REPORT OF THE PRESIDENT'S COMMISSION ON THE THREE MILE ISLAND ACCIDENT

JOINT HEARING

BEFORE THE

SUBCOMMITTEE ON NUCLEAR REGULATION

OF THE

COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS

UNITED STATES SENATE

AND THE

SUBCOMMITTEE ON ENERGY AND THE ENVIRONMENT

OF THE

COMMITTEE ON INTERIOR AND INSULAR AFFAIRS

HOUSE OF REPRESENTATIVES

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REPORT OF THE PRESIDENT'S COMMISSION ON THE THREE MILE ISLAND ACCIDENT

WEDNESDAY, OCTOBER 31, 1979

U.S. SENATE,
COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS, SUBCOMMITTEE ON NUCLEAR REGULATION, AND U.S. HOUSE OF REPRESENTATIVES, SUBCOMMITTEE ON ENERGY AND THE ENVIRONMENT, COMMITTEE ON INTERIOR AND INSULAR AFFAIRS,

Washington, D.C.

The subcommittees met at 2:10 p.m., in room 318, Russell Senate Office Building, Hon. Gary Hart (chairman of the Subcommittee on Nuclear Regulation), presiding.

Present: Senators Randolph, Hart, Moynihan, Stafford, Domenici, and Simpson; Representatives Udall, Bingham, Weaver, Carr, Markey, Kostmayer, Vento, Huckaby, Symms, and Cheney.

OPENING STATEMENT OF HON. GARY HART, U.S. SENATOR FROM THE STATE OF COLORADO

Senator HART. This hearing will come to order. Today's hearing is unprecedented in several respects.

First: This is the first joint hearing of the principal nuclear safety oversight committees of the Senate and the House.

Second: The subject of the hearing is the report of the President's Commission on the Accident at Three Mile Island. The accident was the most serious in the history of the American nuclear power program—indeed the most serious such accident that we know of anywhere in the world. The report is the most candid and the most independent assessment to date of nuclear power. It substitutes close scrutiny and hard criticism for the gloss and the platitudes of past Government studies on the performance and the regulation of nuclear powerplants.

Third: This hearing continues a fair but intensive trial of the nuclear power program. The Presidential Commission report presents a striking indictment of the institutions most involved in that program—principally the nuclear industry and the Nuclear Regulatory Commission. But the Congress is also on trial, as is the executive branch of Government. Ultimately, it is our responsibility as the people's elected representatives to determine whether nuclear power is, or can be made, safe enough to embrace as a principal source of energy. On that overriding issue, the jury is still out.

To my mind, although the Commission report squarely addresses the principal problems that caused and aggravated the Three Mile Island accident, it does not address the one question that, in some form, is on every American's mind. I would state the question this way: "Have nuclear powerplants become too large and too complex to be operated and regulated safely?"

That is the nub of it. The Commission's report stresses the uncertainty of the human factor. According to the findings, the equipment in the plant basically responded, but there were serious problems in design—especially of the control room—and there were serious problems in the way plant operators, industry executives, and NRC officials responded to the accident. Small comfort there, in my view: the equipment is fine; it is just the people running it that are flawed.

Therefore, I am interested in learning the individual commissioner's views as to whether Three Mile Island teaches us that we have gone too far, too fast with our nuclear power program. Are the latest 1,000-megawatt reactors, like the one at Three Mile Island, too big and too intricate to control in an emergency? Would smaller, simpler reactors perform better in terms of safety even if they are less desirable from the standpoint of cost effectiveness? Perhaps the American people are willing to pay more for nuclear-generated electricity if they can be assured it will be safe electricity as well.

Further, I am troubled by the Commission's decision not to recommend a delay in construction of new plants in light of its finding that, for safety's sake, the siting of new plants should be, and I quote the report, "to the maximum extent feasible . . . in areas remote from concentrations of population." Since some of the proposed plants now awaiting construction permits do not meet this standard, why didn't the Commission recommend that new construction permits be held up until safe sites can be found?

Finally, I am concerned by the Commission's recommendation that the independent, multimember NRC be transformed into a single-administrator agency within the executive branch. There are some serious problems with the structure of the NRC, but I am not convinced we can best overcome these problems by putting the agency in the executive branch and eliminating the diversity of views provided by a multimember commission.

I hope the Commissioners will provide further insight on this issue today, and I welcome their presentation. It is particularly significant that, I think, as I indicated, this is the first hearing involving jointly the Senate and House oversight committees. We are particularly pleased that the chairman of the House Subcommittee on Energy and Environment of the House Interior Committee, Congressman Morris Udall, could be present with us and members of his subcommittee.

Congressman Udall?

OPENING STATEMENT OF HON. MORRIS UDALL, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF ARIZONA

Mr. UDALL. Thank you, Senator Hart. It is a pleasure for me to cochair these hearings with you. I think our two subcommittees together probably bear the major responsibility over the next few months or years in coming up with some answers, because the nuclear

dilemma is not going to go away. It is a set of decisions to be made by all of us.

Dr. Kemeny, it is good to see you here today. I remember being in your home at Dartmouth—the nature of these meeting eludes me at the moment. But I look forward to discussing your findings and to having the Commission before us.

I find that I am managing a bill at this moment in the House Chamber—one of these major energy bills—and I am not going to be able to stay very long. I am going to turn my gavel over to Mr. Bingham at that time.

Let me make a few observations before we turn to your comments.

Following the Three Mile Island accident, our subcommittee conducted a comprehensive set of hearings on the major nuclear issues, even as Senator Hart was working at a similar task. These hearings were completed in September. Early this month, the subcommittee began consideration of concepts that might be incorporated into legislation. Perhaps the major issue before us is the question of whether there should be a moratorium on issuance of construction permits for nuclear powerplants. This is a matter on which our subcommittee members hold a wide range of views. And I gather your commissioners are not entirely of a single mind on this issue either. After some deliberation we decided that before proceeding to write a national nuclear policy bill, we would wait and see what words of wisdom you and your associates might offer on the subject.

So that you might understand the basis for some of my questions, I would say a few words as to where I come down on the overall moratorium question. After TMI—and I am speaking about the last 6 months—my position on the issue has been moving from one of opposition to a moratorium to one of tentative support for some kind of a conditional moratorium. Prior to the accident at Three Mile Island, I tried to be intellectually honest and I was beginning to accept assurances that nuclear powerplants could be made sufficiently safe. After all, we had had 400 reactor years of operation without a fatality. And I had hoped they would be made safe because all parties involved had an interest in making sure that accidents did not occur. I had believed instead that if nuclear development were to falter, it would be a result of adverse economics or a failure to solve the waste problem.

Your revelations and those of others have raised so many questions about the manner in which the nuclear technology has been managed that I now lean to the conclusion there should be a pause, a moratorium—perhaps not a permanent or an unconditional one, but a moratorium—until the industry and regulators both get their houses in order. Not because I am confident that we will find economic alternatives to nculear power—although I hope that such alternatives will be found—rather I am leaning this way because our country may still decide that there is a long-term need for some component of nuclear technology. If we so decide—and that is a judgment for the people—we must have assurances that those responsible for these potentially dangerous machines will do a much better job than has been done to date.

Thank you, Senator Hart.

Senator HART. Thank you, Chairman Udall.

The ground rules for the hearing today are that members of the Senate and House committees will make opening statements as they desire, hopefully limited to approximately 3 minutes, and then we will proceed to the Chairman of the Commission for their report.

With that, I would acknowledge the chairman of the Senate Environment and Public Works Committee, Senator Randolph.

Senator RANDOLPH. Chairman Hart, I would prefer the ranking minority member of the subcommittee have an opportunity to speak first and then be given an opportunity to follow.

OPENING STATEMENT OF HON. ALAN K. SIMPSON, U.S. SENATOR FROM THE STATE OF WYOMING

Senator SIMPSON. Thank you very much, Mr. Chairman.

Thank you for your usual courtesy, Senator Randolph.

I am very pleased at having this opportunity to share this opportunity with the House committee and the opportunity to discuss with Dr. Kemeny and other members of the Commission their report on the accident at Three Mile Island. I must say I enjoyed my informal time with you yesterday, and I found you to be a rather spirited and capable group indeed, and I enjoyed that very much. I was impressed.

I feel the members of this Commission are to be commended for the thorough treatment of this most difficult question. The seriousness and dedication with which the Commission and staff approach their responsibilities is quite evident from the Commission report and supporting staff documents. Moreover, the Commission's findings and conclusions appear to me to be a fair and balanced appraisal of the accident and its implications both of nuclear safety and regulation of nuclear power in this country. As such, those findings and conclusions, I think, represent an important addition to the abundance of information available on Three Mile Island, and they will certainly receive my careful consideration in this subcommittee.

Perhaps equally important, the Commission has presented its findings and recommendations in understandable form—in English, a very commendable attribute here in this community—and I think yet, without oversimplification, you have done that. I believe that is essential if the American people are to fully understand both what happened at Three Mile Island and what those events mean for the safety of nuclear power. To me, this contribution to public understanding is, I think, one of the greatest benefits that you will perform.

Mr. Chairman, our own review of Three Mile Island and this accident confirms many of the findings of this Commission. We have seen firsthand the human factors which played an extraordinary and significant part in the accident and in the utility's and NRC's response to it. We have also observed the attitudes on nuclear energy and safety which existed within the industry and regulatory agency prior to the accident. I would fully agree with the Commission as to the seriousness of those problems and need for corrective action.

Based upon what we have seen this far, I would also agree with the Commission that there are serious deficiencies in both the NCR's and industry's treatment of operating experience. Clearly, there are lessons to be learned and there are changes to be made.

Mr. Chairman, in conclusion, I think that the Commission has provided the President and public with a sweeping set of recommendations

for change in the way nuclear plants are operated and regulated in this country. A number of those recommendations are supportive of changes which may now be underway as a result of our effort on the NRC authorization bill, including State emergency planning reforms, changes in the NRC siting practices, and new initiatives in the way of operator training and qualifications. The other recommendations, I think, represent a very novel approach to improving our Government's institutional efforts in this area, and particularly the Nuclear Regulatory Commission, and those are complex proposals which call for careful review. I will give it, the subcommittee will give it, the chairman and chairman of the full committee will give it that review. I look forward to the opportunity to explore this with Senator Hart and the Kemeny Commission and receiving more of their ideas for improving nuclear safety and regulation and the reasons and debate which led them to their significant recommendations.

Thank you, Mr. Chairman. Thank you, Chairman Hart.

Mr. UDALL. Mr. Chairman, I am told they are about to vote on my bill. Before I leave, I would like to welcome Governor Babbitt, who has been a valuable member of this Commission. I hope my colleagues in the Senate and House will treat him gently. He has been razed by the taxpayers enough as it is.

Senator HART. Governor, welcome.

Congressman Bingham from New York?

OPENING STATEMENT OF HON. JONATHAN B. BINGHAM, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF NEW YORK

Mr. BINGHAM. Thank you, Mr. Chairman.

I think this is a memorable day on several counts. First of all, I would like to commend you, Chairman Hart, and also Chairman Udall for arranging this joint hearing. It is unusal for House and Senate committees to meet together. I have long felt that this was an approach that could save us and the representatives of the executive branch a great deal of time if we did more of it. So I think this is a splendid precedent.

I would also like to say that I think the Chairman and the members of the Kemeny Commission have performed a great service for the country and perhaps for the world community which is interested in nuclear safety problems. I have not had a chance to go over the report in detail, but to the extent that I have been able to go over it, I think I agree with about 95 percent of it, and that proves to me it is a very wise report.

I do have some questions, as Chairman Hart indicated he did, about the recommendations with regard to the setup for the Nuclear Regulatory Commission. My own feeling about that is I agree fully with the Commission that there has been a mindset in the NRC, but I think the problem lies particularly with the staff, most of whom are holdovers from the old AEC. I think there is a lot to be said for the multimember commission at the top of the structure. So I will be pursuing that in my questions.

But I do want to say I think you performed a great service for all of us, and I commend the Commission. Thank you.

Thank you, Mr. Chairman.

Senator HART. Thank you, Congressman.

Senator Randolph?

OPENING STATEMENT OF HON. JENNINGS RANDOLPH, U.S. SENATOR FROM THE STATE OF WEST VIRGINIA

Senator RANDOLPH. Chairman Hart and Chairman Udall, in absentia, I want to take this moment personally, rather than speaking for the Senate Committee on Environment and Public Works, to indicate that I think this session and possible further sessions with Members of the U.S. House of Representatives is wholly meaningful and timely. I often feel that we should come together on matters that are very crucial to the passage of legislation or oversight hearings from both sides of the Capitol.

Dr. Kemeny, we appreciate your taking the time to counsel with us today on the findings of the President's Commission on the Accident at Three Mile Island. We also welcome Representative Udall and his colleagues from the House Subcommittee on Energy and the Environment. They share with our committee and our Subcommittee on Nuclear Regulation the congressional responsibility for Federal regulation of civilian nuclear energy.

I commend you, Dr. Kemeny and your associates, for thed iligent and conscientious effort you have made in developing your report. The accident at Three Mile Island, the worst such event in 25 years of nuclear power production, is highly controversial. A balanced report is evidence of your awareness of this situation. All of us look forward to carefully reviewing your findings and recommendations.

This committee, through our Subcommittee on Nuclear Regulation, is carrying out the Senate's investigation of the Three Mile Island accident. Under the able leadership of Chairman Hart and Senator Simpson, the ranking minority member, our efforts are moving forward.

We have deliberately chosen a more lengthy period for our inquiries than the Presidential Commission. It will be our responsibility to develop and act on any legislation that is considered necessary as the result of the accident. We believe, therefore, that we should have the benefit of all other studies of Three Mile Island, including yours, Dr. Kemeny.

The report of the President's Commission recommends several actions to revise nuclear regulation. We will give them careful consideration, both in our own studies and in the development of legislation. I hope that the Congress will not be subjected to pressure to move too quickly on some of these matters.

Shortly after the incident, however, it was readily apparent that some action could and should be taken without delay. In considering the annual authorization bill for the Nuclear Regulatory Commission, our committee and the Senate adopted provisions stimulated by the Three Mile Island accident. Our limited ban on construction of nuclear power plants was one instance in which we anticipated recommendations of the President's Commission. I hope that we can complete action on this legislation very soon.

A major recommendation of the Commission is the reorganization of the Nuclear Regulatory Commission from a five-member body to one which is directed by a single administrator. This is an example of one recommendation that I believe must not be hurriedly acted on. It is one that must be considered in a much broader context. I am convinced that there is little difference if the Nuclear Regulatory Commission is directed by one person or five if there are no other

changes in the regulatory process. More crucial to improving the safety of nuclear power operations is the clear definition of responsibility between Government and licensee and the development of precise responses to emergencies by all of those concerned. It is in this context that the organization of the Nuclear Regulatory Commission must be developed. It is this overall determination of roles and responsibilities and the clarifying of lines of authority that is the greatest task ahead of us.

I am concerned that the President's Commission did not address the issue of disposal of nuclear waste. Waste questions are crucial to the recovery from Three Mile Island. I and others have prepared proposals to create the comprehensive waste disposal program without which the future of nuclear energy is extremely cloudy. We intend to develop and report legislation on this subject.

Dr. Kemeny, again we welcome you and your colleagues to the committee and look forward to counseling with you.

Senator HART. Thank you very much, Senator Randolph.

Congressman Weaver of Oregon?

OPENING STATEMENT OF HON. JAMES WEAVER, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF OREGON

Mr. WEAVER. Thank you, Mr. Chairman.

As chairman of the Three Mile Island Investigative Task Force appointed by the Chairman of the Interior Committee, I arrived at one fundamental question: Can we control this force or does it control us? That is why I was much interested in your report and how you dealt with this problem.

It was clear to me anyway that the operators of Three Mile Island at the time of the accident were overwhelmed that a nuclear plant is so technologically cumbersome. There were 100 alarms in the first minutes of the accident and the operators certainly made errors. But they made errors not because they were incompetent—I found them highly competent—but because the technology was impossible for them to grasp at the moment. I say something is fundamentally wrong with the technology. The aversion, problems, and horrors that nuclear holds, the very fact that great numbers of our people—and perhaps a majority—oppose or fear nuclear power, should be enough to prohibit nuclear development. We are concentrating the very material most dangerous to life, indeed most threatening to the existence and procreation of humanity. I hope to develop these questions.

Thank you very much.

Senator HART. Senator Moynihan.

OPENING STATEMENT OF HON. DANIEL PATRICK MOYNIHAN, U.S. SENATOR FROM THE STATE OF NEW YORK

Senator MOYNIHAN. Thank you, Mr. Chairman.

Mr. Chairman, the public never says its thanks very well. I would simply like to say to the Commission thank you.

Thank you.

Senator HART. Thank you, Senator.

Congressman Markey of Massachusetts?

OPENING STATEMENT OF HON. EDWARD J. MARKEY, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF MASSACHUSETTS

Mr. MARKEY. Thank you, Mr. Chairman.

I want to thank you also for the effort and time that you have committed to this work. Many of your recommendations are going to be very useful to the committees that have jurisdiction in the House and Senate over drafting legislation in the aftermath of the work you have done.

But, quite honestly, I am very disappointed in your report. I am disappointed in the way that finally you concluded with a whimper and not a bang. You did not follow the logic of all of the recommendations that you present to this joint committee. You reached the point at which a moratorium was called for. You tell us that the Nuclear Regulatory Commission is in a shambles. You tell us you cannot guarantee that public safety is adequately protected by the existing nuclear regulatory system. You tell us that operating procedures, the training of personnel, and nuclear plant design are all deficient in our nuclear industry, and yet you do not have the courage of your convictions. You do not have the courage of your convictions to come before us today and tell us that you do indeed recommend a construction permit moratoruim.

You have concluded, for example, that to prevent future accidents as serious as TMI fundamental changes will be necessary in the organization, procedures, practices, and attitudes of the NRC. You have said with its present organization, staff and attitudes, the NRC is unable to fulfill its responsibility for providing an acceptable level of safety for nuclear powerplants.

The Commission has further noted that an accident like Three Mile Island was inevitable and, moreover, that fundamental changes are necessary to prevent future accidents as serious as TMI. You have concluded the accident was a result of poor operator training and inadequate safeguard procedures and the failure of NRC and industry to respond to clear warnings from earlier accidents. You blame operator error, the utility, the reactor vendor and NRC for the serious accident.

Now as the House author of the construction permit moratorium, I cannot help but say I have a proprietary interest in seeing a strong recommendation from your Commission on this subject. The Interior Committee voted 23 to 7 in favor of a construction permit moratorium. President Carter charged you with the responsibility over the last 6 months to come forward with recommendations on this subject. I think to the extent you did not give us a clear recommendation for a nuclear moratorium, your report is tragically flawed and limited. It detracts from the other recommendations you make to us here. You are asking us basically to say there is something wrong with the automobile, but rather than recall it, we are going to try to repair it while it is still moving. I do not think that is a wise or logical conclusion from the recommendations which you make to us today. I hope as we go forward here we might be able on this matter to elicit from the individual Commission members their reasons for reaching your conclusions. I know there were eight members that supported one or another kind of moratorium to tell the American people that we have to end

business as usual, the status quo, and have a moratorium on new nuclear powerplant construction in this country.

Thank you, Mr. Chairman.

Senator HART. Thank you, Congressman.

Senator Domenici?

OPENING STATEMENT OF HON. PETE V. DOMENICI, U.S. SENATOR FROM THE STATE OF NEW MEXICO

Senator DOMENICI. Well, Mr. Chairman, that is another way to say thank you. I might just say if you had asked us what we wanted individually, you would never have recommended anything to the American people. So I am glad you recommended what you feel is in the best interest of the country. Perhaps it is not what some of us want.

To my mind, Mr. Chairman, the report is an objective analysis by distinguished Americans with no axe to grind. It deserves more than rhetoric by this group and Congress. It deserves intelligent study and action.

As I see it, the report highlights two things. First, that the utilities are operating in a horse-and-buggy age when the nuclear age has arrived. They must update their management practices to the level of our country's overall level of management expertise and competence. Second, the Commission found that the Nuclear Regulatory Commission is a rickety regulatory structure with little emergency response capability.

The Congress must now follow through with the Commission's recommendations to upgrade and update the NRC. In my opinion, we can no longer afford to have a Commission which is fashioned after a group which regulates trains and trade. This requires one to regulate the nuclear industry. It must be able to analyze and react to accidents as well as regulate, and it will not work if we model it after a commission that is in charge or setting rates for airlines or that finds fault with certain American trade practices.

It appears to me you are significantly correct in analyzing time for a change is here, and you have told us how. Thank you very much.

Senator HART. Thank you, Senator.

Congressman Kostmayer of Pennsylvania?

OPENING STATEMENT OF HON. PETER H. KOSTMAYER, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF PENNSYLVANIA

Mr. KOSTMAYER. Thank you very much, Mr. Chairman.

I join my colleagues in the House and Senate in thanking you for the hard work that you have put in on this task. Whether we agree or disagree, you are to be commended for the time you have given to the citizens of this country.

The report seems to be important not only because of the questions it answers, but because of those it does not answer. More important, it seems contradictory to me. The Commission states its findings "do not, standing alone, require the conclusion that nuclear power is inherently too dangerous to permit its continuation and expansion as a form of power generation." On the other hand, the report states that its

conclusions "do not suggest that the Nation should move forward aggressively to develop additional nuclear power." We could stand still or move forward.

If the regulatory agency and process is as flawed as the Commission suggests, how can we possibly proceed without implementing the Commission's recommendations? The report is an indictment of both the NRC and nuclear industry. But the report deals exclusively with future actions and recommendations. What about current operating reactors? And what about those plants that are located in or near major population areas—in suburban New York City, in Chicago, in Cleveland, in San Diego? What assurance can be given today to the American people that their safety and health are not in danger?

A final point. If this report demonstrates anything, it is that Congress and the administration and the NRC and the industry have been negligent, and that they have ignored the imminent danger associated with harnessing nuclear power for commercial use. Only a short time ago, in fact, the House rejected an amendment which would have required that new licenses be contingent upon a State-developed evacuation plan. This is now a recommendation of the Commission, but it was overwhelmingly rejected by the pronuclear House. Clearly, the Federal Government and industry have been on the wrong side of the issue. Hopefully, this report will put them on the right side.

