical protection of nuclear materials, China divides its protection requirements for nuclear material into three categories, based on type, quantity, and harmfulness of the nuclear material. For example, the physical protection measures for category I nuclear materials facilities should include i) at least two complete, reliable physical barriers; vault or special security container for storing nuclear material; ii) the technical protection system with alarm and monitoring installations; iii) 24-hour armed forces; iv) special pass for all people entering the site; strict control of non-site personnel to access, including the registrationprocedure, and full time escort by the site-personnel after access; v) "double men and double lock" system.

In 2008, the China National Nuclear Safety Administration (NNSA) issued the Nuclear Facility Physical Protection Guidelines, which should be applied to all Chinese civilian nuclear facilities.[15] These provide that when facility operators design the physical protection system, they are required to follow the Guidelines or must prove their own approaches have at least the same security level as those required by the Guidelines. The designed security system is subject to the competent authority for approval. These new guidelines are mainly based on principles such as design basis threat (DBT) ; protections for category I, II and III nuclear materials and facilities; the graded protection measures, according to the relative attractiveness, the nature of nuclear materials and facilities, and potential consequences; a complete, reliable and effective system with an effective coordination among the three elements of the PPS and an effective integration of protection through personnel and through techniques; and the concept of defense in depth and detection balance. All Chinese civilian nuclear facilities, either old or new, should meet the 2008 Guidelines requirements. Many old facilities have been upgrading their security systems. Some nuclear power plants extensively use modern security equipments, such as microwave detectors, Doppler-infrared detectors, and tensile detectors. [16]

Since the late 1990s, China has developed and applied the modern Physical Protection System (PPS) in its nuclear facilities, which include three elements—*detection, delay and response*. The country has widely applied technical measures for the *detection* function, including perimeter detection, access control, video camera assessment, and personnel identification.[17] Meanwhile, a number of technical measures have been applied to the *delay* function at the materials storage area, including, for instance, fences, hardened doors, meshed windows, locks, fixed devices, and balance magnetic switches. China also has increased its emergency response capabilities. The facility operator is required to have an emergency plan to respond to unauthorized removal of nuclear materials or sabotage of nuclear facilities, and to conduct the annual exercise. The response forces consist of armed forces and security guards.

Since the 9/11 attacks, China has made some substantial changes in its nuclear security approaches that have become much more stringent. But some improvements are still needed. For example, as the 2008 “Guidelines” requested, nuclear facilities should be protect against DBT including both outsider and insider adversaries. However, the 2008 Guidelines do not provide specific and clear standards for the DBT requirements. As Li Ganjie, the director of the NNSA, noted: the existing DBT could be unable to resist attacks larger scale and well-organized terrorist attacks or powerful weapons. He suggested the international community should set up an international and unified standard of the DBT for nuclear power plants. [18]

Before 1998 the concept of vulnerability analysis of physical protection did not receive attention and there was no evaluation and theoretical analysis about physical protection systems. [19] But, now Chinese facilities are required to conduct in-depth vulnerability assessments and performance tests to monitor each site’s ability to protect itself against the threat it is designed for. China uses technical approaches to strengthen the reliability of the security system including the performance test of detection and assessment and using reliable and compensatory techniques.[20] However, China does not conduct realistic "force-on-force" exercises to test the performance of its nuclear security systems.

China has enhanced its nuclear security capabilities through international cooperation. In 2006, the CAEA and the IAEA established a "CAEA-IAEA Joint Training Center on Nuclear Safeguards and Security" with an aim to strengthen the training capability on nuclear safeguard and security. In January 2011, China and the US signed the Memorandum of Understanding for Cooperation in Establishing a Center of Excellence on Nuclear Security. In November 2011, China established the National Nuclear Security Technology Center, which is responsible for the construction, management and operation of the CoE. The center will serve as a forum for exchanging technical information, sharing best practice, developing training courses, promoting technical collaborations to enhance nuclear security in China and through Asia.

