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THREE MILE ISLAND—LOOKING BACK ON 30 YEARS OF LESSONS LEARNED

HEARING

BEFORE THE

SUBCOMMITTEE ON CLEAN AIR AND NUCLEAR SAFETY

OF THE

COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS

UNITED STATES SENATE

ONE HUNDRED ELEVENTH CONGRESS

FIRST SESSION

MARCH 24, 2009

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ONE HUNDRED ELEVENTH CONGRESS
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THREE MILE ISLAND—LOOKING BACK ON 30 YEARS OF LESSONS LEARNED

TUESDAY, MARCH 24, 2009

U.S. SENATE,
COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS,
SUBCOMMITTEE ON CLEAN AIR AND NUCLEAR SAFETY,
Washington, DC.

The subcommittee met, pursuant to notice, at 10:35 a.m. in room 406, Dirksen Senate Office Building, Hon. Thomas R. Carper (chairman of the subcommittee) presiding.

Present: Senators Carper, Inhofe, Voinovich, Vitter, and Merkley.

OPENING STATEMENT OF HON. THOMAS R. CARPER, U.S. SENATOR FROM THE STATE OF DELAWARE

Senator CARPER. Welcome everybody. My voice sounds fuzzy up here. How do I sound out there? OK, all right, good. I don't feel fuzzy. I feel good. In fact, I have been looking forward to this hearing. We have a great lineup, two panels, and we are going to learn a lot. Welcome back, and maybe help us to look forward as well.

We will be joined by Senator Vitter here in a little bit. We're going to go ahead and start. He doesn't want us to hold up, and so we will just go ahead and kick it off.

I want to thank our staff, both Democrat and Republican, for your help in putting together today's hearing. And we are just grateful for all of our witnesses to be here.

Today's hearing is focused, as you know, on 30 years of lessons learned since the Three Mile Island nuclear plant accident. Senators will have 5 minutes or so, for opening statements. Then I am going to recognize our first panel of witnesses, the Nuclear Regulatory Commissioners themselves, in living color, and you are all here and we are grateful that you are here.

Chairman Klein, we will ask you to speak for maybe 5 minutes or so. We will ask each of your colleagues to try to limit your remarks to close to 3 minutes. And then we will go about our first round of questions. I think we just have one round of questions for each of these panels.

And then we will invite our second panel of witnesses to come forward, and we will follow their testimony with one round of questions as well.

We will probably finish up about dinner time tonight.

[Laughter.]

Senator CARPER. No, we will finish up. We have a caucus lunch and it starts at about 12:30 or 12:45, so we will finish up in due course.

Thirty years ago, a nuclear accident occurred at the Three Mile Island nuclear power plant in Middletown, Pennsylvania that would shake America's confidence in nuclear power. The accident was a cooling malfunction that caused a partial meltdown of the reactor core, releasing a small amount of radioactivity. The accident was determined to be caused by a combination of several things: equipment failure, and the inability of the plant's operators to understand the reactor's condition during the event.

Unlike the Chernobyl disaster that occurred I think about 8 years later, the Three Mile Island reactor vessel did not fail. The leaked radioactive gases were vented into the atmosphere through specially designed filters under operator control.

No immediate deaths occurred, and the Nuclear Regulatory Commission estimated that approximately one additional cancer in the area would result from the accident. Although any increases of the cancer death rate is unacceptable, I think we would all agree it could have been much worse.

This accident had a profound impact on the public, on the nuclear industry, and on the NRC. Public confidence in nuclear power generation was, if not shattered, greatly damaged. The cleanup effort took nearly 14 years and some $1 billion to complete.

Three Mile Island served as a wake-up call that we had become complacent on nuclear safety. After the accident, the NRC, Congress, and the nuclear industry took a long, hard look at what we needed to do to make this industry safer and to gain back, to regain the public trust.

Under the direction of the NRC, the industry made sweeping changes. Today, our Nation's 104 operating nuclear reactors maintain high levels of safety and reliability. Our plants have also become more efficient over the past 30 years. As a result, we have been able to almost double our generating capacity, I call it our operating capacity, since 1979. These changes have given the nuclear industry one of the best safety records, really, of any industry in the United States.

Now, Americans realize that nuclear power can provide reliable energy and can do it without polluting. To reduce our Country's dependence on fossil fuels, we need to do a number of things. We need to harness the winds off the shore of Delaware and other places along our coast. We need to harness the sun's rays in Nevada and other places like that. We will need to capture the CO_2 coming off of coal-fired plants in West Virginia and other place around the Country. And we are going to need to build plug-in cars in Detroit and other places around America, and drive them.

We are also going to need, in the end, we are going to need if we are going to reduce the threat of climate change, our dependence on foreign oil, harmful emissions into our air, we are going to need nuclear power. But broad support for the nuclear industry will vanish if another nuclear accident occurs. Without a safe nuclear industry, there will be no nuclear industry.

I like to tell the story, we have a pilot here, our colleague Jim Inhofe, who flies his plane, I think, all over the Country, maybe all over the world, but I like to, for the record, the plane, the plane. This is cool.

[Laughter.]

Senator INHOFE. I also have pictures of my kids.

[Laughter.]

Senator CARPER. And he's got a bunch of them. You have one or two grandchildren, too, don't you? But not as many as Jim Bunning. Jim Bunning has 37 or 38 grandchildren, he and his wife. I said to him, how do you remember all their names? And he says, if they're with their parents, I can remember them.

[Laughter.]

Senator CARPER. But we will look at your grandchildren pictures later, but thanks for sharing that airplane picture.

I was a naval flight officer, 5 years of active duty, and 18 years reserve, mission commander. And our jobs were to hunt for Red October, track Soviet nuclear submarines in all the oceans of the world, try to catch the bad guys coming into South Vietnam to resupply the Viet Cong, in our airplanes. It was interesting, we did mining operations and all kinds of stuff with our planes.

Our skippers, our commanding officers would always say to us, the most important thing you are doing today is not tracking Soviet nuclear subs. The most important thing you are doing is not surveillance of the oceans, it's not a mining missions, it's not trying to catch the bad guys slipping into South Vietnam or Cambodia. The most important thing you are doing today is to take off safely, to fly safely, to land safely.

And we tried to create a culture of safety in my squadron. We tried to do it in every naval aviation squadron. And we need a culture of safety, as I have said once or twice before, including to some of you, we need a culture of safety in every single nuclear power plant that we have now and those that we are going to build.

As the oversight Subcommittee on nuclear safety, it is our job to make certain that the NRC and everyone who works in a nuclear power plant knows that safety is our No. 1 priority. Only with a safety-focused nuclear industry can America reap the benefits of clean, safe nuclear power, not just now, but for a long time to come.

[The prepared statement of Senator Carper follows:]

STATEMENT OF HON. THOMAS R. CARPER, U.S. SENATOR
FROM THE STATE OF DELAWARE

Thirty years ago, a nuclear accident occurred at the Three Mile Island nuclear power plant in Middletown, Pennsylvania that would shake America's confidence in nuclear power.

The accident was a cooling malfunction that caused a partial melt-down of the reactor core, releasing a small amount of radioactivity.

The accident was determined to be caused by a combination of equipment failure and the inability of the plant operators to understand the reactor's condition during the event.

Unlike the Chernobyl disaster that occurred a few years later, the Three Mile Island's reactor vessel did not fail. The leaked radioactive gases were vented into the atmosphere through specially designed filters under operator control.

No immediate deaths occurred, and the Nuclear Regulatory Commission (NRC) estimated that approximately one additional cancer in the area would result from the accident.

Although any increases in the cancer rate is unacceptable—I think we would all agree—it could have been much worse.

But this accident had a profound impact on the public, the nuclear industry and the NRC.

Public confidence in nuclear power generation was shattered.

The clean-up effort took nearly 14 years and $1 billion.

Three Mile Island served as a wake-up call that we had become complacent on nuclear safety.

After the accident, the NRC, Congress, and the nuclear industry took a hard look at what we needed to do to make this industry safe and gain back the public's trust.

Under the direction of the NRC, the industry made sweeping changes.

Today the Nation's 104 operating nuclear reactors maintain high levels of safety and reliability.

Our plants have also become much more efficient over the past 30 years. As a result, we have been able to almost double our generation capacity since 1979.

These changes have given the nuclear industry one of the best safety records of any industry in the United States.

Now Americans realize that nuclear power can provide reliable energy, and can do it without polluting.

Reducing our country's dependence on fossil fuels—we will need to capture the winds off the shores of Delaware, the sun rays in Nevada, and the CO_2 off the coal plants in West Virginia. We will need to plug-in our cars in Detroit. But we will also need nuclear power.

We will need nuclear power to help us meet our clean air goals and our climate goals.

But broad support for the nuclear industry will vanish if another nuclear accident occurs.

Without a safe nuclear industry, there will be no nuclear industry.

As the oversight committee on nuclear safety, it is our job to make certain that the NRC and everyone who works in a nuclear power plant knows safety is the No. 1 priority.

Only with a safety-focused nuclear industry can America reap the benefits of clean, safe nuclear power.

Senator CARPER. And that ends my statement, and the ending of my statement coincides with the arrival of a couple of my colleagues. They wanted to wait until I finished. They have heard me give these statements before. But we have a new Ranking Member here, and it is David Vitter from Louisiana.

Senator Vitter, would you like to proceed?

OPENING STATEMENT OF HON. DAVID VITTER, U.S. SENATOR FROM THE STATE OF LOUISIANA

Senator VITTER. Thank you, Mr. Chairman. I will specifically not say it was perfect timing on our part. The thought never crossed my mind.

It is great to be with you and great to be a new partner with you on this Subcommittee. We had a very good initial discussion last week, a few days ago, which I really enjoyed, and look forward to this work.

I will simply say that I appreciate this hearing because we do have the opportunity, an enormously positive opportunity, for a nuclear renaissance in our Country. We need to pursue that aggressively and effectively to meet all of our energy and related environmental goals. And obviously, we need to pursue that in a context of safety. That is not only the right way to do it. That is the only way it will effectively happen, is to have the proper confidence of the American people in that regard.

We are very active in all these pursuits in Louisiana, and we will continue to be in this nuclear renaissance. I look forward to hearing from all of our witnesses about this.

Thank you, Mr. Chairman.

[The prepared statement of Senator Vitter follows:]

STATEMENT OF HON. DAVID VITTER, U.S. SENATOR FROM THE STATE OF LOUISIANA

I'd first like to thank the Chairman, Senator Carper, for holding this hearing as an opportunity discuss what we have learned and to look forward and advance the

future of the nuclear power industry. I enjoyed our conversation last week and believe there is an excellent opportunity on this subcommittee to work in a bipartisan manner to get some good things done. And for that I want to thank you.

Second, I'd like to thank all the witnesses here today to discuss everything we have learned over the last 30 years. We have a distinguished panel here today that includes current and past NRC commissioners, as well as a former Governor and the head of the foremost institute on nuclear energy and safety. Thanks to all of you for your time.

The accident at the Three Mile Island Unit 2 (TMI–2) nuclear power plant near Middletown, Pennsylvania, on March 28, 1979, was the most serious in U.S. commercial nuclear power plant operating history.

Fortunately, the accident caused no injuries or deaths. In addition, experts concluded that the amount of radiation released into the atmosphere was too small to result in discernible direct health effects to the population in the vicinity of the plant.

Several independent studies have also been conducted. Estimates are that the average dose to about 2 million people in the area was only about 1 millirem. To put this in context, exposure from a chest x-ray is about 6 millirem. In other words, a chest x-ray exposes you to about 6 times the amount of radiation people were exposed to during the most significant nuclear accident in U.S. history.

However, the accident was still an accident and did more to hurt public opinion of nuclear power than it did to the environment. Fortunately, the increased scrutiny came with increased vigilance by the NRC and other organizations.

An important positive impact of the accident was that it brought about sweeping changes involving emergency response planning, reactor operator training, human factors engineering, radiation protection, and many other areas of nuclear power plant operations. It also caused the U.S. Nuclear Regulatory Commission to tighten and heighten its regulatory oversight. Resultant changes in the nuclear power industry and at the NRC have had the ultimate effect of enhancing safety.

Within 9 months of the accident, the industry had formed the Institute of Nuclear Power Operations (INPO), whose mission is to promote the highest levels of safety and reliability in the operation of nuclear power plants.

To improve training, INPO in 1985 formed the National Academy for Nuclear Training. The academy reviews and accredits nuclear utilities' training programs for all key positions at each plant.

INPO has had a profound impact on the way nuclear plants are managed and operated. The proof is the steady improvement in plant performance in the nearly 30 years since the accident at TMI.

Today, the Nation's 104 operating reactors maintain high levels of safety and reliability, as evidenced by the NRC's reactor oversight program and performance indicators tracked by the World Association of Nuclear Operators.

Finally, I believe it is also important to note that universities and students across this Country are very excited about the potential of nuclear energy. On August 14, 2008, a U.S. News and World Report article was titled The New Hot Job: Nuclear Engineering. The article stated, "After decades of declining interest in the field, universities are scrambling to keep up with the newfound demand" and "Not only are the existing programs growing near capacity, but departments that shuttered years ago are finding new life."

As well, Louisiana State University, which of course is in my home State, advertises that "at the present time, demand for nuclear engineers and health physicists exceeds the supply, so that graduates in these areas have excellent prospects for obtaining well paid jobs in some phase of the nuclear field."

Indeed, these are very exciting times for an industry that is quite capable of providing high-paying jobs to American workers as well as providing consistent and reliable energy for decades. Thank you for your time and I look forward to questions.

Senator CARPER. Welcome aboard. We are delighted to have you as my seatmate here.

Senator Inhofe chaired this Subcommittee for a number of years, and he began chairing the Subcommittee at a time that I don't know that Congress was providing especially good oversight over the nuclear industry. That changed under his leadership, and he continues to have a strong interest in this, and I am delighted that he is with us today.

Senator Inhofe.

OPENING STATEMENT OF HON. JAMES M. INHOFE, U.S. SENATOR FROM THE STATE OF OKLAHOMA

Senator INHOFE. Well, I appreciate that, Senator Carper. It is true, too. I recall, we were just talking back here trying to remember just when it was I became Chairman of this Subcommittee. I think it was 13 years ago. And at that time, there had not been an oversight hearing in years. And you know, the interesting thing was that the NRC was very anxious to start having oversight hearings. So we had oversight hearings, and then we kind of put down goals and deadlines, and we got some things really started at that time, I believe.

And of course, at that time it was just 17 or 18 years after Three Mile Island. Our concern was always, you know, did we really learn something from that. And you point out very well, although for different reasons than I would have, nuclear energy in the future, it is going to have to be there. We cannot run this machine called America without the nuclear component.

And it seems to me that it shouldn't take as long as it does take to get new applications working. I hope that we are going to be able to improve that.

Studying the past is useful in so far as it guides improvement for the future, and I am glad that you are having this hearing because it is one that is certainly necessary now. No one should be pleased that the accident did happen, but I am very pleased that the Commission and industry have spent the last 30 years improving the safety of our existing plants and preparing to build new reactors.

So I think that we have done a good job. I think you are certainly carrying this leadership on, Senator Carper, and it is something that, I can't think of anything more important that is happening in America today in terms of our future capability to run this machine than to be talking about nuclear energy.

I would like also to hear in the opening statements from all of you how we can improve the timeframe that it takes to get these applications handled and perhaps something that we will be able to do to reach our goals a little quicker than we otherwise would. I appreciate your having this hearing.

[The prepared statement of Senator Inhofe follows:]

STATEMENT OF HON. JAMES M. INHOFE, U.S. SENATOR FROM THE STATE OF OKLAHOMA

The accident at Three Mile Island was a culmination of several mistakes. As with any mistake, there are lessons to be learned. Critics of the nuclear industry frequently point to it and say neither the industry nor the Nuclear Regulatory Commission have learned anything from it and plants are just as risky today as Three Mile Island was then. Mr. Chairman, I strongly disagree.

My first observation is that this accident validated the defense-in-depth concept which is the basis for nuclear safety. In spite of equipment malfunctions, design flaws, and human errors, radiation exposure to the public was within regulatory limits and was proven to have produced no discernable health effects.

My second observation is that 30 years have passed and we haven't had another accident like this one, which partially melted a nuclear reactor core. That doesn't mean that the industry and the Commission can sit back and relax—they can't. It is our responsibility in this Committee to ensure that they do NOT become complacent.

However, studying the past is useful insofar as it guides improvement for the future. I'm glad that Chairman Carper has chosen to focus this hearing on the con-

structive ways that the Commission and the industry have addressed those shortcomings rather than simply Monday-morning-quarterbacking a 30-year-old event.

Even though there were no discernable health effects, the Three Mile Island accident was a transformational event. Many analyses of this accident were done, cataloging the various equipment malfunctions, design flaws, human errors, and poor communication. The analyses formed the basis for the NRC to impose many new regulatory requirements and for the industry to establish a more coordinated effort to improve safety and performance. The most important lesson is the need for both the industry and the regulator to be vigilant about improving the safety of nuclear energy. As Senator Carper is fond of saying, "If it isn't perfect, make it better."

This vigilance is very evident in the effort to license new plants. The NRC has indicated to this Committee that it will spend approximately 5 years reviewing new reactor designs before granting certifications. While I'm not thrilled with how long that process takes, the current process will be more predictable and is clearly an improvement over how new plant licensing was conducted in the '70s and '80s. Modern technology has also yielded great improvements in plant equipment reliability and control rooms that reduce the potential for human error.

No one should be pleased that the accident happened. But I AM very pleased that the Commission and the industry have spent the last 30 years improving the safety of our existing plants and preparing to build new reactors that are even safer. This vigilance will ensure that our Country will continue to benefit from clean and reliable nuclear energy for years to come. This is the true legacy of Three Mile Island.

Senator CARPER. Senator Inhofe, thanks very much, thanks for your leadership and your continued strong participation.

Another former Chair of this Subcommittee has bailed on me and gone over to be the Ranking Republican on, what is it, the Transportation and Infrastructure Subcommittee, George Voinovich of Ohio, but it has been great working with Senator Voinovich on these issues and a bunch of others.

Senator Voinovich, you are recognized.

OPENING STATEMENT OF HON. GEORGE V. VOINOVICH, U.S. SENATOR FROM THE STATE OF OHIO

Senator VOINOVICH. Thanks very much, Mr. Chairman and Ranking Member Vitter.

I want to welcome Senator Vitter to this Subcommittee. I served on it for 8 years, either in the chairmanship or Ranking Member, and Brother Carper and I have had some fun together.

Mr. Chairman, I take great pride in the fact that this Committee has helped transform the Nuclear Regulatory Commission into one of the best and most respected regulatory agencies in the world. We worked very hard placing the right people on the Commission, providing the Commission with the resources and tools necessary to do its job, and holding them accountable for the results.

We have held more than 20 hearings involving the NRC in the past 8 years. A good number of those hearings were related to the Davis-Besse incident in 2002, and we took the NRC to task as it was initially reluctant to address the issue of safety culture. So it is no accident that we have seen dramatic improvements in both the safety records and reliability of the 104 operating reactors today, compared to 2002.

And I would like to take this opportunity to thanks and recognize each member of the Commission for the outstanding job that you do day to day. Being a regulator often is a thankless job, whether it is the NRC, FAA, FDA, or the Federal Reserve Board. It seems as though the only time people care about what you do is when something goes wrong, and it is almost always to criticize what you did or didn't do. And you should be very, very proud of your record.

Indeed, a regulator's job is a complex and difficult one. It is like a high wire balancing act. You can't be too far to the left or too far to the right. It has to be just right. The Fed has to keep the interest rates just right, otherwise it will result in either recession or inflation. Similarly, the NRC has to be vigilant at all times to keep its regulatory threshold just right. It should be tight enough to prevent complacency, both within the agency and the industry it regulates, but not overly restrictive to a point of stifling the growth of nuclear power in this Country at a time when it is most needed.

I think today's hearing provides us with an opportunity to reflect upon the past, present and future of the industry. Clearly, the nuclear power industry has come a long way since the 1960s and 1970s. The Three Mile Island accident in 1979, however unfortunate, provided an experience through which both the industry and the NRC were humbled, and have matured into stronger, safer entities.

There were many lessons learned from TMI, as we will hear from the witnesses today. But one that resonates with me the most as a policymaker is something that Admiral Rickover said, "Nuclear power is not to be feared, but to be respected."

I recently met with Mr. Andre Lacoste, the Chairman of the French Nuclear Regulatory Agency, and he said something very interesting. He said that many European countries that adopted a policy of phasing out nuclear power following Chernobyl in 1986, countries like Italy, Sweden, UK, and perhaps even Germany, are now re-embracing nuclear power.

I was at the German Marshall Fund this last week and heard again that they are really thinking about really getting back into nuclear power. He thought there were two main reasons for this. One is the recognition that the newly adopted carbon reduction mandate cannot be achieved through energy efficiency and renewables alone. And the other is the recognition of the improved safety records and reliability of nuclear power plants, and maybe the jobs that are created in the nuclear power industry that nobody is talking about. They are tremendous jobs. In fact, in my opinion, we have had more jobs created in this Country in the area of nuclear power than we have in windmills and solar.

And for the benefit of my colleagues on this Committee, I would like to share with you a portion of a speech given by British Prime Minister Gordon Brown last week. The speech is entitled, Nuclear Energy and Proliferation. And I quote Brown's speech. He said, "Because whether you like it or not, we will not meet the challenges of climate change without far wider use of civil nuclear power. Given the scale of global emissions reductions required and the like cost, no cost-effective low carbon technology must be off limits."

And the International Energy Agency estimates that we must build 32 nuclear reactors globally every year, every year, if we are going to meet the emissions standards that they have laid out for 2050.

So he goes on to say, "So however we look at it, we will not secure the supply of sustainable energy on which the future of our planet depends without a role for civil nuclear power."

Mr. Chairman, as you know, this is exactly the message that you and I have tried to convey to the Senate during the climate change debate last year. We conducted four roundtables in the last Congress to identify solutions to making the nuclear renaissance a reality in this Country. And I hope we continue this effort during this Congress through the formation of a Senate Caucus on Nuclear Energy. We have to do that if we are to continue to have this nuclear renaissance that I think is so necessary.

Thank you, Mr. Chairman.

Senator CARPER. Senator Voinovich, thank you so much.

Our first panel of witnesses, I think you folks have been here once or twice before. It is good to see you again. We are grateful for your service and grateful for your preparation and participation today.

Chairman Dale Klein will speak first, and be followed by each of his three colleagues, Mr. Greg Jaczko, Peter Lyons, and Kristine Svinicki.

It is great to see all of you. Thank you for being here. Please proceed.

STATEMENT OF DALE E. KLEIN, CHAIRMAN, NUCLEAR REGULATORY COMMISSION

Mr. KLEIN. Thank you, Mr. Chairman, Senator Vitter, and Members of the Subcommittee. Thank you for inviting me and my fellow Commissioners to appear before you today to discuss the lessons learned from the Three Mile Island nuclear power plant 30 years ago.

My written testimony provides some historical background on the accident, addresses the NRC's response, and outlines some of the regulatory improvements that have been implemented, and mentions one ongoing challenge.

In my brief summary, let me just say that the NRC has come a long way in 30 years. We have an excellent team of highly competent staff who are very focused on the agency's mission. In fact, I should draw your attention to the results of the Office of Personnel Management's human capital survey of 2008 which was reported in The Washington Post on March 13. The NRC ranked first in leadership and knowledge management; second in results-oriented performance culture; first in talent management; and just for the sake of completeness, let me also mention, first in job satisfaction.

On the matter of Three Mile Island, let me assure you that the Commission has not forgotten about the accident that occurred there. Last week, we distributed to all Members of the Committee a recent paper by NRC's historian, Three Mile Island After 30 Years, which was developed as part of an effort to ensure that current and future NRC employees learn from what happened.

In addition, the agency will hold a seminar tomorrow for NRC employees to explain what happened and what lessons the agency learned. A number of our presenters, including former Pennsylvania Governor Richard Thornburgh and former NRC Director for the Office of Nuclear Reactor Regulation Harold Denton, are participating at this hearing during the second panel of witnesses.

One of the most important changes that has occurred over the last 30 years is an intensive focus on what we call a strong safety culture, both in industry and internally within the NRC. The agency's wide-ranging safety improvements include personnel training, internal processes and procedures, infrastructure and planning, technological upgrades, oversight and risk assessment methodologies, and safety culture expectations.

The results of these efforts by the NRC and by industry are evident in the handout which shows in quantifiable terms the significant improvements in safety at nuclear power plants that have been achieved. And these are shown on two posters to my right and to my left.

In addition to safety improvements, the agency has also implemented a variety of enhancements in the area of security, especially since 9/11. In recent years, the NRC has required increased patrols, stronger and more capable security forces, additional physical barriers, enhanced emergency preparedness and response plans, and many other heightened security measures.

With all this, however, the NRC still faces one ongoing challenge, which is something that confronts every industry and every regulator that is concerned with safety. I am referring to the danger of complacency. Guarding against complacency must involve a rigorous and conscientious commitment to maintaining high standards of safety and security. That effort includes remembering the past, learning from where we have been, and ensuring that past mistakes are not repeated.

This hearing contributes to all of these goals, and I appreciate the Committee's interest in understanding the lessons that have been learned and implemented at the NRC.

To answer Senator Inhofe's question about efficiency, I should point out, and we can talk more of this, we are looking at Lean Six Sigma to make sure that we can be more efficient with no compromise on safety, and we can talk more about that as we go forward.

Mr. Chairman and Members of the Committee, this concludes my opening statement. Thank you for having me and my colleagues today, and I look forward to your questions.

[The prepared statement of Mr. Klein follows:]

WRITTEN TESTIMONY
OF DALE E. KLEIN, CHAIRMAN
UNITED STATES NUCLEAR REGULATORY COMMISSION
TO THE
SENATE COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS
SUBCOMMITTEE ON CLEAN AIR AND NUCLEAR SAFETY

MARCH 24, 2009

Mr. Chairman, Senator Vitter, and distinguished members of the Subcommittee, I want to thank you for inviting Commissioner Jaczko, Commissioner Lyons, Commissioner Svinicki and me to appear before you today to discuss the lessons learned from the Three Mile Island (TMI) Nuclear Power Plant accident 30 years ago.

My testimony will provide some historical background to explain what happened, address the U. S. Nuclear Regulatory Commission's (NRC) response and outline some of the major regulatory improvements implemented to enhance nuclear safety and security, and mention two significant challenges that still remain unresolved.

The March 28, 1979 accident remains the single most important event in the history of the NRC and the commercial nuclear power industry in the United States. The TMI crisis revealed weaknesses in the licensing and operation of nuclear plants and brought about critical improvements in assumptions, procedures, and priorities—both at the NRC and in industry.

One of the most important changes that has occurred over the last 30 years is an intensive focus on creating what we call a strong "safety culture"—both in industry and internally at the NRC. In addition to the specific changes made in direct response to the accident at Three Mile Island, I will discuss a number of broader steps the agency has taken to promote a work environment where management and employees are dedicated to putting safety and security first.

It is important to note that we have come a long way in the past 30 years in improving the regulatory oversight of nuclear power plants. But we must also continue to remember the past, to learn from where we have been, and to ensure that past mistakes are not repeated.

This hearing contributes to all of these goals; and I appreciate the Committee's interest in understanding the lessons that have been learned and implemented.

I assure you, the Commission has not forgotten about the TMI accident. In fact, some of the historical background I will outline is adapted from a recent paper by the NRC's historian, Dr. Samuel Walker, entitled "Three Mile Island after Thirty Years," which was developed as part of an effort to ensure that current and future NRC employees learn from what happened at TMI. Moreover, in 2004, Dr. Walker published ***Three Mile Island: A Nuclear Crisis in Historical Perspective*** as Volume 4 in a series of books on the history of nuclear regulation.

Because many current NRC employees are too young to remember what happened at TMI and/or were not working at NRC when the accident occurred, the Agency will hold a seminar tomorrow for these NRC employees. The seminar will include an explanation of the accident from a technical perspective, personal insights from an operator in the control room, and a discussion of the event from the point of view of the White House, State government, and the NRC. A number of presenters—including former Pennsylvania Governor Richard Thornburgh and former NRC director of the Office of Nuclear Reactor Regulation Harold Denton—are also participating in this hearing. Video-teleconferences have been arranged at all NRC locations to ensure that all NRC employees have an opportunity to benefit from this offering.

HISTORICAL BACKGROUND

Unit 2 of the Three Mile Island nuclear generating station was the newer of two reactors located on a sliver of land in the Susquehanna River about 10 miles southeast of Harrisburg, Pennsylvania. The accident was the result of a series of mechanical failures and operator errors that (researchers later determined) uncovered the reactor's core and melted about half of it. The immediate cause of the accident was a pressure relief valve that stuck open and allowed large volumes of water to escape from the reactor coolant system. The instrument

panel did not provide a clear picture of what was happening in the reactor, and the operators failed to recognize that the core was overheating. Although the plant's emergency core cooling systems began to work according to design, the operating crew, acting on the training they had received, decided to reduce the flow of emergency coolant to a trickle. By the time the operating crew recognized that the plant had suffered a loss-of-coolant-accident and flooded the core with coolant, the reactor had been irreparably damaged.

The initial response to the accident by Federal and State authorities was hesitant and uncertain, largely because no one could confidently assess the condition of the reactor or estimate the risk of releasing significant amounts of radiation to the environment. Thus, decision makers and their technical advisers were faced with having to make crucial decisions with only fragmentary information at their disposal. The most important—and the most excruciating—dilemma was whether to order an evacuation of the area surrounding the plant. On the one hand, if the containment vessel leaked, and the walls of the containment building that surrounded the reactor were breached, radioactive material would be released into the environment. On the other hand, Governor Thornburgh was acutely aware that ordering a large-scale evacuation also presented serious risks of panic and injury.

The greatest source of concern was a hydrogen bubble that formed in the reactor vessel, the large container that held the reactor core. At first, experts feared that the bubble could inhibit efforts to cool the core and bring it to a safe shutdown condition. However, another issue soon arose. Scientists, engineers, and government officials began to worry that the bubble, over time, might become flammable or even explosive. Some believe that in a worst case scenario, a burn or explosion could rupture the pressure vessel. If this occurred, it would increase by uncomfortable proportions the chances of a breach of the containment building, the last line of defense against a release of radiation. Eventually, it became clear that the bubble was not as significant a problem as originally thought. The absence of free oxygen

in the pressure vessel prevented the bubble from reaching a flammable or explosive condition. But this was not obvious immediately, and it took time to arrive at this conclusion.

The resolution of the bubble question ended the acute phase of the TMI crisis. However, the accident vividly demonstrated a series of unsettling problems that demanded immediate attention. Internally, the NRC undertook a number of investigations and instituted a Special Inquiry to review and report on the accident. The results of this inquiry, known as the Rogovin Report, described what happened and why, assessed the actions of the utility and NRC personnel before and during the accident, and identified deficiencies in the regulatory regime and areas where further investigation might be warranted. The NRC promptly took action to correct the deficiencies that the accident had revealed in key areas, including operator training, instrumentation, communications, evaluation of operating data, and emergency planning.

In addition to the reforms the NRC adopted based on internal findings, the Agency responded to a series of recommendations made by the President's Commission on the Accident at TMI. President Carter established the Commission on April 11, 1979, and named John G. Kemeny, President of Dartmouth College, as its Chairman. The White House deliberately avoided placing anyone on the panel that was associated with strong pro- or anti-nuclear views. The Kemeny Commission held a series of public hearings, took more than 150 depositions, and collected a vast body of documentary evidence. Findings were presented to President Carter on October 30, 1979, and released to the public the following day. The completed study consisted of a 179-page overview and nine volumes of task force reports that totaled more than 2,200 pages.

The central feature of the Kemeny Commission report was a list of 44 recommendations that the panel deemed of "vital importance" for reducing and managing the risks of nuclear power. The Kemeny panel broke down its proposed reforms into seven broad categories: the NRC, the utility and its suppliers, training of operating personnel, technical assessment, worker

and public health and safety, emergency planning and response, and the public's right to information. Dr. Walker's pamphlet, which I mentioned earlier, is attached to this testimony and provides a detailed discussion of the Kemeny Commission recommendations, so I will not repeat them here. I think it is sufficient to note that they were comprehensive and wide-ranging.

The NRC's response to the Kemeny Commission's recommendations, as well as its own internal investigation, led to important improvements in regulatory approaches and performance. An obvious example was the increased emphasis on human factors, which reflected the Kemeny Commission's conclusion that the "fundamental problems" at TMI were "people-related problems and not equipment problems." In 1989, the NRC published a report, "The Status of Recommendations of the President's Commission on the Accident at Three Mile Island: A Ten-Year Review," that described its response to each of the 44 recommendations of the Kemeny Commission over a period of ten years.