Thank you, Mr. Chairman.

Senator HART. Thank you, Congressman.

Congressman Vento of Minnesota?

OPENING STATEMENT OF HON. BRUCE F. VENTO, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF MINNESOTA

Mr. VENTO. Thank you, Mr. Chairman.

I would like to commend the members of the Three Mile Island task force for their efforts in dealing with this complex issue.

As a member of the House Interior Committee task force, I am familiar with the events that occurred here. But the complexity of the issue which occurred, while your report will be most useful during the consideration by the Congress and the President of our national energy policy, it is not a definitive study of nuclear power and its future limitations. The directive of your Commission and the timeframe under which you worked limited the scope of your review to key questions. Disposal of waste, liabilities for accidents in the future at existing or new powerplants were not considered.

This is certainly not the final chapter on Three Mile Island. We still face many questions. What is the full economic impact of the accident? How is the waste to be disposed of? What is the full impact of Three Mile Island on the health of the residents? These questions cannot be adequately answered at this time. In fact, it will take years of close evaluation and study before we do reach final decision.

While I have not had sufficient time to read completely your report, there are several issues that come to mind that were inadequately considered by the Commission. I would like to raise these issues and hope you will respond by comments during your testimony.

The report states human errors occurred at Three Mile Island. Such problems did and do continue to exist. It was mechanical problems that led to the event. The design and location of the instrument panel

contributed to the crisis. Until a thorough redesign of the mechanics of nuclear powerplants is completed, the possibility of similar events occurring remains very possible.

The last point: I would just like to point out this answer to the question is being begged. We must look at plant design, operational procedures, and basic current facts—the way things are in the real world. Mr. Chairman, the question has not been considered by the Commission or administration nor by Congress. But we must develop an answer with regard to new nuclear power policy. It is an issue that can no longer be avoided.

Thank you very much.

Senator HART. Thank you, Congressman.

Congressman Huckaby from Louisiana?

OPENING STATEMENT OF HON. JERRY HUCKABY, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF LOUISIANA

Mr. HUCKABY. Thank you, Mr. Chairman. I shall be extremely brief.

I, too, would just like to say thank you for the time and effort that you have given our Nation. I am certain that you addressed many, many questions to various degrees that are not really included in your report. I know the issue of a moratorium had to be discussed for many hours. And I personally feel that, in effect, we have a moratorium until Congress further reacts.

Just my brief review of your report: I was disappointed that there was not more emphasis on standardization as far as future plants were concerned. At the proper time, I would like to explore that.

I want to commend you on your efforts in these matters.

Thank you.

Senator HART. Thank you, Congressman.

Senator Stafford?

OPENING STATEMENT OF HON. ROBERT T. STAFFORD, U.S. SENATOR FROM THE STATE OF VERMONT

Senator STAFFORD. Thank you very much, Mr. Chairman.

It is a privilege to be here today and I look forward to participating in this hearing on the report issued by the President's Commission on the accident at Three Mile Island. As ranking member of the Senate Environment and Public Works Committee, I would like, first of all, to welcome the Kemeny Commission to this hearing. The Commission was given a monumental task to complete in a short period of time, and I commend Chairman Kemeny and the members of the Commission for the excellent work they have done in carrying out this mandate. I know the information they have gathered will be valuable as we continue our own investigation on Three Mile Island.

The events at Three Mile Island on March 28 cannot be viewed as an isolated incident. The complicated combination of human and institutional and mechanical failures caused the accident at Three Mile Island. Serious problems raised by the accident have national implications. The solutions to these problems, if they exist, will be complex and, will need to be directed toward human failure, institutional failure and mechanical failure.

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There is a theme throughout the report. It appears that fundamental changes will have to be made if the generation of nuclear power is going to continue—changes in the functioning of NRC, changes in emergency planning, changes in operator training, changes in attitude. I, too, believe that fundamental changes must be made. The question is what those changes should be and how they should be implemented? The Senate Committee on Environment and Public Works will continue to look carefully at this question during the next several months. The report issued by the President's Commission is a substantial contribution to the information available on the incident at Three Mile Island.

Thank you, Mr. Chairman.

Senator HART. Thank you, Senator Stafford.

Congressman Moffett, the chairman of the House Government Operations Subcommittee on Environment, Energy and Natural Resources.

OPENING STATEMENT OF HON. TOBY MOFFETT, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF CONNECTICUT

Mr. MOFFETT. Thank you, Mr. Chairman. On behalf of the members of my subcommittee, we would like to extend our appreciation for your having invited me to make a brief statement and attend these hearings. It is good to see the House and Senate working together. Senator Domenici and I, of course, spend time doing that on conference committee, and I think we ought to do much more of that. So I commend you for this kind of coordination.

I simply want to say that, in addition to thanking you, I must express my envy for any group that gets a chance to focus on one subject for 6 months. I think all of us would be envious of that kind of opportunity.

Second, having had the chance to speak with the chairman of the Commission and members of the Commission, I have nothing but highest regard for your work and dedication. I think that many of the issues that you have raised are important ones and can go a long way toward improving safety at existing nuclear powerplants. Many of the issues are those that have been raised by the subcommittee which I am privileged to chair, have been raised by both Representative Udall and Senator Hart in legislation that they have introduced with regard to emergency planning and siting and operator training and presence of the NRC at facilities.

I must say, however, that I would have preferred that you had put more bite and teeth into your recommendations by having approved a short-term moratorium if, in fact, the recommendations are not improved. In our own report on emergency planning issued in August, we suggested that existing plants be given 2 years to have proper evacuation and other emergency planning procedures implemented, and if not, that they be shut down. This is not really your burden. But the fact is that the central question so many Americans, whether they are in protests or in schools or in gatherings of scientists, want to know is whether we can begin to push ourselves away from the nuclear table.

I appreciate the fact that the Commission only had 6 months, that it did its absolute best in confronting these issues, that it was one that worked very hard and did with a great deal of sincerity and honesty. But the fact is we are still confronted with the very legitimate question is there another way, a better way? Is there a way to proceed with a energy future with reduced dependence on nuclear power? I would submit that there is. And we as consider at this moment on the House floor some fast-track legislation, my hope is that your recommendations will be taken seriously, that they will be implemented almost in toto, that we consider them seriously, but that this report not be considered a fast track for accelerated development of nuclear power in America.

Thank you, Mr. Chairman.

Senator HART. Thank you very much, Congressman.

Congressman Cheney of Wyoming?

OPENING STATEMENT OF HON. RICHARD B. CHENEY, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF WYOMING

Mr. CHENEY. Thank you, Mr. Chairman.

I would like to join with my colleagues in thanking the members of the Commission for the effort they obviously expended on a very difficult task. It seems to me just from what has transpired in the last 24 hours, both advocates and rejectionists have used your report to buttress their preconceived notions of what we should do. I think our purpose would be best served by listening to you.

I yield back my time, Mr. Chairman.

Senator HART. Thank you, Congressman.

Congressman Symms of Idaho?

OPENING STATEMENT OF HON. STEVEN D. SYMMS, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF IDAHO

Mr. SYMMS. Thank you, Senator Hart.

Members of the Commission, I share with all my colleagues in thanking you for your efforts. I might say further, Dr. Kemeny, it appears your ability to harmonize several diverse points of view into a very readable report is certainly commendable, and I congratulate you for that. I believe that your work is going to contribute to a great deal of information that has already been gathered in the development of what corrective action may need to be taken by the Congress. We are all indebted to you for helping us in corroborating the evidence. Your effort complements the work that has been going on both in Government and industry since the Three Mile Island accident.

About 3 or 4 weeks ago, I proposed to our House Subcommittee on Energy and Environment, of which I am ranking Republican member, that we develop a report to present a summary of the 17 days of testimony that was taken before our subcommittee. We heard testimony on issues related to nuclear power that were not covered, nor intended to be covered, by your work, and the information gathered in these hearings clearly must play an important role in the development of any legislation that we would propose.

I would like to note also that the nuclear industry has concurred with those recommendations that you have made to industry. I

believe this acknowledgement is the first step of a new beginning that we have embarked on. As I am sure you are all aware, the nuclear industry has proposed in hearings before our subcommittee to establish several new industry bodies; namely, the Institute of Nuclear Power Operations and the Nuclear Safety Analysis Center. These two groups alone comprise in excess of 250 people dedicated to implementing many of the recommendations you have made in your report to the industry.

Now, of course, the Congress must undertake to do these things which can only be accomplished by legislation. These considerations must be based on the diverse bodies of information that is both well corroborated and substantiated.

Recently, I think it is well to note, in closing, that the General Accounting Office issued a report to Congress that demonstrated at least to my mind that both the immediate and future need of nuclear power for the well-being of this Nation. Those of the upcoming generations who have claim to the future of America will not be served if we fail to provide for them. I hope that the result of your work together with the work of our subcommittee will permit us to legislate in a responsibile fashion. In my opinion, the nuclear industry does not need subsidy from the Government, but it does need sponsorship if it is going to be successful and a future part of our national energy needs and wean us from dependence on foreign oil. I think most of our problems with respect to nuclear power are political problems and not technical problems that cannot be worked out. I look forward to hearing your testimony. Thank you again.

Senator HART. Thank you, Congressman.

Congressman Carr of Michigan?

OPENING STATEMENT OF HON. BOB CARR, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF MICHIGAN

Mr. CARR. Thank you, Mr. Chairman.

I would just simply like to thank the Commission for their labors, and I would associate myself with the remarks of Chairman Hart and Chairman Udall.

Senator HART. Thank you.

Dr. Kemeny, welcome to Congress. You obviously have the commendation of these committees, and I would only add my word of thanks to all of you for the work you have done diligently, and particularly to your fine professional staff. You have heard a lot of what you did not do. Now we would like to hear what you did do.

STATEMENT OF JOHN G. KEMENY, CHAIRMAN, PRESIDENT'S COMMISSION ON THE ACCIDENT AT THREE MILE ISLAND, ACCOMPANIED BY: HON. BRUCE E. BABBITT, COMMISSIONER; CAROLYN LEWIS, COMMISSIONER; PATRICK E. HAGGERTY, COMMISSIONER; PAUL A. MARKS, COMMISSIONER; CORA B. MARRETT, COMMISSIONER; HARRY McPHERSON, COMMISSIONER; AND THEODORE B. TAYLOR, COMMISSIONER

Dr. KEMENY. Thank you very much, Mr. Chairman and distinguished Members of Congress. May I first of all say I am only sorry that all 12 members of the Commission could not be here. Because of

the hurriedly planning for these hearings, four of them are unavoidably absent today because they could not change their plans.

We are delighted to be here. I have thought very hard since yesterday about how I could best help you. It is inevitable that within the first 24 hours of release of a highly comprehensive report, the spotlight is going to focus on a very small number of issues—and they were major issues. Therefore, we have no complaint. We thought we might help by giving a brief initial statement where I might try to underline a number of other recommendations we consider at least as important as those that have been spotlighted so you have a more balanced picture in front of you.

First of all, concerning the Nuclear Regulatory Commission, naturally, the great coverage and discussion was on our unanimous recommendation on the restructuring of the agency; but that has to be read in the context of the remaining recommendations of the Nuclear Regulatory Commission because it is the rest of the recommendations that speak of the kind of agency we are looking for. The restructure is a means to an end to achieve those goals.

We have recommended the following, as an example: We have recommended they should clearly explain to Congress, the American people, their safety cost tradeoffs, that there should be a ground rule for them if there is any doubt at all; that is, unless the cost is absolutely overwhelming, the presumption should always be in the favor of safety.

We have recommended a new higher standard for any utility that wishes to obtain a license. This is one of our most important recommendations: that they should not be allowed to receive a license to operate the plant unless they meet much higher standards than are now required.

We have recommended that this agency must have a public agenda for rulemaking. Most importantly, this must include clear and specified deadlines for resolution of all generic safety issues, some of which have been around for a very long time.

We have recommended very extensive changes in the arm of the agency through which it carries out its mission, the Inspection and Enforcement Office. This has to be strengthened vastly and it must be provided with a system for evaluating the patterns of problems that show up in nuclear plants. We found no evidence that any such system existed prior to Three Mile Island. Therefore, clear patterns of trouble were not spotted.

We also recommended that there should be periodic, intensive reviews of the licensee to see whether they are fulfilling the terms of their license.

A second area is the area of siting of nuclear powerplants, and I will begin with remarks on emergency planning and response.

You have, of course, heard that we have recommended that, as far as feasible, they should be sited at locations remote from populated areas. But we have recommended a good deal more than that. We feel that siting and emergency planning must go hand-in-hand, because one test for a site is whether it is possible to have realistic emergency planning. We have found the NRC-based criteria on concentration of low population zone has proved to be totally flawed in the light of the experience of Three Mile Island. Therefore, we have recommended a quite different approach under which a number

of accidents in areas have to be analyzed for each plant to have realistic plans of how you would respond to specific kinds of accidents. The NRC had analyzed the horrendous accidents and came out with a 2-mile zone. We experienced a much less serious accident and there are recommendations to have evacuation as far as 20 miles. But what we need for emergency planning is clear plans in hand that if an accident should occur, one knows this calls for plan No. 4, which may be evacuation within a small area, protection measures beyond that and prehaps staying indoors for 24 hours in larger areas. We recommended if such clear plans do not exist, the plant should not be licensed.

As you know, we identified operator training as sort of an Achilles heel of this particular industry. There has been data from the industry that the particular plant had a way above average record in terms of the NRC examination for their operators, and our evidence agrees with that. Yet, we heard from those very same operators that they felt that their training left them totally unprepared for the accident they faced. When you put those two facts together, that these operators were above average nationally and totally unprepared for the accident they faced, we feel one of the most urgent needs is a totally new approach to the training of operators. What we are recommending is that operators first go to an accredited training institution where they would learn the fundamentals of nuclear powerplants rather than just on-the-job training. It is only after they have proved they understand the fundamentals would the utility be able to hire them and give them on-the-job training of running particular plants.

We have recommended several vital additional studies, knowing that in 6 months we cannot possibly resolve all issues. I will mention a few of those: An expanded and much better coordinated research effort on the health effects of radiation. Second, a careful review of all the equipment problems for handling such accident, particularly to provide better, more easily available and prompt information to the operators and their supervisors which would, of course, involve redesign of control rooms. Third—and this has received almost on attention—indepth studies of accident scenarios.

If I may make a personal remark. One of the things that really horrified me about our investigation was that in the midst of this threatening accident, the Nuclear Regulatory Commission had to call all around the country to find out whether a hydrogen bubble could or could not blow up in a reactor. That research should have been done years in advance and should have been available for just such an eventuality.

Fourth, a piece of good news—which you may not have spotted in our report—which I would like to underline. About the most dangerous radioactive substance is radioactive iodine. While other things got out of containment, almost none of the radioactive iodine escaped. We strongly urge that somebody conduct an indepth study of what happened here, because understanding it may help us in other situations.

I am down to my final point, Mr. Chairman, the question of a moratorium—and you will no doubt ask a great many questions about moratoria. I would like to comment I don't think the impact of our recommendation No. 8 on the Nuclear Regulatory Commission has been fully appreciated at least by the public news media. This recommendation, which was unanimous by the Presidential Commission,

that no new licenses of any form—either construction permits or operating licenses—should be issued unless three things happen, we recommended that for each of those licenses the NRC, or its successor, must first check three things: first of all, whether the new safety improvements that we have recommended, and others may recommend, have indeed been incorporated in that plant; second, that the licensee lives up to the new high standards and qualifications that we have recommended, including the ability to give first-rate training to operators; and third, that any such license should be conditional on the approval of a State and local emergency plan.

We know at this moment this is in the hands of the present NRC, but we hope that this recommendation will be taken very seriously, because if it is—and Congress could give us a great deal of backbone—if it is, it may be our single-most important recommendation.

Mr. Chairman, Members of Congress, with those brief remarks, the Presidential Commission recommends our report to you fully, knowing that what happens to it is in the hands of the President and the Congress.

Thank you.

Senator HART. Thank you, Dr. Kemeny.

Under the ground rules we have previously established, we will invite individual members of the Commission to make brief comments as they may desire. Dr. Marks?

STATEMENT OF PAUL A. MARKS

Dr. MARKS. Senator, I would like to join in thanking you and other Members of Congress for scheduling this hearing so promptly. It clearly indicates a commitment to an expeditious and thorough evaluation of this Commission's report, which is what we can hope for.

I would like to address my remarks to certain of the findings which I believe led to recommendations that can and should be implemented as promptly as possible.

I am a physician and educator. By training and experience, I would be expected to be particularly interested in the practices and procedures related to people and especially as they affect worker and public health and safety. It is unthinkable to permit a poorly trained surgeon, working in an inadequately maintained operating room, to perform an operation. Frankly, I was not prepared for what the Commission found. The Commission identified technical problems with respect to the design and function of certain components of the equipment. In general, however, the equipment functioned as designed. The equipment failures and the weak features in design of equipment which were identified, however important, do not seem to go to the heart of the concern as to what has to be done to assure safer operation of nuclear powerplants. It is the findings with regard to widespread inadequacies in personnel programs and practices that should be of greatest concern. These inadequacies were found at almost every level that the Commission investigated in relation to the accident at Three Mile Island.

There has been inadequate attention to the human factor. I would emphasize this by citing some of the Commission's findings: The Commission found that the operator training was deficient and left operators and operator supervisors unprepared for the events that took

place at TMI–2. Earlier warnings that operators needed clear instructions for dealing with events like those during the TMI accident had been disregarded by management personnel in both Babcock & Wilcox (the manufacturer of the reactor) and the Nuclear Regulatory Commission (NRC). The emergency radiological medical care training provided physicians under contract to Met Ed was inadequate to care for injured, contaminated workers. The NRC had no requirements for a standardized health physics education of nuclear powerplant workers. Maintenance of equipment was substandard and resulted in Med Ed experiencing several radiation protection problems during the accident.

A number of cases were identified where management personnel in Met Ed, GPU and Babcock & Wilcox failed to acquire enough information about safety problems, failed to analyze adequately what information it did acquire, or failed to act on that information. Serious lack of communication existed about several critical safety matters within and among personnel of the companies involved in the building and operation of the TMI–2 plant. A similar problem existed in the NRC. Management personnel in the utility permitted the operation of the plant with a number of poor control room practices. The NRC set no minimal educational requirements for operators. The NRC standards for operator training allowed an individual to fail parts of either the NRC licensing examination or the utility requalification examination, including sections on emergency procedures and equipment, and still pass the overall examination and qualify to operate the reactor.

The Commission not only identified human errors, but also something that is perhaps even more important. Even in instances where NRC or the industry identified human errors, such as in the reports of engineers from both Babcock & Wilcox and the NRC of a nuclear powerplant accident in September 1977, which dealt with events like those during the TMI–2 accident, there appears to have been a failure or at least an inability to act effectively.

The Commission has recommended fundamental changes in the organization, procedures, and practices, and above all, in the attitudes of the Nuclear Regulatory Commission and, to the extent that the institutions investigated are typical, of the nuclear industry. Perhaps the most fundamental nature of these changes must be the incorporation, in a systematic manner, of higher standards for the selection, training, and practice of personnel at all levels of responsibility in the Federal regulatory agency and in the nuclear industry. It is unlikely that any amount of regulations will be adequate to eliminate human error. Indeed, too much emphasis on regulation may be counterproductive in this regard. Rather, emphasis must be placed on safety as an integral part of the day-to-day activities of regulators, managers, supervisors, and operators. However important it is to establish adequate techniques to deal with emergencies and to mitigate the consequences of accidents, our primary goal must be to prevent emergencies, to prevent accidents. This requires not only the meticulous quality control of design and manufacture of equipment, but at least an equal effort to achieve the highest quality education and training of operators. Licensing and relicensing of operators should be mandatory and based on high criteria of performance, both on theoretical material, as well as in practical, simulated settings of control room operation.

Plant maintenance in all its aspects should be rigorous. Inspections should be carried out with meticulous care to detail. Improperly functioning equipment should be attended to promptly. Lessons learned from accidents should be analyzed and information generated by such analyses appropriately and promptly applied. Close interaction between personnel of the regulatory agency and of the operating companies should be encouraged so as to provide for optimal exchange of information. In short, lax practices at any level should not be tolerated. A failure anywhere in the system may affect the entire system.

Senator HART. Thank you, Dr. Marks.

Other members of the Commission? Mr. Haggerty?

STATEMENT OF PATRICK E. HAGGERTY

Mr. HAGGERTY. Although there is some danger to calling attention to two specific recommendations of oversimplication or making you think they are more significant than they are, I think there are two of the recommendations which will bear on how confident we can be as to avoiding the kinds of things that happened at Three Mile Island. One is relatively short term, the other is long term.

The first of these recommendations is under technical assessment. The first recommendation under technical assessment is on page 27 and it calls for the creation of a single panel of significant indicators relating to the conditions of the reactor and its total coolant system, including the pressurizer. The absence of something as simple and straightforward as that both demonstrates an inadequate attention to the overriding deficiency that caused the accident—it relates to the change of the people—but it also would have prevented it. It would have been impossible to have that accident if the pressure and temperature conditions had been clearly portrayed as they were occurring in the reactor coolant system.

Furthermore, if the warnings associated with that had been grouped on a single panel and distinctive from the others and if, as we recommend, there had been a second such panel in the supervisor's office, it is almost impossible to conceive that the conditions which existed could have been missed.

The second is a recommendation which appears on page 66, and it is recommendation 11(b). It calls for the creation of an overall quality assurance system, one which evaluates the behavior of what happens in these plants. Now the fact is, we now have enough plants and we have enough years of operation going on and we have enough identifiable accidents so that if a proper attention is paid to the total action and if they are described and identified properly, one can develop, as is common practice in complex situation, a quantifiable quality assurance system which will relate the status of the industry as a whole in terms of the number of such incidents that per-reactor year of operation is going up or down, and one can relate the technical programs related to both improving operators' training and performance and equipment itself to the things that are happening in the system.

