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SUBJECT: VISIT OF COMMISSIONER JEFFREY S. MERRIFIELD, U.S. NUCLEAR REGULATORY COMMISSION (MARCH 3-10, 2001)

1. The U.S. Nuclear Regulatory Commission (NRC) Commissioner Jeffrey S. Merrifield made an official visit to China on March 3-10, 2001. He met with senior officials from the State Environmental Protection Administration (SEPA) and the National Nuclear Safety Administration (NNSA) and visited the China Institute of Atomic Energy (CIAE), the Institute for Nuclear Energy Technology (INET), the Qinshan Nuclear Power Plants, the Shanghai Boiler Works, the Daya Bay Nuclear Power Plant, and the Ling Ao Nuclear Power Plant. The Commissioner was accompanied by Brian McCabe, his Technical Assistant, and Kevin Burke, Senior International Relations Officer, Office of International Programs.

2. Itinerary:

March 5: Meeting with SEPA Vice Minister Song and NNSA Director General Zhao
Site visit to the China Institute of Atomic Energy
March 6: Site visit to the Institute for Nuclear Energy Technology
March 7: Site visit to Qinshan NPPs
March 8: Site visit the Shanghai Boiler Works
March 9: Site visit to Daya Bay NPP and Ling Ao NPP

3. Discussions and Site Visits:

Commissioner Merrifield's official visit to China was hosted by the State Environmental Protection Administration and the National Nuclear Safety Administration, under the NRC-NNSA Protocol on Cooperation on Nuclear Safety Matters.

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4. State Environmental Protection Administration (SEPA)

Commissioner Merrifield began his visit to China on March 5 and was warmly welcomed by Vice Minister Song Ruixiang to SEPA. This was their first meeting and an opportunity to discuss current programs and future challenges. Vice Minister Song provided an overview of the National Nuclear Safety Administration's regulatory program (the NNSA is administratively under the control of the SEPA). He expressed his appreciation to NRC for many years of technical support to their regulatory program and discussed the positive benefits of placing NNSA staff on temporary assignment at the NRC for hands-on experience. Recently, Mr. Wang Jun completed a 12-month assignment evaluating reactor incidents for lessons learned. Mr. Jun's NRC experience will be useful to the NNSA as they attempt to better utilize probabilistic safety assessment (PSA) insights in their regulatory process. However, with only three operating reactors, their event database is small, and they have requested a copy of NRC's events database. Under the terms of the NRC-NNSA Protocol, NRC is interested in providing a copy of the database in return for a copy the NNSA's database of reactor and fuel cycle events. NRC will follow up on this request. Vice Minister Song was particularly interested in discussing emergency preparedness and response (EP) related to nuclear power plants. He indicated that improving China's EP capabilities was a high priority for the NNSA. In August 2000, Vice Minister Song visited the NRC and toured the Emergency Operations Center (EOC). Plans are now underway for the Vice Minister to return to the U.S. in July 2001 to observe the Summer Nuclear Power Plant emergency exercise from the EOC. Representatives from the NNSA may also be stationed at the Summer Plant and NRC's Region II office during the exercise. The NNSA recently received approval and funding to construct their own Emergency Operations Center and they would like to pattern it after NRC's facility, including the use of real-time data reporting from the reactor sites to the center. Their initiative to strengthen their response capabilities supports earlier IAEA recommendations. The Vice Minister and Commissioner also discussed the U.S. energy situation, the outlook for nuclear power in the U.S., license renewal, electric industry deregulation in the U.S., the deregulation problems in California, and the control of radioactive sources. The Vice Minister was interested to learn that the NRC may soon be asked to review the pebble bed modular reactor (PBMR) design for licensing in the U.S. China has done considerable work developing a high temperature gas-cooled reactor (HTGR) and its fuel fabrication, similar to the pebble bed technology developed by Germany. The Commissioner expressed NRC's interest in learning about NNSA's experience in its review and licensing the HTGR. The NRC will request a follow-up visit for the staff to explore possible collaborative work in this area. The Commissioner inquired about the status of the 10th 5-year plan. The Vice Minister indicated that the plan was recently released and unlike the 9th 5-year plan, it does not specify a particular number of nuclear projects to be completed. Instead, public statements by the government reflect that China will pursue "appropriate" nuclear development. The Vice Minister did not offer his own prediction on the number of nuclear plants that will be constructed over the 5-year period.

