REFLECTIONS ON 50 YEARS EXPERIENCE WITH AIR AND GAS CLEANING TECHNOLOGY IN THE NUCLEAR INDUSTRY

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This is the 25th in a series of Nuclear Air and Gas Cleaning and Treatment Conferences that have taken place over a half century. In addition, it marks the 50th anniversary of nuclear air cleaning research. The first contract for this activity was awarded to the Harvard School of Public Health in 1948 by the U.S. Atomic Energy Commission (AEC) and the activity grew rapidly into the Harvard Air Cleaning Laboratory (HACL). During this period we witnessed the start and development of nuclear technology in all its applications, both peaceful and military. Many of us would label this development the most seminal event of the 20th century.

Anniversaries are traditional times to reflect on the past as well as times to look ahead. I would like to take this occasion to do a little of both. In spite of the occasion, I find it difficult to get into a celebratory mood. In fact, I am downright saddened to observe the changes that have occurred in the nuclear enterprise during this half century; what the giants of yesterday built in a few brief years, their successors in high places have been unable to manage well. The Nuclear Regulatory Commission (NRC) seems to have lost a vision of its future as a vital participant in the applications of nuclear energy and, instead, to be concentrating its efforts on the uneven regulation of facilities it approved 2 - 3 decades ago; whereas the U.S. Department of Energy (DOE) appears incapable of thinking about anything other than waste, but has not yet learned what to do about it. Perhaps my bitter comments will be attributed to the refusal of NRC and DOE, for the first time in 50 years, to provide funding for this conference - and of course this is upsetting - but I believe my comments reflect a deeper concern over the fact that both agencies have lost all interest in supporting the development of a new and improved air and gas treatment

technology that is urgently needed. This is occurring in spite of acknowledged needs and a severely diminished pool of knowledgeable and experienced practitioners in this highly specialized field. I am unaware of any significant R & D activity in this area that is being supported by either agency - or by any one else, for that matter.

Giving way shamelessly to a superannuated citizen's urge to reminisce about earlier times (that in retrospect are always better) let me recall the unblemished enthusiasm that pervaded the dawn of the nuclear age. It captivated the imagination of the U.S. - indeed the entire world - and created enormous interest in each of the visionary applications that were announced: a new Central American canal would be blasted through the mountains with nuclear explosives; President Eisenhower would solve all the Middle East's problems by building many nuclear seawater desalting plants on the shores of the Mediterranean that would produce enough fresh water to make the desert green and provide food and prosperity for all; nuclear-powered aircraft would circle the earth without a need to refuel; and nuclear-powered electricity would become too cheap to charge for it by the KWH. Everything associated with nuclear possessed high excitement and glamour, including special nuclear air filters, identified at the time as "absolute filters". So potent was this image, that a U.S. cigarette manufacturer developed and sold for a few years a filter for their product that claimed kinship to the nuclear industry's absolute filter and exploited its reputation for efficiency. Some decades later this proved exceedingly troublesome as a component of the filter was crocidolite asbestos from Bolivia. The use of crocidolite asbestos also concerned the armed services at the time, but for a different reason; namely, its source outside the North American continent. In addition, the absolute filter had a large cellulose component making it a severe fire hazard. The search for alternative materials coincided with the development of ultra-fine-glass fiber technology and resulted, by the late 1950's, through the joint efforts of the A.E.C., Naval Research Laboratory, and the Army Chemical Corps, in the product we refer to as the HEPA filter. In addition to reducing the fire hazard, the reconstituted filter reduced the penetration of the absolute filter to half, and the filters made today have further reduced penetration more than 500% - an outstanding research and commercial achievement. Early developments in radioactive vapor collection, with special reference to radioiodine, were equally impressive. They included the introduction of inorganic and organic impregnants on

activated carbon to improve retention efficiency and capacity and the development of mineral adsorbants that eliminated the fire hazard associated with carbon-based adsorbants. A major R & D program was undertaken during these early years to develop methods for capturing and sequestering radioactive noble gases for application to fuel reprocessing operations and liquid metal fast breeder reactors, LMFBRs. Practical solutions proved difficult and the proceedings of many nuclear air cleaning conferences record the tribulations and ultimate successful development of cryogenic separation techniques, plus systems using very deep beds of cooled activated carbon adsorbants to provide long term retention and permit decay of short-lived isotopes. The ultimate step for both was indefinite storage of long-lived isotopes in compressed gas cylinders. These are highpoints in the history of the U.S.'s nuclear air and gas cleaning research program. Sad to say, cryogenic separation systems were never employed to remove radioactive noble gases from fuel reprocessing, and deep carbon holdup beds were only installed in the Fast Flux Test Facility (FFTF) that never went into sustained operation.