There is no particular reason for scaling these machines up. They are still fundamentally the same machines as smaller machines. There is nothing inherent as being 1,000 megawatts that makes it worse

than 500 or 400. What is wrong is the absence of a comprehensive way of looking at the total system and of identifying the specific and important signals that are related to whether the reactor is behaving properly or not.

Senator HART. Thank you, Mr. Haggerty.

Any other brief comments? Dr. Lewis?

STATEMENT OF CAROLYN LEWIS

Dr. LEWIS. Thank you, Senator.

We have had many of these arguments inside the Commission, and Pat and I are always on the opposite side of the fence.

I think what you are looking for from us—you have our report and findings and recommendations—I think at this point you seem to be looking to us for our personal views of, where do we go from here? There were a lot of questions we did not deal with in this Commission. For example, how safe is safe enough? How do we get from this point to the other point? So I would like to give you some of my personal impressions.

I came to the Commission with no knowledge at all about nuclear power. I did a tour of Harrisburg, of the Three Mile Island No. 1. I was rather horrified to find we had these large pipes with rags around them and yellow markings on the floor which said "Contaminated Water." I had had an image of a high, clean technology that was well looked after and well run, and I found something that really, frankly, looked like the underside of a 100-year-old house that I once owned, which was the plumbing underneath with all the little knick-knacks there. It was not high technology.

As the Commission progressed, we found a lot of things that showed the whole operation was not run very well. The thing that really struck me was the admission by those on our Commission who knew most there is no way to make nuclear power failsafe, that the only way to make it failsafe is to turn the reactors off. That means we are going to have to live with the possibility that there will be an accident as long as we have nuclear power operating in this country.

Now perhaps we are willing to accept those risks. But I think what we need is a public dialog on what the risks are in relation to the benefits. And I think the thing that Congress can do for us is to offer a look at the alternatives. Is there some other way to give us the electricity we need, for example, in conservation, in alternative sources of energy? The presumption is we have got to have nuclear power. That obviously was outside the mandate that we had from the President, but certainly our deliberations make me think I would rather have another way to have our electric power. I think conservation is something we ought to try in this country. So knowing that out there is this possibility no matter how much we play with the equipment, no matter how much we try to make the people who supervise it and people who run it better, there is always going to be a risk of an accident. And when you have a look at the possibility of that accident and what it would mean in human terms, not only to this generation but future generations, I think what the Congress and President can do is say, "Let's have another look; let's see if we can find another way to solve our energy problems," and not to really run off in a panic because we have problems with OPEC, but let's look at whether there is another way?

That is a personal view. I know people like Pat probably won't agree with me. This is what I got from 6 months on this Commission.

Senator HART. Thank you, Dr. Lewis. Mr. Taylor.

STATEMENT OF THEODORE B. TAYLOR

Mr. TAYLOR. Mr. Chairman, I would like to focus very briefly on the second recommendation, and that is for the establishment of an oversight committee on nuclear reactor safety.

The purpose of that recommendation, with very little debate, which was unanimously approved by the Commission early on, was to perpetuate a process to which the nuclear industry and the regulatory process has never been subjected before in the history of the probram in the United States, and that is careful, thorough public scrutiny. The purpose of that oversight committee is to examine and report to the President, the Congress, and, therefore, the American people in plain English what has been the response of the industry, of the regulatory process, whether it is a new agency, whether restructuring of the old one, and to allow the political process, on which everything of major importance in this country depends, to work.

The first requirement for that system to work is knowledge of the true situation with respect to any issue. We have not had that knowledge prior to Three Mile Island.

I stress that recommendation because I want to express a personal opinion. If that is not done, I begin to have some serious questions about placing all the regulatory responsibility under the authority of one person. If those are couched together, then the arguments for the collegiate process I think still hold—they are strong arguments. Now if that process were in place, with oversight to the whole system—not just the NRC, but the industry itself—then I think we have really got something that the public needs. We need a time of probation for the nuclear industry and we need to have a probation for the public political process to determine whether or not the delinquent should be kicked out of school or allowed to continue.

Senator HART. Thank you, Mr. Taylor.

Other Commission comments? If not, then we will go to questioning. Under the procedures established by the staffs of the two committees, we will alternate on a 10-minute basis.

To begin with, Dr. Kemeny, if, to use your phrase, the NRC siting policy is entirely flawed, as you stated—and you were referring to the low population zone aspect of that policy—how can the Commission not call for a moratorium on new construction permits for plants until that flawed policy is corrected?

Dr. KEMENY. Mr. Chairman, if I may state what happened to us which is now a matter of public record; 8 of the 12 Commissioners, myself included, voted for at least one version of a moratorium. Our difficulty was agreeing on common criteria on what would terminate such a moratorium on new construction permits. We were able to agree unanimously on recommendation No. 8, as we said. The problems that come out is that it is easy to say "Start the moratorium," but we were unable to get a majority vote on how to terminate one.

For example, personally—I am not arguing I was right or wrong—I, personally, favored one that is tied to the President and Congress having the chance to review our recommendations and act on them. Other Commissioners wished to tie it to the siting policy. There was

one vote that would have had a flat 2-year moratorium. We never could get a majority vote agreeing on one set of criteria for terminating a moratorium.

Senator HART. In other words, you all agreed——

Dr. KEMENY. Mr. Chairman, 8 out of the 12 favored 1 of the 3 votes.

Senator HART. But you all agreed, or did the Commission agree that the siting policy is, to use your terminology, entirely flawed?

Dr. KEMENY. Yes.

Senator HART. But you couldn't agree what to do about it?

Dr. KEMENY. No, we had very specific recommendations on what should be done about the siting policy. But the question was—let me tell you the problem of tying the moratorium to the siting policy. It happened to be the one I did not vote for for the very simple reason the way the vote was, it would have been the present NRC that would have had the ability to say, "All right, we now have a new siting policy; therefore, the moratorium is off." I may have been wrong on that, Mr. Chairman. That is why I didn't vote for that particular one, and other Commissioners didn't vote for other versions of it.

I must say we did not agree on how to call off a moratorium once it is started.

I wish you would give other Commissioners a chance to speak to this.

Senator HART. These questions are directed to the Commission at large. Mr. Taylor.?

Mr. TAYLOR. I would like to comment briefly. I voted for all versions of specific moratoria, which I believe would require congressional action, for reasons which I think have been given eloquently by a number of members of your committee and the House side.

I do, however, want to emphasize what Dr. Kemeny did, and that is, if you look carefully—and we looked very carefully at the wording; this didn't just slip in there—at recommendation 8: no more licenses of any kind on existing reactors that are under construction but don't yet have an operating license or those that don't have a construction permit until certain things have been done. Let me focus on one of those things. No more licenses until an emergency plan approved by the State exists. We then look at what we mean by "an emergency plan." How do you get there? You get there by analyses which have never been done, a number of different routes of a possible accident toward the release of radioactive material that would, under some circumstances, give cause for an evacuation. This is a requirement that we set down and strongly recommend, for an emergency plan.

The point I am trying to make is that we are, in fact, calling for what I would call a moratorium on all new licenses until there are certain actions that are responsive to our findings, not arbitrarily cast into some time in the future, although I see some virtue in doing that and saying there is meaning—there is political meaning if nothing else—to 2 years or to until such and such happens. But this now applies to licenses under present consideration. So I view that as a very strong, I would call, moratorium which received unanimous and enthusiastic vote in the Commission. There was very little debate about this when we came down on it.

Senator HART. Mr. McPherson?

Mr. McPherson. Mr. Chairman, I will speak as counsel for some of our absent members. They didn't think they were voting for a moratorium on recommendation 8.

Senator Hart. So the Commission is in disagreement as to what it actually did.

Mr. McPherson. No, I don't think so. It is just a matter of semantics, in my judgment. One thing that we did in No. 8 was talk about looking at permits and licenses on a case-by-case basis, which makes it different from a moratorium, as I think that word is commonly used in the political arena, which simply means closing her down for awhile.

Since you have asked us to tell why we did what we did, I did not vote for either the moratorium proposal that called for that moratorium until you all and the President had had an adequate opportunity to consider our recommendations, including the recommendation to restructure the Commission, because I frankly didn't know how long that was. I didn't know what event—what is "adequate opportunity"? Does it mean voting up or down? Does it mean 3 years or next month? I just didn't know.

The other one that came along was a 2-year proposal—a moratorium for 2 years. That didn't have an event involved. You all could sit still and do nothing for 2 years up here; take no action at all. All we have done is delay for 2 years any construction permits for nuclear powerplants.

The one I recommended is the one that nearly made it, and it comes from what I thought was a natural development from the siting recommendation, the siting recommendation that we agreed to, to my delight. In order to provide an added contribution to safety—even if you did all the other things with people and plumbing—in order to provide an added contribution to safety, the agency should be required, to the maximum extent feasible, to locate new powerplants in areas remote from concentrations of population. Siting determinations should be based on technical assessment of various classes of accidents that can take place, including those involving releases of low doses of radiation. My proposal was to say, having agreed to that, no new construction permits should be granted in areas that violate that siting proposal. And I thought it was a pretty good idea, but——

Senator Hart. But it failed.

Mr. McPherson. Yes.

Senator Hart. So, in the meantime, we have the conclusion that the siting policy is entirely flawed, but no recommendation for us to do anything about it.

Mr. McPherson. It was an extremely difficult and tough technical issue, and it does involve technical deliberations we were not up to.

Senator Hart. But from the Commission's point of view, licenses can go ahead and be issued to plants sited under a policy that is entirely flawed.

Mr. McPherson. Well, we are saying they ought not be near concentrations of population.

Senator Hart. Dr. Marrett?

Dr. Marrett. Let me first explain I was never voting for or against a moratorium. The approach for me was, what is the nature of the recommendation we are reviewing? And I reviewed each one

of those recommendations that independently all were generally concerned about a moratorium.

My own abstention on the votes—and I will explain them—my own absention was based on what I think Chairman Kemeny expressed as a problem of, what are the criteria? What are the things to be done? The uncertainties about the number of those, as well as the particular complexity some of the recommendations involved, led me to be very uncertain about the wisdom of those recommendations. Thus, I could not in good conscience say I fully supported a number of the recommendations.

On the other hand, if indeed there was some basis for something beyond—that some of the arguments that were made did seem, in a sense, to carry with them a great deal of weight, and not being able to reach a conclusion on recommendations, I found it impossible to vote in favor, but neither was I totally opposed to the idea.

Let me explain where I had problems with reference to the siting acception.

Senator HART. Excuse me, before you do it, I shall turn the microphone and gavel over to Congressman Bingham.

Mr. BINGHAM [presiding]. Please continue.

Dr. MARRETT. With reference to the siting recommendation, and Commissioner McPherson has indicated we certainly have recommended siting in remote areas, it is obvious though that that is a terribly complex issue with reference to what do we mean by remoteness. As someone pointed out, what is remote in certain parts of the country in terms of population might not be the criteria in other parts of the country. We certainly would not favor something done far too hurriedly, if indeed it is far more complex than simply having said this should be an idea. It has to be worked through far more substantially than we were going to be able to do, and thus, having been left with these thoughts of certainties, which in part said what is to be done during the period the moratorium is in effect—with those things left uncertain for me, I had difficulty saying that I regard a vote on a moratorium as certainly the most central thing this Commission should recommend.

Mr. BINGHAM. Mr. Haggerty?

Mr. HAGGERTY. Since I prepared recommendation No. 8, and I voted for none of the so-called moratoria, let me explain why. It seems to me we had to be responsible. What did we look at? We looked at Three Mile Island, Med Ed, B. & W., Burns and Roe to a limited extent, and NRC. You know it is easy to talk from one's emotional background as to what ought to be done generally. All we know is what we had looked at. That recommendation says look at every case and weigh it heavily before you issue another license. But it does not jump from emotional commitment and a limited review to a general castigation of an industry as a whole on which we had absolutely no facts to base such a recommendation.

Mr. BINGHAM. Dr. Marks?

Dr. MARKS. I would like to comment on this, too. I supported the recommendation for a moratorium linked to siting. But I do think that although only six members of the Commission supported it, the substance of the intent is in our Commission report and was supported by all of the Commissioners, and that is on page 64, item six, which

starts off "In order to provide an added contribution to safety," et cetera, which I think Commissioner McPherson referred to before, and I think the comment Commissioner Haggerty just made might have been a factor in why some of the commissioners did not go, if you will, the next step. Several of you are trying to find out why didn't we go that next step? If we come this far, why didn't we go this next step?

I think that I, personally, on the one hand, must respect the fact we did have a limited mandate. On the other hand, the basic recommendation is there, and if, in fact, an effective regulatory body accepts and implements that recommendation, I think that we have a very, very strong proposal with regard to siting. I think that it probably may, in fact, be a moratorium, but at least on a case-by-case basis it is a very strong recommendation which requires examination of every single license.

Mr. BINGHAM. Senator Hart's 10 minutes have expired, but go ahead, Dr. Lewis.

Dr. LEWIS. I voted for the moratorium, and I am sorry that we didn't get enough votes to come to you today and say we are that serious that we want you to take some action to stop it until everything is fixed. But I think if you do read our deliberations, you will have a sense of the anguish in what we saw. Even as we didn't get the votes, as the rules were drawn late in the game, you do have six votes involved for the moratorium. You have three against and three abstentions. And I think if you just overlook the particular rules we had, you will recognize that is a majority of this Commission in favor of a moratorium. It is up to you to read that. It is not an official statement. But as far as I am concerned, that is a majority of the vote.

Dr. KEMENY. Mr. Chairman, may I have one remark of personal privilege. There has been that particular statement that was just made that the rules were drawn late. May I state for the record that this Chairman first proposed rules for adopting the recommendations for the Presidential Commission on August 14. At that time the proposal was eight votes. At our final meeting, the Commission, having had in front of us written rules, unanimously adopted those rules. Therefore, I don't think it is fair to blame the outcome on the rules.

Dr. LEWIS. Can I answer the Chairman?

Mr. BINGHAM. I think we had better proceed. I would like to comment on this matter, and I was about to had Dr. Lewis not spoken.

I would like to say from my point of view, looking at the Commission's recommendation 8 and looking at the recommendation which appears on page 6 of Commissioner McPherson's supplemental view, and also the recommendation which is quoted on page 1 of the supplemental views which six Commissioners signed, I think it is a fair statement that the impression created by the Commission's report—taking into account the rather rigorous set of rules that it adopted for itself—amounts to what appears to me to be a recommendation for some form of moratorium, and indeed a moratorium which might well last substantially longer than 6 months, which is the proposal that is before us in the House. The voting rule which the Commission adopted for itself is more rigorous than we have in the House or Senate or, for that matter, the Supreme Court.

You had a majority of those voting for two of these recommendations which clearly amounted to recommendations for a moratorium. And I would like to call attention also to the fact that the Commission's recommendation 8 addresses itself not only to construction permits, but to operating licenses, which I think is a very significant addition. So it is on that basis that I said earlier I felt the Commission had done a tremendous job. And I recognize the difficulty that you had, Chairman Kemeny, in coming to a particular wording that would require the necessary set of votes.

I think it is unfortunate that the media have picked up the fact that the Commission did not vote formally for a moratorium. I do not know how many other reporters picked up the recommendation by the six Commissioners, as David Burnham did writing in the New York Times. But particularly in view of the fact that some supporters of the industry have pointed to this as something of a victory for the industry, I think the media play is unfortunate. But from the point of view of the way the Congress will look at this report, it seems to me the significant fact is that eight members of the Commission voted for a moratorium in one form or another.

Now I would like to turn for my question to the recommendation for a single administrator. It seems to me that the problem that this Commission confronts is a very different one from, let's say, the problem confronted by the civil aviation administrator. The problem is much more complex, answers are much more subjective, and it is a protection to all points of view to have different points of view represented on the supervisory body.

Dr. Taylor has indicated that if the kind of oversight committee which is recommended by this Commission were created that would provide for an adequate spectrum of opinion. But he has also indicated that if such a committee were not created, there is no opportunity for that. So my question is this: How many of you would agree with Dr. Taylor, that if the recommended oversight committee recommended is not established, you should leave the collegial structure at the top of the Commission?

Dr. KEMENY. Mr. Chairman, I believe I speak for the whole Commission. First of all, both were adopted unanimously, and during the discussion those two recommendations were intimately coupled in our mind. Therefore, I think that that is a package deal, that we would not buy one without the other.

May I say one word on that subject, Mr. Chairman?

Mr. BINGHAM. Yes.

Dr. KEMENY. Unlike a regulatory commission that sets rates, which is primarily judgmental in nature, there is a very large line organization here that must be supervised. Our findings document amply there is no effective leadership of this particular agency. Therefore, we tried to come up with a combination that, on the one hand, would give really strong day-to-day leadership for inspection and enforcement, for rulemaking, for making sure things do not fall between the cracks, if I may quote the agency, at the same time keeping what you are looking for in the collegial body by recommending an oversight committee. I do not think we would have voted for one without the other.

Mr. BINGHAM. Might I ask you to comment on the aspect of this question that arises from the great swing that may occur from one

point to the other? We see this happening in the Commission today where one Presidential administration may favor one type of appointee and another a different one. As I recall, you recommend a term of years for the administrator; you also specify that the administrator can be removed at the pleasure of the President. Does not that permit, in your view, a very dangerous lack of stability in the operations of the NRC?

Dr. KEMENY. That is certainly an issue we discussed at very great length, and we came out at the end with a judgment that it has to be the people who determine what the policy should be on nuclear power. The best place we could tie it to was a national election. If the people elect a President whose platform is to have nuclear power, the people have spoken on that; and if the people vote for one that wishes to terminate it, then the people have spoken on that. Clearly, it is only the President and Congress who can speak for the people of the United States. Therefore, we felt that very fundamental decision should be tied to the judgment of the people of the United States.

Senator HART [presiding]. Senator Simpson?

Senator SIMPSON. Thank you very much, Mr. Chairman.

Apparently I missed some of the indepth discussions on moratorium. We have grappled with that heavily. We have come to some rollcall votes on the floor of the U.S. Senate on moratorium. I recall the vote on the moratorium issue which was just flat out. I think it was 55 to 73 not to call for a moratorium on this industry. I won't get into the various reasons for that, but suffice it to say it was felt that even before Three Mile Island, there was almost a moratorium with a 12-year delay time in the construction of those facilities, with a lead time, of, as I say, 12 to 13 years, change orders at any time, siting regulations, which we deeply went into on the floor in the authorization bill, State emergency plans. Senator Hart and I joined in an amendment which required States to have those emergency plans, and if they did not, the construction would not begin.

So it is easy, so easy, in this business that I have been involved in as deeply as the chairman and as deeply as the members of the House committee, so easy to simply reach down in the bag and pull out the title "moratorium," "meltdown," "China syndrome," and the rest of the stuff, and then to get it all clouded in emotionalism and not deal really with the tenacious issue itself. And I hope that I can always stay away from the ritual, which is merely a trial variety here, to slip over to those terms when all it does is cloud reason and commonsense.

Enough of that. I have 7 minutes left.

Your report indentifies a number of events at the Three Mile Island plant and other plants that were in some way related to events of the accident which were apparently unheeded by the utility, the supplier of the system, and NRC. If the industry and NRC, in your mind, had in place an effective system for identifying and evaluating these operating experiences prior to this time, do you think that this accident would have occurred if there had been that system of identifying an evaluating between those three entities?

Dr. KEMENY. I believe again I speak for the whole Commission. We are quite certain if any one of several things had been followed through to the end, this accident would have been a minor incident that we never would have heard of it.

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Senator SIMPSON. Your report recommends improvements in the NRC's and industry's efforts to evaluate the operating experience and to try to incorporate those experiences into the design and operation of the plant. What specific means would be helpful to accomplish those objectives?

Dr. KEMENY. I think more in-depth study than we were able to do of actually what happened in this particular accident and what were the factors that prevented the operators from carrying out their task as they should.

Could I perhaps ask Commissioner Haggerty to speak to that because I think he could be most eloquent, and I agree with everything he is about to say.

Mr. HAGGERTY. Obviously you have the specific incidents, the Davis-Bessie incident, which was an out-and-out warning of almost the identical set of circumstances which subsequently produced Three Mile Island. But you have a broader problem of how you evaluate the status of the overall industry? How do you measure if you are progressing or going back in that status? Now that we have enough plants and they are operating and have been operating, there are the LAR's, the so-called reports on incidents that occur. If they were identified and scored as a part of a system, it would then become possible to measure progress because the statistical base is big enough, and programs which are laid out for improvement of training and equipment could both be related to the progress or failures against that overall quantative measure of what one is doing. You can't have a narrow, purely statistical examination. One has to know that these numbers have a base, what its meaning is. It can only be a guide. But it is almost inevitable if such philosophy existed, there really had been careful examination of these events, had it been coupled into a system of quality assurance, it would have been improbable for the signals at Davis-Bessie and Creswell that pointed to the incidents to have escaped, and hence avoidance of this particular accident.

Senator SIMPSON. One of the Congressmen brought up the issue of standardization, and one of the things I was interested in in the report and the work we are doing too was the aspect of the custom-made reactor. What did you address in the area of standardization which might alleviate problems, give us a better handle on the type? Not saying that one supplier then, that they would all come together, erect the same type of facility, but what was your discussion on standardization?

Dr. MARRETT. There is a specific recommendation on standardization. I think we need to go back to Commissioner Haggerty's comment about what we did and what fell within our mandate. What we did was actually look at a given vendor, a given plant. For us to extrapolate about standardization from this experience would seem to be far beyond what we have the factual data to do.

One of the other things that I think should be remembered, in our investigation entirely, we were fully aware of the broader kinds of inquiries that are being undertaken here, and we assumed that others will have a chance to ask those sorts of questions with a broader base than we had based on the part of the industry we looked at.

Dr. KEMENY. May I add one word, and I agree with what Professor Marrett said. We had a very brief discussion on standardization.

Let me tell you why, in addition to what she said, we did not come up with a recommendation. I think we all feel if those two plants next to each other had the same kind of control room, it would have happened considering the fact those control rooms were well over 20 years out of date. I was quoted as saying 20 years. We now know from the most high NRC official, going back 10 years, even he said it was 20 years out of date. What worries me about standardization is it could become a recipe for obsolescence. We thought it would be better to stay clear of that subject.