5. National Nuclear Safety Administration (NNSA)

Following Vice Minister Song's departure from the meeting, Director General Zhao focused on the NNSA and its many challenges. He reviewed the status of the three operating reactors (Qinshan-1, a 300 MWe indigenous reactor and Daya Bay Units 1 and 2, two 984 MWe Framatome PWRs) and eight reactors under construction

(Qinshan Phase-2, two 600 MWe indigenous reactors, Qinshan Phase-3, two 700 MWe CANDUs, Ling Ao, two 990 MWe Framatome PWRs, and Tainwan, two 1000 MWe Russian VVERs). The NNSA is satisfied with the operation and performance of Qinshan-1 following the extensive repairs to the reactor internals that were made in 1999. The two units of Qinshan-2 are scheduled to be connected to the grid in 2002 (Unit-1 in June and Unit-2 in December), followed by the two units of Qinshan-3 in 2003 (Unit-1 in February 2003 and Qinshan Unit-2 in November 2003). Ling Ao Unit-1 will connect to the grid in July 2002 and Unit-2 in March 2003

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Developing a standardized reactor design was a common theme heard throughout the entire visit. Although a 600 MWe design was originally being considered for their standard design, energy planners are now considering a larger size and design, similar to the Westinghouse AP-1000. Another area of activity for NNSA is their effort to improve the licensing and handling of China's 10,000 nuclear material licenses. Director General Zhao mentioned that there has been a number of nuclear material misadministrations. As a first step to strengthen national regulations, the NNSA has tasked the Nuclear Safety Center to develop a national data bank of information on these licenses. The NNSA has also started to look more closely at the scrap metal industry and is considering whether to require radiation monitors at scrap facilities.

6. China Institute of Atomic Energy (CIAE)

The Commissioner visited the China Institute of Atomic Energy in the afternoon and was met by Mr. Gu Zhongmao, Director of the Department of Radiochemistry and several other Department heads. The Institute was founded in 1950 and has historically been involved in both the commercial and military aspects of nuclear technology. It is equipped with a 15 MW heavy water research reactor, a 3.5 MW light water pool research reactor, a 27 KW neutron source reactor, four zero-power facilities, eleven accelerators, and several hot cells. The CIAE is currently staffed with 3400 employees, down from a high level of 5000. Approximately 60 to 70 CIAE staff support NNSA's regulatory safety work.

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From the CIAE briefings and remarks, they are trying to transform their research and development so it will have more commercial relevance. The facility has Co-60 irradiation equipment that is utilized for research associated with food irradiation, crop irradiation, irradiation modification of polymer materials, and irradiation sterilization of medical articles. From the limited tour of CIAE facilities, the construction of the China Experimental Fast Reactor (CEFR) appeared to be CIAE's highest priority. The 25 MWe reactor is being developed with cooperation from France on its software, and Russia and Italy for the hardware. Initial criticality of the reactor is scheduled for 2003 and the timetable for a commercial fast reactor is 2050. Other priority programs include a new reactor named the China Advanced Research Reactor (CARR), an accelerator upgrading project, and a new radiochemistry laboratory that will be used to support

initiatives associated with future spent fuel reprocessing in China. CIAE offered very little information on these three initiatives.