What went wrong with the nuclear programs that seemed to have such a glowing future during the 50s and 60s? Was it the hubris of the early prophets of the new nuclear-based Eden that brought down the wrath of the gods? Remember the ancient Greek dramatists who warned that disaster would inevitably result from overweening pride. Or, perhaps, it resulted from more mundane events. From the beginning, the champions of the new nuclear technology chose to base their accident scenarios on protecting the public against the worst possible accidents they could imagine - and they had fertile imaginations - instead of protecting the public against believable risk. The rationale for this, I assume, was to convince the public that no matter how dire the event, the built-in safeguards were a guarantee that no harm would result. Although this was meant to assure the citizenry that all was in safe hands, instead, it scared the hell out of them to the point of paranoia and disbelief, and spawned the anti-nuclear movement that traded on their presumption of moral authority, and that continues to plague the development of nuclear applications to this day. Witness the unwillingness of the public to accept radiation treatment of ground meat to prevent E. coli infections that kill children. So successful was this policy of imagining the improbable in terrorizing the American public that it was adopted whole-hog by the Environmental Protection Agency, (EPA) when it came into existence in 1970 and it has been

undergoing perfection by them since then. Witness the weekly cancer warnings and retractions that emanate from that source.

A second event that turned people against the nuclear enterprise was the Three Mile Island, (TMI) meltdown, and finally, the Chernobyl disaster that cast a very black cloud over the nuclear enterprise in the U.S. and much of Europe. The outcome of these two events is an instructive case study for a nuclear air and gas cleaning conference. At TMI, the installed filters and activated carbon beds did exactly what they were supposed to do, and no measurable amounts of radioactive particles or iodine left the disabled power plant, (although calculations following the event indicated that it was possible that a small amount of radioiodine was released.) Now, contrast the containment of radioactive products at TMI with events at Chernobyl where air cleaning systems were not employed and released radioactive products spread enormous damage over a large area. It is unfortunate indeed that the reliable protective function of the nuclear air and gas cleaning systems at TMI were never explained adequately to the public. Perhaps that was a failure to take appropriate action by many of us in this room, who were actively involved with nuclear air and gas cleaning activities at the time.

The event that hurt the U.S. the most was the presidency of the nuclear engineer, Jimmy Carter, who shut down the fast breeder and fuel reprocessing programs to set an example for the rest of the world on what they should do to prevent proliferation of nuclear weapons. The rest of the world scratched their heads in wonderment and continued as before. We learned the fruits of the Carter policy a few months ago from India and Pakistan, not to mention less-public goings-on of a similar nature in the Middle East.

It has been 20 years since a new nuclear power plant has been commissioned in the U.S. in spite of the fact that the NRC has already approved advanced designs that are even safer and more efficient than the ones now in service. They are being built in Asia but U.S. nuclear power plants are being decommissioned and recent ones are applying to NRC for plant life extensions instead of replacing them with better ones when their licenses expire.

Will a need to reduce greenhouse gases be the salvation of the nuclear power industry in the U.S., or must we wait until a profligate use of natural gas and oil for generating electricity has thoroughly depleted this non-renewable resource? Then, will the U.S. reverse Carter's naive legacy of misbegotten ideology and resume its involvement in international fuel cycle issues? I look forward to the time when this will happen, but if V.P. Gore is our next elected President it is unlikely to happen for a while. In his speeches on reducing greenhouse gases at Kyoto, at Harvard, and elsewhere, he has never once been heard to utter the word "nuclear". I can only assume he would like to carry on the work Carter began and finish off the U.S.'s nuclear energy industry that currently provides 25% of the nation's electricity. A glimmer of hope! The U.S. nuclear power industry seems to have awakened, at last, and is running a big advertising campaign to make the point that nuclear is a cleaner source of electricity and an answer to global warming. Ultimately, the need for nuclear power is likely to prove inexorable and we will have to move ahead with the advanced reactor technology but I fear advanced air and gas cleaning safety devices will not be available for the nuclear reactors yet to come. From my presentation, it may give the impression that I am trying to wag the nuclear dog by its air and gas cleaning tail. I am not - but without this particular tail there may be no dog at all, as we learned at Chernobyl.