Senator SIMPSON. That is helpful, because you referred to it a great deal and you didn't make a recommendation. That was my inquiry.

One other question. Some of the recommendations that you give place a very high priority on prompt regulatory action by the NRC in a lot of areas. For example, you call for development of new siting criteria with population density fed into that determination; prompt review and approval of state emergency plans. You talked about the development of standards for training and qualifications. My question: How will the progress in accomplishing each of those aresa—and I think you pointed out as immediate goals—how will those be affected by the reorganization proposals for the NRC which you are suggesting? Will the delays which accompany, from what I see, those type of reorganizations be a significant factor in hindering the carrying out of those recommendations with the immediacy you seem to address?

Dr. MARKS. This was one of the things that we discussed at length, this so-called transition period. I think that the thrust of our recommendations are, to the extent possible, that they be implemented by the present NRC. We feel that there are recommendations such as you just cited, Senator, which can and should be implemented now. The agency that exists is the agency that we hope feels charged with responsibility to do it now. The restructuring of the agency certainly is not a recommendation intended to in any way either remove responsibility from the present agency to go forward with the implementation of these recommendations where it is possible without statutory change, nor, to use it as an excuse for stalling on going forward with these recommendations.

Senator SIMPSON. Thank you.

Senator HART. Senator Randolph?

Senator RANDOLPH. Thank you very much.

Dr. Lewis, you are nonnuclear; is that correct?

Dr. LEWIS. When you say I am "nonnuclear," I came into the Commission not having a position.

Senator RANDOLPH. What is your position now?

Dr. LEWIS. Now I wish we had never gone in this direction. Does that clear it up?

Senator RANDOLPH. Surely, I understand. I hope that you will now be very prompt and very positive. How do you feel about coal?

Dr. LEWIS. I know you come from a coal State, Senator, so I think that is a loaded question.

I realize that there are risks in using coal, and I am very aware of it. And I know there is a new technology for scrubbers. I was very interested to see recently Vepco has decided to go from nuclear to coal. I think whatever we choose has got a tradeoff in terms of health and safety. My own feeling is the ultimate nuclear power, which I hope never happens, is always possible, and that kind of danger is of such

a magnitude that I don't personally feel it is comparable to the risks we have in coal with the scrubbers and with the present technology. So my feeling is I would rather not have nuclear.

I also feel we have to think of tomorrow. I don't like the idea of having all the waste behind for our children and grandchildren. I think that we really don't know what is out there in the future when you have some forms of radioactivity that have a half-life of 25,000 years. We don't even know if there will be a United States of America in 25,000 years. Who is going to guard it? What is going to happen then?

I know what you are saying. I know coal has some risk. I am sure our technology can find a way to make the risk less. So I would rather go with coal than nuclear.

Senator RANDOLPH. You are a champion of a good cause.

Dr. LEWIS. Thank you.

Senator HART. Whether you knew it or not.

Senator RANDOLPH. Professor Lewis, we do know that not only can we move from nuclear, but we can move from petroleum and natural gas also. We can do it safely and we can do it without danger to health. We can do it now. Conversion of electric generating facilities from whatever source they use now to coal. There are 34 plants at the present time that can make that changeover now. There are 117 installations that can be changed. We would free up petroleum, we would free up natural gas. This is necessary. I would not have asked you this question except that I felt it was important that you yourself had this attitude of caution toward nuclear power, that I might turn toward a positive subject—coal. You have addressed yourself beautifully to it and I am grateful. I am not trying to be facetious. I just feel strongly that what we have we should use.

Dr. Kemeny, the recommendation that the national picture, as you see it today, calls for the Nuclear Regulatory Commission to go out of business; is that correct?

Dr. KEMENY. At least to be completely restructured.

Senator RANDOLPH. Yes, restructured. And that would be replaced, as I understand, by an executive agency with a single administrator; is that correct?

Dr. KEMENY. Yes, sir.

Senator RANDOLPH. I think that history does tell us something, usually correctly, that such agencies are quite vulnerable to policy direction or political influence from the White House—and I don't speak against the White House or even someone within it or even other Federal agencies. Let's just take a supposition. Suppose the Secretary of Energy or a Presidential adviser on the subject of energy, is very pronuclear from the standpoint of development of that type of power. Is it appropriate, is it fair, to have nuclear regulation subject to such pressures, as I say, might come by what you are suggesting should be the alternative to the Commission?

Dr. KEMENY. Senator, may I respond to that. It was precisely for that reason that our recommendation says in the the single administrator should be appointed by the President subject to the advice and consent of the Senate. It is our great trust in the U.S. Senate that enabled us to make that recommendation.

Senator RANDOLPH. Thank you very much, Doctor. Your report, as I interpret it, states that nuclear powerplants are safe. Was that your intention? Are they safe?

Dr. KEMENY. I think that is quite correct. It is just the people who run them that are not safe, sir.

Senator RANDOLPH. The plants are safe. It is the people operating them that don't do the job correctly.

Dr. KEMENY. That is correct.

Senator RANDOLPH. How do we get the people to run them correctly?

Dr. KEMENY. That, sir, is the major issue on which the future of nuclear power will depend. If we get the kind of organization with the attitudes that can run these plants totally safely, as I believe they can be run——

Senator RANDOLPH. You believe that the failure of the operating end of the nuclear powerplant can be overcome?

Dr. KEMENY. I believe it is possible. But it depends on the attitudes and organizational changes that, frankly, certainly not this Commission, nor even the U.S. Congress, can cure completely, because you are talking about attitudes within the private section. And I hope the industry has learned its lesson from Three Mile Island to realize its future depends on the adoption of these quite changed attitudes.

Senator RANDOLPH. The central observation in what we call the overview chapter is that because of the inherent risk of nuclear power, fundamental changes in the regulatory programs will be necessary to keep those risks that you highlight within tolerable limits. Now don't misunderstand me. What is the tolerable limit?

Dr. KEMENY. It is interesting you should pick that particular phrase because its object left considerable discussion in this Commission. What we are saying is that the present situation is not tolerable, and that was sufficient to make that recommendation, sir.

Senator RANDOLPH. So you see the risks of nuclear power as not being within tolerable limits; is that correct?

Dr. KEMENY. That is correct.

Senator RANDOLPH. That is a fair conclusion, is it not?

Dr. KEMENY. Yes.

Senator RANDOLPH. I thank you, Doctor, very much.

Dr. KEMENY. Thank you.

Senator HART. Thank you. Congressman Weaver?

Mr. WEAVER. Thank you, Mr. Chairman.

I would first like to say, Dr. Lewis, I was very pleased with your remark. Out in the Northwest where I come from, in Oregon, we are building nuclear plants while at the same time we have things like wood waste, which will produce energy for one-half the cost of nuclear energy, but we burn it in the woods. It is really an insane policy, and I am pleased to hear somebody commenting in the same fashion.

Dr. Kemeny, your Commission voted unanimously for requiring States to have emergency evacuation plans prior to licensing of a plant. This is an amendment that I sponsored in the House Interior Committee and intend to offer on the House floor when the Nuclear Regulatory Commission authorization bill comes up. I note that in your findings you say that the NRC has not made the existence of a State emergency plan a condition of plant licensing. In your recommendations you say you would want such a plant to be approved and reviewed by the Federal Emergency Management Agency.

Now the House rules are such that I am not able to have the Federal Emergency Management Agency as the supervising body. It

has got to be the Nuclear Regulatory Commission, and the authorization bill is for 1 year. Would you feel that it would be proper to have my amendment adopted or your recommendation adopted requiring the NRC to do this for 1 year? Is that something I could tell the House would be acceptable to you as an interim measure to get that into effect?

Dr. KEMENY. I cannot speak for the whole Commission. Certainly any step in that direction would be a step that we would favor. As one reason why we did not recommend FEMA, we felt it is terribly important to take advantage of the existing emergency machinery in each State. Once I said during the meetings what happens if you have simulatenously a nuclear accident and a hurricane?

Mr. WEAVER. I agree.

Dr. KEMENY. Certainly may I say any step in this direction we would favor. I hope you understand why we thought the single agency that really is geared to working with counties and local communities in their response would be the best one to coordinate it, but not naive enough to think every word we recommend would come out of the U.S. Congress.

Mr. WEAVER. But just as an interim measure, would anyone object?

Dr. MARKS. Yes, I think on the basis of the discussions we had there would be objection to it on the fact that FEMA does exist and NRC simply does not have the kind of resources to really effectively put together——

Mr. WEAVER. Dr. Marks, that is not the option we have. The option we have is to do nothing for at least 1 year or have the NRC at least be consulted. See, that is my point.

Dr. MARKS. I support Chairman Kemeny's position that anything better than what we now have is a move in the right direction. But I think it would be inaccurate to leave you with the impression that we would be very enthusiastic about that incremental measure being very significant.

Mr. WEAVER. I understand. We would get it started. And I appreciate your comments.

I would like to explore the question of the operators. In our task force investigation, we saw some of the same problems you did, of course; but we felt the operators were simply overwhelmed in the errors they did make, were errors that I do not think anyone in the same place would not have made. We accept it as a flip of the coin. You are not blaming Three Mile Island directly on the operators. Given another set of operators, are you saying Three Mile Island would not have happened?

Dr. KEMENY. Excuse me, may I answer that in more than one sentence. We are not blaming those specific operators because their training did not prepare them for this. We are saying either other operators, or the very same operators, if they had had the right training and right lessons learned from things like the Davis-Bessie incident, it would have prevented the accident. But you cannot blame individuals if they do not follow procedures they don't know.

Mr. WEAVER. In the first four moves in chess, there are 2 billion different moves and in a nuclear plant, although there are also not an infinite different number of variations of problems, there is certainly an extremely high finite number. You are not going to get operators that are going to be able to handle all of these in any given situation.

Dr. KEMENY. Sir, I certainly agree with that. However, here the errors were so fundamental. If I may say, I say this as somebody who 7 months ago had no idea how a nuclear plant worked. I have some science background. It is very elementary. You want to keep the combination of temperature and pressure such that the water does not boil out of the reactor, and the operators were not trained to concentrate on that and did not realize that when clear signals came on they ought to be pouring in all the water they can.

Mr. WEAVER. But there were other signals being sent to them that were read the other way very clearly.

Dr. KEMENY. That is correct.

Mr. WEAVER. If I have a minute or two left, Mr. Chairman, I also disagree very strongly with another of your findings, and that is that you were able to determine with a great degree of certainty the amount of radioactivity that escaped from Three Mile Island. I find, as a matter of fact, in conflicting statements from NRC employees that some of the deficiencies in instrumentation were such that you could not know. You say your staff extrapolates and estimates with a certain degree of certainty. I cannot imagine how you could. There could have been a great deal of radioactivity that escaped, given the sad lack of proper instrumentation with which to monitor and measure that.

Dr. KEMENY. Could I ask Dr. Marks to address that.

Dr. MARKS. Mr. Weaver, you are quite correct that there were very significant deficiencies in monitoring at the initiation of this accident. To the best of our staff's ability to ascertain, data starting at about 12 or 1 o'clock on Wednesday, March 28, data largely being collected by the Department of Energy but also supplemented by several other agencies at the State and Federal level, gave what they considered, in their expert opinion, an accurate estimate of the radioactivity dose to the area within 50 miles of Three Mile Island. The estimate is based, therefore, on partial monitoring during the early hours, fairly adequate monitoring from that time on, and also a calculation of the total amount of radioactivity that could have been released from the plant. It is their evaluation that the conclusions which we drew were based on estimates that are, at best, in error by not more than by a factor of two. A factor of two in some areas is a large factor, but with regard to the potential health effects in this particular case, I do not think it would change our conclusions.

Mr. WEAVER. Thank you. If I have another round of questioning, I want to explore this a little more.

Senator HART. Thank you, Congressman.

Senator Moynihan?

Senator MOYNIHAN. Thank you, Mr. Chairman.

Dr. Kemeny and Commissioners, may I first express, once again, my appreciation for what you have done and especially the way that you did it. My colleague, Senator Simpson, said you wrote this in English, and that is a large and considerable achievement. I think that most of you would be very much familiar with the fact that the advent of science has imposed a tremendous task upon people who can translate to the very different worlds that are the scientific, on the one hand, and political, on the other. As you may know, it was not until 1976 that the U.S. Senate elected a natural scientist to its body. I said to Senator Schmitt he was the first scientist in the Senate since Thomas Jefferson presided, but he wasn't elected.

I am struck by something you said, Dr. Kemeny, which is that the plants are safe but people who run them are not safe. That is a very large assertion, and if you are supportive of nuclear energy, a very encouraging one because it is an organizational problem that is almost familiar.

I remember we asked the people who worked at TMI, or asked the Public Service Commission what was the average salary of a man who worked at that control panel. "Oh, they make about $20,000 a year and the plant supervisor makes about $30,000." That is half the salary of an airline pilot. And you can see what has happened. The culture of steam generated public utility plants, being stationary engineering, a technology fully matured a half a centruy ago, with no real dangers involved—you could blow up a few people and spoil a generator—and that clearly transferred to a whole management system of the utility itself.

Changing it around is not a problem. We had experience with this not very distant in time. Two new forms of transportation, one was an automobile and one was airplanes. Automobiles seemed familiar and safe. Airplanes were obviously not familiar and thought to be not safe. In fact, they are inherently about the same—they are machines. But the way society approached dealing with safety in airplanes and automobiles was entirely different, with the result that automobiles were absolutely deadly instruments, and continue to be, and airplanes have been relatively innocuous since their outset. It is just your perception of the old saying if you can drive a horse and buggy. Well, the fact is you can't drive a car either unless the systems are worked out. I think we know a lot about that. That is the kind of thing that a command and control mechanism is needed somewhere. Essentially, you have made the judgment it should be an agency. It is a long way to ask you a question.

Could you tell us a little bit more about your judgment about why the regulatory mode is not appropriate here? We are supposed to at least know something about that. We know very little about other matters. I have not fully read the report of chief counsel on that matter, but it doesn't seem to draw very much on the political signs of this subject. James Key Wilson is, I guess, our ranking authority. He has a new book coming out on regulatory agencies. Could you tell us a little bit about whether you did this guided by judgments of people who studied regulatory processes as against administrative and command and control processes, organizational theory, or did you just decide the present way isn't working very well, let's change it?

Dr. KEMENY. Could I make one brief comment on your first remarks, because I agree. As someone who always sits on airplanes chewing his knuckles, I am extremely happy that pilots get extremely high salaries.

I would like to call attention to one of the recommendations made to the utility on the importance of attracting really highly qualified candidates for positions, and setting salaries adequate to attract those.

Senator MOYNIHAN. If you can consider that taxi drivers have just replaced coachmen, airplane pilots seem to be different.

Dr. KEMENY. I will call on Commissioner McPherson to address your other question.

Mr. MCPHERSON. Senator, your question was whether we had looked at a lot of models when we came to our conclusion that there ought to be a single administrator instead of the present five-man Commission.

The answer is yes and no. I think all of us came into it with some knowledge of mixed history, but as the last commissioner to have gone along with this recommendation, it took me quite a trip to conclude a single administrator would probably be better. The argument I had heard for the five-man Commission expressed by a couple of Commissioners was that it gave a superior antenna system for picking up views and criticisms about the agency and industry. In other words, if you have a supernuke as chairman, then you are likely to have somebody who is sensitive to the antinuke and concerns about safety and so on.

We considered that and weighed it against the following. If you indulge me, I would like to read a bunch of single sentences that came up in the depositions of Commissioners who presently sit on the NRC.

Commissioner GILINSKY. I would say that it runs in the way that the collective groups wants it to run, to the extent that the majority develops within that group.

Commissioner KENNEDY. I share responsibility with my colleagues and am responsible for the general administration and operation of the organizatlon.

Commissioner GILINSKY. The commissioners have been very much insulated from the licensing process, particularly in individual cases, which is where most of the ball game goes on.

Commissioner BRADFORD. We have very little direct involvement in supervising the day-to-day work of the rank and file Commission employees.

Commissioner AHEARNE. It is certainly true that the commissioners—and I guess I would have to include myself too—are not in what I would regard an immediate, total control and cognizant situation with regard to all the things going on in the staff.

Chairman HENDRIE. I am nominally the chief executive officer of the agency and therefore responsible, in effect, for the whole agency.

Counsel asked him twice—

You mentioned you were nominally in control. What do you mean by that? Do you think you are the chief executive officer?

In this agency we really do not have a chief executive officer in the sense that Cabinet departments have a head and, for example, the Environmental Protection Agency has a head. We do not have a chief executive officer in the sense that a number of other agencies that are headed by commissions are headed by the chairman where the founding statute for this agency, in fact, gave pretty full administrative power to the chairman. Here we operate very much under a collegial system which derived from the Atomic Energy Act, the original provision which provided that commission, a body of five equal members, with the authorities and power of the head of the agency to preside in the collegial action and not in the chairman.

Commissioner Kennedy, after saying that he thinks it is a good idea of keeping the five, says:

I recognize there is a lot of inefficiency in it.

Commissioner AHEARNE. I have tried many times to think if I were an officer, how would I try to relate having five somewhat equivalent bosses?

He is talking about the agency setup.

It makes it very difficult to decide how to interact with them. I think it is more easy to decide not to."

There are several others. But the point is what we find is that the NRC is not necessarily a mismanaged agency, it is an unmanaged agency. Nobody is running the show down there.

Question: How do you keep getting information, concerns with safety and so on if you have a single fellow and he is a strong, tough administrator but he is pronuclear? We tried to resolve it with this oversight committee, with a staff on the outside, private citizens who would perform that listening role, and that inside we would have

somebody who could knock heads together and who could try to get a much better response from the various divisions of the NRC.

What you have got here is a gigantic management mess, and it is both in the NRC and in the vendors, the people who make the steam system, and the utilities. Take this Davis-Bessie plant that Commissioner Haggerty mentioned. The same type of transient happened at Davis-Bessie in Toledo, Ohio, 19 months before TMI. A young engineer went up from Babcock & Wilcox, which had made the steam system, and wrote a memo and said, "You know, there is something wrong with your pressurizer, or at least it could be read to give a wrong indication of the water on the core. Maybe we ought to tell the people who buy our system about this." Nothing happened. His boss, a month later, wrote a memo saying, "I think we ought to do something about this." Nothing happened. Some fellow who is in another part of B. & W. wrote a memo and said, "Well, if you turn the water back on, the system might go solid." That sounded like all hell was going to break loose. He asked, "What is 'going solid?' " It seemed like a small consequence to a meltdown. But, in any event, still silence.

Six months later, two fellows met in the hall over the water cooler. Somebody said, "What about that memo?" The other guy said, "No problem." The guy that said "No problem" meant the concern about going solid is no problem, so go ahead and teach them all that. The other guy thought he meant the pressurizer is no problem so there is no need to tell them.

When NRC Inspector Creswell down below out in Chicago came to the same conclusion about this pressurizer, he thought something ought to be done about it, tried his best to do something about it, was a pain in the neck to a lot of people, and finally went to see a couple Commissioners of the NRC, using their open-door policy. Five days before the accident at TMI a guy from TVA who was familiar with Babcock & Wilcox plants sent a memo to the NRC saying, "Do something about that." Nothing was done.

When do you throw up your hands and say something can't run any better? Our judgment was if you had someone who endorsed a policy of safety, an all-absorbing concentration on this agency, and had the executive and managerial power to do it and was not so absorbed in the quasi-judicial role of these five guys who sit up there and allegedly decide licensing decisions and, in fact, are spending an enormous amount of time on export control decisions and not devoting themselves to resolution of generic safety issues, that you would do better. That is why we recommended the change.

Senator MOYNIHAN. Mr. Chairman, my time has expired. Could I just make a point what Mr. McPherson so well described, we are not talking about two different kinds of organizations one of which is better than another, we are talking about two different kinds of organizations. We are talking about, on the one end, you have the way Dr. Kemeny ran Dartmouth and, on the other, the way Mr. Haggerty ran Texas Instruments; and the problem is to match the correct mode to the objective.

Thank you.

Dr. KEMENY. May I add one word because one portion of your question was not answered. In addition to the extremely capable

legal staff, we did also have distinguished outside consultants who helped arrive at this.

Senator HART. Mr. Haggerty, briefly.

Mr. HAGGERTY. Let me just add to that I think it is important in examing the structure of the NRC you remember the difference in policy execution. The present policy mixes the two of them and insists on seeing the role as an adversary position, and all that does is insure the kind of confusion we have over there. Furthermore, it is written into the department heads, so-called executive director, is in charge of administration. You not only have five people on top, you have departments underneath that are not coordinated. The thing is legislated for confusion.

Senator HART. Congressman Cheney, and I apologize to the minority side. I have tried to alternate Democrat and Republican.

Mr. CHENEY. I thank the chairman.

I wonder, Dr. Kemeny, and I would direct the question to the commissioners at large, let's assume hypothetically for a minute that all of your recommendations were to be adopted by the Congress. The President and Congress would look at them and conclude they are indeed wise. Would you be willing then to comment as to whether or not you would feel comfortable having the Nation move forward with respect to nuclear power?

Dr. KEMENY. I think it would be best if each of us spoke to that individually.

If I could add one thing to what you say, in addition if the organizational and attitudinal changes occurred to the industry side, which is equally important, I would personally feel comfortable. That is a personal opinion.

Mr. CHENEY. I recognize the Commission did not really vote. How would others feel?

Dr. MARKS. I think I would feel comfortable about the fact we would have a viable nuclear option. But I also feel that there should be no relaxation in efforts to develop alternative safer forms of energy, because I think no matter how safe we make it, nuclear energy is a potentially dangerous technology. The judgment that I am giving is one that I, personally, am willing to accept the risk under the circumstance you describe.

Mr. CHENEY. Thank you.