7. Institute for Nuclear Energy Technology (INET)

On March 6th, the Commissioner visited the Institute of Nuclear Energy Technology, which is affiliated with China's prestigious Tsinghua University. INET, a premier institution, has the lead on China' s high temperature gas-cooled reactor (HTGR) program. Commissioner Merrifield was met at INET by its Director; Professor Wu Zongxin. While INET has a broad range of nuclear research and programs, the focus of the visit was INET's 10 MW High Temperature Gas-cooled Reactor Test Module (termed HTR-10), which serves as the first major step of the development of modular HTGRs in China. This reactor went critical for the first time in December 2000, and was operating in a low-power testing phase during the visit. Currently, INET is only operating the primary cycle of the reactor for testing but also plans to add a secondary side in the future. The control room uses digital instrumentation. Following the scheduled tour of the reactor, the Commissioner expressed an interest in touring the fuel fabrication facility. Although clearly not prepared to offer such a tour, Dr. Wu did walk the Commissioner through the fabrication facility and was very open in his explanation of the process. INET is fabricating approximately 200 fuel elements a day. The 17% enriched fuel elements are spherical (6 cm in diameter) and coated with compressed graphite. The reactor core contains about 27,000 fuel elements forming a pebble bed. Using a pneumatic process, 25 fuel elements are removed from the reactor daily for testing. Following analysis, 5 fuel elements, on average, are rejected for either quality problems or high burn up and 20 fuel elements are returned to the reactor. Thus, on average 5 new fuel elements are added each day. Russia is assisting INET in testing the fuel balls. South Africa, in an international joint commercial venture, is planning to construct a full scale operational pebble bed reactor without first building a smaller scale pilot reactor. INET stated that they have been approached by South Africa concerning the fabrication of fuel for their reactor. The next Chinese pebble bed reactor may be a scaled-up 200 MWe unit; although there appears to be no rush for commercial application.

8. Qinshan Nuclear Power Station Phase I

On March 7th, Commissioner Merrifield visited the Qinshan Nuclear Power Plant Phase I and was greeted by Deputy General Manager Mr. He Xiaojian. Qinshan-I, owned and operated by the China National Nuclear Corporation, consists of a 300 MWe indigenous PWR that was initially synchronized to the grid in December 1991. During the visit, the reactor was operating at full power following its 5th refueling outage, which was completed earlier in the year. Mr. He, accompanied by a senior staff, briefed the Commissioner on the plant's operation. During the visit, it was clear that the management team remains sensitive to and troubled by the 1998 event. In January 1998, control room operators had difficulties withdrawing the thimble of the in-core neutron flux measuring device from a particular channel. All of the plant's major parameters remained within operational limits, so plant management decided to continue operations until a scheduled refueling outage in July 1998. During that outage, inspections revealed some damaged incore

instrumentation conduits and loosed screws on the lower core support plate and on the flow distribution plate. All tack welds between the nuts of the I-type guide tubes and lower core plate of the core barrel were broken. Several core barrel bolts were damaged. Several guide tubes were damaged. Several nuts, screws, and pins within the reactor internals were missing. The internal surface of the cladding on the bottom closure of the reactor vessel was worn by loose parts and some of this wearing was severe. All eight vessel irradiation surveillance capsule holders were damaged. Some of the loose parts had impacted the fuel, damaging some of the fuel rods. Recognizing the magnitude of the problem, Westinghouse was selected to lead the recovery efforts. According to plant management, Westinghouse did an outstanding job assessing the problem, identifying the root cause, correcting design flaws, and effecting repairs. Because of the extensive damage to the bottom of the lower internals assembly and the utility's desire to return to power quickly, Westinghouse devised an innovative solution which involved inverting the reactor internals assembly to effect the repair. This first-of-a-kind inversion process meant that special equipment had to be designed. The repairs included design changes to various reactor internal components, redesigned component-fasteners and bolted connections, new welds, and an extensive foreign material retrieval effort. Ultimately, the plant returned to commercial operation in September 1999 and has operated without incident since then. The past technical problems at Qinshan Phase 1 raise some question about the robustness of its indigenous design and cause some concern about potential design flaws that have yet to be detected. It is important to note that the Chinese built the 300 MWe Chasma nuclear plant in Pakistan, which is a sister plant of Qinshan Phase I. From the discussions, it was not clear whether the Chasma design had been modified to avoid Qinshan's reactor internals problems. The Commissioner toured major areas of the facility led by Mr. He and several members of his management team. The tour included the control room, areas of the auxiliary building, several Emergency Core Cooling System (ECCS) areas, the spent fuel pool area, the turbine deck, and an emergency diesel generator. The plant's management is focusing on improving material condition, and apparently significant improvement have been made since a very critical OSART mission in 1997