REMEMBERING TMI IN A CHANGING REGULATORY ENVIRONMENT

During the three decades since the TMI accident, the focus of nuclear regulation has shifted in accordance with changes in the nuclear industry. In 1979, the licensing of new plants was one of the NRC's most important and visible activities. By the mid-1980s, however, most of the plants that had been under review at the time of the accident had either been awarded operating licenses or had been cancelled. The NRC received no new applications for construction permits, the first phase of what was then a two-step licensing process, after 1978. As a result, the licensing of plants ceased to be a major function and the NRC focused primarily on regulation and oversight of the operation of existing plants.

The Agency's wide-ranging improvements in ensuring higher standards of nuclear safety and security over the past thirty years include personnel training, internal processes and procedures, infrastructure and planning, technological upgrades, oversight and risk

assessment methodologies, and safety culture expectations. In fact, discussing in detail every specific improvement—such as requiring two NRC resident inspectors at every nuclear power plant site, or the massive overhaul and modernization of our Incident Response Center—would be too extensive for this testimony.

Allow me, however, to list some of the key changes:

- Upgrading and strengthening of plant design and equipment requirements. This includes piping systems, auxiliary feedwater systems, containment building isolation, reliability of individual components (pressure relief valves and electrical circuit breakers), fire protection, and the ability of plants to shut down automatically;
- Identifying human performance as a critical part of plant safety, enhancing and simplifying emergency operating (or accident) procedures, revamping operator training and staffing requirements, followed by improved instrumentation and controls for operating the plant, and establishment of site-specific simulators which has allowed extensive "what-if" training for licensed operators;
- Improving instruction to avoid the confusing signals that plagued operations during the accident;
- Enhancing emergency preparedness to include immediate NRC notification requirements for plant events and an NRC operations center staffed 24 hours a day with access to plant status data. Drills and response plans are now tested by licensees several times a year, and State and local agencies participate in drills with the Federal Emergency Management Agency and NRC;
- Establishing a program to integrate NRC observations, findings, and conclusions about licensee performance and management effectiveness into a periodic, public report;
- Performing regular analysis of plant performance by senior NRC managers who identify those plants needing additional regulatory attention;

- Expanding NRC's resident inspector program – first authorized in 1977 – whereby at least two inspectors live nearby and work exclusively at each plant in the U.S. to provide daily surveillance of licensee adherence to NRC regulations;
- Expanding performance-oriented as well as safety-oriented inspections, and the use of risk assessment to identify vulnerabilities of any plant to severe accidents;
- Strengthening and reorganization of enforcement as a separate office within the NRC;
- The installing of additional equipment by licensees to mitigate accident conditions, and monitor radiation levels and plant status;
- Employing major initiatives by licensees in early identification of important safety-related problems, and in collecting and assessing relevant data so lessons of experience can be shared and quickly acted upon;
- Expanding NRC's international activities to share enhanced knowledge of nuclear safety with other countries in a number of important technical areas.

Although it is not an element of the NRC's work, I would be remiss if I did not mention one other critical improvement: the establishment of the Institute of Nuclear Power Operations (INPO), the industry's organization which promotes excellence in the safety and operating performance of nuclear power plants around the country by sharing data and best practices.

SECURITY IMPROVEMENTS

Of course, one key change in the regulatory environment for nuclear power since 1979 had nothing to do with Three Mile Island. The terrorist attacks on the World Trade Center and the Pentagon on September 11, 2001, brought about a thorough reassessment of the security of nuclear plants.

Since 9/11 the NRC has required many security enhancements at licensed power reactors and other nuclear facilities. Our licensees now have increased patrols, stronger and

more capable security forces, additional physical barriers, greater standoff distances for vehicle checks, more restrictive site access controls, enhanced emergency preparedness and response plans, enhanced coordination with law enforcement authorities, and many other heightened security measures.

In addition, on a voluntary basis, licensees report suspicious activities occurring at or near their facilities. Also, NRC intelligence analysts screen Intelligence Community threat reporting on a daily basis, looking for threats to NRC licensed facilities and materials as well as for changes in the general threat environment that could affect the security posture at the facilities we license. This information is analyzed within the context of other threat data and is shared with DHS and the Federal Bureau of Investigation (FBI).

The NRC also has significantly increased its ability to provide effective oversight of security at power reactor facilities. In 2000, NRC inspectors spent about 40 staff-weeks a year directly inspecting security. More recently, the NRC has been spending over 200 staff-weeks per year on security. In addition, the NRC now conducts much more realistic force-on-force exercises as part of its security inspection program, in which a highly trained mock adversary force simulates an attack on a facility. The transition to this enhanced force-on-force program occurred in November 2004. Since then, NRC has conducted more than 250 of these full-scale exercises and continues to work, using lessons learned, to make the exercises even more realistic. We also have required power plants to add more training and higher qualification standards for security personnel and to increase substantially the numbers of security personnel, among other measures. In our security efforts, the NRC coordinates extensively with the DHS, FBI, and other Federal entities in integrating nuclear security efforts into national security planning. Most recently, the Commission approved a rule that requires applicants for new power reactors to assess the ability of their reactor designs to avoid or mitigate the effects of a large commercial aircraft impact.

THE REMAINING CHALLENGES

The NRC still faces two significant challenges, one discrete and one ongoing. The discreet challenge is something that was recommended by the Kemeny Commission and yet remains partially unresolved to this day. At the time of the TMI accident, the NRC occupied several different office buildings, and the Kemeny Commission called for a consolidation of the Agency in the same location to improve communication and provide for a coordinated emergency response. This was largely accomplished when the NRC moved into adjacent buildings in Rockville, Maryland, between 1987 and 1994. But as the NRC has grown in size in recent years, the Agency has exceeded the capacity of the current two building headquarters complex and has acquired temporary office space in the Rockville area to accommodate this growth. I would like to thank Congress for supporting NRC's efforts to pursue a third building adjacent to the current White Flint complex so that we can accommodate our staff, shed temporary offices, and again have a consolidated headquarters.

The ongoing challenge is something that confronts every industry and every regulatory body concerned with safety: the danger of complacency. Before the TMI accident, reactor experts were confident that they had solved the most important reactor safety issues. This confidence and the complacency it fostered were shattered on the morning of March 28, 1979, by the combined forces of management weakness, limited operator training, inattention to human factors, and confusing instrumentation. In recent years, several identified operating deficiencies have underscored the continuing need for strong safety requirements and effective implementation. The most serious example was discovered at the Davis-Besse plant in Ohio in 2002. Both the licensee and the NRC failed to detect corrosion before it resulted in a large gap in the head of the pressure vessel. Although the problem did not result in a breach of the primary coolant system, it was the most serious safety issue since the Three Mile Island accident, and highlights the potential consequences of careless operating practices and flawed regulatory procedures.

To help guard against complacency, the NRC has been working to improve safety culture, throughout the industry and within the agency, for at least two decades.

- In 1989, in response to instances of operator inattentiveness and unprofessional behavior in the control room of some nuclear power plants, the Commission first published a policy statement to foster the development and maintenance of a safety culture at nuclear power plants.
- In 1996, in response to reports of management retaliation against licensee personnel for raising safety concerns, the Commission issued a policy statement affirming its expectation for NRC licensees to establish and maintain a safety-conscious work environment in which employees would feel free to raise concerns both to their own management and the NRC without fear of retaliation.
- In 2003, the Commission directed the staff to develop guidance that would identify best practices for establishing a safety-conscious work environment and to consider developing objective measures that could serve as indicators of possible problems with safety culture.
- In 2006, the agency enhanced the Reactor Oversight Process to, in part, implement lessons learned from the Davis-Besse incident.

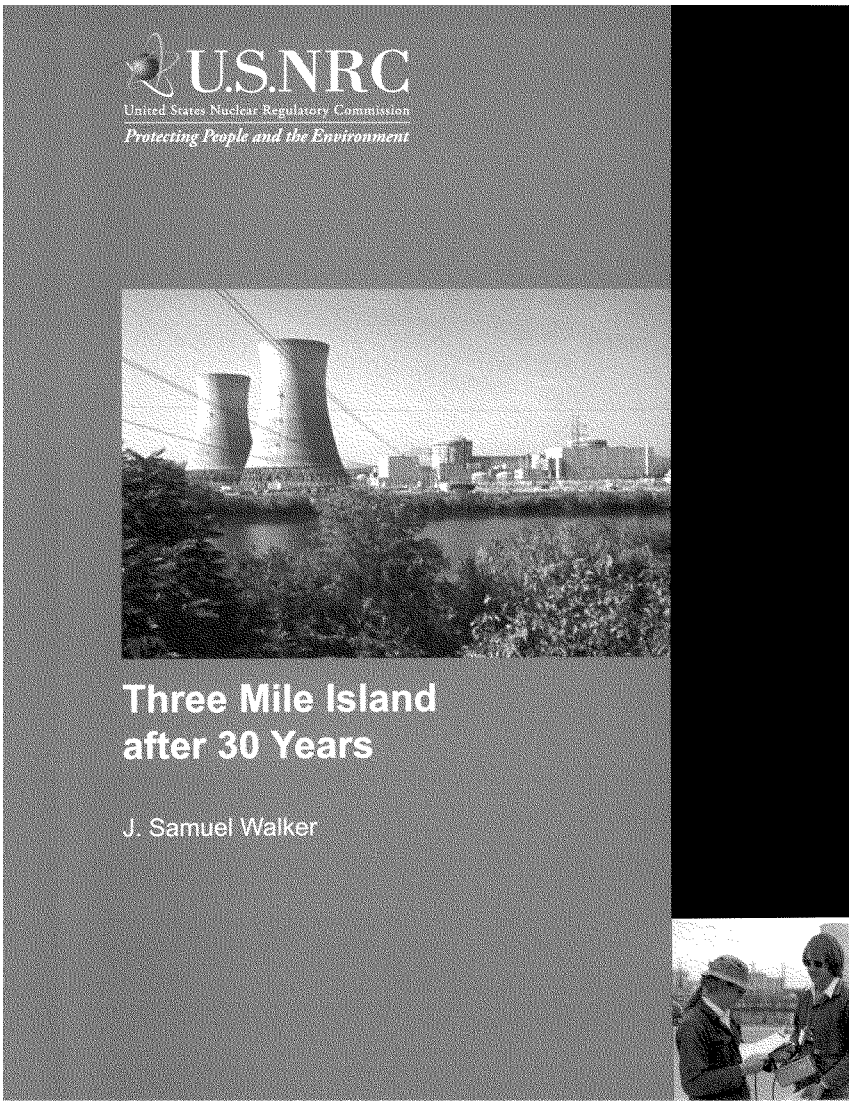
The NRC has a vigorous, ongoing, conscientious commitment to maintaining a strong safety culture. Because it is something that requires constant attention, it is a subject I mention frequently in my speeches and remarks to the staff—including, most recently, my keynote address at the Agency's Regulatory Information Conference two weeks ago.

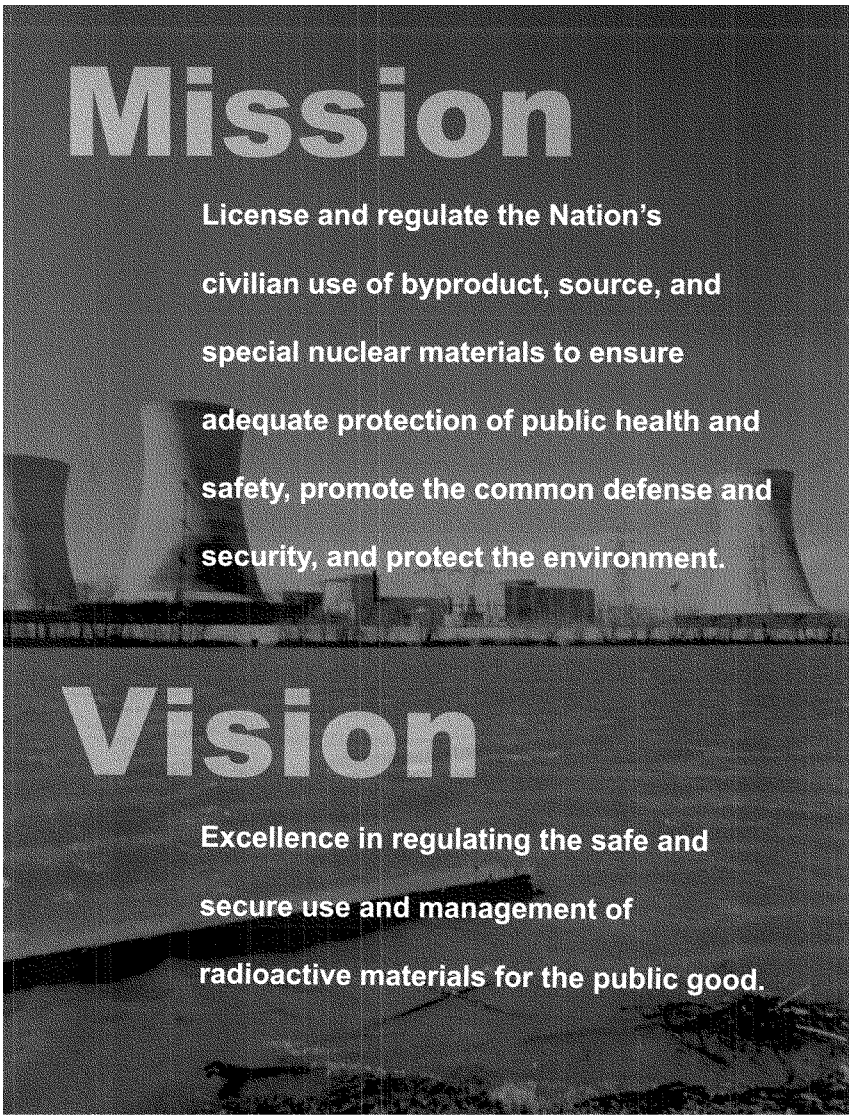
CONCLUSION

As the NRC evaluates the first applications for newly-ordered plants in three decades, the Agency can take pride in the improvements made since the crisis of 1979. However, the

Three Mile Island event remains a stark reminder of the need for strong performance, effective oversight, and unrelenting vigilance. As I said at the start of my testimony, it is important to note that we have come along way over the last 30 years. It is equally important that we continue to remember the past, to learn from where we have been, and to ensure that the mistakes of the past are not repeated.

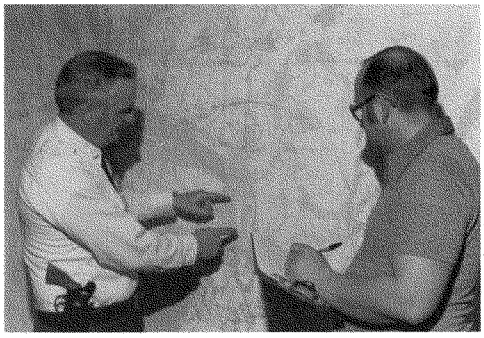
Mr. Chairman and Members of the Committee, thank you for having me and my colleagues here today. I look forward to answering your questions.


U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment
Three Mile Island
after 30 Years
J. Samuel Walker


Mission
License and regulate the Nation's civilian use of byproduct, source, and special nuclear materials to ensure adequate protection of public health and safety, promote the common defense and security, and protect the environment.
Vision
Excellence in regulating the safe and secure use and management of radioactive materials for the public good.

THE ACCIDENT

The Three Mile Island (TMI) accident, which occurred on March 28, 1979, remains the single most important event in the history of the NRC and the commercial nuclear power industry in the United States. The TMI crisis revealed weaknesses in the licensing and operation of nuclear plants and brought about critical improvements in assumptions, procedures, and priorities—both at the NRC and in industry.



Planning for evacuation of the areas surrounding the plant.

Unit 2 of the Three Mile Island nuclear generating station (TMI-2) was the newer of two reactors located on a spit of land in the Susquehanna River about 10 miles southeast of Harrisburg, Pennsylvania. The accident was the result of a series of mechanical failures and operator errors that uncovered the reactor's core, and, researchers later determined, melted about half of it. The immediate cause of the accident was a pressure relief valve that stuck open and allowed large volumes of reactor coolant to escape from the core. The instrument panel did not provide a clear picture of what was happening in the reactor, and the operators failed to recognize that the core was overheating. Although the plant's emergency core cooling systems began to work according to design, the operating crew, acting on the training they had received, decided to reduce the flow of emergency coolant to a trickle. By the time that experts recognized that the plant had suffered a loss-of-coolant-accident and flooded the core with coolant, the reactor had been irreparably damaged.

THE RESPONSE TO THE ACCIDENT

The initial response to the accident by Federal and State authorities was hesitant and uncertain, largely because no one could confidently assess the condition of the reactor or estimate the risk of the release of large amounts of radiaton to the environment. Thus, decisionmakers and their technical advisers were faced with having to make crucial decisions with only fragmentary information at their disposal. The most important—and the most excruciating—dilemma was whether to order an evacuation of the area surrounding the plant. On the one hand, if the walls of the containment building that surrounded the crippled reactor were breached and released radioactive materials to the environment, the result would be a public health disaster. On the other hand, the Governor of Pennsylvania, Richard L. Thornburgh, was acutely aware that

Plant employees in the control room of TMI-2.

ordering a large-scale evacuation would present a serious risk of death or injury to some, perhaps many, of those who evacuated their homes.

The greatest source of concern was a hydrogen bubble that formed in the pressure vessel, the large container that held the reactor core. At first, experts feared that the bubble could inhibit efforts to cool the core and bring it to a safe shutdown. But another issue soon arose. Scientists, engineers, and Government officials began to worry that the bubble, over time, might become flammable or even explosive. In the worst case, it was feared, a burn or explosion could rupture the pressure vessel. If this occurred, it would increase by uncomfortable proportions the chances of a breach of the containment building, the last line of defense against a massive release of radiation. Eventually, after the public became increasingly anxious about the possibility of a "hydrogen explosion," it became clear that the bubble was not a problem. The absence of free oxygen in the pressure vessel prevented the bubble from reaching a flammable or explosive condition. But this was not immediately obvious. Meanwhile, the Three Mile Island accident generated intense media coverage of widely varying quality and triggered severe stress for both Government authorities and the population of central Pennsylvania.

THE KEMENY COMMISSION RECOMMENDATIONS

The resolution of the bubble question ended the acute phase of the TMI crisis. But the accident vividly demonstrated a series of unsettling problems that demanded immediate attention. The NRC promptly took action to correct the deficiencies that the accident had revealed in key areas that included operator training, instrumentation, communications, evaluation of operating data, and emergency planning.

In addition to the reforms it adopted on its own initiative, the NRC responded to a series of recommendations made by the President's Commission on the Accident at Three Mile Island. President Jimmy Carter established the commission on April 11, 1979, and named John G. Kemeny, president of Dartmouth College, as its Chairman. The White House deliberately avoided placing

anyone on the panel who was associated with strong pro- or anti-nuclear views. The Kemeny Commission held a series of public hearings, took more than 150 depositions, and collected a vast body of documentary evidence. It presented its findings to President Carter on October 30, 1979, and released them to the public the following day. The completed study consisted of a 179-page overview and nine volumes of task force reports that totaled more than 2200 pages.

The central feature of the Kemeny Commission report was a list of 44 recommendations that it believed were of "vital importance" for reducing and managing the risks of nuclear power. In light of the experience at Three Mile Island, the NRC and the nuclear industry took the Kemeny Commission's conclusions very seriously. The Kemeny Commission broke down the reforms it proposed into seven broad categories: the NRC, the utility and its suppliers, training of operating personnel, technical assessment, worker and public health and safety, emergency planning and response, and the public's right to information.

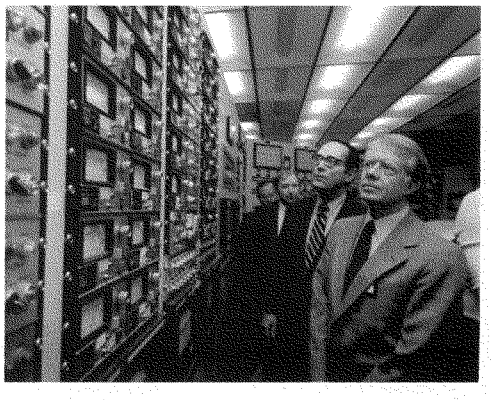
In 1989, the NRC published a report, "The Status of Recommendations of the President's Commission on the Accident at Three Mile Island: A Ten-Year Review (NUREG-1355)," that described its response to each of the 44 recommendations of the Kemeny Commission over a period of 10 years. Without repeating the NRC's discussions of each of the items, they are summarized in the following pages.

CATEGORY A: THE NUCLEAR REGULATORY COMMISSION

1. Agency Organization and Management

The Kemeny Commission concluded that the Commission-form of governance did "not possess the organizational and management capabilities necessary for the effective pursuit of safety goals." It recommended that the Commission be replaced by a single administrator who would exercise "substantial discretionary authority." It urged that the agency be located in the same building or adjacent buildings (rather than being housed in several buildings that were in some cases widely separated), and that the NRC improve its internal communications.

The White House staff and key members of Congress strongly opposed the recommendation to replace the Commission with a single administrator, and this recommendation was not adopted.



President Jimmy Carter, Pennsylvania Governor Thornburgh, and the NRC's Harold Denton, then Director of the Office of Nuclear Reactor Regulation, in the TMI-2 control room, April 1, 1979.

NRC's Denton, Governor Thornburgh, President Carter, and Rosalynn Carter with James R. Floyd, supervisor of TMI-2 operations.

However, in the Reorganization Plan #1 of 1980, President Carter, with the consent of Congress, strengthened the authority of the NRC Chairman, especially in case of an emergency, and the Executive Director for Operations (EDO). The NRC also consolidated its headquarters staff by moving into adjacent buildings in Rockville, Maryland in 1987 and 1994. It sought to improve internal communications by consolidating functions and by creating the positions of deputy EDOs to integrate staff activities.

2. The Agency's Substantive Mandate

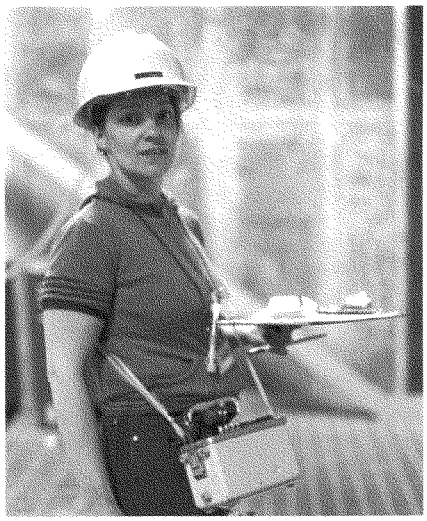
One of the clear lessons of TMI was the need for improved operator training and for better control room and instrumentation design. The Kemeny Commission called on the NRC to upgrade its training requirements for plant operators and supervisors. It also recommended that control room designs be reevaluated because the alarms and instruments at Three Mile Island had provided little useful information to the operators on the morning of the accident. Both of these items fell within the broad rubric of "human factors engineering."

The NRC toughened its standards for candidate screening and operator qualifying examinations. It required more demanding courses and examinations for periodic requalification. The NRC further required that all nuclear power reactor licensees provide simulator training that demonstrated "anticipated plant responses to normal, transient, and accident conditions." The agency also published guidelines for reviewing control room designs. It affirmed that after detailed reviews, licensees and applicants had made necessary improvements. In general, the NRC placed much greater emphasis on "human factors" than it had done before TMI accident.

The Kemeny Commission further recommended that the NRC apply a "broader definition of matters relating to safety," specifically on matters such as systems engineering, safety research, plant management during an emergency, mitigation of the consequences of an accident, and emergency planning.

The NRC addressed these matters in a number of changes in its regulations. For example, it

increased requirements for back-up power, containment building isolation, and rapid shutdown capability. It focused for the first time on the management capabilities of its licensees. It expanded its resident inspector program at each nuclear facility. In 1980, it established the "Systematic Assessment of Licensee Performance" to grade how well plants were meeting requirements. The NRC sponsored major research projects on the causes of severe accidents and ways to reduce the probability and consequences of such accidents. It worked with State and local Governments and other Federal agencies to enhance emergency planning beyond the capabilities that existed at the time of the Three Mile Island accident.



Measuring radiation levels in a plant building.

3. Agency Procedures

The Kemeny Commission called for a series of procedural reforms to improve the NRC's record in "resolving generic and specific safety issues." Among its recommendations was the systematic evaluation of operating plants to detect and report on "patterns in abnormal occurrences." This was intended to avoid overlooking precursors of potential accidents, as had happened at TMI. The Kemeny Commission also strongly urged a more rigorous inspection program and the assessment of "substantial penalties" for unsafe practices.

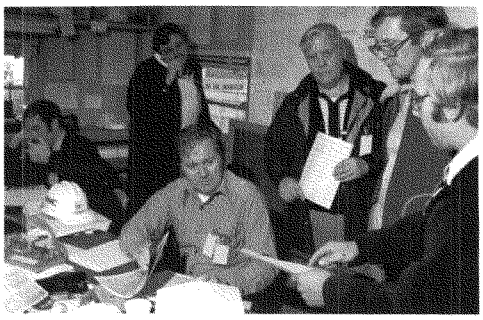
The NRC created the Office of Analysis and Evaluation of Operating Data to track and disseminate information about operating plants. Other offices within the NRC also expanded their review of operating experience and appraisal of plant performance. The NRC prevailed on Congress to amend the Atomic Energy Act to increase the maximum fines from $5,000 per-violation-per-day with a cap of $25,000 for all violations to $100,000-per-violation-per-day with no cap. The agency also increased its enforcement activities and made them "more aggressive."

CATEGORY B: THE UTILITY AND ITS SUPPLIERS

The Kemeny Commission directed the recommendations in this category mainly at the nuclear industry. They duplicated many of the items that it urged the NRC to improve, including operator training, evaluation of operating experience, emergency planning, and resolution of safety issues.

The industry's response to TMI, like the NRC's, was to take prompt actions to correct the deficiencies that the accident revealed. Among other steps, nuclear

utilities and vendors established the Institute of Nuclear Power Operations (INPO) in October 1979. Its mandate was not only to address the problems that the Kemeny Commission cited but also to promote excellence in the safety and operating performance of nuclear power plants around the country. INPO sought to improve the management of nuclear plants by encouraging much greater involvement on the part of senior executives. It also formulated standards for plant performance, rated the operation of plants according to those standards, and exerted a great deal of peer pressure on plant owners to achieve superior performance records. For its part, the NRC adopted criteria for judging corporate management and technical capabilities of utilities and vendors. The purpose of the criteria was "to assure that the corporate management is involved with, informed about, and dedicated to the safe design, construction, testing, and operation" of its nuclear plant(s).



NRC staff members discuss response to accident in trailer at TMI site.

CATEGORY C: TRAINING OF OPERATING PERSONNEL

The Kemeny Commission recommended that reactor operators and supervisors be trained at accredited institutions with "highly qualified instructors." It further advised that the courses should emphasize the fundamentals of nuclear power and the proper response to various kinds of emergencies. The Kemeny Commission also recommended that training be conducted on an continuous basis and that operators participate in regular training programs on reactor simulators.

Both the NRC and INPO took measures to improve operator training and knowledge. As a complement to the NRC's more exacting requirements, INPO set up extensive training and accreditation programs that were monitored by the NRC.

CATEGORY D: TECHNICAL ASSESSMENT

The Kemeny Commission offered a series of proposals on technical and design improvements. It called for changes in the design of control rooms and instrument panels that would provide "proper warning and diagnostic information" to operators in the case of an accident. It also recommended corrections in "design and maintenance inadequacies" that the TMI accident had made clear. Among the systems and functions that demanded attention were iodine filters, hydrogen recombiners, gas venting, containment isolation, and reading of water levels in containment. The Kemeny Commission urged that "in-depth studies" be conducted on the probabilities and consequences

of nuclear accidents, including the effects of a core meltdown.

The NRC required and the industry carried out many changes in control rooms and instrumentation to account more fully for "human factors design criteria." The agency also required that the design and maintenance problems that the Kemeny Commission identified be fixed, though it extended the deadlines for doing so in some cases because the improvements "proved so difficult to implement." The NRC also increased and redirected its research program to investigate critical issues that TMI had raised.

CATEGORY E: WORKER AND PUBLIC HEALTH AND SAFETY

The Kemeny Commission recommended "expanded and better coordinated" research projects to increase knowledge of the health effects of exposure to low-level radiation and ways of mitigating those effects. It also called for a much more effective means of monitoring radiation releases from nuclear plants during routine operations and during emergencies.

Within the constraints of its statutory mandate, the NRC sponsored several research projects on the health effects of exposure to low-level radiation, and it worked with other Federal agencies to increase knowledge of the subject. It required more extensive monitoring of radiation levels both within plants and in the surrounding regions.

CATEGORY F: EMERGENCY PLANNING AND RESPONSE

The Kemeny Commission recommended the preparation of emergency plans that "clearly and consistently" spelled out actions that should be taken to protect the public in the case of radiation releases from a nuclear accident. It urged that utilities, along with State and local Governments, be required to develop emergency plans that would meet the approval of the recently formed Federal Emergency Management Agency (FEMA) before receiving licenses for nuclear power plants.

Helicopters used to monitor radiation land in a corn field.

The NRC worked with FEMA to improve emergency preparedness and to develop suitable, site-specific plans in case of a nuclear plant accident. It cooperated with FEMA in conducting field exercises to test the adequacy of those plans. In August 1980, the NRC issued new regulations that stipulated that it would not approve a new operating license without a satisfactory emergency plan and that instructed owners of existing plants to draw up adequate procedures. It also required

licensees to distribute information about emergency plans and to notify the public about what to do in the event of a nuclear accident.

CATEGORY G: THE PUBLIC'S RIGHT TO INFORMATION

The Kemeny Commission called on Federal and State agencies to make advance arrangements to provide "timely and accurate information" to the news media and the public in the event of a nuclear accident. It urged that this information be presented "in a form that is understandable." It also recommended that major media outlets, including newspapers, magazines, wire services, and TV networks, "hire and train specialists who have more than a passing familiarity" with nuclear power and radiation. The Kemeny Commission advised smaller local news outlets in areas close to nuclear plants to "acquire similar knowledge."

In cooperation with FEMA, the NRC made plans for informing the public in a nuclear emergency by establishing a "Joint Public Information Center" near the site of the accident. The center would offer the means for Federal, State, and utility officials to deliver up-to-date and accurate information to the news media and the public. The NRC had no control over media preparations for a nuclear accident, but it provided training to reporters to enhance their knowledge of nuclear power and radiation.

News media at press conference on TMI.

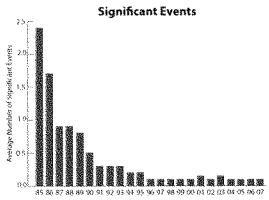
POST-THREE MILE ISLAND IMPROVEMENTS

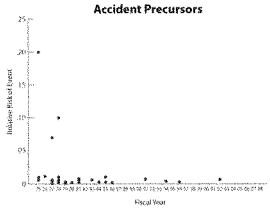
Three Mile Island was a stunning blow to both the NRC and the nuclear industry. It forced the reexamination of policies and priorities and resulted in far-reaching steps designed to prevent another severe accident. The industry was shocked and humbled by the occurrence of the accident and the extent of the damage to the reactor. It adopted a series of reforms, spearheaded by INPO, to correct the deficiencies that had been so graphically revealed. INPO concluded that inadequate management ranked high among the "foremost safety and reliability issues," because safety problems often "were not known by top management." Industry leaders sought to improve the management of nuclear plants not only to enhance safety but also to reduce the role that the NRC might assume. They were keenly aware that another serious accident could adversely affect, if not destroy, the entire industry. A poorly run plant threatened to damage the reputation and undermine the financial stability of every other plant, even

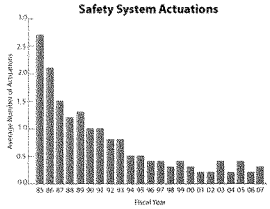
those that were strong performers. This applied to reactors in foreign countries as well as to those in the United States. The nuclear industry and the NRC participated actively in expanded international programs to improve world-wide performance and safety, an effort that was further intensified after the Chernobyl disaster of 1986.

