NRC NEWS

U.S. NUCLEAR REGULATORY COMMISSION

Office of Public Affairs **Telephone: 301/415-8200**

Washington, D.C. 20555-0001 **E-mail: opa@nrc.gov**

Web Site: http://www.nrc.gov

No. S-06-027

"Regulatory Perspectives on the Deployment of High Temperature Gas-Cooled Reactors in Electric and Non-Electric Energy Sectors"

Prepared Remarks
by Commissioner Jeffrey S. Merrifield

at the 3rd International Topical Meeting on High Temperature Reactor Technology
Johannesburg, South Africa

October 2, 2006

Thank you very much for the opportunity to speak to you today regarding regulatory challenges associated with small, innovative reactors. It is a great honor for me to have the opportunity to travel to this beautiful country.

As you may know, I have served on the United States Nuclear Regulatory Commission for eight years. At the time I joined the Agency in 1998, it was not long after a series of operating reactors had permanently shut down in my country, and at that time, the U.S. Energy Information Agency, which is part of the U.S. Department of Energy, was postulating that by the year 2010, 40% of the operating nuclear reactors in the United States would be prematurely shut down. Clearly, things were not looking very promising for the future of nuclear power.

Although I did not have a strong background in nuclear energy when I joined the Agency, I made a concerted effort to develop an understanding as quickly as possible. One way in which I gained a working knowledge of this technology was through seeing it firsthand in operation. During my first term of three and one-half years, I had the opportunity to visit all 103 operating nuclear reactors in the United States. Over the course of the last eight years, I have visited more than 125 nuclear reactors in 29 other countries. As a result of my travels, I have gained valuable insight into where the nuclear power industry is going, not only in the U.S., but also around the world.

Clearly, the past eight years have made a tremendous difference in the outlook for nuclear energy. With the construction activities underway at the Olkiluoto site in Finland, the nuclear industry has taken a decisive step forward in embracing the third generation of nuclear technologies. Similarly, in the United States, as a result of recent tax incentives provided by the United States Congress, the NRC has received a series of letters from utilities expressing an interest in submitting 19 applications for combined construction and operating licenses by December of 2008, with the total number of potential reactor orders potentially exceeding 25 units.

Currently, the utilities in the United States anticipate a large need for increased baseload power in the 2014-15 time range, and they are predominantly focusing on advanced Generation III and Generation III+ pressurized and boiling water reactor designs supplied by Westinghouse, General Electric and Areva. Concurrent with this effort, the United States Department of Energy has undertaken the Next Generation Nuclear Plant project that will result in the development of a nuclear reactor prototype with the capability to produce process heat, electricity, and possibly hydrogen. Clearly, there is a potentially bright future for both Generation III and Generation IV reactors in the United States.

As we have heard in a number of presentations this morning, high temperature gas technologies bring with them opportunities that go well beyond those encountered through the use of light water technologies over the last fifty years. The statistics on reactor technology used around the world, however, demonstrate that few nuclear programs have been willing to take advantage of these opportunities thus far. Today there are 31 countries that operate a total of 442 nuclear reactors. Eighty percent of these reactors utilize light water technologies. There are 45 heavy water reactors in operation around the world, and currently, the United Kingdom is the only country that operates gas-cooled reactors with a total UK fleet of 22 operating gas reactors.

A Regulatory Perspective

This morning, I am speaking from the viewpoint of a regulator whose current nuclear power plant fleet is made up entirely of light water reactors, a position we share with 22 other countries. That is not to say that the United States is inexperienced with the operation of gas reactors. As you may know, two gas-cooled reactors have been built and operated in the United States for power production purposes. The first was Peach Bottom Unit 1, a 40-megawatt experimental test reactor located in Pennsylvania, that operated from 1967 to 1974. The second was the Ft. St. Vrain nuclear power plant, a 300-megawatt gas-cooled reactor designed by General Atomics, and located in Colorado that operated between 1973 and 1989. During its 16 years of operation, it only managed to achieve a total of 447 full power days which amounted to a lifetime capacity factor of slightly more than 14%. This reactor suffered from a variety of problems during its lifetime, the majority of which were associated with the secondary side of the unit rather than the primary system. The reactor was shut down and decommissioned, due in no small part to the difficulties it encountered and was never able to successfully overcome. I had an opportunity to visit Ft. St. Vrain this summer, and was quite interested to see how this unit had been repowered as a natural gas fired generating station.