Mr. HAGGERTY. I think I would answer pretty much the same as Dr. Marks has. I think the important thing is to preserve the option. I think the situation is an extraordinary one in the total energy situation in this country. It is unnecessary to decide the exact role that nuclear energy is going to play after the year 2000 and I think irresponsible to kill it at the present time. All of these other solutions that sound so good are only partial solutions, and what has to be preserved is the option, and I think that is the responsibility that bears on all of us, to preserve the option and decide at the time when all the alternative sources have had an opportunity to be evaluated on the same basis. I mean solar energy, for example, I know something about that, too, and there is a lot of foolishness talk there. Only when we get there with the same kind of technology will we know what will be accomplished. I think the answer is I would feel comfortable if we executed what has been recommended because I think it would preserve the

option with an adequate level of caution and examination so that overall policy decisions, which were certainly not for this Commission, can be made, weighing all of the considerations that are present.

Mr. CHENEY. Dr. Lewis?

Dr. LEWIS. I think everybody knows after all my earlier comments. I don't think I will ever be comfortable as long as there are nuclear powerplants in operation because, as I said earlier, they cannot be made failsafe. Some people may be willing to take that one-in-a-million risk. I am not. I would like to see us eventually reach the point where we do not have any nuclear powerplants operating. I am not so irresponsible to say we could afford to turn them off now. But you asked if I would be comfortable, and to be honest, I am not going to be comfortable as long as those things are out there with all that radioactive material inside of them.

Mr. MCPHERSON. I would agree with Haggerty and Marks.

Mr. TAYLOR. I have a slightly complicated answer. Before TMI, I was reasonably comfortable with the reactor safety situation on the ground that I found it inconceivable that the first accident would be a very bad one in which a lot of people would be killed, and that as long as we remained alert to signals that something needed to be fixed, whether it has to do with people or equipment, then I thought we would respond accordingly and fix things before they sort of leaked or gave some indication they would leak before they burst. As a result of our investigation, I am much less confident about reactor safety on the ground that we have overwhelming evidence that neither the regulatory process or industry was being alert in reactors to, in some cases, very strong signals that things needed to be fixed. They weren't fixed.

Nevertheless, my concerns about nuclear power, in spite of this increased concern about safety that I just mentioned, are primarily centered on another aspect of nuclear power development, and that is its connection with the production of nuclear weapons and their use either by countries in acts of war or by noncountries, criminals, terrorists, blackmailers. I have been very discouraged by what we have turned up in the ability of the Nuclear Regulatory Commission to handle the safety issues. I have been separately concerned about the inadequacy of the safeguards against the diversion and theft of materials still today. They are much better than they were 10 years ago, but I think we still have strong indications that that problem is not solved either.

Mr. CHENEY. None of these were really addressed by you.

Mr. TAYLOR. They were not addressed by the Commission. I am not a particularly well-disciplined person I guess, but I was proud of the fact during our deliberations I never brought these up for discussion by the Commission because they were not our business. I am bringing them up now because you asked a direct question about how each of us felt about nuclear power.

Mr. CHENEY. In light of your 6 months of effort, perhaps you are entitled to have an opportunity today.

Mr. TAYLOR. I think now we are not deliberating about a recommendation or vote. I would also like to say that we do have an enormous opportunity, set of opportunities, in another direction, and that is the use of renewable forms of solar energy. I happen to be a

maverick in these fields. What you see when you look at the status of solar energy economics particularly depends on where you look. If you look at the present Federal program of the United States, and most of the programs by the advanced industrialized countries throughout the world, I would say it is not a terribly optimistic picture. If you look, however, at the reasons why the cost of solar energy are high, both on the commercial side, what is available now, if you look in the yellow pages for something to buy, or if you look at the overwhelming emphasis in the Department of Energy program on solar energy, you find that it is too expensive, but not for fundamental reasons. This is not the proper place, I believe, to go into the reasons why we can, as I have over the last 3 years developed a conviction that with changes, solar energy does offer an immediate alternative—and by "immediate" I mean certainly on the scale it takes for license and construction of a nuclear plant to become an operating plant. That is on the scale of 12 years.

Mr. CHENEY. Thank you for your response.

Dr. Kemeny, did you have an opportunity to look at the risks associated with other technology for producing energy?

Dr. KEMENY. No, we did not. We specifically considered that, and given the enormous charge and given only 6 months, we would have botched that job.

Mr. CHENEY. But it would be fair to say—and I don't mean to criticize—you did not evaluate the risk connected with producing coal, for example?

Dr. KEMENY. No, we did not.

Mr. CHENEY. Second, I wonder, did you have the opportunity, any members of the Commission, to look at facilities outside of Three Mile Island to see how other control rooms might be designed and operated at other utilities, or look at some of the facilities now in existence in connection with training?

Dr. KEMENY. We concentrated on Three Mile Island, its utility and some of its suppliers. We did somewhat accidentally run across incidents in other areas, and some commissioners looked at other plants but not in a systematic way. I think our best view came through our investigation of the Nuclear Regulatory Commission. Of course, we looked at their overall charge. For example, the kind of incredible evidence that their operators, the TMI operators, ran well above average nationally on their examinations. That says something.

Mr. CHENEY. One more question. Do you have any sense at this point, based on your experience, that the goals of nuclear safety that are sought by the members of this committee as well as your own Commission are in any way inconsistent with private ownership of nuclear power?

Dr. KEMENY. We have found no evidence that would indicate that.

Mr. CHENEY. I thank you.

Senator HART. Thank you, Congressman.

Congressman Markey?

Mr. MARKEY. Thank you, Mr. Chairman.

At the outset, I would like to note my concurrence with the feelings of Dr. Lewis and Dr. Taylor on the advisability of pursuing the alternative energy sources in our country—as a means to fulfill our energy needs for the remainder of this century and beyond. Next, I would

like—and I wish there were more members still here—I would like to pose a question to each of you. It was not specifically voted upon by the Commission, but my question is on the proposal that Senator Hart and Senator Kennedy posed to the Senate in July and one of which I am the sponsor that is now pending before the House. That is the question of a construction permit moratorium that would last 6 months. Such a moratorium would give the Congress an opportunity to have an exhaustive series of hearings on the recommendations you have made for restructuring the nuclear industry in this country and protection of the health and safety of people. Such a moratorium would give us a chance to end business as usual, to reclaim that authority of the Congress we have abdicated to the Nuclear Regulatory Commission and industry for the last quarter century. Such a moratorium would give us the opportunity, if we do send that industry forward again, to do so being able to give some assurance to the American people that we, who are the final repository of that responsibility, insisted on that breathing spell, that we stepped back and did make an exhaustive and zero-based analysis of nuclear power.

I am not saying that 6 months is an adequate period of time to do it. Indeed, in that 6-month period of time we might decide we need an additional period of time.

But if you had to vote in Congress tomorrow as to whether or not, on the basis of recommendations that you make here to us today, it would be on whether Congress should require a 6-month breathing spell and say to the Nuclear Regulatory Commission not to shut down any existing nuclear powerplants, but for new plants that have not yet been given construction permits we will not allow you to go forward until they have decided that new siting regulations, and standardized specifications for certain portions of nuclear powerplants, as well as related questions, that Congress wants to reclaim authority just for a brief period of time. If you were a Member of Congress and you could not abstain because your constituents would expect to have you vote, how would you vote tomorrow? Dr. Lewis.

Dr. LEWIS. I obviously would vote yes. If I might make a suggestion to a Member of Congress, I hope that every Member of Congress will have a chance to read this report before that vote and hopefully it will persuade them that 6 months may not be enough. But if that is the best you can get, I certainly would vote that if I were a Member of Congress.

Mr. MARKEY. Dr. Marks?

Dr. MARKS. I would vote yes, too. But I don't think, with all due respect, that that is a very substantive move in terms of the thrust of all of our recommendations. You are not dealing with new operator licensing, you are not dealing with the existing plants. With all due respect, I could not emphasize more that what goes through our findings and recommendations speaks to the ongoing operation of this industry, and I think that nothing should divert us from moving forward to take care of some of these problems, about a third of them could be done promptly, it does not need a moratorium. I would say that so long as it would not divert us from that kind of thrust, I would vote for it.

Mr. MARKEY. I concur. We have to go much further in any of the recommendations that Congress would have to make to the Nuclear Regulatory Commission, or a successor agency. But at the same time,

if this amendment were the consensus of what could get through Congress this year, you would vote for it.

Dr. Kemeny?

Dr. KEMENY. Could I answer that in two parts?

Mr. MARKEY. Yes.

Dr. KEMENY. Certainly I did vote to give the President and Congress a chance to consider the recommendations. But I do want to underline what Dr. Marks said. We have absent all four members who did vote for the proposition. I think I should point that out.

Mr. MARKEY. Mr. McPherson?

Mr. MCPHERSON. No, I wouldn't vote for it. I would vote for something that had a substantive hooker on it, and I offered one in our deliberations. In fact, I was called a few days before these votes by someone connected with the Union of Concerned Scientists, and I told him my dilemma. I recognize the strong merit or logic in the proposition that, having identified a whole lot of things that were wrong in the industry and regulation of it and so on, as Lyndon Johnson used to say, therefore, what are you doing to do about it? And that would suggest something should be done. But I couldn't fix for myself any event upon the happening of which one would feel comfortable in ending the moratorium. It was as if you were putting a bracket in a sentence and you knew where the beginning was but not what event ended it. I invited him to make a suggestion. He made the same one I have been messing around with, and that is siting. I don't think of it necessarily as a moratorium, but it was so identified by other members of this Commission. The notion was that there would be no more construction licenses or limited work authorization permits that were in areas that would violate the siting recommendations. That would take a long time to develop those siting recommendations.

I went on and said if a plant had a limited work authorization, work permit, in an area near a populated zone—in other words, if it only had scraped the ground and dug a hole, the Commission ought to be authorized to revoke that permit and buy them out with your authorization and appropriation; take money and pay them off for what they had expended in good faith reliance on the limited work authorization permit they had gotten. And if they were already into the construction permit phase, that you ought to throw a whole bunch of heavy what they call racheting at them; you ought to make them meet higher standards before they get an operating license. That scheme went down the drain.

I still have a problem with 6 months, not because you should say it is 6 months or 2 years, but simply I do not know what that means, whether it is 6 months out of the Nation's and its energy problems which will be coming to a head in the latter part of the eighties.

Mr. MARKEY. It is basically 6 months out of the life of the Nation. You are an impartial, blue-ribbon panel. You have told us there is a body responsible for securing the safety of this industry, which they have been inadequate in doing. Instead of five NRC commissioners, you recommend, we should have one official in charge of an executive branch agency. I do not know whether five good members of a commission or one lousy member of a commission is better.

I do not know which procedure is going to give us efficiency or sensitivity or education or reanalysis by this Government. Congress is the final repository of the responsibility in this area. This is the

reason for my amendment. It would give us at least 6 months to have you and your counterparts come before us again and let us know what we should do in the aftermath of Three Mile Island. Just that breathing spell. If you do not think that is an adequate period of time or a healthy proposition, I can accept that.

Mr. McPherson. It is just that I do not see the logic frankly. I also would point out what Dr. Marks did, you are talking about the construction permit, you are talking about something that is 10, 11, 12 years away from an operational plant. The more important thing to do, in my view, is to really reform the NRC and help the industry reform itself and require true sanctions that have to do with operating permits.

Mr. Markey. As you know, one problem is that we are being told we cannot shut down the existing powerplants because it would be a burden on the rate payer. This may be true. The utilities have already made a heavy capital commitment and it is protected by the rate base. Further, there may be arguments against halting work on the more than 90 nuclear plants already under construction. I do not know how much of an invasion of their social contract we can really afford to interpose at this point in time. But we are saying for construction permits, as they get into the mill, into the pipeline, that we want to stop that part of the process. For one reason we should not be put in the position of saying, "Hey, we made a mistake, you have to pull it down," and having them say, "You let us go forward, let us finish this one."

Mr. Taylor. I would vote yes and give two reasons why. The first is if we are talking of 6 months, I would be very surprised if any utility is going to apply for new construction permit in the next 6 months anyway.

Mr. Markey. We are talking about the ones already in the mill, seeking a permit. There are around 25 that have already applied.

Mr. Taylor. I see. Then let me say that the penalty of, let's say, a 6-month period of holding up the actual issuance of such licenses that have been applied for, even if it applied to all 30, which it does not, I find is well worth my second reason for voting for such a proposition, and that is I think it is in the nature of things today that a strong signal has to be sent out that this particular set of findings about the nature of the regulatory and the industrial process having to do with nuclear power is not satisfactory. And I still have faith in the political process. I think that if after 6 months individual Members of Congress, in searching their own consciousnesses and their responsibility to their constituents, believe questions have not yet been resolved, then I have faith—I can only call it that—that the Congress would then continue with a high sense of urgency to examine the question of whether this country should then proceed with issuing new construction permits.

Mr. Markey. If I may add, I agree with you. I think we have to send forth that signal to the American people. It is time to call a halt to business as usual. Mr. McPherson says it is a matter of semantics. It is a political Rorschach test, you can see what you want to see. What we are addressing is the seriousness with which you take your recommendations, how much attention you want this body that is representative of the American people to pay to it in the period of time we have to focus on your recommendations.

Thank you, Mr. Chairman.

Senator HART. Thank you, Congressman.

Dr. Kemeny, I would like to ask you about the seriousness of this accident. How close did this reactor come to melting down, in your judgment?

Dr. KEMENY. We made our very best attempt to explore that, and I strongly urge you to very carefully read the written report starting on the bottom of page 13 of the overview. We looked at it from the point that so many things went wrong through the accident, what if one more thing had gone wrong? We explored a number of alternatives, some of which would have made it better or worse, and one, leaving off the high pressure injection system working, could have resulted in a significant amount of meltdown, sufficient that we weren't sure a meltdown wouldn't have occurred.

Our staff went there and explored if there has been a melting through the bottom of the reactor vessel. Here is where I have very carefully to state qualification of what I am about to say. I think the finding is important, but it has a large number of qualifications which I urge you to read very carefully. Under the circumstances of this accident, and this particular plant, even if it had melted through, it would not have resulted in huge amounts of radiation getting out of the containment. Therefore, there still were additional safeguards in the equipment and building in this particular case. For example, this building is built on hard rock, which is a very important part of this finding. Please do not read that as saying there cannot be a meltdown that has results that are catastrophic under any circumstances. It does not say that. We are saying in this particular case we may have come close to total meltdown with cleanup operation of horrendous proportion, but there were still some safeguards left.

Senator HART. Mr. Taylor, what is your response to that question?

Mr. TAYLOR. I would like to say a little bit more because I agree with the chairman's assessment of the result of our work. I think one needs to distinguish carefully between two things. First, how close did we come to a meltdown? By a meltdown, I mean sufficient melting of fuel and core so as to proceed to work its way through the pressure vessel and on down to the concrete on the sump beneath and melt through, if you will. I think we came very close to that.

The calculations that were done to determine what the temperature in the fuel would have been and how close to the melting temperature of the fuel were exploring a new technical field in the sense that they were using calculational techniques that have been recently developed. We used a computer code of zones. That computer code is not capable of paying any attention to a situation in which there had been sufficient damage to the core to allow the fuel pellets—these little objects about an inch long and half an inch in diameter—to fall some distance, most of them not very far, but have high density of core and form what is sometimes called a slumped collection of fuel pellets. That is important because in a situation like that, one can certainly visualize a situation where cooling by steam from the water below doesn't take place significantly. Under those conditions, one can then do a calculation which is very simple: how much heat is being released per second by the fuel and how much heat has been released in the act of accounting for the hydrogen that formed in the bubble and contributed to this burn or explosion, or whatever you want to

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call it, in containment? To account for that hydrogen, you have to assume that something like half—there is some uncertainty—of the zirconium reacted with water. That releases energy. If you also put that energy into the fuel, in addition to the decay heat, in a situation not being cooled, you find that the time to reach the melting down of the uranium oxide after uncovery of a particular part of the core is less than the time we know it was uncovered; therefore, we know if there are places in the core that were not significantly cooled.

We do not know to what extent that happened. We will not know until we get in there and see the fuel itself. We could have seen a substantial, significant, let us say percent at least, we could have actually had in the accident a situation where significant amounts of fuel actually melted. I am not saying that it did. I am saying that we cannot prove that it did not. Let us put it that way.

If you then further assume that there are places in the core that were not being adequately cooled and as how long would it have taken for a majority of the fuel to reach the melting point of uranium oxide, if there had been delay in turning emergency core cooling back on, how long would that take, it is about 15 minutes. I am not suggesting we have done an analysis if the operators delayed 15 minutes, we would have had a meltdown. So I am saying I think there is a way of saying we came close to meltdown.

When it then comes to asking what would that do in terms of releasing radioactive material, there is a popular tendency to equate a core meltdown with a massive release of radiation. I think in our explorations of this, which are subject to lots of caveats, we tried very hard, and I can assure both committees that we tried very hard to find a route of some kind following a meltdown to a large release and were not successful in doing that. I will say that this finding depended on an assumption that there were no further operator mistakes purposefully—it is not purposeful or purposeful—following the meltdown. Now we know that if you put on a computer what would happen at TMI if you ignore the operators, we wouldn't be sitting here.

Following a core meltdown, there could—we did not analyze any of these—manageable mistakes by operators, and whether anyone would be stupid enough to open the valves from the sump and let everything out and activate the sump pump and violate the containment process, and then do things which I would say were just as inappropriate during the process of dealing with the accident before substantial melting happened, that there would have been, under those circumstances of an assumed set of operators' inappropriate actions, a very bad accident. In my view, this is not incompatible with what Dr. Kemeny just said. I am trying to go a bit further in exhibiting the state of uncertainty in that finding.

Senator HART. I understand. What were the critical 15 minutes?

Mr. TAYLOR. From about 215 minutes after the start of the accident, which was the time at which the high pressure injection system was turned back on. If that had not happened for another 15 minutes and there were regions of the core not being cooled by steam or water, then those regions of the core, I think without question, would have melted.

Dr. KEMENY. Could I say the only question is that is how long. I think we are in agreement if the water had been left off for a sufficiently long time, certainly there would be enormous meltdown.

Mr. TAYLOR. Two hours and 1 hour is longer than 15 minutes.

Dr. KEMENY. The only reason I stepped in is not to diagree with Dr. Taylor, but to say if there is any question, it is how much longer it had to happen.

Mr. TAYLOR. I want to make a further statement about this. If you look at the analyses in the staff report on the subject, the calculations that are presented are ones in which this blocking of fuel cooling capacity are not taken into account. The answer there, I believe, to rely formally on the computer printout, to reach 5,200 degrees, which is the melting point of uranium oxide, was 50 minutes. And I am saying that there are questions about the applicability of that computer program.

Senator HART. Congressman Symms?

Mr. SYMMS. Dr. Kemeny, it was my understanding—and you correct me if I am wrong—that the Commission did face the issue of what should be done in the interim period with plants that are currently operating, and the Commission decided that these plants should operate.

Dr. KEMENY. The only recommendation that speaks to that subject is No. 8 under the Nuclear Regulatory Commission, that urging in any licensing action that should take place certain conditions should be met, most importantly taking in new safety regulations.

Mr. SYMMS. Did you confront that issue then of what should be done in the interim period with plants now operating?

Dr. KEMENY. Only indirectly. We recommend the starting immediately of a process by which plants would be periodically reviewed indepth to see whether they are performing satisfactorily under their current license.

Mr. SYMMS. I noticed, and I agree with your recommendation, and I quote from what it says, "responsibility and accountability for safe powerplant operation, including the management of a plant during an accident, should be placed on the licensee in all circumstances." That is on page 63, item 5. I assume from that statement that you would not support a proposal which would transfer control of a plant in a crisis from the utility to NRC or its successor?

Dr. KEMENY. No, sir; we cannot. It is up to the utility to do that, because it is most unlikely someone coming from outside would know that plant sufficiently well to bring it under control. If I may add one point. One of the fundamental reasons for requiring higher standards of the licensee, we felt it the utility is not capable of managing an accident, they should not be running a plant in the first place.

Mr. SYMMS. Dr. Kenemy, am I correct in saying deficient instrumentation to measure radioactivity released as a result of the accident did not affect the Commission staff's ability to estimate the radiation doses or health effects resulting from the accident, and do I also understand radiation released as a result of the accident will have negligible effects on the physical health of people living in the area?

Dr. KEMENY. That is correct.

Mr. SYMMS. I would like to ask you one other question?

Mr. KOSTMAYER. Would the gentleman yield?

Mr. SYMMS. Yes.

Mr. KOSTMAYER. Did you not indicate though that the study to determine whether or not those levels were harmful, as conducted by the NRC, was not adequate?

Dr. KEMENY. I think Dr. Marks tried to speak to that. We had hired our own consultants who were the ablest people in the world. Although the data is incomplete, they feel they can determine, within a factor of two, how much radiation was released.

Mr. KOSTMAYER. But the data, based on your own consultants, is incomplete and the studies of the Nuclear Regulatory Commission on the score are not adequate, generally. Do you concur with that or am I mistaken?

Dr. MARKS. Technically, you are correct. But our consultants felt they had enough data to be very comfortable about the conclusions they reached.

Mr. KOSTMAYER. I thank the gentleman for yielding.

Mr. SYMMS. Thank you. I appreciate the gentleman's contribution.

I want to ask you further in this whole area, if I noticed correctly in the report, it said the only real major health hazard was the emotional trauma of people over what might happen if the worst thing were to happen. I know in these supplemental views, one of your Commissioners, who is not here, mentioned the fact that I think she was quite critical of the handling of the general media reporting. There was too much reporting of what might happen, not what was happening to the American people. After having worked on this Commission and having reviewed it, Dr. Kemeny, how do you feel overall about the general responsibility with respect to the news media in overdramatizing the incident or in not overdramatizing it? What was your consensus on that, if any?

Dr. KEMENY. I think since that task force was chaired by Dr. Lewis, I will ask her to respond.

Dr. LEWIS. We did a content analysis of media coverage of Three Mile Island and found that, contrary to the charges against the media, there was not sensationalism, with one or two minor exceptions. Where there was confusion, it was traced back to the sources. In fact, the NRC itself was confused. The NRC in Washington was giving out alarming information to the press, and the press was merely reporting it.

Mr. SYMMS. Dr. Lewis, where do you live?