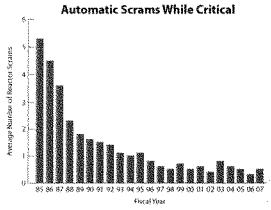
Thirty years after Three Mile Island, the U.S. nuclear power industry can point to vastly improved safety and reliability records. This is partly a result of much greater operating experience. At the time of the accident, the industry was still relatively new. Most of the 65 plants online in early 1979 had only received operating licenses in the past few years. Increased operating experience with the approximately 100 plants that have been in service since the mid-1980s provides working knowledge and data that were in far shorter supply at the time of Three Mile Island.

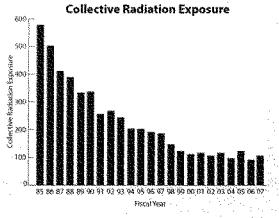
The reforms that the industry undertook after TMI were critical to better performance. Over a period of years, the industry benefited from the technical, operational, and managerial improvements made after the accident. The capacity factor for nuclear plants, which indicated the percentage of time during which they produced power, increased from the 50-60 percent range in the 1970s to the 70 percent range a decade later and to the 90 percent range by the first decade of the 21st century. The cost of generating electricity from nuclear power fell substantially in the same period. A series of safety indicators, including the number of reactor scrams, safety system actuations, safety system failures, and collective radiation exposure for











plant workers, showed consistent and substantial industry-wide improvement after the mid-1980s.

The NRC's response to Three Mile Island and the Kemeny Commission's recommendations led to important improvements in regulatory approaches and performance. An obvious example was its increased emphasis on human factors, which reflected the Kemeny Commission's conclusion that the "fundamental problems" at TMI were "people-related problems and not equipment problems."

Environmental monitoring.

REMEMBERING THREE MILE ISLAND IN A CHANGING REGULATORY ENVIRONMENT

During the 3 decades since the Three Mile Island accident, the focus of nuclear regulation has shifted in accordance with changes in the nuclear industry. In 1979, the licensing of new plants was one of the NRC's most important, most visible, and most controversial activities. By the mid-1980s, however, most of the plants that had been under review at the time of the accident had either been awarded operating licenses or had been cancelled. The industry, which was experiencing a slump even before TMI, ground to a halt in terms of new orders. The NRC received no new applications for construction permits, the first phase of what was then a two-step licensing process, after 1978. As a result, the licensing of plants ceased to be a major function of the NRC and it turned its primary attention to regulating the operation of existing plants.

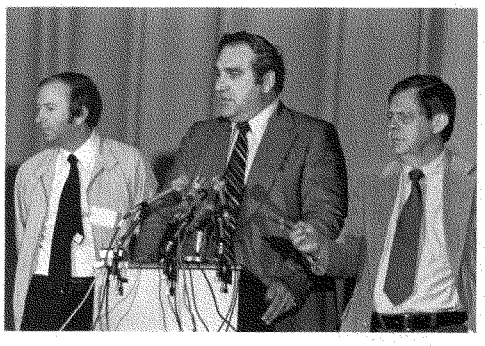
As the nuclear industry improved its performance, it pressed the NRC to modify its approach to regulation. It complained that regulations were in many cases excessive and potentially counterproductive. The NRC addressed this matter by creating a "Committee to Review Generic Requirements" to assess the safety benefits of the design changes it imposed. The industry regarded the NRC's numerical ratings of plant performance, begun after Three Mile Island, as arbitrary and inconsistent. In response to the industry's arguments and its own recognition of a need for reappraisal of its procedures, the agency took action to evaluate and implement performance-based and risk-informed regulation. The objectives were to "focus on those regulated activities that pose the greatest risk to the public" and to ease "unnecessary burdens

on licensees." In 2000, the NRC adopted a new "reactor oversight process" that evaluated plants according to inspection findings and performance indicators on reactor safety, radiation exposures to workers and the public, and physical protection.

Even as the NRC placed greater emphasis on risk-informed regulation, it maintained its traditional reliance on a "defense-in-depth philosophy." This approach required multiple barriers and redundant safety systems that were intended to prevent the occurrence of a nuclear plant accident and, if one occurred, to limit the consequences. The defense-in-depth principle was critical in preventing a major release of the most dangerous forms of radiation at Three Mile Island.

One key change in the regulatory environment for nuclear power since 1979 had nothing to do with Three Mile Island. The terrorist attacks on the World Trade Center and the Pentagon on September 11, 2001, brought about a thorough reassessment of the security of nuclear plants. Plant security was hardly a new issue, but the threat of an airplane piloted by a terrorist smashing into a plant at a high speed had not been previously considered. As a result, the NRC directed its licensees to implement "mitigative strategies" to reduce the potential effects of a "large fire or explosion." The NRC also stepped up plant security with stricter regulations on guard forces, surveillance systems, high-tech physical barriers, and access to plants. In February 2009, it tightened its licensing requirements for new plants to guard against a release of radiation from the impact of a large aircraft.

The improvements in the industry and the NRC since Three Mile Island should not obscure an essential lesson learned from the accident—the dangers of complacency. Before the accident, reactor experts were confident that they had solved the most important reactor safety issues. This confidence and the complacency it fostered were shattered on the morning of March 28, 1979, by the combined forces of management weakness, limited operator training, inattention to human factors, and confusing instrumentation. In recent years, there have been enough operating deficiencies to underscore the continuing need for strong safety requirements and effective implementation. The most significant failure was discovered at the Davis-Besse plant in Ohio in 2002. Both the utility that owned the plant and the NRC failed to detect corrosion before it opened a large gap in the head of the pressure vessel. Although the problem did not come close to an "impending disaster," it raised the most serious safety issues since Three Mile Island. It highlighted the potential consequences



Left to right: NRC's Harold Denton, Victor Stello, and Joe Fouchard at press conference.

of careless operating practices and flawed regulatory procedures.

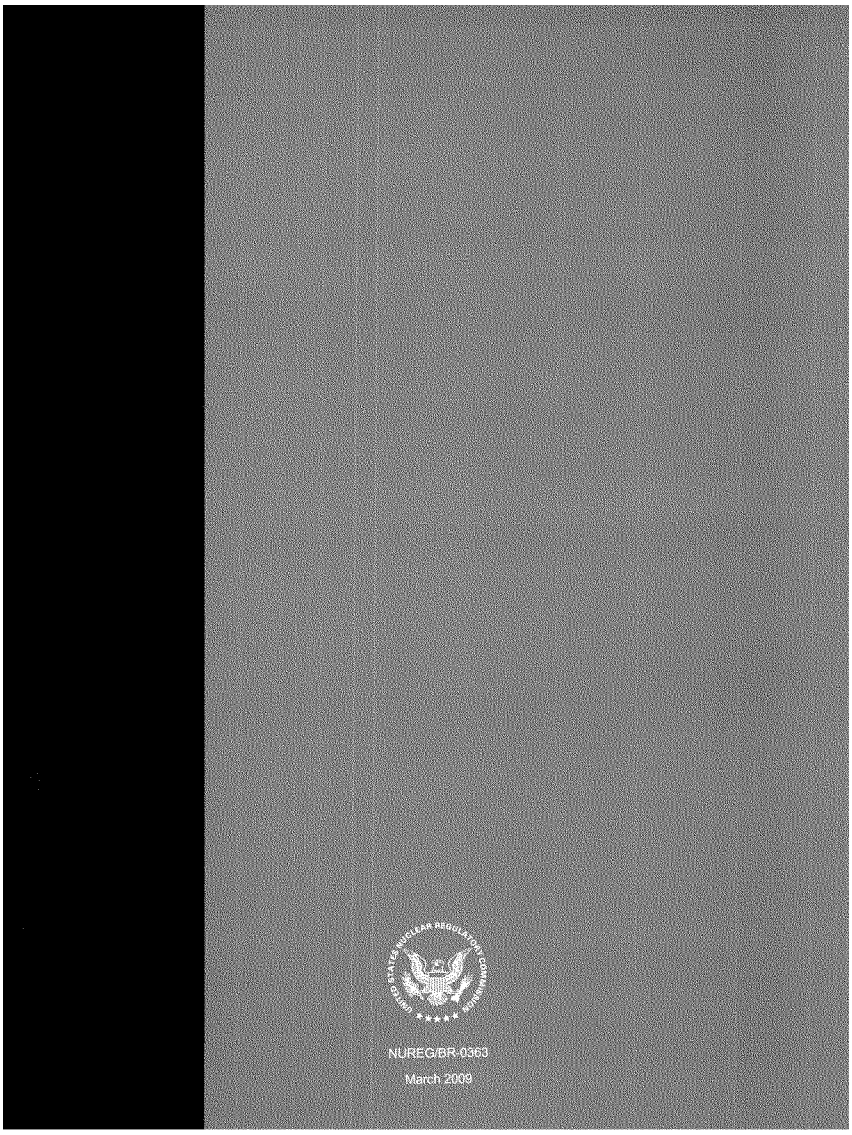
Another problem that the Kemeny Commission pointed out has returned to plague the NRC. At the time of the TMI accident, the NRC occupied several different office buildings, and the Kemeny Commission called for a consolidation of the agency in one location. This was accomplished when the NRC moved into adjacent buildings in Rockville, Maryland between 1987 and 1994. As the NRC has grown in size in recent years, it has exceeded the capacity of the two buildings and is now spread across several sites that are fairly far apart. The NRC is keenly aware that the separation of its staff caused shortcomings in communications and efficiency that the Kemeny Commission cited. Although the agency uses modern communications technologies that did not exist in the 1970s, it is committed to physical "reconsolidation" as soon as possible.

As the nuclear industry appears to be reviving and the NRC prepares to evaluate its first applications for newly ordered plants in 3 decades, both can take pride in the improvements they have made since the crisis of 1979. But Three Mile Island remains a stark reminder of the need for strong performance, effective oversight, and unrelenting vigilance.

TMI plants looking northwest. TMI-2 cooling towers and containment building at left.

EPILOGUE

On the day of the accident at TMI-2, its sister plant on the island, TMI-1, was shut down for routine refueling. After lengthy delays and angry controversy, the NRC authorized the restart of the idled TMI-1 plant in May 1985. Since that time, it has performed with exceptional reliability that reflects the improvements made in the wake of the accident at TMI-2. It has set world records for continuous operations on four separate occasions. In 2006, it achieved a capacity factor of 98.6 percent, compared with a nuclear industry average of 89.8 percent and a coal industry average of 71.1 percent. In 2008, the owners of TMI-1 applied to the NRC for a 20-year extension of its operating license that would authorize it to run until 2034.


NUREG/BR-0363
March 2009

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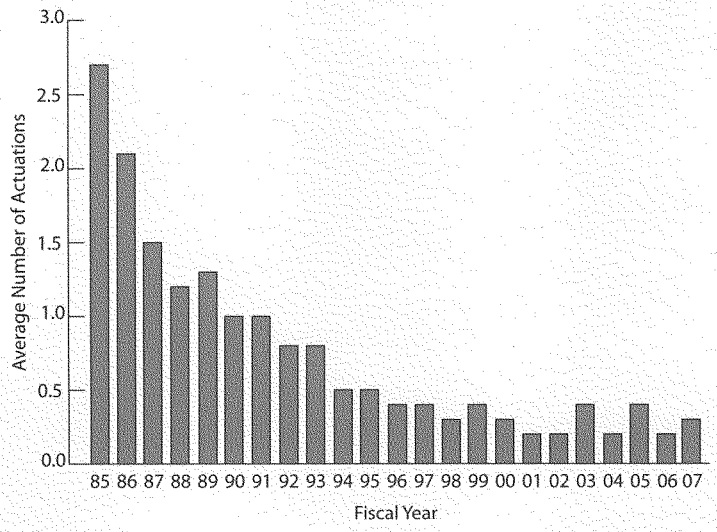
Protecting People and the Environment

Safety System Actuations



Safety systems in a nuclear plant are activated either automatically or manually to deal with a problem detected in the reactor. Since 1985, there have been dramatically fewer activations of safety systems indicating fewer safety-related problems occurring in reactors. The average number of actuations is determined by dividing the total number of actuations occurring at operating reactors in any given year by the total number of operating plants in the fleet (~104). For example, in FY 2007, there were about 25 safety system actuations—far less than one per plant.

U.S.NRC
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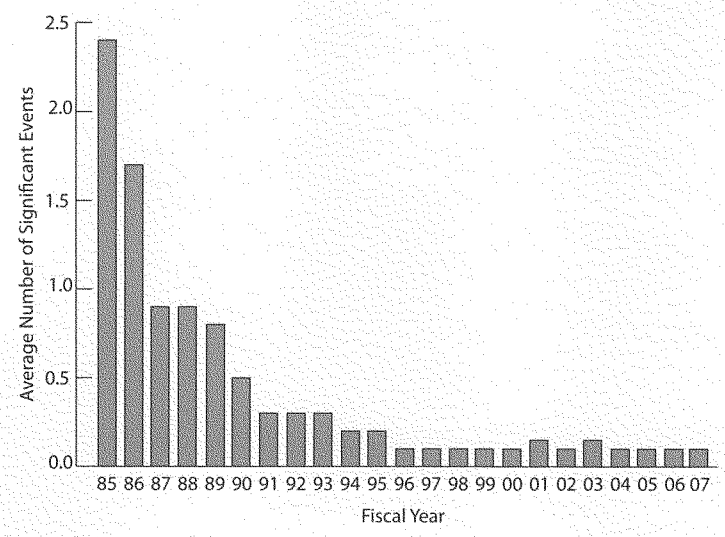
Protecting People and the Environment

Significant Events



This chart shows that the number of significant events at each operating reactor has dramatically decreased from almost 2.5 events per plant in 1985 down to 0.1 events per plant in 2007. Significant events are those events that have serious safety implications and include degraded safety equipment, a reactor shutdown with complications, an unexpected response to a change in a plant parameter, or a degraded fuel rod or coolant piping. The NRC staff identifies significant events through detailed screening and evaluation of operating experience.

Senate Environment and Public Works Committee Hearing
March 24, 2009
Follow-Up Questions for Written Submission

Senator James M. Inhofe to Chairman Dale E. Klein

QUESTION 1. Please describe any public health impacts that resulted from the accident.

ANSWER.

Detailed studies of the radiological consequences of the accident have been conducted by the NRC, the Environmental Protection Agency, the Department of Health, Education and Welfare (now Health and Human Services), the Department of Energy, and the State of Pennsylvania. Several independent studies have also been conducted. Estimates are that the average dose to about 2 million people in the area was only about 1 millirem. To put this into context, exposure from a chest x-ray is about 6 millirem. Compared to the natural radioactive background dose of about 100-125 millirem per year for the area, the collective dose to the community from the accident was very small.

In the months following the accident, although questions were raised about possible adverse effects from radiation on human, animal, and plant life in the Three Mile Island (TMI) area, no adverse effects were found to be directly correlated to the accident. Thousands of environmental samples of air, water, milk, vegetation, soil, and foodstuffs were collected by various groups monitoring the area. Very low levels of radionuclides could be attributed to releases from the accident. However, comprehensive investigations and assessments by several well-respected organizations have concluded that in spite of serious damage to the reactor, most of the radiation was contained and the actual release had negligible effects on the physical health of individuals and the environment.

There is no evidence that the accident at TMI caused an increase of cancer mortality among a group of more than 32,000 people who lived within a five-mile radius of the plant at the time. This conclusion is based on a study "Long-Term Follow-up of Residents of the Three Mile Island Accident," by Evelyn O. Talbott and colleagues from the School of Public Health at the University of Pittsburgh. They published their findings in 2003, based on surveys of the population through 1998. They used data originally collected by the Pennsylvania Department of Health in 1979 from more than 93% of the population who lived within a five-mile radius. The survey gathered information that included the individuals' medical histories, previous radiation exposures, and whereabouts during the ten days after the accident.

Senator James M. Inhofe to Chairman Dale E. Klein

QUESTION 2. Chairman Klein's written testimony stated that regulatory oversight of nuclear power plants has "come a long way" since Three Mile Island. Has the Reactor Oversight Process, established in 2000, contributed to improvements in safety and provided the public more transparent assessment of plant performance?

ANSWER.

Nuclear power plant performance in the U.S. has been consistently improving since the Three Mile Island accident. The NRC's oversight processes, both the Systematic Assessment of Licensee Performance (SALP) process developed after the accident and the current Reactor Oversight Process (ROP) have contributed to this improvement, as have the industry's efforts to improve safety through the creation of the Institute of Nuclear Power Operations.

The NRC continuously oversees and assesses plant performance under the ROP, which is a flexible process that focuses inspections on those activities or areas that are risk significant (i.e., important to plant safety based on each plant's unique design). The ROP has a built-in protocol that increases the level of scrutiny on elements of a licensee's performance that appear to be declining commensurate with the significance of the performance issues. This process focuses on three key strategic performance areas: reactor safety, radiation safety, and safeguards. Satisfactory licensee performance in these areas, coupled with regular NRC inspections, provide reasonable assurance that the facility is being operated in a safe and secure manner.

The ROP was designed to provide sufficient regulatory oversight to ensure that safety and security at power reactors would be maintained. The decision to transition to the current ROP process was made, in part, in recognition of improved operational safety performance demonstrated by the industry between 1989 and 1999, as well as recognition of areas that could be improved in the SALP process. Specifically, the agency noted that the SALP inspection, assessment, and enforcement processes were at times not clearly focused on the most safety important issues, consisted of redundant actions and outputs, and were overly subjective with NRC action taken in a manner that could be, at times, neither scrutable nor predictable. The ROP was designed to address these issues and provide a consistent, transparent, and predictable oversight process.

Consistent with the NRC openness goals, all ROP inspection reports, except those regarding security matters, are publicly available through the NRC website. The ROP contains report-writing guidance to ensure that inspection reports are written in plain language and in a consistent manner. The ROP metrics for each nuclear power plant are also on the NRC public website and include how close each plant is to crossing into a degraded condition which would result in increased NRC oversight. To increase public involvement in the regulatory process, the NRC holds an annual assessment meeting near every nuclear facility to provide the public with the opportunity to hear about the plant's performance, to provide feedback to the NRC, and ask questions of our staff.

Senator James M. Inhofe to Chairman Dale E. Klein

QUESTION 3. I am concerned that new initiatives, such as resurrecting enforcement actions for violations of lesser or no safety significance, may be excessive when compared to the safety record. In light of the safety records that you and this industry continue to achieve, can you assure me that the Commission will take action only on those initiatives that are proven by data, research, or intelligence to be necessary to maintain reasonable assurance of the national defense and public health and safety?

ANSWER.

I can assure you that the relative importance or significance of each violation is assessed by NRC staff. Regulatory requirements have varying degrees of safety, security, or environmental significance. Therefore, the relative importance or significance of each violation is assessed as the first step in the enforcement process. In assessing the significance of a noncompliance, the NRC considers four specific issues: (1) actual safety consequences; (2) potential safety consequences, including the consideration of risk information; (3) potential for impacting the NRC's ability to perform its regulatory function; and (4) any willful aspects of the violation.

Violations having very low safety significance will normally be described in inspection reports as Non-Cited Violations. The Commission recognizes that violations exist below this category that are of minimal safety or environmental significance. While licensees must correct these minor violations, such findings do not normally warrant documentation in inspection reports and do not warrant enforcement action. When such violations are described in an inspection report, they are noted as violations of minor significance that are not subject to enforcement action.

Circumstances may arise where new information reveals that an unforeseen hazard exists or that there is a substantially greater potential for a known hazard to occur. In such situations, the NRC has the statutory authority to require licensee action above and beyond existing regulations to maintain the level of protection necessary to avoid undue risk to public health and safety or the common defense and security.

The NRC also has the authority to exercise discretion to permit continued operations -- despite the existence of a noncompliance -- where the noncompliance is not significant from a risk perspective and does not, in the particular circumstances, pose an undue risk to public health and safety or the common defense and security. When noncompliance occurs, the NRC must evaluate the degree of risk posed by that noncompliance to determine if specific, immediate action is required. To ensure adequate protection of public health and safety or the common defense and security, the NRC may demand immediate licensee action, up to and including, a shutdown or cessation of licensed activities.

Based on the NRC's evaluation of a noncompliance, the appropriate action could include refraining from taking any action, taking specific enforcement action, issuing orders, or providing input to other regulatory actions or assessments, such as increased oversight (e.g., increased inspection). Since some requirements are more important to safety than

others, the NRC endeavors to use a risk-informed approach when applying NRC resources to the oversight of licensed activities, including enforcement activities.

Enforcement is an area where significant improvements were made following the TMI accident. Congress raised the maximum daily civil penalty and removed the statutory limitations on the fine amounts the NRC could collect from licensees. Each enforcement action is dependent on the circumstances of the case. However, in no case will licensees who cannot achieve and maintain adequate levels of safety or security be permitted to continue to conduct licensed activities.

Senator David Vitter to Chairman Dale E. Klein

QUESTION 1. TMI shook people's confidence in nuclear power. As the regulator of commercial nuclear power, how has the NRC worked to gain and maintain public confidence in the agency and its work?

ANSWER.

The problems identified from a careful analysis of the Three Mile Island event led to sweeping changes in how the NRC regulates its licensees. These areas included emergency response planning, reactor operator training, human factors engineering, radiation protection, and many other areas of nuclear power plant operations. Specific examples include: 1) the upgrading and strengthening of plant design and equipment requirements, 2) the installation of additional equipment by licensees to mitigate accident conditions, and monitor radiation levels and plant status, 3) immediate NRC notification requirements and establishment of an NRC Operations Center that is staffed 24 hours a day, and 4) the expansion of the resident inspector program so that at least two NRC inspectors are assigned to a reactor site providing day-to-day surveillance of licensee activities. The impact of all of the NRC improvements is evident in the graphs that were included in my testimony.

In addition, public involvement in the NRC's activities is a cornerstone of strong, fair, and transparent regulation of the nuclear industry. The NRC recognizes the public's interest in the appropriate regulation of nuclear activities and provides opportunities for citizens to make their opinions known. The NRC elicits public involvement early in the regulatory process so that safety, security, and environmental concerns that may affect a community can be resolved in a timely and practical manner. The NRC considers this process to be vital to assuring the public that the NRC is making sound, balanced decisions about nuclear safety.

The NRC believes that openness contributes to the successful implementation of the NRC's two strategic goals – Safety and Security. To communicate clearly and frequently on operating plants and materials activities, documents and correspondence related to license renewals, license applications and inspection findings, except those regarding security matters, are publicly available through the NRC website. Plant performance metrics are also posted on the agency's website and discussed at annual meetings, which are open to the public.

Senator David Vitter to Chairman Dale E. Klein

QUESTION 2. The current state of the economy is no secret. New nuclear facilities are a great opportunity to get struggling Americans back to work in a field that has advanced significantly over the last 30 years. In terms of the current applications filed with the NRC, what challenges do you see in getting projects up and moving and what can we here do in Congress to help?

ANSWER.

As a regulator, it would be inappropriate to comment on incentives outside of NRC's purview, such as financial incentives to stimulate the construction of new nuclear facilities. With respect to NRC's responsibility to review applications to construct and operate a new generation of nuclear plants, the NRC is confident that with sufficient resources and staff with the necessary expertise and training, the agency will be prepared to make timely regulatory decisions. To date, the NRC has received 17 combined license applications for a total of 26 units. One of the current challenges before the NRC with regard to new reactor applications is that some applications received initially lacked information that the staff needs to complete its review. Incomplete applications challenge the staff's ability to make the necessary safety findings in an effective and efficient manner. Staff reviews have been further complicated because some applicants are revising submission dates and submitting modifications to their applications, including changing the reactor design to a different supplier, often with late notice to the staff, which is disruptive to the work planning process. The NRC is working with stakeholders to overcome these challenges.

Further, NRC now knows that, if their license applications are granted, about one-third of applicants plan to begin construction in the 2011-2012 time frame. We are focusing our work in order to ensure that necessary construction inspection resources are available to support anticipated licensing and potential construction work. The NRC is currently proceeding in the review of all the license applications accepted on schedules consistent with budgeted resources. Also, schedules will be adjusted to sequence reviews and place greater emphasis on those projects that are expected to have the highest likelihood to completed the licensing process and proceed to construction in the near term. As this process matures, the Commission will seek the continued support of Congress to sustain these efforts.

Senator David Vitter to Chairman Dale E. Klein

QUESTION 3. Do you happen to have any statistics of how many students are currently enrolled in nuclear engineering programs across the country, and perhaps the number of how many are applying to programs that are too full to accept? In addition, your thoughts on what happens if we don't employ these students domestically, including where you think they are going to look for employment?

ANSWER.

For the 2008-2009 academic years, statistics gathered by the NRC from universities with nuclear engineering programs prove that over 2300 undergraduates and about 1500 graduate students enrolled in nuclear engineering nationwide. This represents a greater than 12 percent increase over the previous year and is fairly representative of the growth in enrollments since the late 1990's when enrollments totaled approximately 600 including undergraduates and graduates. Statistics are not available on the number of students who applied, but were not accepted. At present, most nuclear engineering graduates appear to be receiving one or more job offers, but the job market is not as robust as it was a year or two ago.

In the mid-1990's the number of nuclear engineering graduates exceeded the number of available positions. During this time period, many of the nuclear engineering graduates pursued careers in related fields such as computer science and mechanical engineering.

Senator CARPER. Chairman Klein, thank you for your testimony. Thank you for your leadership at the NRC as well.

Commissioner Jaczko. Welcome, thank you. Please proceed.

STATEMENT OF GREGORY B. JACZKO, COMMISSIONER, NUCLEAR REGULATORY COMMISSION

Mr. JACZKO. Thank you, Mr. Chairman. I also want to thank you for having us here today to discuss the lessons of the accident at Three Mile Island.

I would like to focus on what I see as the larger lesson learned from this event, which, as the Chairman indicated, is the danger of complacency. Three Mile Island and Davis-Besse, which happened decades later, happened in large part because of complacency. There was a fundamental belief at the time of these accidents that they could not occur. The challenge that remembering Three Mile Island raises for us is the need to continue to work to minimize risks, never rest on success, and always be on the lookout for new information and for the unexpected.

We did learn important lessons from Three Mile Island, and I would like to briefly mention three areas where tremendous progress has been achieved. Those would be in the areas of performance assessment, emergency preparedness, and enforcement.

After the accident at Three Mile Island, we developed methods of measuring the performance of operating reactors and making our assessments accessible to the public. We first developed the Systematic Assessment of Licensee Performance and now have the Reactor Oversight Process, which was an improvement on the original systematic assessment of licensee performance.

The ROP was developed to look objectively at licensee safety performance across three broad areas: reactor safety, radiation safety, and protection of the nuclear power plant. While I think the ROP is a very strong program for oversight, we must remember not to get complacent, but rather to look for opportunities to further improve how we assess plant performance, and in particular to continue to look at new ways to measure performance to ensure that we are truly getting an understanding of what safety is at any particular facility.

Another area that I think has shown dramatic improvements directly from the aftermath of Three Mile Island is in the area of emergency preparedness. Following the accident, the Nuclear Regulatory Commission now works closely with the Federal Emergency Management Agency, with licensees, and with State and local officials from around the Country to better prepare and respond to any kind of incident at a nuclear facility.

These programs and the partnerships between all levels of government built the foundation upon which all hazards preparedness work is done in this Country. And when the Commission talks about these issues with members of the public, we are often told by people who live in the communities that have nuclear power plants that their emergency preparedness initiatives are better than any other community because of the preparedness activities that they do with the nuclear power plant.

Finally, I would like to turn to one area which I think was a very important change that came out of the Three Mile Island incident,

and that was in the area of enforcement. Substantial changes were made in the NRC's enforcement authority, and I think this continues to be an important change in an important area as we continue to execute our mission of being an effective regulator.

I would just like to close with a comment and a quote from one of the reports that was issued following the Three Mile Island accident. This is from the Rogovin report, which was a study that was commissioned by the NRC following the Three Mile Island incident. And it stated, "Before March 28, 1979, an attitude of complacency pervaded both the industry and the NRC, an attitude that the engineer-designed safeguards built into today's plants were more than adequate, that an accident like that at Three Mile Island would not occur, and in the particular jargon of the industry, that such an accident was not a credible event." I think that the danger of complacency is as true for us today as it was in 1979, and true in the sense that those are the lessons and the things we need to keep our focus on as regulators.

And briefly, then, if I could just add in response to Senator Inhofe's question, I think an area where we can improve the process for new reactor applications and one which I think the industry has made some comments to the agency about, is in trying to better prioritize the applications that we review, rather than the approach right now where we review all applications that come in based on when they come in. Perhaps we could take our resources and focus first on those applications that are most likely to be completed in the near term, and focus our work there to complete those, and then on the other applicants at a subsequent time.

Thank you.

[Mr. Jaczko's answers to questions for the record follow:]

Senator Barbara Boxer to Commissioner Gregory B. Jaczko

QUESTION 1. You mentioned in your testimony that complacency is the biggest challenge facing the NRC when it comes to preventing accidents. What can Congress do to help ensure the NRC does not become complacent in its regulations and inspection of nuclear power plants?

ANSWER.

Congress has a crucial role to play in ensuring the NRC stays focused on its mission. As an independent regulatory body, Commissioners get important direct feedback from the Members of Congress who authorize the agency's programs and appropriate the agency's funds. Continuing the Committee's active oversight of, and engagement with, the Commission will help to ensure we do not become complacent.

Senator James M. Inhofe to Commissioner Gregory B. Jaczko

QUESTION 1. Please describe any public health impacts that resulted from the accident.

ANSWER.

Please see the Chairman's response on behalf of the Commission.

QUESTION 2. Chairman Klein's written testimony stated that regulatory oversight of nuclear power plants has "come a long way" since Three Mile Island. Has the Reactor Oversight Process, established in 2000, contributed to improvements in safety and provided the public more transparent assessment of plant performance?

ANSWER.

I join in the Commission response enclosed and would add one additional point. As I mentioned in my opening statement, while I believe the ROP is good, we must not get complacent and leave it static in the face of obvious opportunities for improvement. When we look at the ROP's performance indicators and see more and more 'green' results, we can draw one of two conclusions: either everything is working well and there are no issues to be worried about, or, alternatively, that the usefulness of specific indicators is declining. I think we have a duty to consider both possibilities. We have an obligation to make sure performance is consistently high and not just that it is being tuned more finely to the indicator itself. If actual performance is being maintained, then a whole host of indicators should show that. To ensure that is the case, the NRC should develop a new set of performance indicators. They should include a spectrum of indicators used on a rotating basis to give us a better understanding of actual plant performance.

QUESTION 3. I am concerned that new initiatives, such as resurrecting enforcement actions for violations of lesser or no safety significance, may be excessive when compared to the safety record. In light of the safety records that you and this industry continue to achieve, can you assure me that the Commission will take action only on those initiatives that are proven by data, research, or intelligence to be necessary to maintain reasonable assurance of the national defense and public health and safety?

ANSWER.

Please see the Chairman's response on behalf of the Commission.

Senator David Vitter to Commissioner Gregory B. Jaczko

QUESTION 1. Do you happen to have any statistics of how many students are currently enrolled in nuclear engineering programs across the country, and perhaps the number of how many are applying to programs that are too full to accept? In addition, your thoughts on what happens if we don't employ these students domestically, including where you think they are going to look for employment?

ANSWER.

Please see the Chairman's response on behalf of the Commission.

Senator CARPER. Mr. Jaczko, thanks so much for that testimony.
Is it Dr. Lyons? It is, isn't it?
Mr. LYONS. Yes.
Senator CARPER. Yes, Dr. Lyons.
Is it Dr. Klein? It's not Dr. Jaczko, is it? All right. Dr. Svinicki? All right. One mere mortal among all these doctors. That's good.
Senator INHOFE. Is it Dr. Carper?
Senator CARPER. No, I don't think so. I don't think so.
All right. We have plenty of doctors here.
Dr. Lyons, you are on. Thanks for joining us.

STATEMENT OF PETER B. LYONS, COMMISSIONER, NUCLEAR REGULATORY COMMISSION

Mr. LYONS. Thank you very much, Mr. Chairman, and thanks to all of you for holding today's hearing to discuss the 30 years of experience in applying the lessons learned from TMI. These vital lessons, fundamental to safe reactor operation, must never be forgotten if we are to maintain the hard-earned confidence of the American public and the safety of the Nation's nuclear power plants.

I support Chairman Klein's testimony and I would like to offer just a few additional comments.

Evaluating events and learning from them is a simple concept, but an enormous challenge. Until I studied the TMI event, I had not realized that virtually the same situation occurred at the Davis-Besse plant in September 1977. Then, the operators correctly diagnosed the problem. Unfortunately, information from that occurrence was never shared with TMI. If it had been and if the TMI response had duplicated the operator response at Davis-Besse, the Nation would not have experienced TMI.