Improving China's MPC& A System

Chinese president Hu Jintao emphasized at the 2012 Nuclear Security Summit that, " In the future, China will further take nuclear security measures, make sure the security of its own nuclear materials and facilities, improve the overall nuclear security."[21]

While China has significantly improved its MPC&A system over the last ten years, it keeps the MPC&A system in the military sector very sensitive and secret. However, it is believed that the system is much more secure than that of the civilian sector because those materials and facilities are the "most valuable stuff" in China. It is reported that they have been "accident-free" for the past 50 years.

China should take further steps to install a complete, reliable, and effective MPC&A system to ensure that all its stockpiles of HEU and plutonium, nuclear weapons and nuclear facilities are secured and accounted for, with adequate standards to defeat the threats it is likely to face. The following measures, for instance, should be taken to improve China's existing MPC&A system.

Updating and clarifying its rules and guidelines for design base threat. While the new 2008 Guidelines require DBT, it has no clear standards. Moreover, it could be unable to resist extreme adversary scenarios such as 9/11-type attacks. It should review and upgrade its basis used for designing physical protection for facilities and transporters with nuclear weapons, HEU and plutonium to ensure that it reflects the threat as perceived after 9/11 attacks. The DBT should include the full spectrum of plausible adversaries and tactics. The minimum DBT standard should include protection against *a* modest group of well-armed and well-trained outsiders; a well-placed insider; and both outsiders and an insider working together, using a broad range of possible tactics.[22]

China should update its old 1987 Regulations and 1990 Rules and issue the new strict and clear Regulations and Rules based on least the minimum DBT standard. Meanwhile, it needs a strong system of enforcement to ensure the new Regulations and Rules to be effectively implemented in practice.

Consolidating weapons-usable fissile materials. Besides China's CEFR --which is using HUE (64.4% U-235) but will begin to use MOX in the next few years, China only has a few HEU-fueled research reactors, which have been converting or shutting down. China should speed up converting its own reactors and help to convert those exported MNSRs. China should take a lead to reach an international agreement for a phase-out and ultimate ban on the civil use of HEU.

China should constrain its commercial reprocessing plans. Taking into account the costs, energy security, proliferation risks, health and environmental risks, and spent fuel managements issues, it can be concluded that China does not have a convincing rationale for pursuing plutonium recycling in the foreseeable future.[23] China should postpone its decision to build a commercial reprocessing plant.

China should review every location, both in thecivilian and military sectors, where HEU or separated plutonium (or nuclear weapons), and consider to minimize the number of those locations and ensure to secure those locations.

Realistic testing of nuclear security performance. While Chinese facilities are now required to do in-depth vulnerability assessments and performance tests of their security systems, they do not include the realistic "force-on-force" exercises. As the new issued INFCIRC/225/Revision 5 recommends,[24] China should use realistic "force-on-force" exercises to test the performance of its nuclear security systems' ability to defeat either insiders or outsiders.

Promoting nuclear security culture. To ensure that modern MPC&A systems are actually implemented effectively, a strong security culture is imperative. President Hu Jintao emphasized the importance of "promoting nuclear security culture" at the 2010 Nuclear Security Summit.

However, many Chinese professionals in the nuclear field doubt that the terrorism threat is realistic in China. They argue it will be too difficult to get the needed fissile materials or a nuclear weapon due to its strict security system.[25] Some nuclear experts view that the most realistic threat of nuclear terrorism is from the dispersion device of radioactive material.[26] Some managers and employees at Chinese nuclear plants do not appreciate the need for the advanced and stringent MPC&A systems.[27]

In fact, the possible theft of fissile material by an insider cannot be ruled out, in particular, as China increasingly becomes a market-oriented society and increasingly corrupt. Outside terrorist attacks may someday pose another threat to China's nuclear facilities. For example, the terrorist forces of the so-called "East Turkestan", which have close links with international terrorism, have long been recipients of training, financial assistance and support from international terrorist groups. [28] In practice**,** a terrorist attack elsewhere would also doom China's ambitious plan of nuclear power development. In the wake of the Fukushima nuclear accident, the China government quickly responded that China would suspend approval of all new nuclear power stations. A security Chernobyl would definitely damage the development of China's nuclear power.