Fortunately for our Agency, the experience we had in regulating Ft. St. Vrain means that we do not have to start from scratch to understand the challenges we would meet in regulating new gas reactor technologies. Indeed, we were approached in October 2000 by Corbin McNeil who was at the time the Chairman of our largest nuclear utility, Exelon Corporation, who expressed an enthusiastic intention to license the pebble bed technology in the United States. As a result of this significant interest, I personally led a Commission-directed initiative to provide five million dollars in new funding to reinvigorate our capabilities in gas cooled technologies. Indeed, this interest spurred me to travel to

China where I saw firsthand the ten-megawatt prototype pebble bed reactor operated by the Institute of Nuclear Energy Technology of Tsinghua University, as well as the fuel fabrication facility located at that site.

As a Commission, having made the commitment to prepare ourselves to license this technology, we worked deliberately to improve our understanding and technical expertise to support a licensing review of high temperature gas technology. Subsequently, McNeil's successor at Exelon decided not to pursue the pebble bed design. In turn, the NRC, when confronted with decreased domestic interest in this innovative technology, reduced its own efforts in this area. Nonetheless, we have not been standing still. The NRC Office of Research has continued to enhance its capabilities to license this technology, and my comments today will reflect on some of the thinking our staff has been doing in this area.

Concurrently, the U.S. Department of Energy recently solicited expressions of interest for participation in the Next Generation Nuclear Plant program I previously mentioned. This project is primarily focusing on high temperature gas-cooled reactor designs. Additionally, as you may know, President Bush's recent announcement of the Global Nuclear Energy Partnership, which would attempt to close the nuclear fuel cycle, may also have future possibilities for high temperature gas reactor designs. For these reasons, issues related to high temperature gas designs are very relevant to our country even though deployment is likely more than ten to fifteen years away.

Today, I will focus a bit more specifically on the pebble bed design, principally because the NRC has been more intimately involved with this technology. Many of my comments, however, apply equally to other high temperature gas technologies. Over the last six years, the NRC has had frequent contact with PBMR Ltd., and we anticipate receiving a series of information papers later this year that will help us focus on significant technical challenges going forward. I will not make a definitive statement on these issues today, because as a Commissioner, I may have to sit in judgment on these very matters in the future. However, I would like to explore some of the different viewpoints that the NRC will be confronted within determining how to license any high temperature gas designs.

As we have already heard today, individuals who support high temperature gas technology, including the pebble bed, are quite eloquent in outlining its benefits and potential uses.

- Many of these designs would be built in a modular fashion, and thus allow <u>deployment at remote sites</u> with most of the manufacturing conducted at an offsite facility using assembly line-like activities.

- Because pebble bed reactors are modular and can be constructed in 100 megawatt increments, customers can <u>specifically tailor the size</u> of potential plants to meet the particular needs of a project or geographical area.

- Pebble bed reactors, because of their fuel design, have a significantly greater amount of calculated temperature margin between the regulatory limit and the cladding capabilities. The potential inability to cause fuel melt during a design basis accident brings with it the suggestion that <u>containment structures may be unnecessary</u>.

- Pebble bed reactors, utilizing continuous refueling, do not share the refueling requirements of their light water counterparts. The low levels of excess reactivity in PMBRs, in contrast to the large excess reactivity in light water reactors, would result in a meaningful decrease in total source term, and raise the possibility of reduced emergency planning zones surrounding these plants.

- High temperature gas reactors, which have exceedingly high outlet temperatures, allow for innovative uses such as hydrogen production, energy production for remote mining activities, and desalination efforts.

Having outlined some of the promises of this technology, I would like to step back and examine the technology from the standpoint of someone who must be neutral in my position on new reactor designs. One of the issues I have encountered during the eight years I have spent as an NRC Commissioner is the tendency of individuals in this field to look at policy issues through a technological prism. All too often scientists and engineers in the nuclear community, including those within our agency, look at these issues in a vacuum, merely focusing on the technical attributes of the designs, and fail to fully appreciate how the general public will react to these new technologies and applications.

As a former staffer in the United States Senate and as a lawyer, I tend to look at these issues somewhat differently. For better or worse, our Agency, and many of our international counterparts have dozens of years of experience regulating light water reactors in a very specific way, and the public with whom we deal, regardless of their feelings about nuclear power, have become very accustomed to the way in which we regulate these facilities. What this experience brings with it is a general expectation on the part of the public that a nuclear reactor will be regulated in a specific manner. The innovative nature of the pebble bed technology challenges many of these expectations, and brings with it the attendant public policy challenges.

Remote Deployment

The first of these challenges is the issue of remote deployment of these reactors. Given the developments made over the last twenty years related to modular construction and design, I believe it is very plausible to construct modules at a centralized facility and transport these modules hundreds or perhaps thousands of miles to be assembled in remote locations.