I visited TMI and discussed the event with Mr. Ed Frederick, who was a controller and operator during that accident. Prior to that visit, I believed that a simple explanation of operator error largely covered the event. But by hearing his explanation of the actions he took that evening, it became clear to me that the design of the control room and the instrumentation available to him dramatically limited his ability to comprehend the situation.

After TMI, far more attention was given to the interface between operators and the reactor. Today's operators have a clear understanding of key plant parameters. After TMI, the operational experience program was strengthened, and the industry and the NRC thought that we had a solid program. Nevertheless, in March 2002, the cavity in the reactor vessel head at the Davis-Besse nuclear plant was discovered. Although this was a near miss and not an actual event, the magnitude of the cavity and the potential significance of that event again sent shock waves through NRC and industry.

That corrosion also had precursors, such that the industry and the NRC, which were aware of this area of concern, should have been even more alert to the potential for that type of problem. Much like the event at TMI, Davis-Besse once again suggested that the NRC and industry failed to adequately use operational experience.

Today, our operational experience program is a strong, solid contributor to reactor safety. Through discussions with operators at

our plants, I am assured that the reports generated by our program are viewed as very important and taken very seriously. It is my hope and expectation that no future event will be partially ascribed to a failed opportunity to learn from our experiences.

We have come a long ways from TMI. Safety at our nuclear plants has improved dramatically because of TMI and other NRC and industry initiatives. But the recent Davis-Besse incident shows that we must remain ever vigilant that the TMI lessons are never forgotten.

Thank you, and I look forward to your questions.

[Mr. Lyon's answers to questions for the record follow:]

Senator Barbara Boxer to Commissioner Peter B. Lyons

QUESTION 1. You mentioned in your testimony that a problem similar to what started the Three Mile Island accident occurred earlier at Davis-Besse but it was handled differently there and did not become a major accident. If information from Davis-Besse had been shared, the Three Mile Island accident might have been avoided. Is there enough information sharing occurring between nuclear facilities and the NRC today? Does more need to be done?

ANSWER.

I have devoted a significant amount of attention to this area and although I believe both NRC and industry are effectively implementing robust operational experience programs, this is an area that takes constant effort to ensure the programs are effectively implemented. As I will describe further below, our staff obtains information from both domestic and international sources. The dissemination of operating experience internationally is an area the NRC is still working to improve.

In the aftermath of the Three Mile Island accident, the NRC worked with the nuclear industry to strengthen communication and sharing of operating experience information. These improvements also included improving the NRC generic communications program.

The NRC systematically reviews industry and international operating experience from a variety of sources, regularly shares its evaluations of significant issues with industry by publishing generic communications and shares operating experience with international counterparts through the International Atomic Energy Agency Incident Reporting System. A portion of the operating information provided to the NRC is obtained through event reports which licensees are required to send to the NRC. The agency posts and reviews these commercial reactor event notifications and licensee event reports for operating experience applicability and other regulatory and inspection purposes.

The NRC currently uses 5 different types of generic communications which provides a graded approach for communicating operating experience to industry and the public. Each type of generic communication serves a different purpose, such as providing details of safety significant events or security related information, providing guidance and specific details on NRC's regulatory approach to an issue, requesting information from industry to assist with solving a generic technical issue, or requesting specific information and/or actions from industry to address a specific safety concern.

The NRC also receives information from the Institute of Nuclear Power Operations (INPO) in accordance with a Memorandum of Agreement. INPO was formed by industry following the TMI accident to, among other things, improve information sharing among licensees. INPO performs in-depth evaluations of significant operating experience events and communicates the results, lessons learned, and recommendations to its industry members. INPO also performs periodic plant evaluations to ensure significant operating experience recommendations are properly implemented and maintained. In addition, INPO maintains an online database where all domestic nuclear power plants can share operating experience information with each other in a fast, efficient manner.

Advances in information technology allow the NRC and industry to develop large operating experience databases which are used to search for and identify trends in operational data. The NRC uses its intranet to compile, trend, and distribute operating experience information to its internal staff, helping focus the efforts of inspection teams and resident inspectors.

Sufficient tools are in place and information exchanges are sufficient to ensure that all licensees are cognizant of the operating experience from other facilities. Nevertheless, the NRC, industry, and INPO continue to evaluate new methods for improving the operating experience programs through coordination, communication, and leveraging information technology.

Senator James M. Inhofe to Commissioner Peter B. Lyons

QUESTION 1. Please describe any public health impacts that resulted from the accident.

ANSWER.

Please see the Chairman's response on behalf of the Commission.

QUESTION 2. Chairman Klein's written testimony stated that regulatory oversight of nuclear power plants has "come a long way" since Three Mile Island. Has the Reactor Oversight Process, established in 2000, contributed to improvements in safety and provided the public more transparent assessment of plant performance?

ANSWER.

Please see the Chairman's response on behalf of the Commission.

QUESTION 3. I am concerned that new initiatives, such as resurrecting enforcement actions for violations of lesser or no safety significance, may be excessive when compared to the safety record. In light of the safety records that you and this industry continue to achieve, can you assure me that the Commission will take action only on those initiatives that are proven by data, research, or intelligence to be necessary to maintain reasonable assurance of the national defense and public health and safety?

ANSWER.

Please see the Chairman's response on behalf of the Commission.

Senator David Vitter to Commissioner Peter B. Lyons

QUESTION 1. Please provide examples of how operating experience has improved the operations of plants today?

ANSWER.

The NRC has a systematic program for evaluating, communicating, and applying the lessons learned from industry operating experience. The staff reviews operating experience from a variety of sources, and uses this program to determine which events and issues are the most safety significant. Once an issue is identified as safety significant, the NRC can either communicate it directly to the industry, ask its licensees for additional information to help resolve a technical issue, or require specific licensee actions to address the issue.

The Generic Communications Program is frequently used to provide information to, request information from, or call for other actions from operating reactor licensees. Below are 2 recent examples of significant generic communications, along with one example from 20 years ago:

- **Generic Letter 2008-01, "Managing Gas Accumulation in Emergency Core Cooling, Decay Heat Removal, and Containment Spray Systems."** – In this generic letter, NRC referenced a number of events where the inadvertent introduction of gas into the piping of safety-related systems rendered the systems inoperable or resulted in pump failures or water hammer events. While NRC had taken regulatory actions over the years to address individual instances of gas accumulation, it became clear through continuing operating experience that additional actions were required to ensure licensees were managing and inspecting for problems in this area. The generic letter requested specific information from licensees to determine whether they were in compliance with design and regulatory requirements, and to ensure that they had programs in place to adequately inspect for and identify problems related to this issue in the future. Subsequent efforts by licensees to address the Generic Letter (GL) have identified additional issues and resulted in corrective and preventive actions.

- **Generic Letter 2004-02, "Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized Water Reactors."** – There are two generic reactor designs operated in the United States today, Boiling Water Reactors (BWRs) and Pressurized Water Reactors (PWRs). During a severe accident in which the reactor coolant system piping is compromised, recirculation of water from the containment back into the reactor vessel may be necessary to prevent core damage. If debris from the containment environment becomes entrained in this recirculating water, it can result in clogging and eventual failure of safety-related pumps. Several instances of actual blockages in both domestic and international BWR plants were noted in the early and mid 1990s which resulted in regulatory action to solve the technical issue for that type of plant. This operating experience led the NRC and industry to re-consider the possibility of similar failures in PWR plants. GL 2004-02 requested that licensees implement any plant or procedural modifications that would be necessary to ensure proper operation of emergency core cooling systems during a design basis accident requiring recirculation of cooling water from the containment sump back into the reactor vessel.

- **Generic Letter 89-10, "Safety-Related Motor-Operated Valve Testing and Surveillance."** – In this generic letter, NRC expanded its operability program (as defined in NRC Bulletin 85-03) to ensure licensees were testing motor operated valve switch settings in certain safety systems for proper operation under worst-case credible accident conditions. Using operating experience data gathered in response to Bulletin 85-03, the NRC staff realized that the program would need to be expanded to include motor-operated valves from additional safety-related systems, and that more stringent conditions of operation would need to be considered. Licensees subsequently developed and strengthened their maintenance and testing programs and practices to improve the reliability and performance of motor operated valves.

These are a few examples indicating how the NRC systematically applies lessons learned from operating experience into its communications processes in order to effect changes that improve safety in the industry.

Additionally, the expansion of NRC's international activities to share operating experience with other countries and to obtain lessons learned from the international nuclear industry on a number of important technical areas continues.

Expansion and improvements in the NRC's resident inspector program have ensured that at least two inspectors live nearby and routinely work exclusively at each plant in the U.S. to provide a permanent presence for surveillance of licensee conformance to regulation. This improvement has produced the added benefit of daily monitoring, review and reporting of operating experience at each plant. Feedback and observations from the resident inspectors on site activities is now routinely provided to each NRC Regional office and this information is discussed with appropriate NRC headquarters staff to consider during daily operating experience review activities.

QUESTION 2. Do you happen to have any statistics of how many students are currently enrolled in nuclear engineering programs across the country, and perhaps the number of how many are applying to programs that are too full to accept? In addition, your thoughts on what happens if we don't employ these students domestically, including where you think they are going to look for employment?

ANSWER.

Please see the Chairman's response on behalf of the Commission.

Senator CARPER. Thank you so much, Dr. Lyons.
Commissioner Svinicki, welcome.

STATEMENT OF KRISTINE L. SVINICKI, COMMISSIONER, NUCLEAR REGULATORY COMMISSION

Ms. SVINICKI. Thank you, Chairman Carper, Ranking Member Vitter, Senator Inhofe and Senator Voinovich, for the opportunity to appear before you at today's hearing.

I support Chairman Klein's testimony as well, and add my voice to those of my colleagues in supporting the commemoration of this significant event in our Nation's nuclear history. Today's hearing and the seminar to be held tomorrow for all employees at the NRC are important opportunities for the community of nuclear safety professionals to pause, reflect on this historic event, and remain vigilant against technical complacency or overconfidence.

Since I am one of the NRC employees who was not involved in the nuclear profession at the time of the Three Mile Island event, in preparation for this hearing I have studied a number of the written histories and other critical reviews. The President's Commission on the Accident at Three Mile Island is mentioned in Chairman Klein's written testimony. In developing its final report to President Carter on the event, that Commission took more than 150 formal depositions and interviewed an even larger group of individuals. At public hearings, it took testimony and collected documentary material that it estimated filled about 300 linear feet of shelf space.

In analyzing all this detail, however, their strongest conclusions were sometimes startlingly simple. Among their conclusions was the following statement, which I would like to conclude by quoting briefly from their report. It is as follows: "In the testimony we received, one word occurred over and over again. That word is mind set. At one of our public hearings, the director of NRC's Division of System Safety used that word five times in a span of 10 minutes.

"The most serious mind set is the preoccupation of everyone with the safety of equipment, resulting in the downplaying of the importance of the human element in nuclear power generation. We are tempted to say that while an enormous effort was expended to assure that safety-related equipment functioned as well as possible, and that there was backup equipment in depth, what the NRC and the industry have failed to recognize sufficiently is that the human beings who manage and operate the plants constitute an important safety system."

Chairman Carper, in my work at the NRC over the past year, I have found an organization of dedicated safety professionals who are ever mindful of this important fact, and who are committed to its enduring lessons.

I thank you again for this opportunity, and I look forward to answering your questions.

[Ms. Svinicki's answers to questions for the record follow:]

Committee on Environment and Public Works
United States Senate
March 24, 2009 Hearing
Questions for the Record

Senator James M. Inhofe to Commissioner Kristine L. Svinicki

QUESTION 1. Please describe any public health impacts that resulted from the accident.

ANSWER:

The response to this question provided by Chairman Klein will discuss the studies regarding health effects that were conducted after the Three Mile Island accident. I would note that a study published in 2000 by Evelyn O. Talbott and a team of her colleagues from the Graduate School of Public Health at the University of Pittsburgh found no increase in radiosensitive cancer attributable to radiation from the Three Mile Island accident among a cohort of 32,135 people who lived within a five-mile radius of the plant between 1979 and 1992. An update to this study published by Talbott and her coauthors in 2002, surveying the same cohort through 1998, summarized its findings as follows: "When you compare observed with expected cancer, there is virtually no difference."

Senator James M. Inhofe to Commissioner Kristine L. Svinicki

QUESTION 2. Chairman Klein's written testimony stated that regulatory oversight of nuclear plants has "come a long way" since Three Mile Island. Has the Reactor Oversight Process, established in 2000, contributed to improvements in safety and provided the public more transparent assessment of plant performance?

ANSWER:

In my view, the Reactor Oversight Process has contributed to improvements in safety by strengthening objectivity in the assessment of plant performance through the use of standard performance metrics and by providing greater consistency in the application of these metrics across the NRC regions. The NRC issues reports assessing the performance of plants under the Reactor Oversight Process twice a year and following the release of an annual report every March, the NRC meets with the public in the vicinity of each plant to discuss the results. These meetings are in keeping with the agency's commitment to transparency with regard to its oversight activities.

Senator James M. Inhofe to Commissioner Kristine L. Svinicki

QUESTION 3. I am concerned that new initiatives, such as resurrecting enforcement actions for violations of lesser or no safety significance, may be excessive when compared to the safety record. In light of the safety records that you and this industry continue to achieve, can you assure me that the Commission will take action only on those initiatives that are proven by data, research, or intelligence to be necessary to maintain reasonable assurance of the national defense and public health and safety?

ANSWER:

In the context of NRC regulations, safety means avoiding undue risk by providing reasonable assurance of adequate protection of workers and the public in connection with the use of source, byproduct, and special nuclear materials. While safety is the fundamental regulatory objective, compliance with NRC requirements plays an important role in giving the NRC confidence that safety is being maintained. To that end, the NRC enforcement policy seeks to: 1) deter noncompliance by emphasizing the importance of compliance with NRC requirements, and 2) encourage prompt identification and prompt, comprehensive correction of violations of NRC requirements.

In the context of risk-informed regulation, compliance plays a very important role in ensuring that key assumptions used in underlying risk and engineering analyses remain valid. Importantly, the NRC also has the authority to exercise discretion in its enforcement actions where the noncompliance is not significant from a risk perspective and does not, in the particular circumstances, pose an undue risk to public health and safety. I support this balanced approach to enforcement.

Senator David Vitter to Commissioner Kristine L. Svinicki

QUESTION 1. Do you happen to have any statistics of how many students are currently enrolled in nuclear engineering programs across the country, and perhaps the number of how many are applying to programs that are too full to accept? In addition, your thoughts on what happens if we don't employ these students domestically, including where you think they are going to look for employment?

ANSWER:

The response to this question from Chairman Klein will provide statistics gathered by the NRC regarding student enrollment in nuclear engineering programs. As a related issue, I would raise to your attention the evaluation done by the Health Physics Society regarding human capital issues in the field of health physics (i.e., radiation protection), which is available on the Society's website at www.hps.org. Specifically, the Society notes that the number of students graduating with either a bachelor's, master's, or doctorate degree in health physics declined 36 percent between 1995 and 2006 and that the number of health physics programs graduating at least five students annually decreased from 20 programs in 1995 to seven programs in 2002. The Society concludes that a shortage of qualified radiation safety professionals would compromise the rigorous oversight necessary for the continued safe use of nuclear technologies. As a health and safety regulator, the NRC is unfortunately dependent on this same, shrinking educational pipeline in recruiting and hiring the next generation of NRC health physics professionals.

Senator CARPER. Commissioner Svinicki, thank you very much for your testimony and for your service.

I would just say, before I ask a question, just an observation. This is a busy time for the Nuclear Regulatory Commission. This is a very busy time. You have 104 nuclear power plants that require your close supervision. A number of those plants are in the relicensing process to be relicensed to operate for another 20 years. I believe there are either 16 or 17 applications to build maybe 26 or 27 new nuclear power plants. And you have a number of companies that have designed state-of-the-art nuclear power plants and have presented them to you for your review, to determine whether or not they are worth going forward with. I mean, that is a lot. That is a lot.

You have a great agency. It is well known and regarded as one of the best places for people in the Federal Government, and probably in any place in this Country. I think you can be justifiably proud of that.

Chairman Klein, in your testimony you warn against the dangers of complacency when it comes to nuclear safety. I have said as much. Others here have said as much. Other Commissioners have repeated this theme to us. This is not a time to rest on our laurels. Great progress has been made since that day almost 30 years ago, but obviously we have to guard against complacency, and frankly, we can do better.

You say that overconfidence was a factor in the Three Mile Island accident and in the more recent Davis-Besse episode. How are you ensuring, you are you, Mr. Chairman, Commissioners of the NRC, how are you ensuring that your new generation of employees, folks who weren't around, at least not with NRC, 30 years ago, but many of which are new, how do you ensure that they too guard against complacency, particularly when it comes to safe operations?

Mr. KLEIN. Well, Mr. Chairman, we have a large program that reminds people about their self-responsibility and their importance. We do that every time we give our speeches. We do it in training. We do it in our knowledge management catch-up program. And so we demonstrate by our actions that we believe what we say and that they should always be vigilant.

We also have a rotation program where people are able to rotate within the agency. That challenges them so they don't get locked into one mind set, as Commissioner Svinicki had indicated. So what we try to do is continuously reinforce the importance not only to our employees, but also to the licensees, that every individual has the authority they need to carry out their assigned tasks, and we monitor and maintain and check that.

Senator CARPER. OK. You may have said this, but I want to ask specifically, how are you bridging the education gap between the older generation at the NRC and the newer generation of employees?

Mr. KLEIN. A lot of our individuals who have retired still want to work, they just don't want to work the 80 hours a week that sometimes it seems like they do. So they come back and they are training this next generation. And we basically have an entire cadre of people that are making sure that we keep our best practices and our best techniques available.

Senator CARPER. Good. I understand that the NRC is again looking at new license applications, similar to the time up to Three Mile Island. I think there were a lot of applications in at that time as well. But how is the NRC making sure that we don't take our eye off of our current fleet of 104 nuclear power plants, while preparing for what we hope and expect will be a new fleet in the years to come?

Mr. KLEIN. Mr. Chairman, I think one of the ways that we did that was fundamentally in our structure. We created an Office of New Reactors, separate from the Office of Nuclear Reactor Regulation, so that individuals in the one division understand very clearly their role is to monitor and maintain those 104 plants that are running today. That is their full-time responsibility, so they don't get distracted with the new reactors that are underway.

So we created two divisions, one which looks at the new reactors; one which looks at the existing fleet.

Senator CARPER. And do you feel, two questions, do you feel that the new license process is effective? Do you think you have enough resources, employees to meet all these jobs that you are asked to take care of?

Mr. KLEIN. Well, Senator Carper, I appreciate yours and the Committee's support on giving us the finances we need to make our decisions to protect the American people, to ensure that these plants are safe and secure. And I believe that we do have a work force that is adequate to carry out that mission. We work at it very hard. In 2007, for example, we hired 441 people, for a net gain of 219. Sixty percent, six zero, were women and minorities. And so we have a very aggressive recruiting campaign. We have gotten very talented individuals, and I believe we have the resources that are necessary for us to do our job.

Senator CARPER. All right. And a question for Commissioner Jaczko, and then I will yield to Senator Vitter.

But let me go back to the issue of transparency and miscommunication that were problems during the Three Mile Island accident, and just ask, how has the NRC improved, made improvements in those areas? And what do you think we could do better? What do you think the NRC could do better?

Mr. JACZKO. Well, I think some of the areas where we have made real improvements in transparency in particular, as I mentioned in my initial statement, is in the area of emergency preparedness. We have much more clearly defined plans for the plants. We exercise those plants in a significant way, with the local communities, so that provides a much better avenue for communication. Because one of the areas of tremendous challenges for information flow during the accident was what exactly the response needed to be to deal with the evacuation, and who needed to be evacuated, and in what time.

So I think there have been a lot of improvements made in that area in particular, where we have established better processes and better exercise those processes now so that begins to share information.

We just fundamentally live in a much different world now, where information flow is much easier than it used to be, with the Internet, with outreach to individuals. We have a much, I think, more

transparent program. I guess I would just finally add that the new oversight program that we have is also much more geared toward transparency and geared toward providing more information to the public about what the status is of any particular power plant or any particular facility that we regulate.

So I think those are some of the specific areas where we have made real progress in the area of transparency.

I think one area that we can make improvements on, and it was an item that was addressed, I believe, in the Kemeny Commission report, and that is to continue to improve on our ability to communicate in plain English, I guess is the phrase we like to use, where we are communicating complex technical information in a way that the public can understand without necessarily having a background in nuclear engineering or nuclear science.

So that's an area where I think we could continue to improve, and that probably means more training and continuing to train our individuals, not just in their technical expertise, but in how to communicate that to an audience that's not technically educated.

So I think those are some areas where we have done well and where we can work on getting a little bit better.

Senator CARPER. Good. Thanks for those responses.

I think I have consumed 7 minutes. Let's just say each of our colleagues have 7 minutes.

Senator Vitter, you are up next.

Senator VITTER. Thank you, Mr. Chairman.

This is to anyone who cares to answer. Could you give any specific examples since Three Mile Island, not so much Three Mile Island, but since then, of how operating experience has improved plant operations today, including your guidelines for that?

Mr. KLEIN. Senator Vitter, I think there are a lot of examples that we have that can demonstrate that. I think one of those is the sharing of information. It is much more openness between the industry and among the industry. I think the creation of the Institute of Nuclear Power Operations has helped to share good practices and good techniques, and also bad practices and bad techniques, so those are not repeated.

So I think communication is an area that we have really improved on. The success rate, as seen by these two charts, demonstrates that we cannot become complacent, but the trends are positive.

Senator VITTER. Yes, sir.

Mr. LYONS. Senator Vitter, as the Chairman said, there could be a number of examples, but if I can give you just two.

One would be an issue that occurred several years ago in cracking of dissimilar welds at the Wolf Creek Plant. That has led to a concerted effort that the NRC has carried out with industry to evaluate any potential for such cracks at other plants. That would be one example of how operational experience is being used directly to improve safety today.

If I could give you one other example, which is sort of a cross between operational experience, as well as addressing questions on complacency. There is now in the lobby of the NRC a model of the Davis-Besse cavity, the corrosion cavity that occurred in the vessel head. It is not only a constant reminder to our staff of the need

to avoid complacency, but also an aid in operational experience of the importance of being ever conscious of the concern for corrosion.

So those would be two examples.

Senator VITTER. Great. Thank you very much.

Again, this is to each of you, and I would love each of you to give at least a brief response. A lot of folks have suggested, broadly speaking, that in the U.S. we should have more standardization within our nuclear industry of design and operation. What would your comment be on that with regard to both safety improvements and efficiency improvements, particularly in getting new plants online?

Mr. KLEIN. Senator Vitter, I think all of us have commented at one time or another that standardization is very important. When I talk to the industry, and I talk about standardization, I want the walls to even be painted the same colors. And we really do need to standardize. It would make our job as a regulator easier, and it would make lessons learned easier for the industry. And the industry is moving in that direction. We have several different vendors, but within each vendor we expect standardization.

Mr. JACZKO. If I could add, and I certainly agree with the comments of the Chairman. I would perhaps just expand that a little bit by saying that I think standardization is certainly an enhancement for efficiency, and ultimately in the end can allow us to deal with generic issues, generic safety issues that may arise, in a more straightforward manner, because we don't have to tailor the solution to 104 unique plants, which is what we find ourselves in with the situation today with several generic issues that we are wrestling with, that the solutions are so unique and so specific to each plant that it consumes a tremendous amount of resources to have to analyze those individually. So there is, I think, an enhancement, certainly from the safety perspective.

I think the biggest challenge is how we actually achieve that. We don't impose standardization as a safety requirement. We encourage it, and we encourage it very strongly right now because if the designs that we are reviewing are not truly standardized, we simply won't have the resources to review all the applications that we have in a timely manner. So that has been a good incentive from the licensing review perspective to get standardization.

The challenge will be if plants are licensed and then built, how we maintain standardization among different utilities that may all have a similar design. That is not a requirement that we have, as I said, from a safety perspective, so that is where it will be much more incumbent upon the industry to police that initiative themselves, to ensure that plants that were licensed the same are operated and ultimately modified in the same way as we go forward, so that we don't branch out and modify them in unique ways in the future.

Thank you.

Mr. LYONS. I certainly agree with the comments made by each of my colleagues. Standardization is very, very important. It is important not only to the regulator, but also to industry. We can be more efficient. We can better assess safety issues across the fleet. I concur with Commissioner Jaczko that the main way that we can encourage standardization is when we tell industry that if you

standardize, we can be far more efficient and effective in our reviews of your application. That is the main tool we have toward standardization, and maintaining standardization, as my colleague said, is also vital.

Thank you.

Ms. SVINICKI. Senator, I know you don't have much time for questions if you get four answers to each, but I agree with my colleagues. Clearly, standardization holds the potential of a lot of increases in efficiency. The timeframes for review that Senator Inhofe was talking about, more standardization allows us as a regulator to capture the efficiencies in those reviews. And also as Commissioner Jaczko said, it has an enduring benefit as new reactors would be added to the current fleet. Standardization would continue to provide efficiencies for us.

Thank you.

Senator VITTER. Let me end with this follow up question. Given all of your answers, shouldn't we or you or both of us consider actually mandating more standardization than we do at present?

Mr. KLEIN. Well, Senator Vitter, I think the industry has the message. I think we as regulators have the message. In the United States, we support the concept of free enterprise. It was easier for France to standardize when they had one vendor and one utility. We have multiple vendors and multiple utilities. And so, I think the way we will encourage standardization, as opposed to mandate it, is by the review process. If someone comes in with a non-standard design, it will take us a very long time to look at it.

Senator VITTER. That is all, Mr. Chairman. Thank you.

Senator CARPER. Good questions.

Senator Inhofe.

Senator INHOFE. Thank you, Mr. Chairman.

Let me first of all kind of go back a little ways. I am one of the few who actually remembers Three Mile Island and all the hysteria and the public clamor that came out of that thing. Would you, Chairman Klein, describe to us any public health impacts that resulted from that accident 30 years ago?

Mr. KLEIN. Well, Senator Inhofe, I think the concern that people typically have is concern about cancer. And there is no data that shows there has been any negative impact of cancer from that accident.

Senator INHOFE. Is there any data that shows that there was any resultant public health impairment as a result of that accident?

Mr. KLEIN. No evidence of that, Senator Inhofe.

Senator INHOFE. You know, I think that's significant, because you talk to most people and they don't realize that. They assume that. And yet, I would have to say, and I think that each of you in the Commission would agree that because of that incident 30 years ago, that did retard our efforts to move forward with nuclear energy. And I wonder, any thoughts about where we would be today if that had not happened?

Mr. KLEIN. You know, that's a difficult question. One could speculate about that, but as you indicated, I think Three Mile Island should have shown that the safety systems were fairly robust, and that there were no negative health impacts. But certainly the public confidence was shaken, but that also occurred at the same time

that we were undergoing a transition into reduced baseload demand of electricity. So there were, after Three Mile Island, there were a lot of coal-fired plants that were canceled as well due to the lower baseload demand.

But my guess is that had Three Mile Island not occurred, we would likely have had more reactors today than we have.

Senator INHOFE. Well, and we didn't anticipate back at that time 30 years ago that we would be having the energy problems that we have today. I mean, here we are with 20 percent of our energy coming from nuclear and some of the Western European countries, France, I believe is 80 percent.

I have never heard anyone talk in any of these hearings about the performance of whatever the counterpart is called in one of these other countries like France. Are they going through about the same things that we are right now, even though they are way in advance of us? Are they as concerned with safety? Are they concerned with the same concerns that you folks have? How do you compare us to them?

Mr. KLEIN. I think, Senator, if you look at the performance of the plants, in general our plants perform better than a lot of countries. I believe that as the regulatory body, we are still viewed as the world's best regulator. We have more people, a lot more technical details. But we also have things we can learn from other countries, and so we share.

We have a very large international program where we try to share information among various regulators. And I know that Andre Lacoste, the head of the French regulator, is also going through and trying to beef up their regulatory capabilities.

But I think for most countries, they are similar. I think our job as a regulator in an international arena is to share best practices worldwide because, as we learn, even though we have no reactors like Chernobyl in the United States, there was still a lot of uncertainty and apprehension from Chernobyl. So we need to be proactive in the international community.

Senator INHOFE. Mr. Lyons.

Mr. LYONS. Senator Inhofe, France certainly has a very strong safety regulator, a very effective one. But I think it is interesting to note that within the last, I would say, 2 years there have been legislative changes within France that have moved their regulatory system much closer to ours, in that their regulator now has a substantially greater degree of independence, and basically is now an independent regulator, as we are, and in addition has mandates for transparency and public information.

If I were to look across the world, I think that two important trends would mirror what has happened in France, that more countries are recognizing the importance of an independent regulator, of strong public input, and public information as we have. In addition, a quest that I would say that we have been on in many of our international discussions, is to encourage more countries to look at both safety and security as two integrated functions, two very important integrated functions. Many countries handle these completely separately.

Senator INHOFE. You know, I hesitate even getting into the thing on the 5 years that it takes the NRC, as indicated to this Com-

mittee, that it takes about 5 years reviewing new reactor designs before granting certifications, because safety is the most important thing. I understand that.

Commissioner Jaczko, you said when I was saying, you know, if there is a way that we could reduce that 5 years down, move a little bit faster, you talked about prioritizing applications. I would like to ask each of you in my time remaining of any ideas you might have that might shorten that 5-year period of time and maintain the same level of safety that we enjoy today.

I will start with you, Commissioner Svinicki.

Ms. SVINICKI. Senator, one of the practices that Chairman Klein brought from the Pentagon was referred to as Lean Six Sigma, which is a process whereby our staff has gone through and looked at all of the procedural steps for reviewing these applications. The Commission has received some suggestions from the staff of how to better coordinate their internal work and the coordination that needs to occur between offices. So they are looking at it, Senator, if they could take some months off of that process. The Commission has received some recommendations that we are looking at now.

Senator INHOFE. Good, good.

Mr. Lyons.

Mr. LYONS. Senator Inhofe, at least one suggestion I would make would be the hope that industry in the future could follow more directly the path that we anticipated when Part 52 was created. We anticipated that a site would go first for an early site permit, that they would be using a certified design, and only then would be going for the construction and operating license. I believe it is correct that no licensee, no applicant right now is following that exact path. There certainly are other areas where we can look for efficiency, but having that process followed would help us.

Senator INHOFE. I see.

Commissioner Jaczko.

Mr. JACZKO. Well, as I talked about, I think the area of prioritization, as Commissioner Svinicki mentioned, the staff has talked about areas where we could improve our review a little bit, but we are talking about months perhaps. And the biggest challenge that I see right now is really getting the design reviews completed. And for most of the designs that we have right now, there are some challenges in getting those reviews completed.

So once we can have that completed, the licensing review will be a much more straightforward process. But right now, there are challenges, I think, with getting the design review complete. And as I said, I think our focus would be better on taking a few, maybe a smaller number of those designs and a smaller number of licensees or applicants, focusing on getting those through the process once, demonstrate how it will work effectively, and then turn to the other applications.

Senator INHOFE. So we would effectively be getting them online faster by doing that, but not as many of them.

Mr. JACZKO. Not as many.

Senator INHOFE. Yes.

Chairman Klein, any last comments on that?

Mr. KLEIN. Well I think, Senator Inhofe, on the design certifications, those are fairly unique. One thing I have learned is that

a good application takes less time than an incomplete one. And so it is a two way street, I think. I think industry needs to give high quality applications and we need to be responsive in the review of that application.

I think on the license applications, once we go through a few of those and we practice the Lean Six Sigma activities, I think we will become more efficient with no compromise on safety.

Senator INHOFE. Good.

Thank you, thank you, Mr. Chairman.

Senator CARPER. You are welcome. Thank you.

Senator Voinovich.

Senator VOINOVICH. Mr. Chairman, I would be remiss if I didn't say a few words on the Davis-Besse incident, because that facility is located in the State of Ohio. I was Chairman of the Subcommittee when that occurred, and as I said in my opening remarks, we took the NRC to task, as well as First Energy. We devoted three oversight hearings to follow up on the NRC's corrective actions stemming from the GAO and inspector general reports.

We also met with Nils Diaz, the NRC chair at the time, and Ed McGaffigan privately on a quarterly basis to get updates. It took a little while and some pushing, but I was pleased to see NRC formally incorporating safety culture into its inspection and regulatory oversight process.

As you all know, we are trying to launch the nuclear renaissance in this country. We need to get into it for reducing, providing baseload energy. We need it also to meet the emissions caps that we will be seeing probably with new legislation being passed to deal with climate and global warming. And also it is an area of large job creation.