China should have regular training programs performed, not only to improve the worker's professional skills, but also to make workers understand that security and accounting for nuclear materials is a matter of the highest national security priority. Moreover, it is necessary to have a program to ensure the reliability of the personnel who will be operating the system, including security screening.

Strengthening cooperation. Since the 9/11 attacks, China has greatly improved its MPC&A system, which has benefited significantly from CAEA cooperation, in particularly with US DOE and IAEA. While the current cooperation focuses mainly on Chinese civilian sector, it can be expected that the best practice of the modern MPC&A approaches learned from the cooperation should be applied to those fissile materials and facilities in the military sector. Given that the CAEA is responsible to control nationwide fissile materials, including military and civilian stockpiles, it should be easier for CAEA to apply those MPC&A approaches and best practice learned from the cooperation to its military sector. Thus, it is imperative to continue and strengthen CAEA cooperation with the DOE and IAEA.

For example, CAEA and DOE should collaborate on applying the modern MPC&A system and best practice to China's pilot reprocessing plant and the on-building pilot MOX facility. Given the fact that the risk of insider theft at these bulk processing facilities is higher, these facilities should be required to have effective security systems to control and account for all their materials. Moreover, China can apply those MPC&A approaches to its military stockpiles. Another area for CAEA and DOE cooperation should be to help China to adopt the practice of "force-on-Force" exercise. Chinese experts can be invited to witness such exercises at US sites, as it has done with other countries, including France and Japan.

China and US collaboration should be extended from the civilian sector to the military sector. It is time to resume the China-U.S. Lab-to-Lab program on MPC&A. The US and China conducted a Lab-to-Lab Collaborative Program from 1995 to 1998,which was designed to help create a "safeguards culture" in China by demonstrating the advantages of a modern MPC&A system. However, the program ceased in the aftermath of the 1999 Cox Committee Report and allegations of Chinese espionage at U.S. nuclear weapons laboratories. Since September 11, the cooperation between the US and China on fighting against terrorism should provide an opportunity to restart the lab-to-lab program on MPC&A, which would be significantly benefit to China's nuclear materials and facilities in the military sector.

NOTES AND REFERENCES

[1] Hui Zhang, "China's HEU and Plutonium Production and Stocks," *Science & Global Security* (19) 1: 68-89, 2010. Available at: http://belfercenter.ksg.harvard.edu/files/huizhangSGS2011.pdf.

[2] Hui Zhang, "Nuclear Modernization in China," in *Assuring destruction forever: nuclear weapon modernization around the world,* edited by Ray Acheson, published by Reaching Critical Will, a project of the Women's International League for Peace and Freedom, March 2012, http://reachingcriticalwill.org/images/documents/Publications/modernization/assuring-destruction-forever.

[3] Mark Stokes, "China's Nuclear Warhead Storage and Handling System," Report of Project 2049 Institute, March 12. 2010. Available at: http://project2049.net/documents/chinas_nuclear_warhead_storage_and_handling_system.pdf.