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9. Qinshan Nuclear Power Station Phase 2

In the afternoon, Commissioner Merrifield visited the Qinshan-2 that is owned by the Qinshan Nuclear Power Joint Venture Company. Dr. Ye Qizhen, Chief Engineer, welcomed the Commissioner to the construction site and provided an overview briefing and tour of the project. Qinshan-2 is currently in the late stages of construction and consists of two indigenous 600 MWe PWRs. The two units are scheduled to be put on-line in June and December of 2002. The Chinese nuclear

industry has made progress on the road to self-reliance, through technical cooperation and technology transfer from foreign countries. Qinshan -2 uses Daya Bay as its reference plant, although there are significant design differences between the two plants. Phase-2 is designed and built under the full responsibility of Chinese engineering institutes and construction companies. Necessary technical support and technology transfer came from France and the U.S., thus incorporating international experience and technology. Many of the reactor's major components such as reactor vessels, pressurizers, and steam generators were, or are being, manufactured at the Shanghai Boiler Works. Commissioner Merrifield toured some of the major areas of the facility including inside containment. The construction efforts appear to be proceeding in a professional manner. However, site management indicated that construction was slightly behind schedule as a result of manufacturing delays/problems experienced at the Shanghai Boiler Works. Apparently, these delays/problems have been resolved and site management was confident that the scheduled completion target dates could be met. Although the Commissioner saw nothing on his tour that would lead him to think that the completion dates could not be met, it was obvious that a significant amount work remains.

10. Qinshan Nuclear Power Station Phase 3

The last site to be visited on March 7 was Qinshan-3. Mr. Jiang Guoyuan of the Third Qinshan Nuclear Power Company briefed Commissioner Merrifield on the site's construction. The two 600 MWe units are under direct Canadian AECL management, with architect engineering support from Hitachi & Bechtel. The Chinese lack the infrastructure necessary to construct and operate CANDUs, so Qinshan-3 is a turnkey project. The construction is slightly ahead of schedule with 27 milestones completed out of 55. With a construction force of 4000 workers, Qinshan-3 Unit 1 is scheduled to begin commercial operation in February 2003 and the second unit in November 2003. The Commissioner toured some of the major areas of the facility including the control room and inside containment. He was able to observe work being performed on an open calandria; as well as construction surrounding the steam generators and primary heat transport pumps. The construction efforts appear to be proceeding in a professional manner, and site management is confident that the scheduled completion target dates will be met. In several discussions throughout the visit, it was apparent that the Chinese are striving for greater design standardization within their nuclear program in the future.

11. Shanghai Boiler Works

On March 8th, before departing Shanghai, the Commissioner toured the Shanghai Boiler Works (SBW) and met with SBW Chairman of the Board, Mr. Zhou Guo Ren. During a tour of the facility, the Commissioner was able to observe work being performed on the Qinshan-2 reactor vessel and pressurizer. A steam generator for Qinshan-2 was completed and delivered in 2000. The fabrication shop that was visited was equipped with an array of international tools and equipment, appeared to be well-maintained, and appeared to have high standards. Throughout the tour, site representatives repeatedly stressed quality assurance and training, as well as their close working relationship with Westinghouse. The SBW is clearly interested in expanding its international business opportunities. Mr. Zhou was aware that the U.S. no longer has the capabilities it once had in the manufacturing of large reactor