But I still run into people out there that are saying, well, what about safety? What about the security of these plants? Aren't they, you know, vulnerable right now to terrorist attack? That is one thing. Then you hear another story out there about all this nuclear waste that is all over the United States being held in dry and wet storage, and how safe is that stuff?

And also, if something would happen, you know, what kind of insurance do they have? They have no idea about Price Anderson and the way the insurance if something would happen. All of the insurance carried by all of the 104 would be used to deal with a situation.

And I still think, and it is a complaint I have, is that you are not doing a good enough job getting information out there in the country. There is still a lot of stuff that is floating around, and these same people that are out there, you know, talking about this are the ones that are standing in the way of our moving forward right here in Congress in some areas that we should be going forward with.

I would be interested in your commenting on these.

Mr. KLEIN. Well, Senator Voinovich, I believe that as an agency, we can be more proactive on education. We have to walk that fine line, as Senator Carper indicated. We have to remember we are the regulator, and not a promoter.

I would like to see the Department of Energy be more proactive in their roles and responsibilities. The area of communication,

though, is one in which I believe the NRC can do better. I think we would like to modernize our Web sites so that we become the site of first choice if someone has a question.

As Commissioner Jaczko indicated, we do need to train our individuals to communicate clearly and succinctly. As I oftentimes say, I am an engineer, so if you ask an engineer what time it is, they will tell you how to build a watch.

So I believe we can do a better job on communication and we are working on it.

Senator VOINOVICH. How about the whole issue of the nuclear waste that we are generating, and the fact that we continue to have it located in dry and wet storage, and people are concerned about that all over the Country? What do we say to them about that? How long can that last?

Mr. KLEIN. Dry cask storage is safe. We license those facilities. We currently have made a determination that we can safely secure and store that material onsite for as long as 100 years. But as a Nation, it would be good to come forward with a long-term waste solution.

For us, as a regulator, we make sure that the dry cask storage is done safely, properly and securely. As you know, we have the application before us for the Yucca Mountain site. We by law are required to look at that application and we will do that in a very effective manner, depending on the resources that we have available.

Senator VOINOVICH. So what you are saying to me and saying to the public is that the current way of holding that waste at the facilities around the Country is safe. And second of all, that there is some extended life in terms of it being stored in that fashion. Because most people today believe Yucca ain't going to happen, and so there is a concern about that. And some of us are considering doing something as an alternative to that.

So you are telling me and telling the public that the waste that is out there today being stored in dry storage is safe, and that we can continue to do this for some time in the future without being concerned about it?

Mr. KLEIN. Yes.

Mr. JACZKO. Senator, if I could add, the NRC did a study about dry cask storage several years ago, and that study found that the risks from any of the spent fuel, particularly in dry cask storage, was about a million times less than the risk from the power plant itself. So what you often find is communities that are very accepting of the power plant, may have concerns about the waste. And in fact, I think the waste, we have shown through our analysis, is much, much, much less of a risk.

So I think that is a message that we can communicate. I think the licensees themselves can do a better job communicating that message as well in the communities that do have facilities, about really what the areas of focus from our perspective really should be from a safety standpoint.

Senator VOINOVICH. And also security.

Mr. JACZKO. And security as well.

Senator VOINOVICH. In terms of, you know, terrorist attack, you hear that. Oh my goodness, if something happens there that, you know, we will have calamity.

Do you want to comment on that, the security aspect of this? We are talking about safety and security.

Mr. JACZKO. Senator, the Nuclear Regulatory Commission has one of the most longstanding programs in security. It goes back to the 1970s, our ideas of how we deal with facilities and deal with security. And I think the agency was in a very good position, in particular, following September 11 because we had a well established program, that we were able to quickly make changes, make modifications to deal with that new issue.

We have a very rigorous program right now where we do exercises at facilities on an ongoing basis to test their security programs. We have put in place new requirements for the existing fleet of reactors to ensure that they can mitigate the effects of any kind of 9/11 type incident. And we put in place very strong requirements for new reactors to ensure that they will be able to deal with some of the 9/11 type incidents and things that could happen in the future.

So I think we have a very robust program in security. We are continuing to make that better. We are continuing to improve our communication in our work with other members of the Federal family, including the Department of Homeland Security, the FBI, to ensure that we have security covered from all the different angles, whether it is from the facility itself, whether it is from responding to an event at a facility, or developing the emergency preparedness and training and interface that is necessary to successfully deal with an incident.

Senator VOINOVICH. Thank you.

Ms. SVINICKI. Senator, if I could just draw together your last two questions on communications and security. I would like to add that one of the unfortunate outgrowths of the enhanced security at reactors post-9/11 is that so many had to close their visitors centers and their information centers. As I visit reactor sites now, I often notice that along the roadside, the entrance to the plant, they have large signage for a visitors center with a big placard across it that says now closed to the public.

I am heartened that some of the new reactor applicants are considering how they are able to site some sort of public information center that they can put far enough away from the reactor at new sites so that they could once again be communicating with the public.

Senator VOINOVICH. Thank you.

Mr. LYONS. If I could just suggest, Senator, that one way of perhaps reinforcing in the public's mind the safety and security of dry cask storage, and this would be something that industry could do, would be to make some of those casks available for public inspection.

I think anyone who has had the opportunity to view those casks, to simply stand beside them, realizes the number of tons of concrete and steel that are in those things. I think they would develop a very healthy respect for both the safety and security of dry cask storage.

But I also agree with your point and I personally hope that the Congress would be looking toward development of a long-term

spent fuel policy that would give the American public a clear view of where we would be going far into the future.

Senator CARPER. Senator Voinovich introduced me to the concept of roundtables, as opposed to committee hearings, several years ago. And I like them a lot, and we are going to hold a roundtable in Cambridge, Massachusetts on Monday morning, May 18, and invite some very smart people up there to come and share with us what they know about spent fuel.

We talk about it as nuclear waste, but actually I understand there is a fair amount of energy still unrealized and unextracted from this spent fuel. So we are going to find out their ideas, hear a little bit about what is going on in other places around the world, and tape the brains of some very, very bright people, and also have an opportunity to bring in maybe a person or two to talk with us about clean coal and sequestration of CO_2.

The responsibility of this Subcommittee is dual in purpose. One is clean air, and the other is nuclear safety, and they are related, but we want to make sure we have an opportunity while we are there that morning, and my hope is that Senator Vitter and Senator Voinovich and others on the Subcommittee, Senator Merkley, can join us for that time.

All right. Speaking of Senator Merkley, he has joined us here, and we are delighted you are here. He is not a new Member anymore. He is an old veteran, and we are happy he is here, and welcome to our hearing.

Senator MERKLEY. Thank you very much, Mr. Chair.

And thank you for your testimony. I will just have a couple of quick questions. One is, I believe that there are some facilities that still have nuclear rods stored in pools, whether they are in dry cask. But if you could just kind of characterize, if you could, the amount of storage that is still done, wet storage if you will, and does that pose greater risks, and is there a strategy for moving to a dry cask system?

Mr. KLEIN. All nuclear power plants use wet pools. In fact, we require the ability to offload the entire core of a reactor, if need be, into the adjacent spent fuel pool that is in water.

So every commercial reactor that is running has a wet pool. They typically want to utilize that one first, and then they only go to dry casks once that wet pool is filled. Both are safe.

Senator MERKLEY. And why is it they want to utilize the wet pool first?

Mr. KLEIN. It was a part of the initial design. That was the initial concept. It also has decay heat removal, so you will remove the decay heat from the spent fuel for several months before you would ever consider putting it into dry casks for decay heat removal.

Senator MERKLEY. I had the experience a few years ago of being up at Hanford, and walking on the metal grating on top of a pool. And it is a strange feeling, with the nuclear rods down at the bottom. And I asked the question, well, what happens if an earthquake comes through here and this water is lost? And the answer was just summarized as, well, that would be bad.

But could you kind of give us a better sense of kind of the safety issues related to the wet pool storage?

Mr. KLEIN. Well, Senator, as you might expect, all of those facilities have to meet earthquake requirements. They typically are robust. There are very thick walls. Some have liners. And so in the event that there could be a crack in that pool that water would leak out, and again these are very thick pools, several feet of concrete, it is important that the plant has the ability to quickly add water.

Senator MERKLEY. Turning to another safety issue, in terms of the dry cask above-ground storage, are there issues there related to potential terrorist actions? What happens if a dry cask is blown up in terms of radioactivity in nearby areas? Is there a terrorist risk? How do we address it?

Mr. KLEIN. Well, Senator, we have analyzed the terrorist risk on those dry casks. You know, there are a lot of factors that go into that, much of which we can't say publicly, but we have analyzed a lot of what if scenarios, what kinds of attacks, and how they might occur. These are very robust canisters, and so we believe that from all of our analyses that it is a minimal risk.

Senator MERKLEY. Thank you.

Senator CARPER. Thank you, Senator Merkley. Thanks for joining us.

Let me just conclude as this first panel wraps up, with a couple of thoughts. One point I made earlier, folks at the Nuclear Regulatory Commission are busy these days, very busy. You are always busy, but especially these days, saying grace over the safe operation of 104 active nuclear power plants; relicensing probably I think a couple dozen of them right now; reviewing the applications for I think 26 or 27 new nuclear power plants which could be built in the years to come; and examining carefully, closely the new designs for nuclear reactors that are being presented to you. And you are doing it all at once.

And trying to provide a good working environment for people, and providing diversity in your work force. That is a lot. That is a lot to do well. It is a lot to manage. And we are counting on you to continue to do that work and to do it well. It is important. Our Nation needs safe nuclear energy as much now as we ever have.

I have been reminded several times in this economic calamity that we are going through in the last year or so, especially the last several months, of the words of Franklin Roosevelt, who said to the American people a long time ago, "We have nothing to fear but fear itself."

We have, oh gosh, earthquakes to fear. We have terrorist attacks, I suppose, to fear. We have most I think to fear complacency, complacency. If we think that, oh, we have come a long way, we haven't had an accident, a major incident for all, lo, those many years. We have done a much better job in terms of raising the operating capacity to realize more nearly the full capacity of the generation of electricity by these nuclear reactors. We have come a long ways in the last 10 or 20 years.

Here is what we have to fear. We have to fear complacency. To sit back and rest on our laurels, that would be the worst thing that could happen. This is a time to remain vigilant. Several of you have used that word, vigilant. And this is indeed a time to remain vigilant. And if we do, then the future for nuclear energy in this

Country, along with it the prospect of cleaner air, the prospect of less dependence on fossil fuels, the prospect of maybe even smaller trade deficits is actually enhanced.

So all that would be great news for our Country, which right now needs some great news.

All right. That is it for this panel. Again, our thanks to each of you for your service, for being with us today. We will provide probably for the record some additional questions. We will ask that you respond to those promptly.

Thank you so much.

Mr. KLEIN. Thank you for your support.

Senator CARPER. You are quite welcome.

Gentlemen, welcome, one and all. We are delighted that you are here. We are very much looking forward to your testimony. It is great to see some of you for the first time, and to be able to welcome others back. Thank you for joining us today.

Just a real short review of your bios, and we will start with Hon. Peter Bradford. Mr. Bradford was an NRC Commissioner during the Three Mile Island accident, served at the age of, what, 12, I think he told me? He was 12 years old at the time. Today, he is an Adjunct Professor from the Institute for Energy and the Environment at the Vermont Law School. Welcome.

Is it Dr. Bradford? Yes, it is. Thank you.

He is a former Chair of the New York and Maine Utility Commissions and has advised many States on utility restructuring issues and he is also on the board of the Union of Concerned Scientists. I think in reading Governor Thornburgh's testimony, I think he alluded to calling on the Union of Concerned Scientists to help out during the time that that was most helpful.

Mr. Harold Denton, it is great to see you, sir. I read all about you in Governor Thornburgh's testimony and the kind of role, the key role that you played all those years ago, 30 years ago. And I understand you were onsite directing NRC's staff activities and served as the Federal Government's spokesperson for the Three Mile Island accident. You were also the first, in the first group of Americans allowed to visit the Chernobyl site. And after retiring from the NRC, you consulted on other nuclear safety matters and retired and currently live in Knoxville, Tennessee, where my wife went to graduate school.

Welcome. We are glad you are here.

Governor Dick Thornburgh, Governor Thornburgh was Governor of Pennsylvania for, what was it, 72 days or so before this incident?

George, can you imagine that? Senator Voinovich, a former Governor like you imagine being Governor of Ohio or Governor of my State of Delaware and having something like this dropped on you 72 days into your first term. That would be quite an experience.

But not only, I call guys like you and Senator Voinovich and me recovering Governors, but not only are you a recovering Governor, but you had a public career spanning some 25 years, including Attorney General for not one, but two Presidents, and currently of counsel to the national law firm of Kirkpatrick and Lockhart here in Washington, DC.

Thanks for joining us.

Finally, Dr. Marvin Fertel. Mr. Fertel is President and Chief Executive Officer of the Nuclear Energy Institute, with 35 years of experience consulting for electric utilities.

We are delighted that you are all here. We would ask you, I have read your testimony, wonderful testimony. We would ask you to try to limit your comments to about 5 minutes.

Mr. Bradford, I think, has to leave around 12:30. We have a Caucus luncheon that starts just after that, so we will try to get us out the door close to that time. But Mr. Bradford, if you need to leave right at 12:30 and we are not quite done, feel free to slip out. But you go first, and we are just delighted that you are all here. Thank you so much for coming.

STATEMENT OF PETER A. BRADFORD, ADJUNCT PROFESSOR, INSTITUTE FOR ENERGY AND THE ENVIRONMENT, VERMONT LAW SCHOOL

Mr. BRADFORD. Thank you very much, Senator Carper. I apologize to you and my fellow panelists for the scheduling constraint. The consolation I can offer Governor Thornburgh is that I am inconveniencing him less this morning than I did on the morning we were on opposite ends of the phone line between Washington and Harrisburg 30 years ago.

I appreciate the opportunity to reflect on the lessons of Three Mile Island. With all of the interest in new nuclear power reactors in the U.S., as well in extending the licensed lives and increasing the output of the existing plants, getting the lessons right is crucial, just as important as not learning the wrong lessons.

The principal conclusion of the Kemeny Commission was, "After many years of operation of nuclear plants, with no evidence that any member of the general public has been hurt, the belief that nuclear power plants are sufficiently safe grew into a conviction. This attitude must be changed to one that says nuclear power is by its very nature potentially dangerous, and therefore one must continually question whether the safeguards already in place are sufficient to prevent major accidents."

The Kemeny Commission also found, "That the NRC is so preoccupied with the licensing of plants that it has not given primary consideration to safety issues."

Occasional mishaps in the 1980s and 1990s notwithstanding, the NRC and the industry made many significant improvements after the accident at Three Mile Island. Then at the Davis-Besse Plant in Ohio in 2002, complacency and excessive concern for the finances of the power plant owner very nearly cost them all the ground that they had gained.

Davis-Besse had received the NRC's highest safety ratings throughout 2001, even as boric acid was eating away the reactor vessel head. Only a three-eighths of an inch thick steel liner performing a function for which it was not designed avoided a hole in the pressure vessel, an event not analyzed in NRC licensing because it was considered impossible.

Among the lessons of Three Mile Island is that nuclear power is least safe when complacency and pressure to expedite are highest. A key corollary to this lesson is the importance of congressional

oversight, emphasizing that safety must be the NRC's highest priority.

Of course, this goal is always stated verbally, but at times the message has been mixed. Senator Pete Domenici wrote that he changed the NRC's priorities in a 1998 meeting with the NRC Chair in which he threatened to cut the agency's budget by one-third if the NRC did not modify its adversarial attitude toward the industry.

If, when the NRC regulates seriously, it is hammered for delay or indifference to cost, as the NRC was in the weeks before the Three Mile Island accident, that message will have an impact. Today's hearing can be a very useful antidote to the dangers that lie on that road.

Finally, avoiding the wrong lessons is as crucial as learning the right ones. An oft-repeated Three Mile Island story line goes something like this. "The most important lessons is that the safety systems worked as intended. Interveners exploited the accident to tie up nuclear reactors in interminable and costly hearings. These problems have largely been solved. If Congress will further streamline the licensing process and shift financial risk from investors to taxpayers, nuclear construction can resume its rightful place in furthering national energy goals".

But this story line is a harmful fantasy, inviting the wasting of a lot of money and effort in solving problems that nuclear power never had, while repeating the cycle that caused Forbes Magazine to proclaim in 1985 that the failure of the U.S. nuclear power program ranks as " the largest managerial disaster in business history".

When TMI is seen together with the fire at Browns Ferry 4 years earlier, and with other expensive mishaps such as fuel cladding failures, emergency core cooling system shortcomings, seismic design retrofits, and absence of offsite emergency plans, a clear picture emerges of a technology pushed far ahead of its operating experience.

In 1968, the largest nuclear plant in operation was half the size of the smallest plant under construction. This was as if the airline industry had gone from Kitty Hawk to jumbo jets in 15 years. In 1972, the Atomic Energy Commission forecast that the Country would need 1,000 nuclear power reactors by the year 2000. This would have required the regulators to issue a license every week for the next 28 years, a pace that could not possibly have been sustained. In hindsight, trouble and disappointment were inevitable.

The nuclear regulatory problem culminating in the accident at Three Mile Island was not that the United States had licensed too few nuclear plants too slowly. The Country had in fact licensed too many reactors too quickly. That is why within a decade of the TMI accident, we had a landscape dotted with nine figure cost overruns. Every State in a crescent from Mississippi to Washington, and in a line across the northern tier from Illinois to Maine, was touched by at least one event involving the waste of more than $100 million.

NRC hearings did not close Three Mile Island. NRC hearings had nothing to do with the quality assurance breakdowns at Diablo Canyon and Zimmer. NRC hearings did not cause the diesel gener-

ator building at Midland to sink into the soil, or the tenfold cost overruns at the never-operated Shoreham Nuclear Plant in New York.

Indeed, study after study made clear that NRC hearings have little to do with nuclear power's real problems. The reasons for nuclear power's inability to compete in U.S. power markets are beyond the scope of this hearing. But they have not been fixed by measures that assume that they were caused by Three Mile Island or by an overly cautious regulatory process. Indeed, they have not been fixed at all.

Again, my thanks to the Subcommittee for the chance to expand on some of real and some wrong lessons of Three Mile Island. Undertakings such as this hearing as the way for the U.S. to learn history, rather than repeat it.

[The prepared statement of Mr. Bradford follows:]

Hearing on "Three Mile Island: Thirty Years of Lessons Learned"

Testimony of Peter A. Bradford
Senate Committee on Environment and Public Works
Subcommittee on Clean Air and Nuclear Safety
March 24, 2009

I'd like to begin with a review of the status of nuclear power and nuclear regulation the day before the accident at Three Mile Island. As of that time, the NRC's licensing process, maligned though it often was, had issued more licenses than the next five nations combined, though half of the construction permit recipients did not complete their power plants.

Some of those licensing hearings had been contentious, but they had not delayed the plants because they either preceded construction or went on while the plants were being built.

However, many plants were being cancelled or delayed by their owners in the face of rising costs and falling demand. Even the very high oil prices and supply uncertainty occasioned by OPEC's successes could not offset the facts that electricity prices had tripled in the U.S. in the 1970s and that surprising events in the operating plants had caused many cost estimates to double and then double again. A few would increase tenfold in the years ahead.

In Congress, the principal focus was on the Nuclear Siting and Licensing Act of 1979. It was intended to create a one stop licensing process and limit opportunities to litigate issues repeatedly and late in the process. On the morning of March 31, 1979, as Energy Secretary Jim Schlesinger – not suspecting the seriousness of the accident by then two days underway at Three Mile Island - was testifying before the Congress on ways to expedite the nuclear licensing process, NRC Chairman Joe Hendrie was transmitting the NRC's evacuation to Governor Thornburgh in Harrisburg.

* * *

Here are some of the critical events from the months immediately before the accident:

- The price of oil reached $40 per barrel in 1979 dollars, which would be around $115 per barrel in today's dollars. Gasoline lines stretched for blocks here in Washington. Eliminating oil dependence in the electric sector was said to justify building otherwise uneconomic nuclear units, even as climate change does today.

- The NRC ordered the shutdown of five nuclear power plants based on errors discovered in a computer code used to assess the stresses on power plant piping during an earthquake. For this action, the Commission was summoned before Congressional committees and criticized in terms such as "asinine" and "stupid" by the some Congressmen.

- The movie "The China Syndrome" starring Jack Lemmon and Jane Fonda was released in March, 1979 and was a big hit, with industry spokesmen expending great effort to explain that the accident sequence depicted in the movie could not happen.

- The projected opening date for a spent fuel repository was postponed from 1985 to 1988, sparking considerable dismay in the industry and elsewhere.

- And an NRC inspector named Jim Creswell came to see Commissioner John Ahearne and me to stress his concern that - based on an earlier accident at the Davis-Besse plant in Ohio - all nine of the plants of the TMI design were unsafe and should be shut down until the problem was fixed. We were troubled by several aspects of Creswell's presentation, which foretold TMI in significant respects, but he requested that his identity be protected. This required us to devise a cover for our follow-up on his concerns. We were not to have time to pursue that undertaking, for Creswell's visit occurred on March 22, 1979. The Three Mile Island accident was six days away.

* * *

The accident at Three Mile Island taught different lessons to different people. One implausible example was an advertisement that ran across two full pages in many prominent newspapers a few months after the accident. This ad featured a picture of the nuclear physicist Edward Teller under the caption, in very large bold-faced type, **"I WAS THE ONLY VICTIM OF THREE MILE ISLAND".**

Dr. Teller, who had years earlier been a pioneering proponent of nuclear power and nuclear safety, was nowhere near the accident. He had suffered a heart attack a few weeks later because, he asserted in the ad, he had been working 20 hour days to refute the anti-nuclear propaganda being "spewed to the news media by Ralph Nader, Jane Fonda and their kind". Dr. Teller offered his readers several lessons from the accident.

The least controversial - and one which I think has proven true - was that nuclear safety would improve as a result of the accident.

More problematic was Dr. Teller's conclusion that the accident showed "that nuclear reactors are even safer than we thought".

Most problematic was Dr. Teller's conclusion that "unless the political trend toward energy development changes rapidly, there may not be a United States in the 21st Century." Dr. Teller feared also that his grandson Eric might grow up under Soviet Communism, presumably in the event that US energy policymaking's trend away from nuclear energy went uncorrected.

We did stop building new nuclear plants, but Dr. Teller's grandson does not seem to have suffered. Now called Astro Teller, he specializes in artificial intelligence and has published a novel. It is Soviet communism that is defunct.

After the accident at Three Mile Island, the Soviet Union sent a delegation to the TMI site. The delegation held a press conference. The TMI design, they pointed out, was unique to the U.S. Nothing like TMI could occur in their country, and, of course, they were right. The Chernobyl accident was quite different.

* * * *

The story of the accident has been exhaustively told and retold. Some tend to minimize its significance because the hydrogen bubble that caused such widespread public concern on the accident's third, fourth and fifth days had never been a problem. However, a full appraisal of those five days must also acknowledge that the greatest danger was during the first two days, when no one knew what was going on in the reactor core, when the NRC commissioners were working on other matters. We know now, as a

result of examinations of the reactor core that were not possible for several years, that the melting of the core during the early hours of the accident was far more severe than was known at the time, indeed that half of the core had melted.

* * * *

A principal conclusion of the Kemeny Commission, appointed by President Carter to investigate the accident, was "After many years of operation of nuclear plants, with no evidence that any member of the general public has been hurt, the belief that nuclear power plants are sufficiently safe grew into a conviction.....This attitude must be changed to one that says nuclear power is by its very nature potentially dangerous, and, therefore one must continually question whether the safeguards already in place are sufficient to prevent major accidents."

That lesson, that safety must always be a higher priority than economic interest or the licensing of more power plants in specified time periods is one that needs constant reiteration. Among the lessons of TMI is that nuclear power is least safe when complacency and pressure to expedite are highest. The sense that everything is safe enough already may be its worst enemy.

Nuclear power performance has improved. Perhaps the industry is - waste management aside - about where it would have been if its handlers had proceeded with appropriate caution in the 60s and 70s. But there have been uncomfortable events in some plants in recent years -- especially the near rupture of the reactor vessel at Davis Besse in Ohio. That event, which the NRC's Inspector General ascribed in part to undue solicitude for the profits of the licensee, came too close to renewing our acquaintance with a nuclear power plant out of control, operating beyond the understanding of those in the control room.

* * *

When TMI is seen together with the fire at Brown's Ferry four years earlier, the fuel cladding failures, the Emergency Core Cooling System shortcomings, the seismic design retrofits and the absence of offsite emergency plans, a clear picture emerges of a technology that had rushed far ahead of its operating experience. The nuclear regulatory problem illustrated by the accident at Three Mile Island was not – as is widely asserted today – that the U.S. had licensed too many plants too slowly. It was that we had licensed – and made large financial commitments to – too many plants too quickly. That is why within a decade of the TMI accident we had a landscape dotted with nine figure cost overruns, a nine figure accident, eight figure cancellations and eight figure mishaps in such areas as steam generator tubes, pressure vessels, seismic design and quality assurance.

From an economic and a political standpoint, TMI was only one of many nine figure accidents. Some of the others were at Shoreham, Seabrook, Nine Mile Point, Midland, Zimmer, Marble Hill, WPPSS, Byron, Braidwood, Grand Gulf, Comanche Peak, South Texas and Diablo Canyon. Every state across the

northern tier from Illinois to Maine was involved in at least one.

NRC hearings did not cause Three Mile Island. NRC hearings did not bring about the cancellation and bond default at the WPPSS units. NRC hearings had nothing to do with the quality assurance breakdowns at Diablo Canyon and Zimmer. NRC hearings did not cause the diesel generator building at Midland to sink into the soil or the tenfold cost overruns at the never-operated Shoreham nuclear plant in New York.

In 1968, the largest plant in operation was one half the size of the smallest plant under construction and one-sixth the size of the largest. This was as if the airline industry had gone from Kitty Hawk to jumbo jets in 15 years. In 1972 the Atomic Energy Commission forecast that the country would have a thousand nuclear power plants by the year 2000, complete with breeder reactors, reprocessing plants and, of course, waste repositories. This would have required the regulators to issue a construction or an operating license every week for the next 28 years, a pace that could not possibly have been sustained. In hindsight, trouble and disappointment were inevitable. The only question was how much.

The lessons for economic regulation and energy policymaking were at least as abiding. Wall Street learned that a group of licensed operators no worse than any other could transform a billion-dollar asset into a two billion dollar clean-up in ninety minutes. No more nuclear plants were ordered in the U.S., and none started after 1974 were completed.

At first, the lessons for the economic regulators from these costly disasters seemed to be to regulate more and better. The quality of state commission appointments improved, as did the budgets. The mandates expanded as regulators were told to further energy efficiency, undertake integrated resource planning, perform management audits and make a market for power plants built by nonutility companies. For a time, this mix sufficed, for energy efficiency more than filled any void created by the nuclear cancellations.

But the regulatory assumptions - such as hundred dollar a barrel oil and limited natural gas - eventually produced their own price surges and with them came a skepticism as to whether any system based on locking the forecasts of state and industry officials into long-term arrangements was likely to be superior to giving freer rein to customer choice. This skepticism was reinforced by the fact that the newly competitive power supply market produced falling construction and fuel costs where regulatory and nuclear orthodoxy had foreseen only endless increase.

And so we had electric utility restructuring, an event largely traceable to the overly exuberant nuclear construction experience that TMI embodied but did not cause.

With competition came new cost pressure and a shift in risk from customers to investors. It is that risk shift, not Three Mile Island or NRC regulation that explain the fact that we had no new nuclear orders for decades after TMI.

It is a hard time to generalize. Nuclear power provided 12% of the nation's electricity at the time of TMI. It provides 20% today. The number of events of safety concern has declined. The operating costs of the plants have been trimmed far below levels prevailing few years ago, though not to levels that make new nuclear units able to attract private capital without government shifting of risks to investors or to taxpayers.

Finally, a word about the lessons of Three Mile Island for Congressional Oversight. If the message that the NRC gets from the Congressional oversight committees is that what's wanted is strong commission focus

on expedited licensing of new reactors and deemphasized enforcement, that message will have an effect over time. Senator Pete Domenici asserted in his 1998 book that he singled-handedly changed NRCs priorities in a 1998 meeting with the NRC chair in which he threatened to cut the agency's budget by one-third if the NRC did not modify its "adversarial attitude" toward the industry.

This doesn't seem to me to be the type of oversight that the Kemeny Commission had in mind.

Environment and Public Works Committee Hearing
March 24, 2009
Follow-Up Questions for Written Submission

Questions for Bradford
Questions from:
Senator Barbara Boxer

1. In your testimony you mentioned that utility restructuring is the real reason there were no new nuclear plant orders in the decades following the Three Mile Island accident. Can you expand on this statement? Do you believe that today's investors are more willing than they were following the Three Mile Island accident to accept the risk that comes with building a new nuclear power plant?

Actually there have been no new nuclear plants ordered in the U.S. since the advent of competitive power procurement in the U.S. following the passage of the Public Utility Regulatory Policies Act of 1978. It is the process of contracting for power from all possible suppliers, not electric restructuring (which occurred in the mid-late 1990s, and not in all states), that doomed new nuclear orders.

Competitive power procurement requires builders of new power plants, nuclear or otherwise, to make commitments to supply power on particular schedules and at particular prices or price formulas. If they then fail to meet these commitments, their investors take the consequences, just as they keep the profits from the successful plants. Electric restructuring compounds this risk to investors by creating power markets that set a price ceiling and do not allow cost recovery to begin until a plant begins to generate. Thus the risk of cancellation too is borne by investors, not customers or taxpayers.

Investors are no more willing to bear these risks today than they were when PURPA took effect 30 years ago. That is why Congress and state regulators are told repeatedly by those proposing new reactors that they will only proceed if they have loan guarantees that put the economic risks on U.S. taxpayers and/or legislation putting all of the risks on customers.

Senator James M. Inhofe

1. In your testimony, you are critical of Sen. Domenici's efforts to make the regulatory landscape less "adversarial." Yet out of his admonition came open and free dialogue between the Agency, the industry, and non-governmental stakeholders that led to the establishment of the Reactor Oversight Process. This process has been widely viewed as successful, even by the GAO. Doesn't this belie your opinion of that "oversight" and your apparent belief that the relationship between the regulator and the industry must be "adversarial"?

Any regulatory process requires a balance between dialogue and enforcement. Enforcement is likely to have adversarial characteristics. We do not expect the policeman who stops a drunk driver to spend much time on dialogue. The consequences of regulatory ineffectuality are now visible throughout our financial system. Time will tell whether parallel shortcomings will emerge among health and safety regulators such as the NRC.

Senator Domenici's threat to cut the NRC budget by one-third unless it complied with his instructions was extraordinary and punitive, especially since the agency was already moving with appropriate caution in the directions that the demanded. Within four years of his extraordinary meeting with Chairman Jackson and her compliance with his demands, NRC regulatory laxity became an essential ingredient in the near accident at Davis Besse, as discussed in the Gilinsky appendix to my testimony. I'm told that to meet the licensing deadlines emanating from the Domenici/Jackson meeting, the NRC sometimes shifted staff off of safety inspection duties, including those at Davis-Besse.

Senator David Vitter

1. A nuclear plant, such as the Grand Gulf Nuclear Station in Port Gibson, MS, generates electricity, approximately 1,200 Megawatts, approximately 90% of the time (90% capacity factor.) Assuming that wind provided power 90% of the time, it would take 60,000 acres of wind power (93 square miles of wind turbines) to produce the same amount of power. [That is, 93 square miles with quality wind 90% of the time. Realistically, wind farms typically have a capacity factor of20 - 40%.] Do you think it is better for the environment to cover 93 square miles of land with unreliable wind turbines when less than a couple hundred acres of nuclear power could provide just as much and more reliable energy?

It's not clear that new wind is less reliable or predictable than new nuclear. After all, the U.S. has built some 28,000MW of new wind in recent years and no new nuclear plants (although we have certainly increased the output of the existing units). The builders of new wind turbines have been willing to bid them in competitive power procurements, which new nuclear plant builders have not.

Wind energy's intermittency should not be confused with unreliability. The availability of wind energy can be forecast with some confidence far enough in advance for any given grid to adjust without difficulty to weather-drive fluctuations at today's levels of wind power in the U.S. Wind energy is not subject to the sudden (and sometimes prolonged) loss of large blocks of capacity that can occur with large power plants, nuclear or otherwise.

New wind and new nuclear pose different environmental challenges. The land use associated with new nuclear plants will include a uranium mining, enriching, waste transport and waste disposal infrastructure considerably larger than the power plant sites themselves. But my recent work on new nuclear units has focused more on the ways in which large loan guarantees will expose taxpayers to unnecessary risk and undermine wise energy policy. I don't claim to be expert in the relative environmental impacts of different types of generation.