Dr. LEWIS. In New York.

Mr. SYMMS. And where does the Commissioner who wrote these views live?

Dr. LEWIS. In Middletown.

Mr. SYMMS. She lives right at Three Mile Island.

Dr. LEWIS. She was giving her personal view, and I highly respect it.

Mr. KOSTMAYER. Would the gentleman yield again?

Mr. SYMMS. I do not have much time.

Mr. KOSTMAYER. Dr. Lewis, what is your profession?

Dr. LEWIS. I am a former Washington reporter. I am now associate professor of journalism at Columbia.

Mr. KOSTMAYER. I thank the gentleman for yielding.

Mr. SYMMS. What I am getting at, there was a great todo on the national media about the fact that there might be some kind of explosion that might endanger the lives of 200,000 people, then it was all settled down to confusion. I agree with the report, due to the confusion on the part of the NRC and other experts that were in the area that were not quite sure it could be safe. But do you not believe that there

was some example of overstating what was happening there and creating more trauma than necessary?

Dr. LEWIS. Well, the evidence that we collected, imperfect as it was, indicated it was not so. In fact, we found through the content analysis, the media gave more reassuring statements than alarming statements in terms of Three Mile Island. No doubt the overall impact of suddenly living in a town like Middletown and having the media reporting basically alarming things is going to frighten people.

There is no doubt about it. Suddenly, to be confronted with the facts of Three Mile Island, it was frightening. But if you look at what the press did in the scientific way that we did, that the reporting was not more alarming than was justified by the information that it was given.

Dr. KEMENY. Could I add one word to that. I think that the study that Professor Lewis quotes was an extremely thorough and professional job. There are some things that I believe have not been picked up in the news media. This is, of course, Commissioner Trunk who lives in the area. If I may recite a very small anecdote, it may show what we are saying. My hometown newspaper carried a portion of the Times article. I read very carefully the article in the New York Times on the study on low-level radiation conducted by the National Academy. It was a story where you had to read to near the end to get the full picture of it. It appeared in our hometown newspaper, but only the first third of it was quoted under a banner headline—which is very rare—"2,000 Nuclear Deaths Predicted." That particular kind of incident did not say anything wrong, but since it only printed one-third of the article you never found out that was over a period of 25 years for all States in the United State that would have shown up.

Mr. SYMMS. I thank you very much. I think it is a very good point.

Just one more question. What, in your opinion, if you could sum it up, were the conclusions in the report on the viability of nuclear technology to provide part of the answer for keeping America from being dependent on foreign sources of energy? Is the technology still a viable technology, after looking into the report, or not a viable technology?

Dr. KEMENY. I think, as several of us spoke, that if the kind of recommendations that we have said are implemented, both with respect to regulation and industry, that we would feel that it is an option. I think, as many of us have said, we hope the United States will explore all options.

Mr. SYMMS. Do you think there is any way when that is all over, because I am sure this Congress will respond and I am sure that the industry will respond and the American people will respond, as they always have when confronted with a necessity, that this incident at Three Mile Island may in some way make nuclear power safer in the long run rather than going on as it was, and some day down the road nuclear power will be much safer than it has been up to this point?

Dr. KEMENY. I think the one thing we are all agreed on, if the right lessons are learned from this particular accident, that it would lead to a significant increase in the safety of it, that if the right lessons are learned—and that is why we titled our report "The Need for Change"—if that legacy is that the changes necessary are made, there will be a significant contribution to make the technology safe.

Mr. SYMMS. Thank you.

Mr. BINGHAM [presiding]. Mr. Kostmayer?

Mr. KOSTMAYER. Dr. Kemeny, the editorial in today's New York Times said the Commission's report is an indictment. Do you concur with that characterization?

Dr. KEMENY. Yes, I do.

Mr. KOSTMAYER. Can you tell me if at any time you think that MetEd misled or deceived, either deliberately or not, putting aside the technology for the moment, but the constant news conferences that the public relations fellow had up there, was there a deliberate misleading or deceiving of the people by MetEd?

Dr. KEMENY. Our report says they were certainly very slow in sharing bad news with the world. We have some partial evidence in our report. I know your committees are doing a much more thorough job. We felt there was such a total degree of confusion there, we did not concentrate on the question of whether people were deceiving or just didn't know what the heck was going on.

Mr. KOSTMAYER. You did not really address the question as to whether it was deliberate or not?

Dr. KEMENY. No. We were more concerned about the degree of confusion in what is being done about managing the accident.

Mr. KOSTMAYER. I am concerned about what appears to be a contradiction. "Our findings do not, standing alone, require the conclusion that nuclear power is inherently too dangerous to permit it to be continued and expanded as a form of power generation." Quoting still, "Neither do they suggest that the Nation should move forward aggressively to develop additional nuclear power." I am not exactly sure what we should do.

Dr. KEMENY. We do mean precisely that.

Mr. KOSTMAYER. You seem to be saying two contrary things at once.

Dr. KEMENY. Our report says neither of those.

Mr. MCPHERSON. What we were attempting to say, Congressman Kostmayer, only makes sense if you go on to the next sentence that says they simply state our findings. "If the country wishes, for larger reasons, to confront the risks that are inherently associated with nuclear power, fundamental changes are necessary if those risks are to be kept within tolerable limits." That is a highly compacted paragraph.

Mr. KOSTMAYER. You are saying fundamental changes are necessary before we make that decision?

Mr. MCPHERSON. I am saying that you folks have to make a decision up here.

Mr. KOSTMAYER. But if we do?

Mr. MCPHERSON. Knowing that nuclear power has risks in any event, if you decide nevertheless that for larger reasons, obviously economic and foreign policy reasons, energy supply reasons, if you decide that we ought to go ahead with nuclear power to the extent that it is presently planned to, then to make that a tolerable decision, to keep those risks within tolerable limits, there have to be these changes.

Mr. KOSTMAYER. Is that the same, Mr. McPherson, as saying we should not proceed until these fundamental changes, namely your recommendations, have been implemented?

Mr. McPherson. That would mean I guess——

Mr. Kostmayer. Because we are proceeding.

Mr. McPherson. Until all these changes are put into effect.

Mr. Kostmayer. No; I do not think so. We are, in fact, proceeding. I recognize that the practical effect is there are not going to be any plants constructed at least in the immediate future. But we are actually proceeding. Nothing has changed since Three Mile Island. There is no Government prohibition on the construction of plants. We are proceeding. Yet you have recommended fundamental changes. There seems to be a gap in the report between the severity of the report—and Dr. Kemeny characterized it as did the Times editorial—there seems to be a gap between the severity of the report and how far you are willing to go to correct that severity to do something about it. You have said all these things and they seem to me to be a very damning indictment of the agency, of the industry, and of us in Congress, of the Government's response. Yet you are proceeding just as we have always. You are not changing anything.

Dr. Kemeny. May I speak to that, please, because I think you have to realize what we did not do. We did not examine the alternatives. It has been said sometime today that this risk has risk associated with it, and we all agree with that. But you have to look at the risks of alternatives. I do not believe there is a fail-safe technology to provide energy for the United States. I think it would have been irresponsible of our Commission to take a position on that without taking a look at the alternatives to decide if it is more risky or significantly less risky.

Mr. Kostmayer. What the alternative is to not simply shut down the 13 percent of the electric power we currently generate through nuclear plants.

Dr. Kemeny. May I say something on that, then I will yield.

Mr. Kostmayer. You are not recommending any changes.

Dr. Kemeny. That means a shift to an alternative, and if through the political process you determine there is a safer, more desirable alternative, so be it. We did not examine that question, and therefore were in no position to say that would lead to an alternative that is safer.

Dr. Marks. I am having trouble with your question.

Mr. Kostmayer. I am having trouble with your answer.

Dr. Marks. I hope we come out understanding each other better. We have 72 operating plants out there now. This report says that they are not being operated to a level of safety that we think is acceptable and attainable if the plant that we visited is typical of the industry as a whole.

Mr. Kostmayer. We do not know that.

Dr. Marks. We do not know. Our findings do not permit us to extrapolate without such a caveat.

Mr. Kostmayer. But if we have to make a practical assumption that these are bad or good, should we not err on the side of safety and say things today are bad?

Dr. Marks. I, personally, think so. For you to think we are recommending full steam ahead is what I do not understand, because we are saying quite the opposite—get on the stick. One of the things I appreciate about this hearing today is that you could not have been more responsive, in my opinion as a citizen and member of the Commission. I deeply appreciate it. Somehow or other the NRC has to be

told the same thing. I do not feel they are getting the message yet. Much of the message we are delivering here, many of the recommendations, do not need a legislative mandate or Executive order. The recommendations need to be read and implemented. We do not have the power to try, I do not know if the Congress has the power to make them do it. They can do it if enough pressure is brought to bear. They can start today. There is no reason, today, in this country, why there should be anyone in the operating room who has not passed all parts of the exam. The NRC does not require that today. An operator can fail the part of the exam dealing with emergency equipment and still pass the whole exam and be in the control room. We do not think that is a good thing. We think somebody should do something about it.

Mr. KOSTMAYER. I would say I think you did have the power. I think you did have enormous power. The whole country was looking at this responsible, objective, bipartisan Commission. And I think it is extraordinary that the number of members did vote for a moratorium that did.

Mr. SYMMS. Would the gentleman yield?

Mr. KOSTMAYER. Yes.

Mr. SYMMS. Dr. Marks, have you had the opportunity to look at the NRC's report on the lessons learned from Three Mile Island?

Dr. MARKS. We did.

Mr. SYMMS. What is your opinion of that? Do you think they learned anything?

Dr. MARKS. We think there is some evidence they learned something, but not enough. And I will say, first of all, I was one of those who supported the moratorium, so all my remarks are in that context. I think we have given you a very strong report. If it fell short of your personal expectations, I understand it and respect it.

Mr. KOSTMAYER. I am just confused on the condemnation of the standards that exist, yet the reluctance to come out and say we ought to consider shutting them down completely. I understand the practical effects. You have acknowledged if the other 72 existing plants are comparable to the Three Mile Island plant, there is a good chance they are unsafe and people living in the areas surrounding them may be subject to considerable danger. Having said that, having delivered an indictment, what is the result of that?

Dr. MARKS. The only thing I can say—and I am sorry the other Commissioners are not here to speak for themselves, but I respect their feeling that the mandate was so narrow as it was interpreted—and we might have been in error—that we did not feel they could go beyond where we come out. On the other hand, there is the unanimous feeling of this Commission that it is a strong report, moratorium or no moratorium; you can go forward with a great deal here.

Mr. KOSTMAYER. It is a good report and strong report.

Dr. MARKS. I understand what you are saying and respect that.

Mr. KOSTMAYER. I appreciate that. I have exceeded my time. I would only say I think at the final moment you shunted the obvious conclusion.

Dr. MARKS. I respect that judgment.

Mr. MCPHERSON. May we always slip from that final, essentially simplistic action if it is not logical to take. I think it was described as largely symbolic—a 6-month or 2-year moratorium or until enough of you all have had an adequate opportunity to look at it.

Mr. KOSTMAYER. It seems to be eminently logical. It seems so logical to proceed. In other words, you did all this, you said all this, you delivered a damning indictment.

Mr. MCPHERSON. If it is logical to take a largely symbolic action, which is saying as far as construction permits on something 10 or 12 years from operation, we will have a moratorium.

Senator HART. Gentlemen, in the interest of time.

Mr. KOSTMAYER. Thank you, Mr. Chairman.

Senator HART. I would strongly urge since we are in a little bit of a trial between whether the Commission or the committee will last longer that we limit ourselves to 2 or 3 minutes.

Myself, I will ask only one final question. As you know, there is a current area of controversy which I do not believe your report addressed whether the possibility of a core-melt accident or a so-called class IX accident should be considered in the licensing process. Do you or any of the other commissioners have a belief on that?

Dr. KEMENY. Yes. I believe, at least indirectly, that is simplied in view of the fact the NRC has viewed this as a class IX accident, which was defined as an accident that cannot happen, something has to happen to the definition of class IX accident. We do have a very strong recommendation saying that a much larger variety of accidents should be explored as a part of licensing emergency preparedness.

Senator HART. Congressman Bingham?

Mr. BINGHAM. Thank you, Mr. Chairman. I just have two questions.

If I could call your attention to the wording of recommendation 8, which you have said, Chairman Kemeny, is the key recommendation. Is it your intention in that recommendation that all three conditions—a, b, and c—should be satisfied before a construction permit is issued?

Dr. KEMENY. Yes, that is my understanding, sir.

Mr. BINGHAM. Is there any difference of opinion on that? That is quite significant, I think, because letter b applies to operating competence.

Dr. KEMENY. I am sorry, may I modify my answer in view of your pointing that out. Presumably the ability of the operator training would be more appropriate to the operating license than construction permit. Certainly, the competence of the licensee and its management capability would apply.

Mr. BINGHAM. That is something that should be explored before a construction permit is issued.

Dr. KEMENY. Yes.

Mr. TAYLOR. Mr. Chairman, I am not sure if I heard you correctly. I would like to point out the last phrase of the recommendation says before issuing a new construction permit or operating license; it has included both.

Mr. BINGHAM. Yes; that is significant, too, but my question is: Must a, b, and c be found before the construction permit issues, and Dr. Kemeny says: Yes.

Dr. KEMENY. I believe I answered that correctly. I am not sure how you would do operator training in the construction permit stage. What it does say is if a firm that has already gotten into construction now comes to the operating license stage, all of these should be checked.

Mr. BINGHAM. I am now somewhat confused as to your answer, because I think that the competence of the applicant to operate a

nuclear plant safely is something that should be examined before the construction permit is issued.

Dr. KEMENY. I agree. All I said is the one phrase in there about the operator training program, it is unlikely they would have one in place about that time.

Mr. BINGHAM. The other question, and I know you said you did not examine nonproliferation or problems, but did you consider in your recommendations for structural changes of the NRC the fact that it has to deal with export licensing and nonproliferation problems? Was it, as I have been informally advised, the conclusion of the Commission that the NRC should not have anything to do with the problems of export licensing?

Dr. KEMENY. I can tell you precisely what happened on that. We have a recommendation in here now that in the restructuring, Congress should take a careful look at what the NRC could be relieved of so they could concentrate on the safety of nuclear powerplants. In an earlier version of it, which leaked, we tried listing examples, and we decided in the final version we did not have the competence to determine which were the appropriate things to remove. Therefore, it is not included.

Mr. BINGHAM. Thank you.

Senator HART. Senator Simpson?

Senator SIMPSON. Thank you, Mr. Chairman.

First, just a comment; again, my appreciation and my thanks for the way in which you shared your thoughts in a most authentic way. It has helped me. It has firmed my opinion about your capabilities and your deep desire not to go out of the mission that you were assigned. That must have been a tough one, and I think you achieved it. The issues of symbolism are rich in this area, and I want to commend you particularly, Harry McPherson, and I understand your remarks at the White House the other day. Your summary there was a highly capable presentation of the entire thing in a manner not to confuse the technology with the use of English.

One more question. Your report seems to recommend a review to identify and remove all unnecessary burdens from the NRC that are not germane to safety. I was interested in that part of the comment. In view of any of those, are there statutory responsibilities that are assigned to the NRC which ought to be removed, and what are the most flagrant ones that should be removed because they are not germane to safety? What were the most flagrant ones that are just baggage?

Dr. KEMENY. I would be happy to comment on that with the preface that in the end the Commission decided we are not competent to recommend any specific item be removed. But we found that the Commissioners were spending an enormous amount of time on things like export licensing. We know there is that difficult, but important, activity that must lie somewhere. It was not clear to us it had to be the Commissioners of the NRC. We wished they would spend a lot more time on the safety questions. Again, as I say, we left the language as is because in the last analysis we felt we did not have the competence to make a decision.

Mr. TAYLOR. Mr. Chairman, there was discussion about the time the Commissioners spent on export licenses and some discussion about whether to suggest that that be removed from the responsibility of the NRC. I spoke up several times about that. I certainly would have

strongly objected to the suggestion that the attention that should be given to export licenses in the nonproliferation context was less important than safety. I happen to think it is more important. That is not to say this agency restructured to look at safety necessarily should not have that responsibility. I must say I am very grateful for the fact that export licenses have been reviewed by the NRC. I understand that this has removed attention perhaps from other issues, but someone in the Government decides the direct line of the process of implementing foreign policy. I think it is extremely important.

Senator SIMPSON. I have heard the comments about the export licensing, and I concur there. But I am thinking of the other areas. Time is limited. But I was fascinated at the report when it listed as a nonsafety item the relief valve and one of the condensers at the foot of the problem. I think we are going to have to deal with that statutorily through regulation.

Senator HART. Congressman Symms?

Mr. SYMMS. Thank you, Mr. Chairman. I will be brief. I only would like to say I would hope—and I appreciate all of you that have been here—I would hope we might get the opportunity to have the remaining Commissioners—those who are not with us today—up here some day so we may continue to discuss this with them. I appreciate the fact that the Commission actually did go up to that point, but did not make a recommendation for a moratorium. I think that is something that will have to be wrestled with in the Congress.

I think when one reviews the overall question of alternative sources of energy, the number of people killed when you use coal as a source is important in comparison to nuclear. There are other factors that have to be considered. You should be commended you did not actually make that recommendation.

I may have a few more questions that we would like to submit so that we could get some answers back for our record, Mr. Chairman, and then I will yield back my time.

Senator HART. Thank you, Congressman.

Congressman Cheney?

Mr. CHENEY. Mr. Chairman, without asking any questions, thank you for being kind enough to join in this event. I want to once again thank the members of the Commission for the work they have done. I know it has been a difficult task. Clearly, you are wrestling with the same kind of emotions about the subject that all of us feel.

Senator HART. Thank you.

Senator Moynihan?

Senator MOYNIHAN. Mr. Chairman, this is late to put this question, and I will not ask for an answer now, but rather to ask if it would be intolerable if the Commission might put something in writing to this general point, which is the key recommendation of yours about whether nuclear power is inherently too dangerous, and then your statement that fundamental changes are necessary if those risks are to be kept within tolerable limits. You assume there are risks, and can they be kept within tolerable limits. Would it be possible to ask you to write us something about how you conceive of your concept of tolerable limits? I am sure you know this is an extremely difficult question for the political system to deal with. We encounter them now in the health area. Fifty years ago, influenza removed most of the decisions we had to make in government today—how much money

will you pay to keep somebody alive? And there is always a cost. You don't do something else.

How much more pathology would you take for this form of energy as against another? Is this uniquely dangerous such as you run the risk as against the grim events of coal mining? Would you accept coal mining as tolerable limits, as it were? Am I making myself clear? I see that Mr. McPherson is nodding.

Mr. McPherson. Always willing to respond to you. I came out of this with a personal reflection both more nervous about nuclear energy and less. More nervous about the likelihood of an accident as serious as TMI happening. The Washington 1400, the Rasmussen report use figures that I can't understand, so many exponential powers of the chances of a major disastrous accident. This was a small break LOCA, a little bitty thing, they thought they had it bounded by covering the consequences of a large break LOCA. Given all the possibilities for messing up, operators do, in the face of some rather compelling conditions, hit the wrong button and kept the water off for too long so you have core uncovery. That chance seems higher than it seemed to me it was when I started on the Commission. I just assumed they ran them better than that.

On the other hand, the result of the study by the team that we asked to look at the "what ifs," all the list of things, the one other variable, including leaving the water off for another couple of hours than it was, shows no break of containment.

So it makes me feel more comfortable, even with all human error or breakdown you don't have a Jane Fonda "China Syndrome" occurring. Nevertheless, there are lots of other ways, as our report says, that we did not cover, lots of ways in which there would have been releases of major amounts of radiation from the containment. So it does not leave you terribly comfortable. Even though it is flawed, the initial reliance that goes back to the AEC days on building 5-foot thick, reinforced concerte walls has some value. They hold. Going to a 30-pounds-per-square-inch pressure spike, you don't come anywhere near busting open the building.

What is tolerable? Obviously we did not do risk analysis. We did not try. It will be you and the President who have to take a whole list into consideration, whether these particular risks are high enough, given the economic and foreign policy considerations in the world which also affect it, which are considerable.

Senator Moynihan. This is, I guess, my point. I do not want to pursue it too much, Mr. Chairman, but if you could hear me on this. Is it possible to make estimates, if we were to cut the energy consumption in the country by half, you would raise the mortality rate by some unappreciable amount? A member of the Canadian Atomic Energy Commission estimated the risk associated with various forms of energy and came up with solar power as the most costly in health terms because of the news of people that correspondingly fell off ladders.

I think it would help us if we were to know, since we have to make relative decisions, well, we know the system is 6 people per 1,000, and you are prepared to have six people die per year. We will get Congressmen prepared not to have 6 people die per year. That is the difficulty of even raising these questions, but I think we need to know from you, are you talking about a range that would be associated

with most other forms of energy and say this comes within that range or risks of catastrophe have a sort beyond anything associated with the now compartmentalized risks of energy?

Dr. KEMENY. Senator, could I answer that in two parts? First of all, we did look at the Canadian study and also various criticisms of it, and we decided there is no way we could do a decent assessment. Let me say we, of course, very strongly urge you to carry out that kind of estimate to make sure that people are doing it, because I think it is terribly important for the energy future of the United States to know the relative risks of sources of energy.

I think our statement is really a much more modest one; that is, we found certain faults that we feel are sort of underlined there, and there is a constant danger. We also feel these are things that are correctable. I think we have come up with eight sets of recipes, but they are correctable errors that very significantly increased the risk of this particular technology, and what we addressed is how to correct that.

Dr. MARKS. May I comment. I think you have asked the critical question, in my opinion, and one to which you will, I think, not be able to get a quantitative answer even of the sort you suggest. But I certainly would like to be able to respond to you in writing if I may, because we have done a great deal of thinking about this issue. You can get some qualitative parameters within which to make your judgments. It is a very difficult call.

Mr. TAYLOR. I would like to say I would like to respond to Senator Moynihan's question, and the general nature of the answer is going to be that your question is unanswerable, and, therefore, there are certain things that need to be done in setting energy policy in the light of the impossibility of answering that question to everyone's satisfaction.