[4] *Ibid.*
[5] *Ibid.*
[6] NTI, "Civilian HEU: China," available at: http://www.nti.org/analysis/articles/civilian-heu-china/
[7] *Communication received from China Concerning Its Policies Regarding the Management of Plutonium* IAEA INFCIRC/549/Add.7/10, 8 July 2011. www.iaea.org/Publications/Documents/Infcircs/2011/infcirc549a7-10.pdf.
[8] Zhao Zhixiang, " Closed Nuclear Fuel Cycle and Sustainable Development of Nuclear Power in China," presentation at Harvard-Peking University Workshop on Economics of Nuclear Reprocessing, October 15,2011, Beijing, China.
9 Xu Mi, "Fast Reactor Development for a Sustainable Nuclear Energy Supply in China," presentation at Harvard-Tsinghau University Workshop on Nuclear Energy and Nuclear Security, March 14-15, 2010 , Beijing, China.
[10] *National Progress Report on Nuclear Security of the People's Republic of China*, March 27, 2012. Available at: http://www.china.org.cn/world/2012-03/27/content_24998059.htm.
[11] *Regulations for Control of Nuclear Materials of the People's Republic of China*, the State Council, June 1, 1987. Chinese version is available at CAEA website: http://www.caea.gov.cn/n16/n1130/77219.html.
[12] *Rules for Implementation of the Regulations on Nuclear Materials Control of the People's Republic of China*, the National Nuclear Safety Administration, the Ministry of Energy, and the Commission of Science, Technology, and Industry for National Defense, September 25, 1990. Chinese version is available at CAEA website: www: http://www.caea.gov.cn/n16/n1130/77224.html.
[13] Tim Hanley, et al., "An Overview of the Cooperative Effort between the United States Department of Energy and the China Atomic Energy Authority to Enhance MPC&A Inspections for Civil Nuclear Facilities in China," presentation at the Institute for Nuclear Materials Management 52nd Annual Meeting, in Palm Spring, CA, 17-21 July 2011.
[14] Communications with Chinese nuclear experts on China's MPC&A, March 2010 and October 2011.
[15] *Nuclear Facility Physical Protection Guidelines (2008 version) (HAD501/502)*, the National Nuclear Safety Administration, September 1, 2008.
[16] Yun Zhou, "The Security Implication of China's Nuclear Energy Expansion," The *Nonproliferation Review*, No.2, 2010.
[17] Liu Daming, "Practice of the Physical Protection of Nuclear materials and Nuclear Facilities in China," *Journal of Nuclear Materials Management,* Summer 2010, No.4.
[18] Li Ganjie, "Nuclear Security: The New Challenges for Security of Nuclear Power Plants," presentation at IAEA meeting, 2008. Available at: http://www-pub.iaea.org/mtcd/meetings/PDFplus/2008/cn168/Presentations/Session3_Li.pdf.
[19] Tang Dan, et al., "Physical Protection System and Vulnerability Analysis Program in China," Presentation at the *8th ISODARCO Conference on Arms Control*, Beijing, October, 2002.
[20] Liu Daming, "China National Nuclear Material Control System," presentation at Harvard-Peking University Workshop on Nuclear Security, October 13-14 ,2011, Beijing, China
[21] "Hu Jintao Makes Important Remarks to the Seoul Nuclear Security Summit," March 27, available at: http://www.fmprc.gov.cn/eng/zxxx/t918472.htm.
[22] Matthew Bunn, Eben Harrell, and Martin B. Malin, *Progress on Securing Nuclear Weapons: The Four-Year Effort and Beyond*, (Cambridge, Mass.: Project on Managing the Atom, Harvard University, March 2012). Available at: http://live.belfercenter.org/files/Progress_In_The_Four_Year_Effort_web.pdf
[23] Hui Zhang, "Rethinking Chinese Policy on Commercial Reprocessing," Presentation, 18th Pacific Basin Nuclear Conference, Busan, Republic of Korea. March 18-23, 2012. Available at : http://belfercenter.ksg.harvard.edu/files/ChinaReprocessing_hzhang.pdf
[24] International Atomic Energy Agency, *Nuclear Security Recommendations on Physical Protection of Nuclear Material and Nuclear Facilities*, INFCIRC/225/Revision 5, (Vienna: IAEA, 2011). Available at: http://www-pub.iaea.org/MTCD/publications/PDF/Pub1481_web.pdf (accessed 3 February 2012).

[25] Communications with Chinese nuclear experts in Beijing, March and June 2010, October 2011.
[26] Liu Senlin, "The Status of Research on Nuclear Security Technology in CIAE," presentation at Harvard-Peking University Workshop on Nuclear Security, October 13-14, 2011, Beijing, China.
[27] Zhou, "The Security Implication of China's Nuclear Energy Expansion," *op .cit.*
[28] Hui Zhang, "Evaluating China's MPC&A System," Paper presented at the Presented at the INMM 44th Annual Meeting, Phoenix, Arizona, 13-17 July, 2003.