2. The United Arab Emirates is looking at increasing long term reliable energy through a nuclear portfolio. Should we be educating the next generation of Americans to contribute to the international market and advances in science and technology, as well as supporting U.S. businesses to grow internationally, or should international markets be left to foreign businesses and foreign workers?

Of course we should be encouraging future generations to benefit from international markets and advances in science and technology. But neither international markets nor domestic ones choose new nuclear power. It remains too expensive and freighted with too much economic risk. Shifting that risk from investors to taxpayers through federal loan guarantees seems an eccentric way to educate the next generation of Americans in the working of markets.

Senator CARPER. Dr. Bradford, thanks very much for those comments and for your presence here today.

Mr. Denton, welcome. Glad to see you. Thank you for joining us.

STATEMENT OF HAROLD DENTON, FORMER NRC EMPLOYEE

Mr. DENTON. Thank you, Mr. Chairman and members of the Committee. I am glad to have this opportunity to meet with you.

On Friday morning following the accident, Chairman Hendrie requested I go to the site and take charge of the NRC response. I would be President Carter's contact and work closely with Governor Thornburgh. A few hours later, the White House sent a helicopter to take me and Members and our staff to the site. On arrival, I asked the utility to inform us in advance of any changes they made in the status of the plant so that we could review them, and we began around the clock coverage of all the operations at the plant.

Within a few days, we had over 100 NRC people at the site. The President asked during that time to be kept fully informed and had specific times that he wanted to be called in the morning and night. In addition, he indicated that all the resources of the Federal Government would be made available to bring the situation to a safe conclusion. I briefed Governor Thornburgh each evening and as events required, and he and I held press conferences nightly for many days there.

I had never met President Carter or Governor Thornburgh before, but they appreciated the gravity of the situation. They were personally involved every day, and it was just remarkable cooperation that occurred during that whole crisis, between the Federal Government and State government.

For example, I hadn't signed any paperwork through those weeks. I did not approve or request any formal assistance that required paperwork. The military provided logistical support. They brought in plane loads of equipment from around the Country and people. The Department of Energy did environmental surveillance around the plant with all their capability.

We were not an operational agency. We were a paperwork review agency, so we had very little capability, operational capability. So someone found phones available for the fire service, so they served as our phones for communicating within our staff members. I stayed there for 3 weeks. The event was hectic and challenging and at times surreal.

We were not sure and did not understand the full consequences of that accident for a long time afterwards. We originally knew that there had been a severe accident. That was inferred from measurements made outside the containment. When the core was finally accessible and people were able to look inside the core, the examination showed a drastically different appearance than most people thought.

The uppermost fuel assemblies were completely destroyed, and research showed that about 45 percent of the core had melted. The critical phase of the accident was actually over Wednesday morning in looking at this accident in retrospect. Operators turned off redundant emergency core cooling systems, although the reactor was losing water continuously through a failed valve. No core damage

would have resulted if the emergency pumps, which were started automatically had been left running, instead of being shut off.

About 100 minutes into the accident, the water level dropped below the top of the core and the fuel began to overheat. As the water level continued to drop, more and more of the central core melted and flowed downward and solidified when it reached the bottom of the reactor vessel.

Approximately 4 hours later, nearly 20 tons of molten core material had reached the bottom of the reactor vessel. The circular area at the bottom of the reactor vessel experienced extremely high temperatures for about 30 minutes before cooling.

At 16 hours into the accident, the operators managed to re-start pumps and provided a way of getting water back into the core and providing subsequent cooling. A robust reactor containment structure proved valuable during this accident. The offsite radiological consequences were minimal.

The history of containments is kind of interesting to me. The first containment was in use proposed back in 1947 by a blue ribbon committee of the Atomic Energy Commission. Since that time, containment structures have always been a safety feature of commercial reactors.

During the TMI accident, the total amount of iodine released, which is a particularly hazardous material, was about one million times less than that released as a result of the uncontained Chernobyl accident in the Ukraine. Also, we found that as a result of studies after the accident that the possibility of the penetration of the containment basemat by a molten core, commonly referred to as the China Syndrome, which had not been studied since prior to the accident, is very unlikely to have penetrated the containment basemat even if the hot core had reached the basemat.

A second topic that was subject to a lot of review at the time was the possibility of a hydrogen explosion within the containment. There had been a hydrogen explosion in the containment, but that led people to start thinking about could there be a hydrogen explosion within the reactor vessel. Calculations had been done, but they had neglected a reported factor that indicated that oxygen would recombine with the hydrogen in the water essentially as soon as it was generated, so there never was a chance for a hydrogen explosion in the reactor.

As you mentioned before, the accident was comprehensively examined by a number of investigations, including the President's Commission.

Senator CARPER. Mr. Denton, you are a little bit over 6 minutes. I am going to ask you to try to wrap it up here very shortly if you can, please.

Mr. DENTON. All right.

My conclusion is that the safety of power plants today is better than ever as a result of all the lessons learned. Federal and State preparations for emergency planning are better than ever, coping with new standard designs, and coping with the fact that the nuclear technology doesn't really exist in the U.S. today as it did back in those days, there will be continuing challenges for the NRC Commission.

[The prepared statement of Mr. Denton follows:]

STATEMENT OF
HAROLD R. DENTON, RETIRED
FORMER DIRECTOR OFFICE OF NUCLEAR REACTOR REGULATION
BEFORE
SUBCOMMITTEE ON CLEAN AIR AND NUCLEAR SAFETY
SENATE COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS

"THREE MILE ISLAND – LOOKING BACK ON
THIRTY YEARS OF LESSONS LEARNED"

MARCH 24, 2009

Mr. Chairman and members of the Committee, I am pleased to have this opportunity to discuss, from today's perspective, safety lessons learned from the accident at the Three Mile Island Unit 2 nuclear power plant.

On Friday morning following the accident, Chairman Hendrie requested that I go to the site and take charge of the NRC response. I would be President Carter's contact and work closely with Governor Richard Thornburgh of Pennsylvania. A few hours later, the White House sent a helicopter to take me and staff members to the plant site. On arrival, I asked the utility to inform us in advance of any planned changes in the status of the plant and of any unusual events. We initiated around the clock coverage in the control room and in a command trailer. Within days there were over 100 NRC staff at the site. An industry support group for the plant management was also assembling at the site.

The President asked to kept fully informed and set specific times for morning and afternoon briefings. In addition, he indicated that all necessary Federal resources would be made available to achieve a safe resolution of the crisis. I briefed the Governor each evening and as events required. He and I held a press conference each night in the capitol. Daily, I briefed the public in nearby Middletown.

I had never met President Carter or Governor Thornburgh. Their appreciation of the gravity of the situation, and their direct personal involvement led to remarkable cooperation during the crisis. Bureaucracy was set aside. For example I never signed any paperwork throughout those weeks. The military provided invaluable logistical support by bringing people and equipment from around the country to the site. The Department of Energy conducted extensive environmental sampling and monitoring. Mobile phones for use by the ever growing NRC staff onsite were borrowed from the Forest Service. My three weeks on site were challenging, hectic and, at times, surreal.
A widely held view at the time of the accident and for years afterwards, was that most damage was confined to fuel cladding, and not to fuel pellets themselves. This view was inferred from measurements outside the containment and from computer simulations. However, the first visual examination of the reactor core showed a drastically different picture. The uppermost fuel assemblies were completely destroyed. Subsequent research revealed that at least 45% of the core was melted.

The critical phase of the accident was actually over by Wednesday morning. Operators turned off redundant emergency core cooling water systems although the reactor was actually losing water continuously through a failed valve. No core damage would have occurred if the emergency pumps, which started automatically, had been left running instead of being shut off. About 100 minutes into the accident, fuel at the top of the core was uncovered and began to overheat. As the water level in the core fell, more and more of the central core melted, flowed downward and solidified when it reached water. Approximately four hours later, nearly 20 tons of molten material reached the bottom of the reactor vessel. A circular area at the bottom of the vessel reached extremely high temperatures for about thirty minutes before cooling. At 16 hours into the accident, operators managed to restart pumps thereby re-establishing water flow and stabilizing core conditions.

A robust containment structure proved valuable as off-site radiological consequences of the TMI accident were minimal. The use of a leak tight containment preventing a significant release of radioactive materials can be traced to the foresight of a blue-ribbon safety committee of the Atomic Energy Commission in 1947. At its' first meeting, the committee considered a containment concept to prevent serious releases of radiation to the environment in an accident situation. Since then, containment structures have been a required safety feature of commercial reactors. During the TMI accident, the amount of Iodine 131 (a particularly hazardous radionuclide) released to the environment was about a million times less than that released as a result of the uncontained Chernobyl accident in the Ukraine. The possibility of penetration of a containment basemat by a molten core i.e. China syndrome, had not been studied extensively. Based on research information now available on failure mechanisms, and industry studies, it is unlikely that the TMI containment would have failed even if the hot core had reached the thick concrete basemat.

A hydrogen explosion occurred inside the reactor containment on the first day of the accident. Thus, the possibility of an explosion in a hydrogen bubble within the reactor vessel was explored. The bubble concern arose when it was realized that a large bubble of hydrogen might burn or explode if sufficient oxygen was present. It was recognized that oxygen was being generated over time from radiolytic decomposition of water. Unfortunately, the phenomenon was initially modeled incorrectly, and neglected the an all important chemical reaction which would cause the oxygen to recombine with dissolved hydrogen in the water essentially as soon as it was formed. My deputy at the site NRC's Victor Stello, had concluded by Saturday night that no explosion was was possible at any time.. Unfortunately, this factor was not sufficiently appreciated initially, and led to the near-hysteria in the Harrisburg area on Saturday night. By Monday, April 2, the operators had mooted the question by reducing the size of the "bubble" to an insignificant level.

The accident was comprehensively examined by a number of official studies and investigations, including the President's Commission on the Accident at Three Mile Island, an NRC Special Inquiry Group, the Congress, the General Accounting Office, and the State of Pennsylvania. Although the accident was the result of many deficiencies, the most significant causes were in the area of operational safety. This includes qualifications and training of the plant staff and management, as well as NRC's licensing and inspection of operating plants.

Follow up recommendations for all sites included the expanded use of plant simulators, improvements both in the content and level of training, and in procedures and design of control rooms. Changes resulting from the accident have significantly reduced the overall risks of a future serious accident. Today, reactors are operating far more safely and reliably than ever. The number of precursor events that could presage another severe accident has declined markedly. Another significant outgrowth of the accident was the creation of the Federal Emergency Management Agency by President Carter. This agency is responsible for off-site planning for nuclear emergencies and reviewing state emergency plans.

Nuclear power plants being considered by industry today are designed to minimize events that could lead to a need for safety system action. They also provide improved means for operators to recognize and take appropriate corrective actions. France and Japan have continued their nuclear power programs while ours have languished since TMI. They have benefited from the learning curve associated with a single reactor design.

Much of the specialized industry capability that existed at one time in the U.S. has disappeared. Special NRC attention to procurement and testing of components for any new plant construction

appears warranted. Even Finland, which is building one of the advanced French designs, has encountered delays and cost overruns due to poor quality controls.

In conclusion, nuclear power plants in the U.S. are safer today than ever. Federal and State Governments as well as Utilities, are much better prepared to deal with an emergency, should another one occur.

Question from Senator Inhofe
Your wealth of experience at the Commission came during the industry's peak period of new plant licensing and the event at Three Mile Island. Do you believe the Nuclear Regulatory Commission is equipped to handle new plant licensing while maintaining the safety of existing plants?

Answer
Based on the information available from the NRC's web site and on informal conversations with staff members, congressional funding has been substantially increased during the past few years. As a result, the commission's needs and congressional funding now appear reasonably congruent. Also, I would not be surprised if schedule slippages and deferrals are announced by some of the COL reactor applicants. First quarter electrical demand this year is significantly below last year's usage in some regions, and financing may be more difficult than had been anticipated. In fact, last week one such applicant announced a project suspension citing financing uncertainties.

In 1978, immediately prior to the TMI accident, NRC was operating with an authorized personnel level of 2723 and funding of 292 million.

Question from Senator Vitter
We have spent much of this hearing talking about the past. Can you please spend a little time talking about the advances we see today in countries that are looking at increasing domestic nuclear power and what the future looks like for those countries that increase nuclear production? In particular, I'd appreciate your sharing some of your thoughts on the advances in science and technology and the potential this industry has Domestically and internationally.

Answer

As of April 2009, there were 436 nuclear power plants in operation around the world. The USA has 104 plants, the most of any country. France ranks second in terms of number of plants with 59 plants in operation. The French have had a national objective for many decades of becoming energy independent and the world's leader in nuclear power. Japan ranks third, with 53 plants. Japan decided to rely on nuclear power for about on half of its electrical power production, and on imported LNG. Both countries expanded their use of nuclear power during the past thirty years while the U.S. has not.

With regard to future international trends, 14 countries have a total of 45 nuclear power reactors under construction. IAEA Director General Mohamed ElBaradei of the IAEA gave the following assessment in April of this year:

"2008 was a somewhat paradoxical year for nuclear power. It was the first year since 1955 in which not a single new power reactor came on line, but it also saw construction start on no fewer than ten new reactors. This was the highest number since 1985, the year before the Chernobyl accident. ..... Growth targets have been raised significantly here in China, in India and in the Russian Federation. Asia remains the focus of growth in nuclear power. Of the ten construction starts in 2008, eight were in this region – and six of them were in China. .... In Europe, Italy plans to restart its nuclear power programme while the Swedish government has proposed dropping plans to phase out nuclear power and building replacement reactors. Other European countries also have expansion plans"

These new plants reflect numerous advances in science and technology that will achieve much greater safety and reliability levels. I think the most important advance has been in computer technology. For example, this has led to integrated nuclear designs using detailed probabilistic risk analyses. As an example, a recent NRC safety evaluation concluded:

"The AP1000 PRA is an integrated view of the AP1000 behavior in response to transients and accidents, including severe accidents. The AP1000 core damage frequency for internal events from at-power conditions is extremely low. The core damage frequency calculated for internal events at shutdown conditions is also very low. The combined core damage frequency from internal events at power and at shutdown conditions meets the NRC and URD safety goals with substantial margin."

Computer advances have also permitted the utilization of full scale, real time, plant simulators at every site for operator training and procedure development. Computer technology advances have also led to the use of digital instrumentation and control systems in many new nuclear power plants around the world. Digital systems can significantly increase the safety and performance of nuclear plants and are in use in a number of European plants. Another illustration of the benefit of computer technology is data link between NRC emergency centers and every plant.

The industry's worldwide sharing and use of operating data, especially component reliability information, is contributing significantly to improved plant performance. The world now has around 12,700 reactor-years of experience.

In summary, the most advanced nuclear power plants and research reactors are operating outside the U.S. although many of the original concepts originated here. The proposed new power reactors in the U.S will be comparable in safety and reliability to those advanced designs elsewhere in the world.

Senator CARPER. Thanks. Your entire statement will be made part of the record. When we add new questions, I am going to come back and ask you to kind of go back and revisit that last part of your testimony for us, if you would. Thanks so much.

Governor, General Thornburgh, we are delighted that you are here. I don't know how many people have been both a Governor and Attorney General for two Presidents, but not too many. So it is a real honor for us that you are here. Thank you.

STATEMENT OF DICK THORNBURGH, OF COUNSEL, K&L GATES LLP, FORMER GOVERNOR OF PENNSYLVANIA

Mr. THORNBURGH. Thank you, Mr. Chairman, members of the Subcommittee. My full written statement attempts to recount on a day by day, hour by hour basis the events of March 28, 1979, and the days immediately following, from my vantage point as a newly minted Governor of Pennsylvania.

Senator CARPER. I think we all found it just very interesting. All the testimony is very good, but it was just riveting the way you documented it. So it was very interesting.

Mr. THORNBURGH. Thank you.

The statement addresses a couple of things that I want to emphasize about the emergency management side. One is the constant frustration that existed concerning the inability to acquire reliable information about what was transpiring at the damaged reactor, and the difficulty in communicating between various centers of activity.

Remember, this was an era before we had cell phones, the Internet, BlackBerrys, video conferencing and the like. Land lines, which were the exclusive way to communicate, were frequently jammed, even the so-called hot line which had been established between the White House and President Carter and myself.

Reliable information concerning potential threats to health and environment were equally hard to come by. Experts proliferated, but most of them were of little use. They either exaggerated the safety or exaggerated the threat of the situation.

I would be remiss if I didn't pay particular tribute to Harold Denton, who proved to be the real hero of this episode. He had an ability to translate nuclear jargon into plain English. He had a calm demeanor that built confidence and credibility, and he served as an effective antidote to the coincidental opening of the movie The China Syndrome in the Harrisburg area just prior to the accident. Talk about surreal events. That had to be one at the top of the list.

We have seen 30 years pass since the time of the event, and I want to offer some brief observations on the future of nuclear power in light of present day circumstances.

Energy independence is a byword today. A familiar litany has developed about the need to rely more on alternate sources of energy, but most people acknowledge that the prospects of substantial and timely relief from hydro, wind, solar, biomass, et cetera, is highly unlikely.

As a result, there is a growing and renewed interest in nuclear energy, which is now supplying in many countries around the world more than the majority of their energy needs.

There is more and more interest in all non-carbon producing sources, such as nuclear, even among some environmentalists who are traditional opponents of nuclear energy. Concerns about global warming have made strange bedfellows indeed.

The predictions of a comeback for nuclear power must be tempered, however, by major concerns that exist, and I will refer to those briefly. Nuclear technology, as has been referred to today, has become increasingly complex and demanding, and more expensive, and we have to rely more and more on foreign component manufacturers. Even the pioneer in this area, Westinghouse Electric in my State of Pennsylvania is now owned by Toshiba.

The costs of construction are going to go up, increased financing costs, the $18.5 billion loan guarantee program authorized in 2005 has been underfunded and understaffed, and now must compete with other priority needs.

The safety record that has been referred to this morning, and it is certainly improved since pre-1979 times. Emergency management capabilities at the State and local level, while they have no doubt been upgraded, have not been tested, and with the passage of time no doubt have not been the high priority that they were in the immediate aftermath of TMI.

I think the most important and sizable barrier to a vigorous development of nuclear power in the U.S. is the inability thus far to solve the problem of the disposal of spent nuclear fuel. President Obama's scuttling of the Yucca Mountain site is only the most recent setback in the effort to tackle this vexing challenge.

Surely, this has to be a high priority in the expenditure of Federal research and development funds, even to the point of committing to a Manhattan Project type undertaking, to call upon our technological expertise to remove a significant barrier to helping to solve our energy problems and contribute to a better quality of life for all of our citizens.

Thirty years after the Nation's most serious nuclear accident, we have yet to address many of these key issues in a systematic way, and I compliment you, Mr. Chairman, and your Members, in calling this hearing to spotlight some of these issues.

If we continue on our present path, we threaten to deprive ourselves of a potential green source of much-needed electric power.

Many thanks. I look forward to your questions.

[The prepared statement of Mr. Thornburgh follows:]

**"Three Mile Island – Looking Back
On Thirty Years of Lessons Learned"**

**Testimony
by
Dick Thornburgh
Former Governor of Pennsylvania
Counsel, K&L Gates LLP**

**To
Subcommittee on Clean Air and Energy
Committee on Environment and Public Works
United States Senate**

**Room 406
Dirksen Senate Office Building
Washington, DC**

Tuesday, March 24, 2009

It is not easy for me to forget that date nearly 30 years ago – March 28, 1979 – when we were called upon to deal with something that had never occurred on the face of the earth, the threat of a nuclear meltdown at the Three Mile Island nuclear plant, not far from the state capital in Harrisburg, Pennsylvania.. You have asked that I share with you some of the lessons learned from that event which occurred shortly after I had taken office as governor of Pennsylvania and I am pleased to join you this morning for that purpose.

Let's begin at the beginning. Only one thing was on my mind at 7:50 that morning. As a governor in office only 72 days, I was vitally interested in securing passage of my first budget – one that would reflect my administration's priorities for the Commonwealth of Pennsylvania – and I was hosting a breakfast meeting at the Governor's Home for freshmen Democratic legislators to seek bipartisan support for my fiscal plan.

At 7:50 a.m., however, a telephone call from the state director of emergency management interrupted our meeting. Hew told me that there had been an accident at the Three Mile Island nuclear power plant, located just ten miles downstream of us, in the middle of the Susquehanna River.

I knew immediately that our ambitious agenda for leadership was about to be rudely amended.

What happened in the next five days is history.

I.

DAY ONE

The problem had actually begun at 4 o'clock in the morning, when vital cooling water started to escape through an open valve in the newer of two nuclear reactors at the plant.

For the next two-and-a-quarter hours, plant operators failed to read these symptoms correctly, failed to close that valve, and mistakenly shut off an emergency cooling system that otherwise would have operated automatically.

The reactor core overheated, and the worst accident in the history of commercial nuclear power in the United States was well underway by sunup.

We know now that while some of the reactor fuel heated to the point of melting, a disastrous "meltdown," as suggested in the popular movie "China Syndrome," would be avoided.

We know now that while detectable amounts of radiation escaped into our air and water, and even into our milk, during the days of tension that were to follow – the amounts were limited and their impact on public health, if any, remains debatable.

And we now know that a massive evacuation of the up to 200,000 people residing in the area, and its potential for panic, injury and even loss of life, would have been far more dangerous and damaging than was the accident itself.

But when I answered the phone at 7:50 on that March morning in 1979, we knew none of this.

Nuclear power was still the technological marvel of our time – to some the ultimate answer to our growing energy problems, a source of electricity once described as "too cheap to meter" – and an industry whose safety record had been, or at least was thought to have been, second to none.

I had neither reason nor inclination to challenge these assumptions – except, perhaps, the one about my light bill being too cheap to meter. Nuclear jargon was a foreign language to me, and my exposure to emergency management at a nuclear power plant was limited to a perfunctory briefing just after taking office.

I knew enough, however, that the thought of issuing a general evacuation order first entered my mind at 7:50 that morning and never left me through the unprecedented days of decision that followed.

On the first day, it was not yet clear that the governor would have to personally manage the civilian side of this crisis, but it was very clear that a new administration, with ultimate responsibility for public health and safety, had better start asking questions, analyzing answers, and preparing for the worst.

Because we were so unfamiliar with the existing state bureaucracy, and because there simply was no state bureau of nuclear crisis management, as such, let alone a precedent to study, we did something at the outset which was to serve us very well.

In lieu of the existing bureaucracy, I assembled what might be called an "ad hocracy" – a team of close associates whose judgment and competence I had come to trust and a support group of relevant state specialists whose judgment and competence were about to be tested under pressures none of them ever had known before.

The ad hocracy reported to me only periodically at first, and those reports were sandwiched between other pressing, but somewhat normal, affairs of state.

At the outset, I believed it was important to try to conduct business as usual in the governor's office, and perhaps even more important to appear to be doing so.

As the implications of the accident became more apparent, however, I began to cancel other appointments, and the ad hocracy virtually moved into my office for an extended, and unforgettable, stay.

Our first task was to find out exactly what was happening at the site of the accident. My training as an engineer and a lawyer had given me a well-developed respect for the integrity of

facts which was to serve me well throughout this experience. As I had in those professional endeavors, I was to instinctively demand much more of my sources than mere opinion, conjecture, guesswork or contradictory allegations. I wanted the facts as best as they could be determined and as quickly as they could be assembled.

In the case of TMI, this could prove to be far more difficult than any of us imagined.

The utility, its regulators and other groups and institutions appeared to be contradicting each other, or telling the public either less than they knew or more than they knew. Self-appointed experts began to exaggerate either the danger or the safety of the situation.

The credibility of the utility, in particular, did not fare well. It first seemed to speak with many voices, and then with none at all.

On that first day, it made its debut by seeking to minimize the accident – assuring us that "everything is under control" when we later learned that it wasn't, and that "all safety equipment functioned properly" when we later learned that it didn't.

And even when company technicians found that radiation levels in the area surrounding the island had climbed above normal, the company itself neglected to include that information in its statement to the public.

The company had also vented radioactive steam into our air for two-and-a-half hours at midday, without informing the public.

It fell to us then, to tell the people of central Pennsylvania, as my lieutenant governor did at a 4:30 p.m. press conference, that "this situation is more complex than the company first led us to believe," that there had indeed been a release of radioactivity into the environment, that the company might make further discharges, that we were "concerned" about all of this, but that off-

site radioactivity levels had been decreasing during the afternoon and there was no evidence, as yet, that they ever had reached the danger point.

Although we continued, throughout the crisis, to monitor what utility officials were saying, we began to look elsewhere for sources of information that would be more credible to the public, as well as helpful to us. Among others, we turned inevitably to federal engineers and inspectors who had spent most of the first day inside the plant.

Three of these on-site government experts briefed us at the Governor's Residence that night and joined the lieutenant governor in a 10 p.m. press conference that was to put a long Day One to bed for most members of the ad hocracy.

I was to prove an exception. My past reading habits would delay what otherwise might have been a deep, comfortable and much-needed sleep, because I recalled reading a book, reassuring entitled "We Almost Lost Detroit," an account by John G. Fuller of problems at the Enrico Fermi nuclear power plant in Michigan. I remembered Fuller's discussion of the consequences of core damage at the Michigan plant and realized that our federal experts had not raised this issue with respect to TMI during our evening briefing.

It is well to remember that, in 1979, few people realized there really was no danger of an actual nuclear explosion – mushroom cloud and all – from a nuclear power plant. That isn't physically possible.

The real catastrophe – as outlined by Fuller – would be the overheating of the reactor core to the point where it actually melts down and burns through its concrete and steel containment, thereby releasing massive amounts of radioactive material which, silently, but lethally, could contaminate the environment for miles around, and for centuries to come.

The term "China Syndrome" was derived, in fact, from the theory that such a core would be so hot it actually could burn its way through to the other side of the earth.

Ironically, the movie of that name was running in Harrisburg area theaters that week and its script incredibly described a meltdown as having the potential to contaminate an area "the size of the state of Pennsylvania"!

I did manage to get to sleep that night, but I began Day Two with my new skepticism toward the experts and the industry fully intact.

II.

DAY TWO

As the authors of a specially commissioned report were to write much later, the second day of the crisis was an "Interlude, a day for the drawing of deep breaths . . . a good time for Members of Congress to put in an appearance," which, of course, they did.

Chairman Joseph Hendrie of the NRC, meanwhile, was telling a congressional committee in Washington that we had been "nowhere near" a meltdown, although he had no way of really knowing this at the time. The company was holding its first full-fledged press conference since the accident and telling reporters that the plant was "stable" and that the controlled release of limited amounts of radioactivity into our atmosphere soon should be terminated. There seemed to be a feeling among those in charge that the worst of the accident had been passed. I wanted to believe that, of course, but I was not so sure.

The effort to get a true "fix" on the situation was hampered by self-appointed experts and eyewitnesses of dubious distinction who continued to feed us unsubstantiated stories about dead animals, along with exaggerated warnings, various evacuation schemes, and a ridiculous tale – prompted by a poorly-worded NRC press release in Washington – of radiation so powerful that it

was penetrating four feet of concrete and spreading across the countryside up to 16 miles from the plant. There also were signs popping up in grocery store windows proclaiming, "we don't sell Pennsylvania milk."

At the same time, we were aware that utility company efforts to cool down the reactor were not working as well as expected and that a certain air of apprehension was beginning to affect all those monitoring the process of recovery.

Public faith in the experts and institutions was beginning to erode and it was clear that the credibility of the governor's office was to become much more than simply a political asset for its occupant. That credibility was to become, perhaps, the last check against a possible breakdown in civil authority, and the chaos and panic such a breakdown surely would ignite. Obviously, we were determined to preserve that check.

The time had come, I felt, for the state to become more visibly active and to use whatever credibility we had maintained to put things back into perspective – to establish, in other words, that the situation was not as bad as some would have us fear, nor as good as others would have us believe. We all agreed it was time for me to become publicly involved in the effort.

In my briefing to the press that day I noted that while there was no cause for alarm, we would remain alert. I stated that "I have spent virtually all of the past thirty-six hours trying to separate fact from fiction about this situation. I feel that we have succeeded on the more important questions . . .", although I privately suspected that the latter was a bit of an exaggeration. I was followed by one of the experts from the NRC – a staff member who declared, to my astonishment, that "the danger is over," a comment definitely not in the script.

I learned later that night that another on-site expert privately disagreed with this assessment, and that water samples indicated that "core damage is very bad."

Thus, Thursday ended on this somewhat edgy note, but it was a mere prelude to a Friday I will never forget.

III.

DAY THREE

That was to become known as the day of the great evacuation scare – the day that illustrated not only the folly, but the very real danger, of trying to manage this kind of an emergency by long distance.

It began, once again, in the early morning hours, when the shift operators at TMI were alarmed by a buildup of steam pressure in a valve. Without approval from anybody, they simply opened the valve and allowed the steam, along with a substantial amount of radioactive material, to escape into the atmosphere.

It so happened that, at that precise moment, a helicopter was taking radiation readings directly above the plant's exhaust stack. Not surprisingly, they indicated a very high radiation exposure rate – 1200 millirems per hour – a rate certainly high enough to warrant an evacuation, if the readings had been taken in nearby Middletown, in Harrisburg – or anywhere off the plant site itself.

But coming directly out of the stack, where the materials immediately were dispersed, such a reading was no more significant than those taken on the previous two days of the crisis.

Unfortunately, in a classic manifestation of what I later was to call the "garble gap" between Harrisburg and Washington, the NRC's Washington-based Executive Management Team thought that the readings had, indeed, been taken in an off-site area and decided to recommend that we evacuate all residents within a five-mile radius of the plant.

Also, unfortunately, this Washington group forwarded its recommendations up to us through our Emergency Management Director instead of our radiation protection director – the latter of whom could have corrected the error and spared central Pennsylvania from reaching the very brink of panic which was to ensue.

And even more unfortunately, the emergency management director called a local civil defense director, who called a local radio station with the news that an evacuation order from me might well be imminent. I had yet to be so informed.

When the word finally did get to me that a "Doc Collins" from Washington was saying we should evacuate, I was dumbfounded. I had no idea who "Doc Collins" was or by what authority or for what reason he was making such a recommendation – and I certainly did not intend to evacuate thousands of people on such incomplete information.

For no matter how well planned, massive evacuations had the potential to kill or injure people – especially the aged and infirm, infants in incubators, other hospital patients, and even the able-bodied bystander who, like the usher in a burning theater, happens to be in the wrong place at the wrong time.

I finally connected with the NRC chairman, and by the time I reached him, his staff had discovered what my own radiation experts were telling me: that the evacuation advisory was a mistake. The NRC group withdrew that advisory, and I immediately went on the radio to assure our people that the alarm was a false one and that there was to be no general evacuation. My difficulty in getting answers was compounded by the jamming of the switchboard – thanks not only to the premature disclosure of an erroneous evacuation advisory, but by the mysterious tripping as well of an emergency siren that soon had hearts pounding and eyes widening all over the city.

People were throwing their belongings into trucks and cars, locking up their shops and homes and packing to get out of town. If ever we were close to a general panic, this was the moment.

For the moment, however, the evacuation question was not entirely settled. While relieved that a general evacuation was unnecessary, the confusion which that episode exposed in Washington as well as in the plant and the uncertainty over what might happen next, troubled us deeply.

We began to wonder on our own if pregnant women and small children, those residents most vulnerable to the effects of radiation, yet relatively easy to move, should be encouraged to leave the area nearest the plant. We decided to put that question directly to Chairman Hendrie, who answered, "If my wife were pregnant and had small children in the area, I would get them out, because we don't know what's going to happen."

Shortly after noon on Day Three of the crisis, therefore, I recommended that pregnant women and preschoolers leave the area within five miles of the plant until further notice, and that all schools within that zone be closed as well.

I also ordered the opening of evacuation centers at various sites outside the area to shelter those who had no place to go.

"Current readings," I told the people, "are no higher than they were yesterday [but] the continued presence of radioactivity in the area and the possibility of further emissions lead me to exercise the utmost of caution."

Shortly after that, I was on the phone with President Carter at the White House. It was time to go to the top. Our two staffs had put aside partisan interests in dealing with this crisis

from the beginning, and rightly so. They had developed the kind of "friendship under fire" such incidents frequently promote.

My first conversation with the president was therefore honest, open, direct and above all, productive.

I asked for, and the President agreed to send us, a high-ranking professional who could go to Three Mile Island as his personal representative, merge solid technical and management expertise with an on-site perspective, and report accurately and directly to the White House, to me, and to the people on what was going on out there, what was not going on, and why.