Senator MOYNIHAN. That is a very important fact.

Thank you, Mr. Chairman.

Senator HART. Thank you, Senator.

Congressman Weaver?

Mr. WEAVER. I want to thank the chairman for holding this hearing, because we have developed here something that the newspapers this morning missed. As a matter of fact, the biggest story has become very clear in this hearing, and that is that you have asked for a moratorium on the operating licenses of nuclear powerplants. You said no operating licenses will be issued, in your recommendations, unless these three criteria are met, and they are tough criteria.

So this indictment, which is your word, is, in effect, a moratorium, and I think the newspapers missed it. It is actually a much more tough one than Congressman Markey is going to propose in the House because this could go on for a number of years meeting this criteria. Did anyone in the White House ask you or suggest to you not to use the word moratorium, because you have?

Dr. KEMENY. No, sir. As a matter of fact, may I say for the record, during the entire period of the investigation, from when we were first appointed, at no point did either the President or any member of the White House try to influence on anything that should or should not be there.

I wish to say on that particular one, I think it is, within the Commission, a semantic problem as to what people have their own feeling about.

Mr. WEAVER. I see that.

Dr. KEMENY. It was a difference between a moratorium that is across-the-board versus what you are describing as a moratorium, which is a case-by-case basis, which has a different effect on which we all agree.

Mr. WEAVER. On a technical matter, Dr. Kemeny, did you go into the background of the operators of Three Mile Island? The one thing in my investigation about this was a very interesting thing; most of them had the same training.

Dr. KEMENY. From the U.S. Navy.

Mr. WEAVER. In other words, they were highly trained.

Dr. KEMENY. Sir, could I say something on that. We did have, some of us, a conversation with Admiral Rickover, who is a fascinating person. I will tell you something very interesting, and we have checked this. A company cannot get the record of an individual in the U.S. Navy without a release of the employee, and this company does not require such a release. We were alerted to that by Admiral Rickover, and, therefore, I know that the Navy program is a superb training program, for all I have heard about it. And I am sure there are superb people there. Do not misunderstand me. I am just saying if you have not looked at the complete record of an individual, how do you know that was a superb product of the U.S. Navy or somebody who has flunked out? I claim they just do not know.

Mr. WEAVER. Mr. Chairman, I have one final question, and that is in my estimate more significant. It was something that came out in my investigation at Three Mile Island, that came out almost by accident in questioning various people, the NRC and engineering firm. I was curious to know if you developed the same thing, because it was almost an accident. What would happen to a nuclear plant such as Three Mile Island if there were a power failure, if they lost their electricity?

Dr. KEMENY. I believe I am going to have to ask staff to respond.

Mr. WEAVER. I know Mr. Taylor knows.

Dr. KEMENY. I believe that is one of the things they are required to check out during the licensing process.

Mr. WEAVER. Check out? We do have power failures in this country; they have occurred.

Dr. KEMENY. Certainly.

Mr. WEAVER. I am saying what would happen if you had a power failure at a nuclear plant in the electricity coming in, what would happen if that failed and the generator failed, the standby generator failed or were sabotaged?

Mr. TAYLOR. That is two different things.

Mr. WEAVER. A power failure is a power failure. One comes from outside the plant into it, from the utility system; the other is the standby diesels in the plant. A power failure comprises both. That is one question, what happens if you have a power failure?

Dr. KEMENY. You are getting into things I learned in the last 6 months.

Mr. WEAVER. It is the same with me.

Dr. KEMENY. It seems to me several things. For example, the control rods, if they lost their power, drop in.

Mr. WEAVER. The answer—and I have checked this out with every single top NRC person—is a core meltdown occurs, irreversibile, absolutely and completely.

Mr. TAYLOR. I think that is correct as long as you assume that no electric power from any source is available to activate the pumps, the various emergency control equipment, it is correct. I think it is very important——

Mr. WEAVER. It is extremely important. I figure it would take about 8 minutes to disrupt the power.

Mr. TAYLOR. I was going to say one aspect of that, that Dr. Kemeny referred to, if there is a total power failure, the design of the control rod mechanisms are such that those drop down.

Mr. WEAVER. You have still 250 megawatts of power. It is enough to get that uranium oxide up to 5,200 degrees. But that was the most astounding fact I discovered. I was asking one of the top people in the NRC this question. I said what would happen. He said, "We would put on the steam system." I said, "That would have failed because you have no power." He said, "My God, that's right." He had not thought of that.

Mr. TAYLOR. I guess I would have to put in a slight caveat. I think your answer is correct, but there are some directions to the high-pressure injection system. It may be a problem similar to the one of our house in Damascus after we got 5 inches of snow. We are heated with oil. The electric power failure triggered an inability to turn on the oil furnace. So, although we are without electricity, we could not heat the house.

Mr. WEAVER. I agree, and I went into this with many on the steam significance. It turned out it is the same way.

Thank you, Mr. Chairman.

Senator HART. Are there any other comments?

Dr. Kemeny and ladies and gentlemen, you have served not only the President and this country and, in my judgment, well, you have served in the highest and best traditions of democracy as responsible citizens. You have the thanks of the Congress of the United States.

With that, the hearing is adjourned.

[Whereupon, at 5:45 p.m., the joint hearing adjourned.]

[Supplemental views of the Commissioners and an excerpt from the Commission's report follows:]

SUPPLEMENTAL VIEWS

BY MEMBERS OF

PRESIDENT'S COMMISSION ON THE

ACCIDENT AT THREE MILE ISLAND

ADVANCE COPY

NOT FOR PUBLIC RELEASE

BEFORE AMs, WEDNESDAY, OCTOBER 31, 1979

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These Supplemental Views will be included in the permanent edition of the Commission's report.

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SUPPLEMENTAL VIEW BY SIX COMMISSIONERS

The Commission has unanimously recommended that: "In order to provide an added contribution to safety, the NRC should be required to the maximum feasible extent to site new power plants in locations remote from concentrations of population. Siting determinations should be based on technical assessments of various classes of accidents which can take place, including those involving releases of low dosages of radiation."

The undersigned six Commissioners voted for and support the following recommendation: "No new limited work authorization permits or construction permits should be issued until such time as the NRC or its successor has adopted siting guidelines consistent with the above recommendation."

Bruce Babbitt
Carolyn D. Lewis
Paul A. Marks
Harry C. McPherson, Jr.
Russell W. Peterson
Theodore B. Taylor

October 22, 1979

SUPPLEMENTAL VIEW BY COMMISSIONER BABBITT

It is with some misgiving that I feel compelled to add separate views to the report, for I find it to be a strong and lucid piece of work in almost every respect. Yet there are two areas where I feel the Commission stopped short of providing meaningful recommendations.

The most serious unresolved issue, in my opinion, of the entire inquiry is: Who should be allowed to run nuclear power plants?

A careful review of the the Commission findings and conclusions, along with the technical and legal staff reports upon which these are based, readily demonstrate that the utility in charge at Three Mile Island was not qualified to do and was not doing an adequate job. The record includes a listing of failures and inadequacies from maintenance to management, from operator's training to a lack of nuclear expertise at higher management levels. Our own findings state that "Met Ed did not have sufficient knowledge, expertise and personnel to operate the plant or maintain it adequately," and that "as a result of these deficiencies the safe operation of the TMI-2 plant was impaired."

This is a far reaching indictment of the utility in charge, the entity given the responsibility for controlling 15 billion curies of radioactivity. By the nature of its charge, the Commission explored in depth the operation capability and performance of just one nuclear utility and found it seriously wanting. But there are many indications that Met Ed is not an aberration, and that there are other nuclear utilities that do not measure up to even minimal standards. Inevitably, this raises serious questions about who should be licensed and entrusted to run our nuclear power plants. In my view, nuclear power is far too complex and dangerous to be left to any utility that wants it -- which has been the case until now. Nor can we allow utilities to go through a learning process at the expense of the public.

As a Commission, we had a real problem coming to grips with this issue because of the time constraints on examining the characteristics of other utilities operating nuclear power plants. I can, therefore, understand the difficulties in formulating a specific recommendation at this time.

Yet I must believe that our findings do support more than what we have said here by way of recommendations. We cannot simply urge the utility, industry, and the Nuclear Regulatory Commission to pay more attention to safety and to establish higher standards.

While this Commission has clearly addressed the institutional shortcomings of the NRC in its recommendations, it has not addressed the institutional problems of the industry.

Met Ed's operating license stems from an unquestioned assumption by the NRC, until now, that any utility that wanted to produce nuclear power could do so -- a policy that no matter how small or unsophisticated the utility, it was eventually entitled to wrap its arms around a nuclear reactor. Nuclear technology continues to proliferate throughout the

industry with some forty utilities now operating reactors and with many more waiting in the wings.

There is no question that the management quality of utilities varies much more -- from very good to very mediocre -- than other major industrial sectors such as large chemical companies or computer manufacturers. And because utilities are necessarily monopolistic in nature, normal laws of competition do not apply; badly managed utilities suffer financial problems but somehow survive.

It is now time to assess this situation and determine which companies are qualified to handle such a technology and which companies are not. It is remarkable that this issue has not been previously confronted, but it is again a product of the "accidents can't happen" syndrome. Discriminating the good from the mediocre, the nuclear goats from the nuclear sheep, however unpalatable to the industry, must be done. One well known nuclear expert, Dr. Alvin Weinberg, has argued persuasively that the generation of nuclear power should be completely separated from the distribution of electricity and entrusted to just a few sophisticated entities with both the resources and the organizational depth to provide safe nuclear energy as their only task.

I believe that this is one area where fewer entities with more depth and expertise might be justified for the sake of public health and safety. Precisely how to control this proliferation of nuclear power management should receive a lot more study and I strongly urge the appropriate over-sight committees to place this issue near the top of their agenda.

Second, the Commission with its limited time and resources did not pursue in detail the issue of whether facts, known by Met Ed on the first day of the accident, were not communicated to NRC and state officials.

It now appears there is evidence to indicate that Met Ed technicians understood, within a few hours of the accident, that the nuclear core had been uncovered and that this specific information was transmitted to supervisory personnel at the plant early Wednesday. There seems to be little question that the technicians who took the temperature readings that morning understood what they found. The real question is what happened to this information and whether it was transmitted to the appropriate management personnel. It certainly did not get transmitted to responsible public officials, including Lt. Governor Scranton during a meeting with Met Ed that afternoon.

This incident again demonstrates the total inadequacy of the utility's internal communication system and raises serious questions about crisis management. As a Governor, it seems to me beyond question that a responsible public official must have immediate access to all available information about the status of a nuclear accident.

There is no question that this information might have influenced state and federal concerns over the need for evacuation then and subsequently. Whether or not an evacuation should have been ordered on the basis of the evidence known at the time is not particularly relevant now but the fact of the matter is that key decision-makers - those

responsible for the public health and safety of the citizens - did not have access to the information that was known to the utility.

This issue should be intensely scrutinized by other investigatory bodies continuing the inquiry into nuclear power and this accident.

There are still unresolved questions about what happened at Three Mile Island, the answers to these may well lead to other recommendations about the responsibilities of utilities operating nuclear reactors.

Bruce Babbitt

October 25, 1979

SUPPLEMENTAL VIEW BY COMMISSIONER KEMENY

The Commission considered three different possible recommendations for a temporary halt on construction permits. Eight different Commissioners voted for at least one of these proposals. Unfortunately, we could not agree on the appropriate criteria for such a halt. Our reasons for failure to reach agreement are complex and may be found by examining the transcripts of our meetings of October 16, 20 and 21.

The following proposed recommendation was discussed extensively by the Commission:

> "No new construction permits should be issued until the reports and recommendations of this Commission, the NRC self-evaluation and the Congressional investigations are complete and until the President and Congress have had an adequate opportunity to consider such recommendations, including the recommendation to restructure the NRC."

I was one of six Commissioners who voted in favor of this recommendation; four voted against it and two abstained. I very much regret that this important recommendation failed to obtain the seven-vote majority necessary to adopt it.

I was also one of four Commissioners who voted for a stronger version of the above recommendation.

John G. Kemeny

October 25, 1979

SUPPLEMENTAL VIEW BY COMMISSIONER PETERSON

Although I believe that our report fulfills well the President's charge and believe that our recommendations, if they were carried out, would reduce the likelihood of accidents, I wish to comment on the work of the Commission in three areas:

I. The Commission failed to summon the 7 votes necessary to adopt the following two resolutions:

A. "No new construction permits should be issued until the reports of this Commission, the NRC self-evaluation, and the Congressional investigations are completed and until the President and Congress have had an adequate opportunity to consider such recommendations including restructuring the NRC."

Six of the ten Commissioners who voted supported this resolution.

B. "No new limited work authorization permits or construction permits should be issued by the present NRC or the restructured NRC that are inconsistent with the siting recommendations in 6 and 6a."

(This reference is to approved recommendations that call for requiring, to the maximum feasible extent, the siting of new power plants in locations remote from concentrations of population.)

Six of the nine Commissioners who voted supported this.

In view of the strong support in our Commission for these two measures, I recommend that the Congress and the President enact them.

A minority within the Commission strongly resisted recommendations that might delay further nuclear plant construction. Neither the Commission nor its staff was free from the mind-set that nuclear energy is adequately safe--the mind-set for which the Commission criticized the NRC and the nuclear industry.

II. The study was not subjected to the penetrating critique which could have been provided by one or more of the highly technically qualified critics of nuclear energy safety available in our country. I recommend that the President and the Congress involve such experts in the continuing appraisal of the safety of nuclear energy. This is especially important when considering the possible accident conditions which can lead to a major release of radioactive material from the plant.

III. The Commission ruled that an investigation of the disposal of the TMI-2 nuclear wastes lay outside its assignment. Yet, in my view, this constitutes, over the long run, the most hazardous aspect of the nuclear power industry. While the industry waits for the government to

finish its decades-long effort to determine how to safely dispose of these long-lived wastes such as plutonium, cesium and strontium, each nuclear power plant continues to store its growing amount of spent fuel containing these wastes in a pool of water immediately adjacent to the containment building.

I recommend that a serious study be undertaken of how such storage may exacerbate the threat from accidents or sabotage and of whether or not such waste should be moved away from the power plants, especially when the plant is located in a heavily populated area.

Although there is no commercial plant today for reprocessing spent fuel and our government refuses to approve one, the accident at TMI-2 has in effect converted that plant to a reprocessing plant. A large-scale chemical processing plant is being built at TMI-2 for handling the huge quantities of highly radioactive waste that have escaped from the disintegrated fuel rods. The safe processing and disposal of these wastes merit prompt and close surveillance by some independent group.

As a final comment, I wish to emphasize my conviction, strongly reinforced by this investigation, that the complexity of a nuclear plant--coupled with the normal shortcomings of human beings so well illustrated in the TMI accident--will lead to a much more serious accident somewhere, sometime. The unprecedented worldwide fear and concern caused by the TMI-2 "near-miss" foretell the probable reaction to an accident where a major release of radioactivity occurs over a wide area. It appears essential to provide humanity with alternate choices of energy supply. Accordingly, I recommend the development by our federal government, before we become more fully committed to the vulnerable nuclear energy path, of a strategy which does not require nuclear fission energy.

Russell W. Peterson

October 25, 1979

SUPPLEMENTAL VIEW BY COMMISSIONER PIGFORD

I generally concur with the conclusions and recommendations of the Presidential Commission on the Accident at Three Mile Island. However, some of the principal results of this investigation need clarification and discussion. Among these are some that warrant immediate, but necessarily limited, comment.

1. The Performance of Equipment and Engineering Systems

The Commission has properly recognized that, with the very heavy emphasis upon equipment to attain reactor safety, there has been too little emphasis upon the adequacy of people to help achieve that safety. The lack of such people emphasis has been properly stressed in this report. However, that stress has now obscured the very important fact that, in spite of the very crucial errors of operators and supervisors at TMI-2, the safety equipment did indeed function. In spite of the open PORV, leaks in the vent gas system, and other equipment failures, the overall system of equipment was sufficiently good that, without the human errors, the accident at TMI-2 would have been only a minor accident.

The reactor containment and its auxiliary equipment did indeed function to protect the public. Except for the small fraction that escaped to the environment, the radioactivity was contained. The off-site radiation doses were small. We have found that the actual release of radioactivity to the atmosphere will have a negligible effect on the physical health of individuals. Equipment failures were not the proximate cause of the TMI-2 accident. The accident was, in fact, a demonstration that the equipment is effective.

Although there has been considerable speculation about how near TMI-2 came to a worse accident, our staff analyses show that even if all of the reactor fuel cladding had been oxidized to form hydrogen, or even if appreciable fuel melting or even a meltdown had occurred, the containment would still have survived and protected the public. The accident demonstrated that the "defense-in-depth" approach towards nuclear reactor safety has indeed yielded significant results.

The emphasis in this report upon equipment vs. people obscures the fact that the equipment itself is only one product of the defense-in-depth or multiple-barrier design approach, which also encompasses the analysis of how equipment components must perform and how systems of equipment must operate. The accident demonstrated that this system of equipment performed better than expected. Earlier assumptions and studies by AEC/NRC (TID-14844 and WASH-1400) have suggested far greater core damage and greater releases of radioactivity from the fuel and into the containment under such degraded cooling conditions.

The accident has also demonstrated many areas wherein equipment modifications can result in further improvements in safety of existing and future reactors in this country.

These are important positive results from our investigation.

2. The People-Related Problem

The nature of the people-related problems needs clarification. One such problem--and a most serious one--was the errors made by operators and operator-supervisors, whose training was insufficient in scope and understanding. Another was the failure of many individuals to respond adequately to the earlier experience from other reactors and to other advance information that might have alerted the operators and avoided the accident.

Another problem was the errors made by some NRC officials, who misinterpreted the release of radioactivity on March 30 and recommended evacuation, and who erroneously concluded on March 31 that the hydrogen bubble might explode. The public trauma from these mistakes resulted in severe but short lived mental stress, which was evidently the only serious health effect of the accident.

Having identified the particular people-problems involved, many of the necessary direct remedies are apparent. There seems to be some unwillingness to recognize that many of these remedies are already being implemented. The NRC and the nuclear industry have taken and are taking steps on a broad basis to analyze and rectify these problems, as evidenced by the post-TMI NRC bulletins and by the establishment of the utilities' Institute for Nuclear Power Operations (INPO) and the reinsurance program. After experiencing the shock and comprehending the cost of this accident, the nuclear industry has clearly set into motion programs to institute many of the remedies that this Commission seeks. The problem with "attitudes" emphasized in the Commission's report must refer largely to pre-TMI attitudes.

It is reasonable to expect that other such human-related problems, not uncovered by this investigation, may exist. That, and the need to instill and continue a strong emphasis upon reactor safety, suggest some of the broader institutional changes recommended in this study.

3. Scope and Limits of the Investigation

The limits of this investigation and the effect thereof upon the Commission conclusions and recommendations need clarification.

This investigation was limited to the accident at TMI-2, and possible variations thereto, and, to a limited extent, similar transients at other places. The many other aspects of reactor safety were not investigated, although we do recommend that these be more systematically studied. The facts of the present investigation provide no basis for concluding that reactors are unsafe. They also show that, although more emphasis is needed on the analysis and planning for small-break accidents, the possibility of an accident of this type was known and had been analyzed and predicted prior to the TMI-2 accident. Therefore, any conclusions as to new fears of reactor safety do not arise from, and imply large extrapolations from, the facts of this investigation.

This investigation has not included a study of reactor siting. Consideration of the calculated "low population zone" occurred only in our consideration of its implication on the specification of radiation

doses for evacuation decisions. Therefore, proposals made by some Commissioners to reverse existing site approvals in favor of more remote sites have no justification with the facts of this study.

We have recognized in this investigation that decisions as to whether or not safety improvements are to be implemented must be based in part upon a weighing of the costs against the benefits. However, we did not evaluate the costs of possible safety modifications, nor did we evaluate the probabilities of some of the large hypothetical releases that have been postulated by some Commissioners. Such proposals, and claims as to risks therefrom, have no basis within the facts of this investigation.

We have not investigated the availability, cost, overall safety, and environmental effects of nuclear energy and of other energy alternatives. Nor have we investigated the effect of various energy alternatives upon the nation's economy and security. We have not examined the effect of a speed-up or delay of nuclear power upon the many energy problems which affect the nation. Therefore, proposals by some Commissioners to impose sanctions which affect the availability of nuclear energy as an option are based upon their own personal extrapolations, which leap far beyond the facts of this investigation. The Commission, in its final consideration of the moratorium proposals, repudiated the issue by a vote of 8 to 4.

4. Lack of Input from Those Parts of the Nuclear Industry Not Involved Directly in TMI-2

Through its investigation of the Nuclear Regulatory Commission, the Commission staff has uncovered problems and practices which have suggested extrapolations to those many parts of the nuclear industry not involved directly with the TMI-2 accident. However, little proof of the validity of these extrapolations has been established. Moreover, to my knowledge, no representatives of those other parts of the nuclear industry were interrogated or asked to present evidence on any of the relevant issues, except for one company interrogated within the narrow issue of the Beznau incident. This further limits the validity of the industry-wide extrapolations that are implied in many places in the report and that are implied in some of the moratorium recommendations still endorsed by some of the Commissioners.

5. Attitudes

The framing of the Commission's overall conclusion around the question of

> "attitudes of the Nuclear Regulatory Commission, and to the extent that the institutions that we investigated are typical, of the nuclear industry"

requires comment and interpretation. "Attitudes", especially prior to TMI-2, were not directly examined, nor could they be. Valid conclusions can only be drawn on actions taken, i.e., problems addressed and not addressed, regulations issued and complied with, and the occurrence of events that reflect upon the adequacy of those processes. Even if

"attitudes" could be assessed, it is not clear how they could be changed by any recommended rule, reorganization, or other mandated influence. It is more constructive to assume that attitudes are symptomatic of the forces at work in the systems, and it is those forces which must be addressed.

The actions already taken by the industry in setting up INPO, the Nuclear Safety Analysis Center, and the program of self insurance against the cost of replacement power, with the self-policing actions thereby implied, signal a genuine, if somewhat belated, recognition of the need for greater effort to prevent nuclear accidents and cope with their consequences. These actions show a significant change in industry attitude which can only be beneficial.