Clearly, there are many sites around the world where dispersed populations or isolated industrial and mining facilities are a potential market for modular small nuclear reactors. What is a challenge, however, is ensuring that you have sufficient nuclear professionals, both for the utility and the regulator, to staff these new sites. Attracting highly capable engineers to sites where they may be separated from their families, or from the social life to which they have become accustomed is no small concern when considering staffing questions. In the United States, we have a requirement that all nuclear power plants have at least two NRC resident inspectors at each site. Whether a reactor is 1500, 800 or 100 megawatts, our public will expect that we maintain that capability at each site we oversee. Nuclear technologies clearly demand seasoned professionals to control their safe use, and any discussion of remote deployment will need to address how we can ensure that this critical need is met.

Containment Structures

When it comes to the matter of containment versus confinement, I have heard and I understand the theory regarding the lack of a need for an inerted containment at pebble bed reactors, due to their calculated inability to have fuel melt during a design basis accident. Having said this, I have traveled all over the world speaking with a wide variety of people about nuclear power. Setting aside scientific principles, which at least in the United States people are frequently quite willing to do, many members of the public clearly equate the lack of a containment structure with the 1986 accident at Chernobyl. To an average member of the public in the United States, a containment structure, with at least three feet of heavily reinforced concrete, is seen as a standard feature for any nuclear reactor.

Indeed, the fact that there were no significant health or environmental impacts arising from the 1979 accident at Three Mile Island Unit 2 was due in greatest part to the fact that there was a containment structure at that site. Now having said that, I want to make it clear that I am not sitting in judgment today asserting that you cannot have a nuclear reactor without a pre-stressed concrete containment. Instead, I would only state that in my country, and I would suggest in much of the world -- particularly in a post 9/11 security posture -- the notion of building a nuclear power plant without a containment structure would engender a significant public policy debate.

Emergency Planning Zones

As I am sure many of you know, the United States has a requirement that all nuclear power plant licensees prepare an emergency evacuation plan for all of the individuals who live and work within a ten-mile (or 16-kilometer) radius of the plant. Having put this plan into practice after the Three Mile Island accident, the American public, particularly those who live within these zones have become very accustomed to this added layer of protection to public health and safety. Not only does public opinion strongly support this requirement, but in light of the events of September 11, 2001, some have called for our government to increase the size of our emergency planning zones out to 20 miles.

I am aware that advocates of high temperature gas designs are of the opinion that the nature of many of these designs justifies a reduction in the current emergency planning requirements. It is not my intention to either support or refute that claim today. However, what is clear to me is that in my country, any reduction in emergency planning requirements would be a matter of major public policy debate, including active involvement by non-government organizations. Even if I were to postulate that our Commission would allow a reduction in these requirements, I believe that the U.S. Congress, and not the Commission, would likely have the final word on this matter.

Alternative Uses for Pebble Bed Reactors

Finally, I would like to comment briefly on my own views about high temperature gas reactors being used for such purposes as energy production for remote mining activities, water desalination plants, or hydrogen production. Setting aside the comments I made earlier about the staffing issues associated with remote reactors, I am not aware of any significant safety or technical issues associated with the use of a high temperature gas reactor as a power or heat source for mining, manufacturing or desalination purposes in remote areas.

The case of hydrogen production, however, seems to be a somewhat more complicated question. For many members of the U.S. public, the use of hydrogen is equated with the Hindenburg dirigible disaster dating back to 1937. Now I am not suggesting that this is my view. I am quite aware that we have moved far forward in our ability to safely produce and utilize hydrogen. Nonetheless, when the use of nuclear power is tied to hydrogen production, one receives the predictable questions regarding the safety of having these two technologies side by side, and one cannot disregard the fact that hydrogen production facilities have equally stringent safety and fire protection requirements. The fact remains, however, that nuclear safety regulators such as myself will have to ask the hard questions regarding these issues because our public and our Congressional and Parliamentary overseers will clearly expect us to answer these issues in a clear manner and with a sound technical basis.

Conclusion

With that, I would like to thank you once again for asking me to contribute to this important conference. It has not been my intention today to quench your enthusiasm for this technology, instead, I hope I have stimulated your thinking regarding the public policy challenges that I and my fellow regulators around the world will grapple with as we continue to evolve in our use of nuclear technologies. Clearly, there are some very promising aspects to the use of high temperature gas technology, but this industry must be prepared to answer the hard questions that we will receive from the public about how this technology will be used and how it will be safely maintained. I leave you with my best wishes for a productive conference.

###