His choice for this task, Harold Denton, the NRC's director of nuclear reactor regulation, turned out to be a near-perfect one, and his arrival later in the day would represent a turning point in the crisis.

Harold Denton arrived at the plant that afternoon. A three-way hotline was installed there to connect him with me and with the President. Later that night, Harold and I met for the first time and spent an hour-and-a-half reviewing the situation.

It was quite clear that his slow and relaxed North Carolina drawl, his way of smiling naturally as he spoke, his ease and apparent candor with the press, his ability to speak plain English as well as nuclear jargon – all of these factors soon were to make him the world's most believable expert on the technical situation at TMI. And it wasn't to be long before his value would be put to the test.

While he was on his way up to Pennsylvania, his colleagues in Washington finally referred publicly to the theoretical possibility of a meltdown, an accurate but poorly handled statement which caused even that most credible of all Americans, Walter Cronkite, to lead the CBS Evening News by saying, "we are faced with the remote but very real possibility of a

nuclear meltdown at the Three Mile Island atomic power plant." One could almost feel the collective shudder going through central Pennsylvania at this pronouncement.

Harold Denton joined me in a press conference at 10 that night, put the facts in perspective, lowered the level of concern and earned his spurs with the press -- and with me.

While we did continue to crosscheck his observations against those of my own team, we quickly became convinced that he was as credible as he appeared to be.

As Day Three wound down, I felt we finally were equipped to handle the misstatements, second-guessing and false alarms that were certain to continue.

IV.

DAY FOUR

Harold Denton's long series of regular press briefings in Middletown, near the plant site, began on Day Four, Saturday, March 31.

A brief visit to those young mothers and mothers-to-be who had been evacuated to the Hershey Sports Arena that day preceded yet one more scare to the people of central Pennsylvania.

Based on information given to it by an anonymous NRC source in Washington, a wire service ran a news bulletin that evening that read:

"U-R-G-E-N-T . . . The NRC now says the gas bubble atop the nuclear reactor at Three Mile Island show(s) signs of becoming potentially explosive . . ."

This fear was totally groundless. The hydrogen bubble never would explode in the reactor vessel. As one review of the crisis later recalled: "It would blow up, instead, in the media."

The bulletin, in its most cryptic and chilling form, moved like a hurricane advisory across the bottoms of prime-time television screens everywhere that Saturday night. In Harrisburg, people streamed out of downtown bars and restaurants. Our switchboard jammed again, and a herd of reporters stampeded into my press office, not for the story itself, but demanding to know if they should get out of town. Obviously, we had to move fast.

We called Harold Denton at the plant and learned that there was no danger of imminent explosion and no cause for alarm. My press secretary, skipping our normal clearance procedures, banged out a three-paragraph statement to that effect and literally ran it down to the capitol newsroom.

Concurrently, we asked Denton, who was on his way to my office, to go directly to the newsroom instead – which he did.

Within minutes, stories quoting our statement, and then Harold's impromptu news conference, began to move on the wires, and another potential panic seemed to have been avoided.

In the course of this "bubble" drill, we had been in touch with the White House and discussed the possibility of a visit to the area by the President himself. Press Secretary Jody Powell authorized me to say that the President would, indeed, be joining us in the near future, and I did. Powell issued a similar advisory out of Washington. That was to be, in effect, the end of the panic avoidance phase of our crisis.

V.

DAY FIVE

The President and Mrs. Carter did arrive the very next day, and he and I toured the plant together – in full view of network television cameras. The image beamed around the world on

April 1, Day Five of the crisis, had its desired effect. If it was safe enough at Three Mile Island for the Governor of Pennsylvania and the President of the United States, it had to be safe enough for anyone.

Over the next several days, Harold Denton continued to oversee the cooling of the reactor core and offer progress reports to a press contingent that was fast losing interest in the story.

On Friday, April 6, just ten days after that fateful opening of what had become the most famous power plant valve in the world, I prepared to tell our people that the crisis had been passed, and that those who had chosen to leave the area "can, indeed, come home again." And the crisis wound down.

VI.

LESSONS LEARNED

The experience of Three Mile Island provided a number of lessons useful not only in managing unforeseen crises, but some of the normal problems of governing as well. Let me try to summarize these.

1. Perhaps the first among these lessons is to "expect the unexpected" and be prepared to adjust accordingly. As governor, I was to find that if it wasn't Three Mile Island, it was three-mile gas lines. If it wasn't a water shortage, it was a flood. If it wasn't a transit strike, it was a subway crash. And so it went throughout my eight years in office.

The importance of limiting those things that any executive should attempt to do in the time allowed, the importance of carefully choosing one's battles, is implicit in the fact that some of the toughest of those battles are chosen for us.

Of prime importance in mounting those battles is to insure that good men and women are in place to handle the planned agenda – should the boss become occupied by an item that never was planned at all.

2. When an emergency does strike, a trusted "ad hocracy" may be far more useful than an entrenched or untested bureaucracy. It was not in our job description to function like a virtual grand jury, grilling witnesses to a nuclear emergency, and then to serve as a worldwide communications center, but it worked. A manager should not be afraid to scramble the organization chart, as in a familiar example, President Kennedy did during the Cuban missile crisis, when his own brother's advice weighed more heavily with him than that of the Secretary of State or the Joint Chiefs of Staff.

3. Be ready to restrain those who, as described by our emergency management director during the crisis, may be "leaning forward in the trenches," helmet, sirens and all, and thinking solely in terms of "doing something," regardless of the safety or necessity. This applies not only to emergency volunteers and staff, and not only to emergencies, but to bureaucrats, technocrats, academicians, medical and other professionals, and, yes, even to those in the political end as well. The impulse in government to act merely for the sake of action, or to test a plan or agency simply because it is there, must be kept firmly under control.

4. Be wary of what might be called "emergency macho" – the temptation to stay up all night and then brag about it, or, more likely, allow the press staff to brag about it. While it often is important for a manager to maintain a visible and reassuring presence, anyone making life or death decisions for thousands of innocent people owes those people a mind that is clear and a body that is rested.

5. Don't try to manage an emergency away from the site. This does not mean, of course, that one must be on-site personally, but someone must be in charge there whose competence and judgment you can trust.

As you have seen, most of our communications problems originated in Washington. Even Harold Denton, I later learned, had been a major participant in that bogus evacuation advisory the NRC sent up to us on the third day.

Harold later was to concede that "I've learned that emergencies can only be managed by people at the site. They can't be managed back in Washington."

6. Search for and evaluate the facts and their sources again and again, and communicate those facts truthfully and carefully to the people, remembering that credibility can be as fragile as it is crucial in the cauldron of a genuine public emergency. Of course, the fact-gathering task would have been immeasurably easier had we access to cell phones, text messaging, the Internet and the like in March, 197, but none of them had yet been invented!

7. Respect but do not depend on the news media. Throughout the Three Mile Island incident, we developed a considerable empathy for the more than 400 reporters from around the world who were assigned to cover this event. Their frustrations mirrored ours in the attempt to establish reliable facts. In many instances, our decision makers and members of the media "compared notes" on vital issues to ensure both the quality of the reporting and the quality of action within the state government. Not all of the reporting was reliable, however, and some was downright outrageous. For example, I was informed that a British news organization, in its attempt to convey the gravity of the situation, carried an item to the effect that "the governor's wife, pregnant with their first child, has left the area." In fact, my wife was not pregnant; we already had four children, and most important, she stayed with me in Harrisburg during the entire

episode, as did the Lt. Governor, incidentally, whose wife was pregnant with their first child and who also stayed with him.

8. Forget partisanship, for there is no Republican or Democratic way to manage a real emergency. In our stewardship of this most basic of all public trusts, we inevitably survive or suffer together, and not incidentally, so do the people we are elected to serve.

9. Value and learn from history. While the Fuller book on the Fermi plant proved useful, let me assure you that if one of my colleagues already had experienced a nuclear emergency like Three Mile Island, and had recounted it in published form, such a publication would not long have lingered on my bookshelf.

10. And finally, as that well-known American philosopher, Yogi Berra, once said: "It ain't over 'till it's over."

Within a year after the accident, I had to step into a new furor over a plan to vent radioactive krypton gas into the atmosphere as part of the TMI cleanup operation. Public hearings on the safety of the plan almost turned into riots.

One imaginative opponent of the krypton venting put on a "Superman" suit and proceeded to "choke" himself on the front steps of the capitol.

I took the unorthodox step of asking the Union of Concerned Scientists, a well-known group of nuclear industry critics, to study the venting plan. When that organization concluded that it posed no physical threat to public health and safety, the venting proceeded peacefully.

The year after that, however, we learned that no plan had yet been devised to fund the billion-dollar effort necessary to decontaminate the damaged reactor.

Because the site could not be considered truly safe until cleanup has been completed, and because the established institutions appeared to be at an impasse, I had no choice but to develop

and push my own $billion-dollar national cost-sharing plan for its funding, a plan which was finally contributed to by the utility, state and federal governments and the nuclear industry and which finally accomplished the cleanup in August of 1993.

Protracted proceedings were held as well involving the utility's application to restart the undamaged Unit I reactor at Three Mile Island. This question ultimately went to the Supreme Court of the United States and consumed thousands of hours of state time in our effort to ensure a maximum commitment by the plant operators to public health and safety and the integrity of the environment in the area of the facility before restart was undertaken. And new problems were raised almost daily with regard to the process of decontamination and the legal, economic and social aftermath of the accident.

Of course, the effect of the accident on the nuclear power industry in America was devastating. New construction was stopped dead in its tracks and no new plants have been undertaken since 1979. And while we still derive about 20% of our electrical power from nuclear sources, the added cost and increased scrutiny by regulatory authorities since the accident, together with the decreasing costs of competing sources, have added up to an uncertain future for an industry which, prior to 1979 appeared to hold so much promise. One positive fallout from the Three Mile Island era, to be sure, has been a much higher emphasis on safety at the over 100 presently operating facilities in the country.

One final postscript is of interest. In December 1979, some eight months following the accident, I visited the then-Soviet Union and met in Moscow with top governmental and scientific leaders in their nuclear energy and emergency management programs to share with them some of the lessons of Three Mile Island, or as our interpreter called it, "Five Kilometer Island." To our discomfort, they told our party that they regarded nuclear safety as a "solved

problem"; that the problems raised by our experience had been "over-dramatized"; and quoted the head of their National Academy of Science as saying that Soviet reactors "would soon be so safe as to be installed in Red Square."

The rest, of course, is history. How hollow those boastful observations rang on April 26, 1986, when a far more terrifying event occurred at Chernobyl. One must wonder if that accident might have been prevented if the people of the Soviet Union had been as free to question their authorities as were Americans following the Three Mile Island accident in 1979.

Without a free press, however, the Soviet people had no opportunity to learn that Chernobyl was probably more dangerous than TMI, or even to alert their people to the accident itself, which became known only after unusually high radiation levels were detected in other countries with a free press.

There was no right of free speech to protect a Soviet citizen who might have warned of such a danger or the need to quickly evacuate.

And, of course, there were no free elections which might have prompted the Soviet government to be more accountable to its constituents and more attentive to their health and safety needs.

For all of its shortcomings, the genius of our political system is that its open nature makes it difficult, if not impossible, to ignore or suppress problems such as those raised by TMI.

And that suggests the larger lesson of the accident of March 28, 1979. Democracy may indeed be, as Winston Churchill once observed "the worst system of government man could possible devise – except for all the rest."

One parting observation which may be self-evident.

A prominent Pennsylvania judge, in observing the challenges of emergency management, recently wrote:

> "The ability of decision makers to make wise choices and to exercise good judgment depends on their ability to receive accurate technical information whether it is medical, engineering, epidemiological, biological or whatever."

To this I can only lend a loud "Amen." That, I suggest, is the essential take away from my presentation this morning.

Thank you.

Senator CARPER. Governor, thank you so much.

Mr. Fertel, Marvin Fertel, welcome. We are happy that you are here. Thanks.

STATEMENT OF MARVIN S. FERTEL, PRESIDENT AND CHIEF EXECUTIVE OFFICER, CHIEF NUCLEAR OFFICER, NUCLEAR ENERGY INSTITUTE

Mr. FERTEL. Chairman Carper and Members of the Committee, thank you for holding this hearing today.

As you know, this month marks the 30th anniversary of the accident at Three Mile Island. Since then, the nuclear energy industry and the Federal Government have dramatically increased safety and reactor operating standards and developed a safety culture that we believe is demonstrably among the best in American industry and worldwide.

The accident at Three Mile Island has had profound and lasting effects on virtually every aspect of nuclear power plant safety and operations. Lessons learned from the accident are permanently ingrained in the nuclear industry's training, procedures, regulations, and culture.

The Kemeny Commission, which has been referred to earlier, recommended two things that we took very seriously. First, "that the nuclear power industry should establish a program that specifies appropriate safety standards, including those for management, quality assurance, and operating procedures and practices, and that conducts independent evaluations." And second, "that there must be a systematic gathering, review and analysis of operating experience at all nuclear plants, coupled with an industry-wide international communications network to facilitate rapid flow of information to affected parties."

The industry took those recommendations and formed the Institute of Nuclear Power Operations 9 months after the accident, and charged it with promoting the highest levels of safety and reliability in the operation of our plants.

The institute drives operational excellence, open communications, and continuous improvements among all U.S. nuclear plant operators. All U.S. energy companies that own and operate nuclear plants are members of INPO and they are driven by INPO to continuously strive for excellence in reactor operation.

INPO has had a profound impact on the way nuclear plants are managed and operated. The proof, we believe, is in the steady improvement in plant performance over the last three decades since the accident. To improve training, INPO in 1985 formed the National Academy for Nuclear Training to focus and unify industry efforts to continuously improve training and qualification programs and to promote professionalism of nuclear plant personnel. The academy reviews nuclear utilities training programs for key positions at each plant.

Since TMI, the industry also introduced the use of plant-specific reactor control room simulators at every site. In 1979, there were only four simulators for the use of all nuclear plant operators. The number of operating crews was expanded, and each crew spends a week in training in the plant-specific simulator every 6 weeks.

INPO also provides a unique form of self-regulation and recognition that the nuclear industry's standard is excellence. INPO teams conduct onsite 2 week inspections at each plant once every 2 years to assess the knowledge and performance of plant personnel, the condition of systems and equipment, the quality of programs and procedures, and the effectiveness of plant management. Each year, INPO conducts meetings with all of the industry chief executive officers, in which both the good and poor performance is openly discussed, providing accountability for plant performance at the highest level of management.

INPO also reviews significant events at nuclear plants and communicates lessons learned and best practices throughout the industry. INPO provides assistance with specific technical and management issues in areas related to plant operations and support.

And as mentioned by the Governor, although emergency preparedness procedures had been in place prior to the TMI accident, it was clear from the event that additional action was required. As a result, the industry developed comprehensive emergency preparedness and response programs in cooperation with Federal, State and local leaders, and additional requirements were imposed by NRC and FEMA.

The TMI–2 accident caused no injuries to workers or the public, but there was emotional distress as a result of the event and related evacuation of residents near the plant. A dozen epidemiological studies conducted since 1981 have found no discernible direct health effects in the population in the vicinity of the facility, and these studies are all summarized in my written testimony.

Since TMI, one of the nuclear industry's tenets is to never, and this is a term you have heard from everybody so far today, become complacent in our vigilance for safe operations of nuclear facilities. To prevent complacency, the industry is taking proactive actions to identify and resolve any emerging issues promptly and effectively, and to communicate operating experience broadly across the industry.

The goal is to identify equipment or human performance problems well in advance of any significant impact on plant operations.

Mr. Chairman, to conclude I would want to assure this Committee that the accident at Three Mile Island has had profound and lasting effects on virtually every aspect of nuclear power plant safety and operation. Today, the industry is more efficient, more productive, more professional and above all, more committed to safety. We continue to share operating experience and lessons learned because we will not allow history to repeat itself.

Safety is and will continue to be our highest priority. The safety of our reactors today is evident in the world class performance of the facilities, and the exemplary worker safety record across our industry.

Thank you for this hearing, and thank you for your interest in our industry.

[The prepared statement of Mr. Fertel follows:]

STATEMENT FOR THE RECORD

by

Marvin S. Fertel
President and Chief Executive Officer
Nuclear Energy Institute

to the

Subcommittee on Clean Air and Nuclear Safety
United States Senate

March 24, 2009

Chairman Carper, Ranking Member Vitter, and members of the committee, thank you for your interest in nuclear energy and in addressing the dramatic improvements in nuclear plant safety and efficiency that have occurred since the accident at Three Mile Island.

My name is Marvin Fertel. I am the president and chief executive officer of the Nuclear Energy Institute (NEI). NEI is responsible for establishing unified nuclear industry policy on regulatory, financial, technical and legislative issues affecting the industry. NEI members include all companies licensed to operate commercial nuclear power plants in the United States, nuclear plant designers, major architect/engineering firms, fuel fabrication facilities, materials licensees, and other organizations and individuals involved in the nuclear energy industry.

Introduction

This month marks the thirtieth anniversary of the accident at the Three Mile Island 2 nuclear power plant. I'm proud to report that since then, the nuclear power industry and the government have dramatically increased their standards and developed a culture of safety among the best in American industry. No member of the public has been injured by radiation from a U.S. commercial nuclear power plant in over 50 years of commercial operation.

The accident at Three Mile Island had profound and lasting effects on virtually every aspect of nuclear power plant safety and operation, including training, maintenance and regulation. The lessons learned from the accident are permanently ingrained in the nuclear industry's training, procedures, regulations and culture.

One of the most significant outcomes of the accident was the formation by the industry of the Institute of Nuclear Power Operations (INPO) in Atlanta. INPO was formed nine months after the accident to drive operational excellence, open communications and continuous improvement among all U.S. nuclear plant operators. All energy companies that own and operate nuclear power plants in the United States are members of INPO and they continuously strive for excellence in reactor operations. As part of this commitment, INPO coordinates the sharing of operating experience

among all U.S. nuclear plants. The sharing of best practices and lessons learned from operating experience is instilled in the work force culture at all plants and this has been a model for worldwide sharing of information related to reactor operations.

Another noteworthy enhancement in the industry was the development of emergency planning and response programs at each nuclear energy facility. These programs are among the best in the nation. These also serve as model programs to other industries and to state and municipal emergency response programs.

Industry Commitment to Safety Is Paramount

The key lesson is that safety is paramount and must forever be the industry's highest priority. Workers at all levels are trained to focus on safety to protect the health and well-being of the public, their coworkers and the environment. Following the accident, all aspects of plant design, operations and equipment reliability were studied and substantially upgraded to ensure safety. Today, the U.S. nuclear energy industry is performing at the highest levels of safety, reliability, efficiency and productivity in its history and is the global leader in nuclear energy production.

The U.S. nuclear energy industry's top priority is, and always will be, the safe and reliable operation of our existing plants. Safe, reliable operation drives public and political confidence in the industry, and America's nuclear plants continue to sustain excellent levels of performance.

The industry's safety performance at 104 commercial reactors around the country has been sustained at exemplary levels, as indicated by numerous government and industry safety measures. This performance is the result of several factors, including high standards of operations, plant designs built and operated with a "defense-in-depth" safety philosophy, government and industry oversight of plant operations, and the dedication of a well-trained and experienced work force that recognizes that safety is the key to successful plant operations.

The U.S. Nuclear Regulatory Commission (NRC) recently highlighted the dramatic improvements in every aspect of nuclear plant performance over the last two decades: "The average number of significant reactor events over the past 20 years has dropped to nearly zero. Today there are far fewer, much less frequent and lower-risk events that could lead to reactor core damage. ... Radiation exposure levels to plant workers have steadily decreased to about one-sixth of the 1985 exposure levels and are well below federal limits. The average number of unplanned reactor shutdowns has decreased by nearly ten-fold."

In 2008, the average capacity factor for U.S. reactors was over 90 percent, and output of more than 800 billion kilowatt-hours represented nearly 75 percent of U.S. carbon-free electricity. According to the quantitative performance indicators monitored by the NRC, last year's performance was the best ever. This performance represents a solid platform for license renewal of existing plants and construction of advanced reactor designs.

No Public Health Impacts

TMI-2 was permanently shut down after the accident in 1979. It is now in long-term monitored storage, which means that no further use of the plant is anticipated. TMI-2 is no longer licensed to operate. FirstEnergy Corporation owns TMI-2 and is responsible for its eventual decommissioning. Exelon Corporation, owner of Three Mile Island-1, monitors the closed reactor and maintains equipment necessary to keep the plant in safe, long-term storage.

TMI-2 has been cleaned and safely decontaminated. The fuel was removed and shipped to Idaho for long-term storage at the Idaho National Laboratory. Low-level radioactive waste from the accident was shipped to Richland, Wash. Approximately 1 percent of the fuel and debris from the accident remains in the TMI-2 reactor vessel because it is in inaccessible parts of the vessel. This will be removed when the unit is fully decommissioned.

The TMI-2 cleanup took approximately 14 years to complete and cost about $1 billion. Cleanup began in August 1979 and was completed in December 1993. In February 1991, the TMI-2 cleanup program was named by the National Society of Professional Engineers as one of the top U.S. engineering achievements completed during 1990.

The TMI-2 accident caused no injuries to workers or the public, but there was emotional distress as a result of the evacuation of residents near the plant. At least a dozen epidemiological studies conducted since 1981 have found no discernible direct health effects to the population in the vicinity of the facility. Studies of the consequences of the accident were conducted by the NRC, the Environmental Protection Agency, the Department of Health, Education and Welfare, the Department of Energy and the state of Pennsylvania. The average dose to about 2 million people in the area was only about 1 millirem, according to the results of these and independent studies. In comparison, a chest x-ray results in about 6 millirem of radiation exposure. The public's average dose from natural radiation is 100-125 millirem per year for that area.

A federal appeals court in 2003 dismissed the consolidated cases of 2,000 plaintiffs seeking damages against the plant's former owners for health problems they alleged were caused by the accident. The court said the plaintiffs had failed to present evidence they had received a radiation dose large enough to cause possible health effects.

Decades of research and scientific studies have shown no negative health effects on the population surrounding the plant. Several studies were conducted by the Pennsylvania Department of Health. The conclusions are summarized below:

- A 1981 study reported that if the accident had any effect on infant death rates, there would have been a significant increase in the six months after the accident. Instead, the infant death rate was lower than normal.

- A 1982 study found that the incidence of congenital hypothyroidism within a 10-mile radius of the plant was well within a normal range in the year after the accident.

- A 1982 study found no measurable impact on infant mortality within a 10-mile radius of the plant, compared with infant mortality rates for Pennsylvania for 1977-1979.

- A 1985 study found no significant difference in cancer mortality within a 20-mile radius of the plant during the five years preceding the accident and the five years following it. In a more detailed analysis of four communities downwind of the plant, the study found no significant abnormalities in either cancer mortality or cancer incidence among residents considered to be at potentially higher risk.

- A 1988 study found no connection between radiation or psychological stress and failed and complicated pregnancies, such as fetal and neonatal mortalities and other problems.

- A 1989 study found no significant abnormalities in cancer mortality or incidence among residents of selected communities near the plant.

- Two 1991 studies showed no increased cancer incidence among people who lived near the plant in 1979. One study involved the general population living within a 5-mile radius of the plant; the other involved women of child-bearing age who lived within a 10-mile radius.

In addition to the Pennsylvania Health Department studies, several other studies have examined the health impact of the TMI accident on the population:

- A study presented at the 1988 annual meeting of the American Public Health Association compared post-accident cancer deaths over a six-year period for residents within a 5-mile radius of the plant with cancer deaths of a large control population. The study concluded that the normal death rate and life expectancy for people around TMI were not affected by the accident.

- Another study presented at the meeting concluded that—based on a comprehensive analysis of statistical data by health researchers—fetal and infant mortality in the vicinity of the plant were neither significantly higher than expected nor significantly different from those in the years before the accident.

- Several prominent scientists from Columbia University and the National Audubon Society studied cancers among the nearly 160,000 residents within a 10-mile radius of the TMI plant. The principal cancers considered were leukemia and childhood malignancies. The study, issued in September 1990, concluded: "Overall, the pattern of results does not provide convincing evidence that radiation releases from the Three Mile Island nuclear facility influenced cancer risk during the limited period of follow-up."

- In 1990, the National Cancer Institute of the National Institutes of Health released the results of a two-year study of cancer data in 107 U.S. counties that contained, or were adjacent to, major nuclear facilities that had begun operations before 1982. Among the counties were York, Lancaster and Dauphin near the TMI plant. The study found no increased cancer mortality for people living near nuclear installations. The study also found no evidence that leukemia for any age was linked to routine operations at the TMI reactors or to the accident at TMI- 2.

- In 2002, researchers at the University of Pittsburgh's Graduate School of Public Health (GSPH) conducted a 20-year follow-up study of mortality data on residents living within a 5-mile radius of the plant. The study found no significant increase in overall deaths from cancer. "This survey, which covers the normal latency period for most cancers, confirms our earlier analysis that radioactivity released during the nuclear accident at TMI does not appear to have caused an overall increase in cancer deaths among residents of that area over the follow-up period, 1979 to 1998," said Evelyn Talbott, professor of epidemiology at GSPH and principal investigator on the study.

Comprehensive Insurance Protection in the Event of an Accident

The nuclear power industry has an industry-financed umbrella of more than $10 billion in liability insurance protection to be used in the event of a reactor incident. This protection consists of two tiers. The primary level provides $300 million in liability insurance. This first-level coverage consists of the liability insurance provided by two private insurance pools. The pools are groups of insurance companies pledging assets that enable them to provide substantially higher coverage than an individual company could offer. If this amount is not sufficient to cover claims arising from an accident, secondary financial protection applies.

For this second level, each nuclear plant must pay a retrospective premium equal to its proportionate share of the excess loss, up to a maximum of $100.6 million per reactor per accident. This includes a $95.8 million premium and a 5 percent surcharge that may be applied, if needed, to legal costs. Currently, all 104 operating nuclear reactors are participating in the secondary financial protection program.

The TMI accident demonstrated the ability of this insurance to effectively provide care for the public. People who suffered financial losses as a result of the precautionary evacuation following the incident were promptly paid, demonstrating the effectiveness of the industry's liability insurance protection under the Price-Anderson Act. In addition, businesses were compensated for loss of revenue, and the state and local community were compensated for the expenses incurred during the response to the accident. There was no financial payment from federal funds.

Immediately following the accident, Pennsylvania's governor recommended the evacuation of pregnant women and families with young children living in the area closest to the plant site. At the time of the accident, the private insurance pools had $140 million in first-level coverage in force.

The pools immediately assembled insurance adjusters from across the country at a central claims office in Harrisburg, Pa.

These adjusters advanced money to families affected by the governor's recommendation for living expenses incurred while away from their homes, with the request that any unused funds be returned. Recipients responded by sending back several thousand dollars. In addition, the insurance pools reimbursed 636 individuals and families for lost wages as a result of the accident.

In addition to the cash advances and reimbursements, the insurance pools later settled a class-action suit for economic loss filed on behalf of people living in a 25-mile radius of TMI-2. The last of the litigation was resolved in early 2003. Industry insurance pools have paid approximately $71 million in claims and litigation costs connected with the Three Mile Island 2 accident. Utilities—not the public or the federal government—pay for this insurance.

A Watershed Event That Enhanced Nuclear Safety

The Kemeny Commission–established by President Carter to investigate the TMI accident–recommended that:

- The nuclear power industry should establish a program that specifies appropriate safety standards, including those for management, quality assurance, and operating procedures and practices, and that conducts independent evaluations.

- There must be a systematic gathering, review and analysis of operating experience at all nuclear power plants coupled with an industry-wide international communications network to facilitate rapid flow of this information to affected parties.

As a result of TMI and the commission's recommendations, the industry began safety and operational performance improvements that have now reached a level considered to be the premier benchmark of global nuclear plant performance.

The industry formed the Institute of Nuclear Power Operations and charged it with promoting the highest levels of safety and reliability in the operation of nuclear power plants. Accordingly, it does not supplant the role of the government regulator, but rather complements a strong and capable NRC by providing a means for the industry, acting collectively, to make nuclear operations safer and more reliable.

INPO has had a profound impact on the way nuclear plants are managed and operated. The proof is the steady improvement in plant performance in the nearly 30 years since the accident.

To improve training, INPO in 1985 formed the National Academy for Nuclear Training to focus and unify industry efforts to continually improve training and qualification programs and to promote

professionalism of nuclear plant personnel. The academy reviews nuclear utilities' training programs for key positions at each plant.

Nuclear professionals from all levels of their organizations attend training at the INPO facility in Atlanta and take various INPO online courses. INPO also evaluates individual plant and utility training programs to identify strengths and weaknesses and recommend improvements. Selected operator and technical training programs are accredited through an independent National Nuclear Accrediting Board composed of academic scholars and business executives.

The industry also performs evaluations of nuclear power plant operation. INPO provides a unique form of self-regulation and recognition that the nuclear industry standard is excellence. INPO teams conduct on-site, two-week inspections at each plant once every two years to assess the knowledge and performance of plant personnel, the condition of systems and equipment, the quality of programs and procedures, and the effectiveness of plant management. INPO provides a detailed report and a formal post-inspection briefing with the company leadership, including the chief executive officer of the company that operates the plant, to report on plant strengths and areas for improvement and to provide an overall assessment of performance relative to industry standards of excellence.

Yearly, INPO conducts a private meeting of all industry chief executive officers, in which both good and poor performance is openly discussed, providing accountability for plant performance at the highest levels of management. INPO also shares plant assessment information with Nuclear Electric Insurance Limited (NEIL), providing one source of information used in each company's insurance rating.

INPO also reviews significant events at nuclear plants and communicates lessons learned and best practices throughout the industry. INPO provides assistance with specific technical or management issues in areas related to plant operation and support.

TMI Lessons Ingrained in Industry Training and Procedures

The lessons learned from the TMI accident will not be forgotten because they are permanently ingrained in the industry's training, procedures, regulations, and the culture of its work force. The accident profoundly and forever changed how the industry operates and maintains the plants and where it focuses its attention. That focus is on safety.

The industry and the NRC acted swiftly after the accident to determine the causes and take action to prevent any similar occurrence. All aspects of plant design, operations and equipment reliability related to nuclear safety were substantially upgraded throughout the industry. Expanded capabilities were put in place for accident prevention, mitigation, radiation monitoring and emergency preparedness. This includes greatly enhanced notification and communications systems, dedicated emergency response facilities, rigorous training and NRC-graded exercises that include local, state and federal authorities to test each plant's ability to respond to emergency conditions. Immediate

NRC notification is required for plant events and the NRC staffs an operations center 24 hours a day.

As a result of the accident, the industry increased staffing levels and the number of reactor operating crews was expanded. Reactor operator training is extremely rigorous, including biennial NRC licensing examinations and the use of a full-scale, state-of-the-art control room simulator at every plant. Every nuclear reactor operator in the nation is trained on the TMI accident so they can understand how it happened, how it was responded to, and the changes that have been made to ensure it doesn't happen again.

The NRC said, "The TMI-2 accident had the greatest impact on nuclear generation of any single event in history." After the incident, the NRC greatly expanded and intensified its controls and oversight and introduced additional regulations requiring numerous plant modifications that increased the operational safety margin. Other improvements include upgrading and strengthening of plant design and equipment, including instrumentation and controls, fire protection, piping systems, auxiliary feedwater systems, containment building isolation, reliability of individual components (pressure relief valves and electrical circuit breakers), and the ability of plants to shut down automatically. The NRC also expanded its resident inspector program— first authorized in 1977— whereby at least two inspectors live nearby, have unlimited access to the plant, and work exclusively at each plant to provide daily surveillance of licensee adherence to NRC regulations.

The industry also introduced plant-specific simulators at each site. Before the event, there were only four simulators for the use of all nuclear plant operators. The number of operating crews was expanded and each crew is rotated through training in the plant simulator every six weeks. Companies that operate U.S. reactors also introduced additional and more detailed administrative, engineering and operational procedures. Most importantly, the emphasis given to training was significantly increased, not only for operators but also for support personnel. Each plant had to attain accreditation through the independent National Nuclear Accrediting Board.

Although emergency preparedness procedures had been in place prior to the TMI accident, it was clear from the events that additional action was necessary. As a result, the industry developed comprehensive emergency preparedness and response programs in cooperation with federal, state and local leaders. Additional requirements by the NRC and Federal Emergency Management Agency improved public alerts and public communication. Sirens were required to be installed and protocols were established with local communities and officials to ensure the local population was aware of what actions to take in the event of an accident.