components for its commercial nuclear fleet. Naturally, he expressed a great deal of interest learning more about the potential for new nuclear plant construction in the U.S. When asked, he indicated that his facility does not have an ASME N-stamp certification, but was adamant that the facility's standards are more stringent than those required for N-stamp certification. However, he realized that in order to get into the U.S. commercial nuclear market, the facility would need to get the N-stamp certification. SBW manufactures large components for the Chinese military and for its commercial power industry (nuclear and fossil) and it has an extensive international customer base, primarily in the area of large components for commercial fossil power plants.

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12. Daya Bay Nuclear Power Plant

On March 9th, Commissioner Merrifield visited the Daya Bay Nuclear Power Plant, owned and operated by the China Guangdong Nuclear Power Plant Corporation (CGNPC). The two 984 MWe Framatome-designed and built PWRs were placed into commercial operation in 1994. Mr. Steven Lau, Executive Deputy General Manager and key members of his management team, welcomed the Commissioner to the site. Prior to touring the plant, the Commissioner received an extensive briefing on plant performance, improvement initiatives and future plant construction. CGNPC also owns the two Ling Ao units (990 MWe Framatome PWRs) under construction. Ling Ao is adjacent to the Daya Bay plant and several managers have responsibilities at both facilities. With Guangdong's energy growth currently at 13%, CGNPC is planning an additional two units at Ling Ao, most likely 990 MWe Framatome PWRs, and six 1000 MWe units at Yangjiang, in southwest Guangdong. The design for the Yangjiang units has not been determined. It was apparent that the management team at Daya Bay places a great deal of emphasis on benchmarking. Particular attention is paid to WANO performance indicators, international operating experience, international human and process improvement initiatives, critical self-assessment, safety culture, and international benchmarking trips. As a result, plant performance has improved significantly over the last five years. Unplanned reactor scrams have been reduced from 9 in 1995 to 0 in both 1998 and 1999, and 1 in 2000. Capacity factors have risen from 65% in 1995 to 87% in 2000. Equipment reliability has also improved dramatically. Based on the information provided by plant management, it appears that most of the plant's performance indicators are in WANO's second quartile. Plant management is placing a great deal of emphasis on improving the safety system performance index which is below the WANO mean. The Commissioner was briefed on an array of fuel issues. Of particular note, the spent fuel pool at Daya Bay will reach full capacity in 2003. However, plant management indicated that it has solved its spent fuel storage problem by paying the China National Nuclear Corporation $900 million over ten years to remove the spent fuel from Daya Bay and ship it by rail to a central storage facility for disposal. On other fuel matters, MOX is not currently utilized at the Daya Bay, and the plant intends to extend its fuel cycle from 12 to 18 months.

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13. Ling Ao Nuclear Power Plant

In the afternoon, the Commissioner visited the Ling Ao nuclear power plant, two 990 MWe Framatome PWRs . Ling Ao is in the latter stages of construction and Unit 1 is scheduled to begin commercial operation in July 2002 and Unit 2 will begin commercial operation in March 2003. This schedule represents a construction period of 62 months and 70 months respectively. Ling Ao uses Daya Bay as its reference plant. The major equipment of the nuclear island and the secondary systems are supplied by Framatome and Alstom, respectively, while Electricite' de France provides the engineering consulting services. Total investment associated with the construction of these first two units is expected to be approximately 4 billion U.S. dollars. The Chinese are currently planning the construction of two additional units at Ling Ao. Plant management representatives indicated that these units would most likely be 990 MWe Framatome PWRs. The Ling Ao and Daya Bay plants do share some common facilities, including the 5th emergency diesel, technical support staff, and service organizations. During the tour, Mr. Lau reiterated the importance China is placing on self-reliance within their nuclear program. YY