So, lets see where we stand today with this nuclear air cleaning enterprise. I have already commented on the sorry state of nuclear air and gas cleaning R & D. For several critical areas, the proceedings of these Conferences contain a grim story of unmet needs, and this session is likely to add to the list. Noteworthy among unresolved issues is the effects of in-service aging on HEPA filters and carbon-based adsorbers. A DOE-funded inquiry into filter aging, a half dozen years ago, was conducted just long enough to raise a number of red flags, but not long enough to resolve important findings related to measured declines in structural strength and reliability; even when periodic penetration tests met acceptance criteria. There is currently no test for determining remaining safe service life, but surely this is a worthy subject for research. Another unanswered question is, whether filter units that have been in service for a decade or two (and there are many in this category) will be able to perform their intended safety function should they be needed. There is no forthright answer, but I think it would be useful to inquire how in-service aging is being handled by the nuclear power people when they do their periodic risk-based maintenance

evaluations. Just how heavily do they rely on their aged and aging filters? Adsorbent beds are also tested periodically for leakage and there is a test for residual service life, but uncertainties persist regarding the reliability of test canisters to deliver a representative sample of the entire adsorber bed, as well as which laboratory test protocol is the appropriate one to use.

Although HEPA filters and impregnated activated carbon adsorbers have well-established safety roles in nuclear power reactors, there are new and different requirements associated with nuclear waste operations that have yet to be explored; let alone resolved. In a very real sense we are coming full circle in the types of nuclear air and gas cleaning equipment that will be needed for waste management operations. Very early in nuclear development activities there were major concerns about atmospheric emissions from conventional, high-volume uranium mining, as well as ore processing, concentrating, and extracting operations that involved the added factor of radioactivity. Radioactivity was considered, at the time, somewhat of a minor added hazard for unenriched material over the basic toxicity of the metal itself. Similar concerns were associated with the recovery of beryllium from beryl-containing ores. Although conventional technology from the fields of mining, ore processing, and chemical manufacturing was employed for these operations, there was an urgent requirement to improve reliability and efficiency in recognition of the greater than usual hazard. This was precisely the mission assigned to HACL and other research laboratories during the late 40s and early 50s and resulted in an order-of-magnitude improvement in the variety and performance of industrial cleanable cloth dust filters and in the development of high efficiency wet collectors such as the Venturi scrubber and high pressure fog scrubber. But, when nuclear power operations began, interest shifted to HEPA filters and activated carbon adsorbers. The point I am making here is that with interest shifting to waste processing, in which fairly conventional, large scale, continuous chemical processing unit-operations will be conducted, air and gas cleaning devices similar to those that engaged the attention of an earlier generation of engineers specializing in nuclear air and gas cleaning will again be needed. Much of the same can be said about nuclear power plant decommissioning operations. If there is any development on-going to meet these anticipated needs, I haven't heard about them. It would be possible to go on with additional examples of unaddressed nuclear air and gas cleaning research and development needs, but I think I have made it clear that important

needs that require significant lead times for resolution are being ignored. What I find most disturbing about this situation is the rapid disappearance, from neglect, of a cadre of scientists and engineers who will be sufficiently knowledgeable and experienced in nuclear air and gas cleaning research to answer the call when the need is finally recognized.

What of the future as we prepare for the new millennium? It is so close that the 26th Conference will take place in the next century. I believe we must adhere tenaciously to our basic and vital job of protecting workers, public, and environment from harm. I entreat all to keep the faith and hold on until the climate for R & D undergoes a sea change for the better, and the new generation of air and gas treatment experts will be allowed to solve all the problems I have alluded to, and to get on with the new ones that will, inevitably, arise.

Such are my partial thoughts as I reflect on the anniversaries I referred to at the beginning of my talk. But no discussion of this nature can end without acknowledging my gratitude for the opportunity to work and contribute to this important and challenging field, and for the many dedicated co-workers I have encountered along the way who have been my esteemed friends and colleagues. With that comment I bring my remarks to a close and thank you for your kind attention.