Once the initial TMI modifications had been completed, the industry embarked on a series of additional assessments to identify possible latent vulnerabilities. The insights and recommendations from these assessments resulted in additional plant modifications and procedural enhancements that further increased the operational safety margins and reduced the probability of a reactor accident. The assessments covered plant transients as well as events caused by natural phenomena, such as extreme hurricanes and floods.

One of the nuclear energy industry's tenets is never becoming complacent in our vigilance to safely operating nuclear energy facilities. An industry culture that evaluates operating issues of many types and applies lessons learned from them across all nuclear power plants continues today. This was most recently demonstrated after reactor vessel head corrosion was discovered at the Davis-Besse plant in Ohio. The industry's detailed examination of this event and the lessons learned from it resulted in a multi-million dollar commitment by industry leaders to expand research into materials issues at all nuclear power plants. The industry is taking a proactive approach to identify and resolve emerging materials issues more effectively. The goal is to identify materials performance problems well in advance of a significant impact on plant operation.

Industry Performance

The nuclear industry measures its overall progress through the World Association of Nuclear Operators Performance Indicator Program. The 2010 goals, which are based on individual unit goals and current industry performance, provide challenging benchmarks of excellence against which safety and operational progress can be measured. These indicators are: collective radiation exposure, fuel performance, unplanned automatic scrams, forced loss rate, unit capability, safety system performance, industrial safety and chemistry performance. An example of the continuing drive toward excellence and guarding against complacency are the steps INPO took in 2003 to establish principles of safety culture:

- Nuclear safety is everyone's responsibility.
- Leaders demonstrate commitment to safety.
- Trust permeates the organization.
- Decision-making reflects safety first.
- Nuclear is recognized as different.
- A "what-if" culture is cultivated.
- Organizational learning is embraced.
- Nuclear safety undergoes constant examination.

Performance at Three Mile Island-1 Is World-Class

Three Mile Island 1, which is owned and operated by Exelon Nuclear, has one of the best safety and operating records in the industry. It has held four world records for continuous operation and was rated among the top 20 reactors in the world for capacity factor, a measure of plant efficiency, in 2008 by Platts. TMI-1 operated at 99.37 percent capacity factor during 2008, according to Platts.

TMI-1 generates 852 megawatts of clean, safe and reliable electricity for more than 800,000 homes in Pennsylvania. Power needs across central Pennsylvania and the United States are projected to increase, and there is growing concern about climate change. To help meet that growing demand and to help keep our environment clean, Exelon Nuclear applied in 2008 to the NRC for a 20-year extension to the plant's operating license. The current license expires in 2014. With license

extension, TMI can continue to provide central Pennsylvania with safe, clean, reliable power until 2034.

Without TMI-1, the region would need an alternative energy source to meet electricity demand. By replacing TMI-1 with a coal-fired power plant similar in size, 271 metric tons of carbon dioxide *per hour* would be emitted into the environment by the coal plant. The operation of Three Mile Island avoids harmful air emissions and improves the region's air quality.

The plant generated about 7,768,614 kilowatt-hours of electricity in 2008. This low-cost electricity helped keep energy prices affordable in the Mid-Atlantic Area Council sub-region, where the plant is located. Three Mile Island's production cost was 1.76 cents per kilowatt-hour in 2004, compared with an average production cost of 2.84 cents per kilowatt-hour for the rest of the regional market.

Three Mile Island's economic impact reaches beyond the local community to the state and nation, according to a 2005 study by the Nuclear Energy Institute. In 2004, plant operation increased Pennsylvania's economic output by $86.1 million, including $5.8 million in Dauphin County, where the reactor is located.

Conclusion

The accident at Three Mile Island had profound and lasting effects on virtually every aspect of nuclear power plant safety and operation, including operation, maintenance and regulation. The lessons learned from the accident are permanently ingrained in the nuclear industry's training, procedures, regulations and culture.

One of the most significant outcomes of the accident was the formation by the industry of the Institute of Nuclear Power Operations (INPO) in Atlanta. INPO drives operational excellence, open communications and continuous improvement among all U.S. nuclear plant operators and all energy companies that own and operate nuclear power plants. We continuously strive for excellence in reactor operations.

Given the improvements in operational and design safety margins, the modifications and increased accident mitigation measures and procedures, and the increased emphasis on training and quality, nuclear power plants will continue to operate safely. Through the embedded safety culture and principles that have been established through INPO and strict NRC oversight, complacency among the industry's well trained and professional workforce is kept at bay.

Thirty years after the TMI accident, the industry has become more efficient, more productive, more professional, and, above all, more committed to safety. We will not allow history to repeat itself. Safety is, and will continue to be, our highest priority. It is only by operating our 104 reactors safely that nuclear energy will continue to be a vital part of our nation's low-carbon energy portfolio.

Nuclear Energy Institute Responses to Follow-Up Questions From the Senate Committee on Environment and Public Works Re: March 24, 2009, Hearing on "Three Mile Island – Looking back on Thirty Years of Lessons Learned

Question from Senator James Inhofe

1. We have heard a fair amount about how the accident spurred regulatory and operational changes that strongly improved safety. Would you please describe for us how the accident left its mark on the remaining unit at Three Mile Island and how it has performed since then?

Impact of the Lessons Learned from the Three Mile Island Unit 2 accident on Three Mile Island Unit 1

The lessons learned from the TMI Unit 2 accident are engrained in every aspect of the operation of TMI Unit 1. They encompass enhancements made in human performance, procedure upgrades, plant modifications and most importantly, training. Today, TMI Unit 1 uses a site-specific replica simulator to train control room operators. This simulator, similar to a cockpit simulator for airline pilots, can replicate any event that can occur in the plant. TMI Unit 1 operators spend one week out of every six in training.

The safe and reliable operation of the plant speaks to the results of these enhancements. Since TMI Unit 1 restarted in 1985, the station has set four separate world records for continuous days of operations for a pressurized water reactor (PWR). There are more than 200 PWR's worldwide. The most recent record was set in 2005 when the station operated for 689 consecutive days. Continuous days of operations is an excellent indicator of a safe and reliable plant since to achieve such records of continuous operation, equipment must be maintained at very high standards, workers and control room operators need to be well trained and exceptionally competent, and the regulator (NRC) must be satisfied with plant safety as shown by compliance with the regulations. In 2007, TMI Unit 1generated 6.6 million MWh of electricity, and its 3-year average capacity factor (%) for the years 2005 – 2007 was 97%.

Less obvious, but just as important, is the impact the accident has had on the mindset of the people who run the plant. TMI Unit 1 employees come to work every day committed to ensuring an accident will never happen again.

Questions from Senator David Vitter

1. In terms of nuclear energy versus renewables such as wind and solar, I'd appreciate your discussing some of the differences in reliability? [I know that the sun doesn't always shine and the wind doesn't always blow.]

America Needs a Reliable Electricity Supply

A credible program to produce the electricity our country needs while reducing greenhouse gas emissions will require a portfolio of technologies and approaches and nuclear energy is an indispensible part of that portfolio.
Nuclear generation provides baseload electricity that is the foundation for a reliable and robust electricity supply. Nuclear generators run 24 hours-a-day, 7 days-a-week, 52 weeks-a-year. For wind or solar to function as baseload generation would require other generation sources, such as hydro or natural gas-fired generation to operate when the wind or the sun is of insufficient strength to meet the electricity demand.
A measure of generation efficiency is capacity factor, the ratio of electricity produced in a given perios of time to the the electricity that could have been produced based on the nameplate power production capability. Average annual capacity factor for nuclear power plants over the past 8 years has been about 90 percent each year. Average capacity factors for coal-fired power plants are about 70 percent; natural gas-fired power plants are about 40 percent; wind power projects are about 30 percent and solar projects are about 20 percent. The nuclear industry averages capacity factors higher than any other industry, about 90 percent each year.

In terms of reliability, a recent study conducted by the North American Electric Reliability Corporation detailed the accommodations the electric grid would have to make to integrate high levels of variable resources. The study found, for example, that "the output of variable resources is characterized by steep "ramps" as opposed to the controlled, gradual "ramp" up or down generally experienced with electricity demand and the output of traditional generation. Managing these ramps can be challenging for system operators, particularly if "down" ramps occur as demand increases and vice versa. Insufficient ramping and dispatchable capability on the remainder of the bulk power system can exacerbate these challenges."

According to the NERC study, "high levels of variable generation will require significant transmission additions and reinforcements to move wind, solar, and ocean power from their source points to demand centers and provide other needed reliability services, such as greater access to ramping and ancillary services."

Nuclear plants are baseload plants which mean they provide the reliable, constant power to meet the minimum load requirements of the electric grid. By being able to provide reliable power to the grid, nuclear plants can help integrate high-levels of variable resources to maintain grid stability.

2. Secondly, let's imagine somewhere in the country there is interest in an additional 1,000 megawatts of electricity, what is the difference in the number of full time employees at a nuclear plant versus a wind farm?

Permanent Jobs

A new nuclear generating reactor, during operation will employ 500 – 700 full time permanent employees for three generations. During refueling outages, which occur every 18 – 24 months, an additional 2000 people will be employed on maintenance, refueling, and plant improvements. In addition, there are several hundred offsite engineering support personnel working at engineering firms around the country in support of each nuclear power reactor. An equivalent wind farm will employ about 100 – full time permanent employees. This data comes from Ventyx and the Department of Energy.

Senator CARPER. Mr. Fertel, thank you for joining us today and for your testimony again today.

Dr. Bradford, I would just ask my colleagues to direct their first questions to you, and then we will come back and ask questions of our other three guests.

The question, the first question I would like to ask of you, if I could, I am reminded, I think it was Harry Truman who used to say, "The only thing that is new in the world is the history we never learned or have forgotten." And I like to think of Three Mile Island in the context of lessons that we learned, lessons that we didn't learn, and maybe lessons that we learned, but we have forgotten.

Let me just ask you, thinking back, taking that approach of lessons learned, lessons never learned, and maybe lessons learned, but forgotten, just kind of tell us what you think in those three broad categories.

Mr. BRADFORD. Well, I probably can't do much with the learned but forgotten category because I have forgotten it.

[Laughter.]

Mr. BRADFORD. But in the context of the push for a nuclear renaissance, it does seem to me that one lesson that at least has faded from the forefront is the difficulty of maintaining a strong, clear focus on safety at a time when the rest of the Government seems entirely focused on licensing additional plants. That was very much the concern at the time of the accident at Three Mile Island. The pace of new applications had fallen off, review times had gotten longer. And many of the congressional hearings and much of the media's focus was why can't we get this process started up again.

And in some ways, that pressure did contribute, I think, to the combination of complacency and haste that led to the accident.

So my concern today in a context in which the industry is seeking your support for all of, essentially financing all of the plants that they see in the pipeline, is similar to the concern that Commissioner Jaczko echoed, or articulated well in the last panel, that there really is a need to prioritize, to pay attention to the pace at which the NRC can license and the taxpayer can afford to build the new plants. It may be different from the pace that the industry would like to move forward at.

And that the setting of limits based on what the process can handle, rather than what the industry would like might make a significant contribution to safety. So maybe that one lesson, in a way, answers all three of your questions. It seems to me to have been an important lesson at the time of Three Mile Island, and there is a danger of its being overlooked and forgotten in the climate that exists today.

Senator CARPER. All right. Thank you.

One last question from me, and then I will yield to Senator Voinovich.

I think you expressed concerns in your comments, or at least in your testimony, about the streamlining of the license process. What are your views on the current new and renewal license process? And do you feel public input is adequate on those?

Mr. BRADFORD. I am glad you asked that question, Senator. In the context of your discussion with the previous panel on commu-

nication, I was running through in my mind all the areas in which I agreed that communication has improved.

But there is one respect in which I think communication has regressed, and that is that the public has far less access to the licensing process today, not just because of the one step process. In many ways, that change is constructive. But the NRC has also adopted a number of rule changes that drastically curtail the ability of people participating in their process, first to raise contentions effectively, and second, to pursue them.

Attorneys can no longer cross examine directly in many situations. They have to submit questions through a panel chair. And that's really an area of the Kemeny Commission and the NRC's own Special Inquiry Group Report that has just been ignored in the years that went by.

The Kemeny Commission recommended that the NRC create an Office of Special Counsel to represent the public in its hearings. The Rogovin Group actually went further and recommended intervener funding. None of that has happened. In fact, the NRC hearing process in some ways has become almost a show trial in terms of the public's ability to be heard effectively.

So I think the reforms in the direction of one-step licensing posed difficulties, but they also offer benefits. The exclusionary regulations that the NRC has adopted seem to me to be a mistake, an unfortunate one.

Senator CARPER. All right. Thank you, sir.

Senator Voinovich.

Senator VOINOVICH. One of the things that we try to concentrate on during the last number of years is human capital. And I have found because of my experience on the management side of government that so often regulatory agencies aren't able to do the job that you would like them to do because they don't have the resources to get the job done.

I would be interested, Mr. Denton, in your reaction to what Mr. Bradford said earlier, and that is that there was a movement in the Country of having too many, too fast, that by 2000, 1,000. I don't know who predicted that, but that was pretty ambitious.

And then contrast that today with the situation where the Nuclear Regulatory Agency is probably the only Federal agency that has been able to replace the retirees that they have had, and in addition to that bring on new people to take care of the challenge of the new licenses that are coming before it.

Mr. Fertel, you are watching this, too, and I might be interested in your comment in regard to that because the impression that you have, Mr. Bradford, is that they are not able to get the job done.

I have to tell you that Senator Carper and I have worked very, very hard to create an environment there where they can replace their people. We have given them flexibilities that other agencies don't have. They are No. 1 in the Federal Government in terms of job satisfaction with their people. We have reached out to MIT, even Ohio State in Ohio, Cincinnati, to get the schools back on track in terms of producing the people that we are going to need for this renaissance that we hope takes place.

So I would just throw that up, a jump ball, and give you all a chance to comment on it.

Senator CARPER. Dr. Bradford, feel free to go first if you would like.

Mr. BRADFORD. My concern is less with resources directly, because I agree that you have been very supportive of the NRC with regard to getting people for processing additional licenses. The concern is, that I have is more that when the Commission comes before various congressional committees and if the message is constantly one of are you meeting the licensing deadlines, are you avoiding delays, how can we squeeze a few more months out of the process, and they are never asked about the resolution of generic safety issues, and never asked to put——

Senator VOINOVICH. But you see, that is not the case, Mr. Bradford. Have you followed the numerous hearings that we have had? Twenty of them over the last number of years. That is not the case.

Mr. BRADFORD. No, sir. I have only been here this morning.

Senator VOINOVICH. Well, I think it would have been good for you to maybe check in to see what has happened during the last 8 years.

Mr. BRADFORD. Well, you know, if you have put the same emphasis on getting a schedule for the generic issues, getting them on a track, being sure that the resources are available, that is terrific. And if all the other committees that they come before have done the same thing, that is terrific, too.

But if that isn't the balanced communication that they are getting, then there is the possibility, indeed the likelihood, that in trying to be responsive to the Congress, people will be shifted into the areas that the Congress is most concerned about.

It happened certainly at times in the 1970s. That is the era that I am familiar with.

Senator VOINOVICH. Can I ask you something? Do you believe that we should go forward with a nuclear renaissance? Do you believe that nuclear energy is something that we should increase in this Country in terms of baseload generation? Do you believe that nuclear power is something that is available to reduce our greenhouse gas emissions?

You know, or are you just, I mean, where do you stand on that?

Mr. BRADFORD. You know, I spent 20 years in positions of responsibility for the power supply to two States, and by the end of that time, my effort was devoted to creating processes that made the wisest economic choice essentially through the kinds of competitive market processes that we use in every other area, with the investors responsible for taking the risks and the customers responsible for paying off the costs once the plants are serving them.

When those processes were put in place, nuclear power never bid. The investors would not take those risks. I would be glad to see nuclear power be part of a climate change solution package when it reaches the point in time that it is able to compete effectively in those power supply markets. And those markets have made sure that more than half of the customers in the U.S. in the regions that have gone to power supply markets, have had adequate electric supply for the 25 years now that we have been relying on them.

But nuclear power can't play in those markets. And it troubles me greatly to see the Congress asked to pick this one technology and favor it heavily in financial terms.

Senator VOINOVICH. Do you know something, that nuclear power has, in terms of, if you look at solar and wind power and see where the money that we have spent during the last several years is going, that is where the money is going.

I think the only thing that the industry is concerned about is the issue of loan guarantees that would be necessary to go forward, and of course a little bit more important today because of the fact that the financial markets are in such bad shape.

But if you look at where we have spent money, it is amazing. You know, if I were somebody out there today, I would invest in solar and wind power because of the subsidies that are coming out of the Federal Government in that regard.

Mr. BRADFORD. When it comes to government support, they have a long way to go to catch up with nuclear.

Senator CARPER. I am going to have to interrupt here. I will call on Senator Voinovich here in just a moment, but I want to yield to Senator Merkley for any questions you have of Dr. Bradford, and then he will be free to leave.

Senator MERKLEY. Thank you very much, Mr. Chair.

Professor, I thank you for your service as a Commissioner and the other work you have done. I find it very interesting to see the story, the history of the Davis-Besse Nuclear Plant, and essentially a leaky nozzle eroded the carbon steel, multiple inches of carbon steel over a series of 4 years, and then there was a football-sized hole in that, and the inner lining, stainless steel lining, was deformed by the pressure of the vessel into that hole.

And the role of the NRC in this was multiple. First, they had been requested to require inspections of these nozzles because they had been known to leak. After 4 years of debating that, they decided not to require those inspections.

Then fast forward to 2001, they did take much stronger action and require plants to inspect those nozzles. The Davis-Besse Plant was one of two plants they decided not to do that, and resist that requirement. And the NRC did relent at that point and decided it would be safe to wait until the plant inspection in 2002. They decided that, no, it should really be done, and ordered the plant shut down for emergency inspection, but the plant resisted and then they went back to the position of waiting until the safety inspection. It is when they had that February inspection they discovered this football-sized hole.

Does kind of this story give us any sense of insight into the role of the Commissioners, the pressure they are under to keep plants operating? And do we have an adequate system in place to be able to address the real safety risk? Because I think this is believed by all to have been a substantial safety risk. Do we have a system now? Have we learned from that enough to restructure the way NRC operates in order to have them be able to stand up and really ensure that inspections take place, even when it involves shutdowns and costs and so forth? Have we figured out that balance? Or is there more we need to do?

Mr. BRADFORD. I wish you had asked that question of the previous panel, of course, because I am not there today and can't——

Senator MERKLEY. But they are in the middle of it, whereas you get the objective experience to——

Mr. BRADFORD. It is, you know, it is clear certainly that the licensee made its concerns known at the Commission level, and that would probably happen today, too.

On the other hand, I assume the Commissioners with the benefit of what happened at Davis-Besse would almost certainly push back perhaps more than occurred at that time.

At the end of the day, the public's greatest safeguard in this area lies in the process of the appointment of Commissioners, the questions and decisions you make in confirming Commissioners, and the practices and procedures the Commissioners themselves put into place to protect the staff's technical judgments from any political or financial intrusions.

The protection that the public will get in these kinds of situations will be just as good as the standards that you insist on in confirming and that the President insists on in making the appointments.

Senator MERKLEY. Thank you. I think you have summarized that it remains an inherent challenge. We have to protect the integrity of the staff judgments and try to insulate the Commission from political or economic pressures that might overrule the safety judgments of the technical staff. Is that a fair way to summarize your point?

Mr. BRADFORD. It is. Yes.

Senator MERKLEY. OK. Thank you.

Mr. BRADFORD. I think there is perhaps some encouragement to be had in the study that Chairman Klein cited regarding the high staff morale in the agency, because that is not suggestive of a place where the staff feels beaten down at the moment in its ability to raise concerns. At least that is my hope that that is what that study is suggesting.

Senator MERKLEY. Thank you.

Senator CARPER. Thank you, Senator Merkley.

And then Dr. Bradford, it is 12:30. Thank you so much for joining us.

Mr. BRADFORD. Thank you very much. Again, my apologies to the Committee.

Senator CARPER. We are glad that you could come, and thank you very much for your input.

A question, if I could, for Governor Thornburgh, and perhaps for Harold Denton as well.

Governor, how important was it looking back 30 years, how important was Harold Denton's ability to communicate complicated technical information to the lay public, to ordinary people during an event of this nature?

Mr. THORNBURGH. It was crucial. It was crucial because this was a technology not known to the general public or to those of us in public office. The so-called experts were beleaguering us with conflicting advice, and we really, I told President Carter, I said send us one good person who could provide us with reliable information upon which we could make judgments with regard to emergency management.

And without embarrassing him, I have to say that when Harold showed up, it was clear that he filled the bill.

Senator CARPER. Mr. Denton, how did you feel when you were tapped for this assignment? It is not every day that a President calls and says, Harold, I have a job for you.

Mr. DENTON. Well, I was shell-shocked probably at getting this assignment. When I went up, I thought that perhaps the White House would have a staff member up there and I would report to that person, and then this person would report to Governor Thornburgh. But I found out the moment I landed at the site the word had come in to us somehow that I was to call the White House, and I remember turning to my secretary, who had gone up with us, and I said, call the White House. And she replied, well, how do I do that? And I said, I don't know, Doris, that is your problem.

[Laughter.]

Mr. DENTON. And I must have been under a lot of stress to snap at her like that, but she did get the White House, and the fact that the President was so willing to commit the resources of the Federal Government and so concerned about our relations with Governor Thornburgh and others, I felt pretty confident at the time that we would make every effort to bring things to a safe conclusion, and that is what we did.

And there was just unparalleled cooperation among all the Federal agencies. I had never participated in any of the training for public affairs or public speaking sort of thing, but I did hold a press conference every day, and I think that was part of the secret that I came away with from that is that you need both technical people, subject matter specialist I will say, and elected officials to properly talk to the public.

Technical people don't really communicate well. They are not elected. They don't necessarily understand the local context. The Governor brought that aspect to the communication process. Without that, people would probably still be evacuating.

Senator CARPER. The two of you made a good team.

Let me ask both Governor Thornburgh and you, Mr. Denton, do you believe that the NRC has gone some way toward rectifying their communications problems? Doing a better job at it now or not?

Mr. DENTON. You mean in operation of reactors or in licensing reactors?

Senator CARPER. Just being able to communicate their work, their role, their concerns, their efforts to focus on safety. Some of these issues are pretty technical. Most people in the Country aren't all that good at understanding some of that stuff. I struggle with it as well.

Mr. DENTON. I don't think there has been a real advance in that area. I have wondered at times if Commission meetings held out in the region of the plant might be, you know, one way to do that. Not all meetings have to happen in Washington, for example.

We would hold staff meetings in regional areas when there were problems, but usually the Commission didn't feel willing to move Commission decisionmaking out to a region.

We have also been very uneasy about appearing to take sides on these arguments about should the plant be licensed or not, except through formal mechanisms. So a lot of people who are unhappy

with Commission decisions never get a chance to see their decision challenged, so to speak, outside of a courtroom.

Senator CARPER. One last question for Governor Thornburgh, and perhaps for you, Mr. Denton. But do you feel that the States are better prepared? Do you think they have more of the tools that they need to meet an accident of this nature today, than maybe 30 years ago?

Mr. THORNBURGH. That is still an item of concern to me. Thirty years have gone by, really a whole generation has grown up without having fresh in their memory the experiences of Three Mile Island. I think one would hope that those lessons have been learned. I did a lot of yapping about it when I was a Governor. We spent a lot of time focusing on emergency management issues.

But it really bears substantial repeating, because the first lesson that I set forth in my written statement was expect the unexpected. And I think sometimes we are not as good at that as we would like to be.

I would just add one thing to Harold Denton's observations. Mercifully, I haven't since 1979 had occasion to deal with the NRC in an emergency situation. But I don't think there is any question but what at the very least that got their attention.

I think that one of the things that both Harold Denton and I agreed upon in the aftermath of the Three Mile Island incident was you can't manage this kind of an emergency situation away from the site. And most of the problems that evolved during this experience resulted from a failure to observe that.

And I think his observations about getting the Commission and its staff out among the folks is good for any government agency, and I would second that motion as well.

Senator CARPER. Thank you.

Mr. FERTEL. Mr. Chairman.

Senator CARPER. Just very briefly. My time has expired and I want to go to Governor Voinovich. Just very, very briefly. Go ahead, very briefly. Thank you.

Mr. FERTEL. OK. The only thing I would add to what the Governor just said to your question is that there are exercises around every site every 2 years, which has gone on very, very rigorously. Where I think there has been significant improvement, not only in analytical tools like dose assessments and communication things and siren systems, is in relationships among the site people who interface on drills and everything else with the local and State people.

Where I actually think what we do around our sites is negative training goes a little bit the other way. You heard the Governor and you heard Harold talk about how long this event took to evolve, and how it went. Well, when we do an exercise, we get to a general emergency as severe, if not much more severe, than what happened at Three Mile Island in a half a day.

And we are conditioning people in decisionmaking in the State and local government to think that this happens that fast, and it doesn't. So I think we have improved a lot, but we may be doing negative training in certain respects.

Senator CARPER. OK. Thanks for that comment.

Governor Voinovich. Senator Voinovich.

Senator VOINOVICH. I am thinking about the security at these facilities. Several years ago, someone asked if we were going to have a terrorist attack or something in Cleveland, where would you go? And Davis-Besse is about 20 minutes from my house, and I said I am going to Davis-Besse. It is just amazing what they are doing out there. I have even said I visited other Federal facilities in the United States, and the security just is really not up to what it should be, and I said, why don't you get in a car or fly a plane and get out and see how we are securing our nuclear facilities around the Country.

I think it is important for everyone to understand that not only has this Committee, Subcommittee, had 20 hearings in 8 years. That is two and a half a year. But I can tell you that Senator Carper and I have met, and I personally have met with Nils Diaz and now with Dale Klein, who I believe is really doing an outstanding job, in my office. I think sometimes people think that the oversight that is getting done by Congress is done at these hearings. And yes, they are very important, but it is that special time that a Senator spends with the people that run the agency and the Commissioners that make a difference.

Senator Carper, since he has taken over the chairmanship, has also had these groups of people together, and getting their input. We are going to be going up to MIT to get their slant on things.

So I think it is real important that people understand that we are pretty sincere about what we are doing, and I think it is important. Maybe Mr. Fertel you could comment on the fastidiousness now that we have at the NRC since Davis-Besse. There is no question that they weren't getting the job done. There were lessons learned there. The industry wasn't doing the job. And they weren't doing the job.

But I think there is, and I would like to share with you some of the things that they have done since then to really demonstrate that if there is anything that looks like it's not where it should be, they just shut them down. It is a very interesting difference of the way they are handling it.

Plus one other thing, and that is INPO, your organization, that I think the people that run these places understand today that they really have to be on their toes. I have had some people tell me that this peer pressure is enormous in terms of getting them to do the things that they should be doing.

So Mr. Fertel, would you like to comment on that?

Mr. FERTEL. I had the distinct pleasure of sitting here before you after Davis-Besse and saying how it was a failure not only on the company's part, and the NRC's part to some degree, but also on INPO's part from an industry standpoint. And INPO has dramatically modified its assessment process, with safety culture being a core portion of it now.

In every INPO evaluation, safety culture is considered and in addition the plants do self-assessments on safety culture biannually. So from an industry standpoint, to some degree Davis-Besse had a real ground-breaking change for us, just like TMI did 30 years ago for operational safety.

At the NRC, they did a very significant lessons learned. As you said, Senator Voinovich, they now look at safety culture as part of

their reactor oversight process, which they didn't before. They are looking at improving how they do that, and they have implemented, I think, on the order of 18 to 20 different lessons learned that came out of the Davis-Besse experience.

So we have seen a dramatic change within our own industry in how we look at it. And NRC has implemented a pretty dramatic change within their own oversight the way they look at it. So it has had a big impact.

Senator CARPER. All right.

Senator Merkley, the last word here.

Senator MERKLEY. Thank you, Mr. Chair.

Governor Thornburgh, in your testimony, you noted that the added cost and increased scrutiny by regulatory authorities since the accident, together with decreasing costs from competing sources, have added up to an uncertain future for the industry.

I am assuming you are describing a situation in which the process of responding to the risk of human error, the risk of natural catastrophe, the risk of terrorist attack have driven up costs, while some other non-carbon sources, we have new innovations that are reducing the cost of solar, wind, or so forth.

When you see these things through the picture of a non-subsidized competition, if you will, is there a clear hierarchy in terms of the most cost-effective strategies to produce carbon dioxide-free electricity?

Mr. THORNBURGH. It would take a wiser man than me to answer that question, I think. It's not an area that I feel comfortable in. I think the point that is made here is that given the enormous concern about safety and the experience of the Three Mile Island accident, the regulatory overburden is bound to be greater for the nuclear industry than for other competing sources of energy.

Now, how that breaks down quantitatively and what kind of a box score you come up with in making that comparison, I am really not qualified to say. But I think it is without doubt that that regulatory overburden varies directly with the amount of public concern over safety and threat to the environment, both of which have underscored a lot of the opposition to nuclear power over the years.

Senator MERKLEY. Mr. Fertel, did you want to?

Mr. FERTEL. Yes, I mean, what I would say in response to your question, Senator, is that right now our 104 plants are basically the lowest cost electricity in our Country outside of hydro. So with the burden of the regulation, which is appropriate in most cases, both security and safety, we are still after hydro the least expensive cost to consumers.

With regard to new plants, our capital costs are certainly higher than others, but we think the electricity will be competitive. With regard to Peter's comments about subsidies, the loan guarantee program that we are in, we pay for. So it is not a subsidy. We actually pay the government money for a loan guarantee that we would get, just like you would pay the bank money for a loan that you would get. So I am not quite sure where the subsidy comes in.

Senator MERKLEY. Could I follow up on that point?

Senator CARPER. Sure. Go ahead.

Senator MERKLEY. So my understanding was that there is a cap on liability of $10 billion, with the estimate of a single major inci-

dent being perhaps up to $300 billion, and that the private cost of providing that kind of insurance is so high that essentially investors would not invest if the government didn't provide that cap.

Is that the subsidy you are referring to?

Mr. FERTEL. No, that may be something Peter refers to, and he's totally wrong. To just be straight about it, Price Anderson, which is a law that Congress enacted and has renewed I think five times, doesn't cap our liability. It imposes a liability. There is no other industry in the world, chemical industry, nuclear industry, elsewhere, anywhere, that has a $10 billion liability for an accident that might happen.

The most severe accident that we have ever had is Three Mile Island, and basically Price Anderson ended up paying out money to people around there on the order of about $100 million. So we have a liability of $10 billion, which is a pooled liability for our industry, no taxpayer money. There is insurance for the first primary coverage of $300 million, but you have a pooled liability. It's not that you can't purchase liability insurance. But if you look at 64 sites with $10 billion at each site, it is $640 billion worth of third party liability, which I believe is much greater than all of the third party liability insurance in the country though I honestly have never been able to get an answer from the insurance companies on what the capacity is.

But I don't think there is that much liability capacity in the country to try and do it. So we would argue, we have the best liability program in the world, that other countries try to copy, as opposed to a subsidy.

Senator MERKLEY. I will just look forward to following up with you, because my understanding was that you are required to buy insurance, but at the same time the law caps your exposure to $10 billion. So we can follow up and get more information.

Mr. FERTEL. Sure. What Price Anderson does is it requires us to buy $300 million, whatever is in the market at the time, and that's what everybody has. And then it requires, escalating with inflation, each site, if I have an accident at my site and I have to basically go into bankruptcy, all the other plants have to pay the rest of the liability up to $10 billion.

If we ever got to $10 billion, and keep in mind we have had no accident that gets you anywhere near it, if you ever got there, the way the law is written, Congress would then decide whether or not the industry should continue to pay more, or Congress would intervene and decide that, no, the industry shouldn't, but it would be a decision by the Congress.

Senator MERKLEY. Thank you.

Senator CARPER. Well, gentlemen, this has been an enlightening morning and early afternoon. I want to really thank you for joining us today.

Governor Thornburgh and Mr. Denton, it is just really heartening for me and I think to all of us to see the two of you sitting together side by side, arm in arm, still trying to help get us through some tough, challenging times.

Mr. THORNBURGH. A mutual admiration society.

Senator CARPER. Oh, it's a good one there.

Mr. THORNBURGH. We saved each other's necks.

[Laughter.]

Senator CARPER. And you saved some other people's necks as well.

I want to conclude just by saying that we may have some follow up questions that we will submit in writing, and if you could respond in a timely manner, we would very much appreciate that.

With that having been said, to my colleagues and to our staff who worked on this hearing today, thank you all.

This hearing is adjourned.

[Whereupon, at 12:50 p.m. the subcommittee was adjourned.]

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