It becomes clear, as the theme of "attitudes" is developed in the Commission report, that what is of concern is an apparent failure of the system to incorporate an effective mechanism to assimilate lessons from plant experience and to incorporate the appropriate up-to-date technology, particularly as it applies to control room design and to develop sufficiently trained and competent people to manage this technology. This is a more manageable and appropriate focus for the overall conclusion of this Commission.

I believe that such technology is being or will be used by the industry and that changes and improvements in design and operating procedure will be effected, not merely to satisfy critics nor to demonstrate attitudinal penitence, but on the basis of sound judgment resting on sound data.

6. Commission Judgments on Overall Safety

In its Overview the Commission acknowledges that it has not examined "how safe is safe enough or the broader question of nuclear vs. other forms of energy," recognizing the complexity of the issue and the limitations of staff. However, the Commission soon leaps this hurdle and speaks of the "risks that are inherently associated with nuclear power," and it holds that "equipment can and should be improved to add further safety." Even the conclusion that "accidents as serious as TMI should not be allowed to occur in the future" may imply that an assessment of risk and safety has been made. This conclusion is more understandable if interpreted in terms of what was really serious about this accident. The only serious health effect was the mental stress resulting from the confusion and public misunderstanding concerning the March 30 release and the March 31 hydrogen bubble. The financial loss to the utility and ultimately to the ratepayer is also serious.

Every technology imposes a finite degree of risk upon society, both in its routine operation and in the occurrence of accidents. Over a long enough time period, even low probability accidents may occur. The essential question is the trade-off between the risks and the benefits. The Commission neither received any evidence nor reached any conclusions that the risks of nuclear power outweigh its benefits.

7. The NRC "Promotional Philosophy"

The NRC's assignment is indeed difficult, but not because of dichotomy of safety, on the one hand, and the industry's convenience on the other. The problem is more complex. There is in each issue the element of how much cost, how many man-years of expert analysis, and how much delay is justifiable to achieve an increment of safety. Seldom are these issues black and white, since the designers and engineers must recognize that absolute absence of risk in any project is unattainable, and that social costs accrue to both inaction and overreaction. Efforts to balance costs and benefits should not be considered evidence per se of a promotional philosophy.

It should be expected that industry will logically resist unwarranted changes proposed in the name of safety.

8. Hydrogen from Small-Break LOCAs

Finding A-10 may be misinterpreted as suggesting that, because of the experience at TMI, the generation of large amounts of hydrogen gas is an inevitable consequence of small-break LOCAs. This misinterpretation leads to the erroneous conclusion that NRC over-emphasis on large-break LOCAs, at the expense of small breaks, is what left the TMI operators unprepared for the hydrogen produced during the accident, since significant amounts of hydrogen are not predicted in the typical analyses of large breaks. Such inference is without basis. Large-break analysis or any-break analysis will predict the generation of large amounts of hydrogen whenever the cooling water added to the reactor core from the emergency systems is reduced to the extent that was done at TMI-2.

9. The Two-Step Licensing Process

Finding G-6 implies that, in the two-step licensing process (Construction Permit and Operating License), safety may be compromised due to the large financial commitment prior to the operating license stage, with the implication that insufficient information is known at the construction permit stage for an in-depth safety review. A review of actual license applications will reveal that major safety features are sufficiently described at the construction permit stage. The issuance of an operating license several years later facilitates consideration of appropriate technological developments and feedback from operating plants which may be factored into the design toward the end of the construction period. Safety review in licensing is not a discrete two-step process. There is, and should be, continuing dialogue between the NRC staff and the applicant during this interim period.

10. Single-Failure Criterion

Finding G-8(a) that applicants "are not required to analyze what happens when two systems or components fail independently of each other" conveys some misunderstanding of the "single-failure" criterion. The requirement is that the applicant must show that applicable off-site radiation exposure limits will not be exceeded in the event of an accident initiated by:

(a) any credible component failure, and in which
(b) either all external or all internal power supply to the plant is lost, and

(c) there is, in addition, failure of that single active component whose failure would most worsen the results of the accident.

Although confusingly called a "single-failure" criterion, it is clear that this criterion requires the assumption of at least three failures.

It is further required that if failure of one component causes failure of other components, the entire series of failures must be regarded as one failure. The single-failure criterion is applied on a system-by-system basis, which implies single-failure tolerance in each of the systems.

11. Safety-Related

Finding G-8(b) concerning NRCs handling of "safety-related" items needs clarification in several respects. First, the well-established practice of the NRC is to require that any component, system, or feature needed for the prevention or mitigation of a serious accident must meet documented requirements of quality, redundancy, testability, environmental qualifications, etc., and must be categorized as "safety-related." Although other components, systems, or features are classed as "non-safety related" they must meet requirements appropriate to their operational function. NRC practice is to subject all "safety related" items to review. Additionally, "non-safety related" items are reviewed by NRC to reassess their possible reclassification.

Second, in analyzing postulated accidents, one is not permitted to assume that an active "non-safety related" item will be capable of performing its function. As a result, either an active item must meet "safety related" requirements of quality, etc., or no credit can be taken for its functioning in an accident.

In the TMI-2 accident it appears that the NRC's pre-occupation with the "safety-related" item list was not the fault, but rather the safety analyses did not take into account the actual lack of training, the inadequate operating procedures and practices, and their potential capability for producing an accident if the PORV stuck open.

Finally, the NRC is in some degree responsible for the level of safety consciousness in the industry. In this sense NRC's emphasis on "safety related" categories has probably been less influential than its reluctance to give credit for safety innovations and its requirement that the industry comply with many technically unreasonable rules. These practices encourage the industry merely to comply with NRC rules.

With regard to Finding G-8(c), it is not the reliance on "artificial categories of safety-related items" which has caused NRC to miss important safety problems. Rather, it was the failure to recognize that some items not part of the safety system may challenge that system at an undesirable frequency. Moreover, the capability of the operators to defeat the safety system was not given sufficient attention. These important issues are apart from safety-system classification and the single-failure criterion.

12. Plant Instrumentation

Finding G-8(f) does not provide a balanced account of all the considerations identified by AIF in its 1978 response to an NRC proposal to institute a new guide requiring a wider range of response for in-plant instrumentation, nor does it recognize the seeming lack of technical basis for the NRC request.

The relevance to the TMI-2 accident of the AIF response is not clear, since the range of the in-plant instrumentation at TMI-2 was adequate for diagnosis and plant control during the accident. Instead, the problem during the TMI-2 accident was that only part of the range of the in-plant instrumentation was displayed to the operators, and the manner of display was in some ways inadequate. Additionally, the operators misinterpreted some instrument readings. However, a greater range of instrument response might have aided the later assessment of the core damage that occurred.

13. Backfitting

Finding G-8(h), that there is no systematic backfitting review on a plant-by-plant basis of operating plants and plants under construction, appears to take too little account of the NRC's Systematic Evaluation Program (SEP), initiated more than three years ago. Under this program, operating plants have been categorized by NRC, issues have been identified by NRC, and information about older plants has been supplied to NRC by the utilities. In a number of cases, physical modifications of operating plants have been made in order to comply with updated NRC requirements. In some areas, such as that of the up-grading of emergency plans cited in the Commission's report, progress does appear to have been somewhat slow.

14. Independent Testing by I&E

In Finding G-9(a) and Recommendation 11(d) the recommended improvement of NRC's inspection and auditing of licensee compliance with regulations and the need for major and unannounced on-site inspections of particular power plants is logical. It calls for NRC to do more of what it already does and to do it better. In fact, NRC has, for over a year, stationed full-time inspectors at some operating nuclear power plants. At some plants, unannounced on-site inspections appear to be so frequent as to be commonplace.

The implication that NRC's I&E inspectors should do a substantial amount of independent testing of construction work and should place little reliance on work done by the utility is clearly impractical because of the enormous resources which would be required. Careful auditing of industry's testing is the only practicable and effective approach.

15. Emergency Procedures

In addition to the fact that some of the existing TMI-2 procedures were unworkable, as indicated in the Commission's report, the procedures did not provide a step-by-step pathway for identifying the problem

implied by the information available in the control room. Given the philosophy that the operators had to adhere closely to written procedures, the unavailability of diagnostic procedures and training in their use was a significant factor among the causes of the TMI-2 accident.

16. The Major Problems with NRC's Approach to Reactor Safety

The Commission report has identified many mistakes by NRC personnel in their handling of the TMI-2 accident and deficiencies in NRC's regulatory practices. However, this criticism does not reach some essential elements of the problem. I believe that the following are some of the more important problems at NRC:

... Lack of quantified safety goals and objective. When a safety concern is postulated, there is no yardstick to judge the adequacy of mitigating measures.

... Inability to set priorities and to allocate resources in proportion to the estimated risk to the public. In my view, a disproportionate effort is being required for some issues which have only a marginal impact upon risk to the public.

... Lack of experienced staff. An undesirably large proportion of NRC staff and management have little or no practical experience in designing or operating the equipment which they regulate.

... Arbitrary requirements. Too many of the NRC requirements are mandated without valid technical back-up and value-impact analysis.

... A stifling adversary approach. The existing process inhibits the interchange of technical information between the NRC and industry. It discourages innovative engineering solutions.

... Ineffective evaluation of operations. NRC has no effective system for evaluating data from operating plants. Data should be analyzed systematically to identify trends and patterns.

... Lack of a comprehensive system approach to the whole plant. A large percentage of the NRC staff are specialists focusing upon narrow topics. There are relatively few systems engineers within NRC who can integrate individual safety features into an overall concept and who can place issues into perspective.

... An overwhelming emphasis on conservative models and assumptions. Realistic analyses are needed to identify the margins of safety and to aid competent decisions.

17. The Staff Report

The tight schedule and deadline for the Commissioners' report has allowed little opportunity for careful review of the Staff reports upon which our findings are to be based. Some Staff reports are not yet completed. There are several parts of some key Staff reports with which I cannot agree, particularly the staff report on the NRC.

18. The Staff Report on the Nuclear Regulatory Commission.

The Staff report on the Nuclear Regulatory Commission is a companion document published in Volume 2 of the Commission Report. Some deficiencies in this report are already reflected in earlier comments on Findings and Conclusions concerning the NRC. Having reviewed that report in search for understanding for many of the findings and conclusions adopted by this Commission, I noted several deficiencies, varying from technical error to unbalance in the investigation. Two examples are given below.

18.1 Performance Characteristics of Large Light-Water Reactors

The Staff report contains generalities by an NRC staff member, who seriously questioned the state of knowledge of the performance characteristics of the larger light-water reactors in this country, an opinion apparently also echoed by some other individuals within NRC. The cited statement was adopted by the authors of this Staff report. However, the Staff report reflects no attempt by the Staff to obtain evidence from the nuclear industry on this issue, even though the various companies in the nuclear industry are the parties impugned by the cited statements.

Statements were recently obtained from Saul Levine, Director of NRC's Office of Nuclear Regulatory Research, and from two different companies which design light-water reactors and which are not connected with the TMI-2 accident. It should not be construed from reference to "economy of scale" that the regulators were being asked to accept reduced safety margins. Rather, the growth was largely achieved by adding more fuel assemblies of the same or similar volumetric and linear power density, and by adding more heat transfer loops having the same mechanical and hydraulic characteristics as in the plants previously licensed. Saul Levine said, "as far as I know, there have been no size-dependent factors found in the operation of large reactors to affect the safety of the plants adversely." There appears no supportable suggestion that safety was compromised as a result of the extrapolation of technology.

The unqualified acceptance of the cited testimony in the Staff report is an indicator of insufficient balance in this part of the investigation.

18.2 Reliance on Books and Magazines

The Staff report relies to a considerable extent upon excerpts from a book authored by E. Rolph without establishing the author's qualifications. Ms. Rolph did not testify in this investigation. The undue reliance upon this secondary source, without first establishing a primary source for its support and without establishing its reliability, is a further example of insufficient balance in this part of the investigation.

In my view, the Rolph book does not express a comprehensive, accurate, and balanced knowledge of the NRC and of the nuclear industry.

19. Concluding Statement

The rather extensive criticism of NRC in the Commission report, and as implied in this supplementary statement, should not obscure the

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central issue that primary responsibility for nuclear safety lies with the utility, shared to a large extent with the equipment suppliers and the architect engineers. This also reflects my view of the responsibilities for the TMI-2 accident.

However, these criticisms of both industry and NRC should not obscure the fact that in 480 reactor years of commercial nuclear power operation in the United States there has still been no identifiable effect upon the physical health of the public, and that this record has been achieved by the industry and NRC, the parties that have been criticized and under the system that has been criticized.

It must be emphasized that nothing learned from this investigation suggests that the nuclear power option should be curtailed or abandoned as a result of the TMI-2 accident.

Thomas H. Pigford

October 25, 1979

SUPPLEMENTAL VIEW BY COMMISSIONER TRUNK

The following is a minority view on two issues raised in the report.

ITEM 1:

This item represents the feelings of the undersigned and a majority of her circle of citizens who lived through the TMI accident.

The report concluded that the errors and sensationalism reported by the news media merely reflected the confusion and ignorance of the facts by the official sources of information. It further concluded that the press did a creditable ("more reassuring than alarming") job of news coverage.

In fact, these conclusions are not generally supported by the staff reports. There were reliable news sources available. Too much emphasis was placed on the "what if" rather than the "what is." As a result, the public was pulled into a state of terror, of psychological stress. More so than any other normal source of news, the evening national news reports by the major networks proved to be the most depressing, the most terrifying. Confusion cannot explain away the mismanagement of a news event of this magnitude.

It is requested that the news media undertake a self evaluation on an individual basis and review their role in this accident which was not limited to equipment damage but also included psychological damage.

ITEM 2:

The undersigned could not support a motion for an undefined time frame moratorium on all new construction permits because it was not shown how this could result in a safer plant at TMI nor attain higher standards of safety and performance by the Industry.

A defined period (say two years) to act on this report's recommendations along with a separate probationary operating period (say five years) for the licensee at TMI could accomplish both the above objectives and is therefore recommended.

Anne D. Trunk

October 25, 1979

Report Of
The President's Commission On

THE ACCIDENT AT THREE MILE ISLAND

The Need For Change:
The Legacy Of TMI
October 1979 Washington, D.C.

President's Commission
on the Accident at Three Mile Island
2100 M Street, NW Washington, DC 20037

October 30, 1979

The President
The White House
Washington, D.C. 20500

Dear Mr. President:

In accordance with Executive Order Number 12130, we hereby transmit to you the final report of the President's Commission on the Accident at Three Mile Island.

Faithfully yours,

John G. Kemeny
Chairman

Bruce Babbitt

Harry C. McPherson

Patrick E. Haggerty

Russell W. Peterson

Carolyn Lewis

Thomas H. Pigford

Paul A. Marks

Theodore B. Taylor

Cora B. Marrett

Anne D. Trunk

Lloyd McBride

PREFACE

THE CHARGE TO THE COMMISSION

On March 28, 1979, the United States experienced the worst accident in the history of commercial nuclear power generation. Two weeks later, the President of the United States established a Presidential Commission. The President charged the 12-member Commission as follows:

"The purpose of the Commission is to conduct a comprehensive study and investigation of the recent accident involving the nuclear power facility on Three Mile Island in Pennsylvania. The Commission's study and investigation shall include:

(a) a technical assessment of the events and their causes; this assessment shall include, but shall not be limited to, an evaluation of the actual and potential impact of the events on the public health and safety and on the health and safety of workers;

(b) an analysis of the role of the managing utility;

(c) an assessment of the emergency preparedness and response of the Nuclear Regulatory Commission and other federal, state, and local authorities;

(d) an evaluation of the Nuclear Regulatory Commission's licensing, inspection, operation, and enforcement procedures as applied to this facility;

(e) an assessment of how the public's right to information concerning the events at TMI was served and of the steps which should be taken during similar emergencies to provide the public with accurate, comprehensible, and timely information; and

(f) appropriate recommendations based upon the Commission's findings."

PREFACE

THE ACCIDENT

At 4:00 a.m. on March 28, 1979, a serious accident occurred at the Three Mile Island 2 nuclear power plant near Middletown, Pennsylvania. The accident was initiated by mechanical malfunctions in the plant and made much worse by a combination of human errors in responding to it. (For details see "Account of the Accident" within this volume.) During the next 4 days, the extent and gravity of the accident was unclear to the managers of the plant, to federal and state officials, and to the general public. What is quite clear is that its impact, nationally and internationally, has raised serious concerns about the safety of nuclear power. This Commission was established in response to those concerns.

WHAT WE DID

The investigation of the Commission was carried out by our able and hard-working staff. We also had the help of a number of consultants and commissioned several studies. It is primarily due to the work of the staff that we accomplished the following.

We examined with great care the sequence of events that occurred during the accident, to determine what happened and why. We have attempted to evaluate the significance of various equipment failures as well as the importance of actions (or failures of actions) on the parts of individuals and organizations.

We analyzed the various radiation releases and came up with the best possible estimates of the health effects of the accident. In addition, we looked more broadly into how well the health and safety of the workers was protected during normal operating conditions, and how well their health and safety and that of the general public would have been protected in the case of a more serious accident.

We conducted an in-depth examination of the role played by the utility and its principal suppliers. We examined possible problems of organization, procedures, and practices that might have contributed to the accident. Since the major cause of the accident was due to inappropriate actions by those who were operating the plant and supervising that operation, we looked very carefully at the training programs that prepare operators and the procedures under which they operate.

As requested by the President, we examined the emergency plans that were in place at the time of the accident. We also probed the responses to the accident by the utility, by state and local governmental agencies in Pennsylvania, and by a variety of federal agencies. We looked for deficiencies in the plans and in their execution in order to be able to make recommendations for improvements for any future accident. In this process we had in mind how well the response would have worked if the danger to public health had been significantly greater.

We examined the coverage of the accident by the news media. This was a complex process in which we had to separate out whether errors in media accounts were due to ignorance or confusion on the part of the official sources, to the way they communicated this information to the

media, or to mistakes committed by the reporters themselves. We examined what sources were most influential on the people who needed immediate information, and how well the public was served by the abundant coverage that was provided. We also attempted to evaluate whether the coverage tended to exaggerate the seriousness of the accident either by selectively using alarming quotes more than reassuring ones, or through purposeful sensationalism.

Finally, we spent a great deal of time on the agency that had a major role in all of the above: the Nuclear Regulatory Commission. The President gave us a very broad charge concerning this agency. We therefore tried to understand its complex structure and how well it functions, its role in licensing and rulemaking, how well it carries out its mission through its inspection and enforcement program, the role it plays in monitoring the training of operators, and its participation in the response to the emergency, including the part it played in providing information to the public.

We took more than 150 formal depositions and interviewed a significantly larger number of individuals. At our public hearings we heard testimony under oath from a wide variety of witnesses. We collected voluminous material that will fill about 300 feet of shelf-space in a library. All of this material will be placed into the National Archives. The most important information extracted from this in each of the areas will appear in a series of "Staff Reports to the Commission."

Based on all of this information, the Commission arrived at a number of major findings and conclusions. In turn, these findings led the Commission to a series of recommendations responsive to the President's charge.

At the beginning of this volume will be found an overview of our investigation, followed by those findings and recommendations which commanded a significant consensus among the members of the Commission. Each recommendation was approved by a majority of Commissioners.

WHAT WE DID NOT DO

It is just as important for the reader to understand what the Commission did not do.

Our investigation centered on one accident at one nuclear power plant in the United States. While acting under the President's charge, we had to look at a large number of issues affecting many different organizations; there are vast related issues which were outside our charge, and which we could not possibly have examined in a 6-month investigation.

We did not examine the entire nuclear industry. (Although, through our investigation of the Nuclear Regulatory Commission, we have at least some idea of the standards being applied to it across the board.) We have not looked at the military applications of nuclear energy. We did not consider nuclear weapons proliferation. We have not dealt with the question of the disposal of radioactive waste or the dangers of the accumulation of waste fuel within nuclear power plants adjacent to the

containment buildings. We made no attempt to examine the entire fuel cycle, starting with the mining of uranium. And, of course, we made no examination of the many other sources of radiation, both natural and man-made, that affect all of us.

We have not attempted to evaluate the relative risks involved in alternate sources of energy. We are aware of a number of studies that try to do this. We are also aware that some of these studies are subjects of continuing controversy.

We did not attempt to reach a conclusion as to whether, as a matter of public policy, the development of commercial nuclear power should be continued or should not be continued. That would require a much broader investigation, involving economic, environmental, and political considerations. We are aware that there are 72 operating reactors in the United States with a capacity of 52,000 megawatts of electric energy. An additional 92 plants have received construction permits and are in various stages of construction. If these are completed, they will roughly triple the present nuclear capacity to generate electricity. This would be a significant fraction of the total U.S. electrical generating capacity of some 600,000 megawatts. In addition, there are about 200 nuclear power plants in other countries throughout the world.

Therefore, the improvement of the safety of existing and planned nuclear power plants is a crucial issue. It is this issue that our report addresses, those changes that can and must be made as a result of the accident -- the legacy of Three Mile Island.

OVERVIEW

OVERALL CONCLUSION

In announcing the formation of the Commission, the President of the United States said that the Commission "will make recommendations to enable us to prevent any future nuclear accidents." After a 6-month investigation of all factors surrounding the accident and contributing to it, the Commission has concluded that:

> To prevent nuclear accidents as serious as Three Mile Island, fundamental changes will be necessary in the organization, procedures, and practices -- and above all -- in the attitudes of the Nuclear Regulatory Commission and, to the extent that the institutions we investigated are typical, of the nuclear industry.

This conclusion speaks of necessary fundamental changes. We do not claim that our proposed recommendations are sufficient to assure the safety of nuclear power.

Given the nature of its Presidential mandate, its time limitations, and the complexity of both energy and comparative "risk-assessment" issues, this Commission has not undertaken to examine how safe is "safe enough" or the broader question of nuclear versus other forms of energy. The Commission's findings with respect to the accident and the regulation of the nuclear industry -- particularly the current and potential state of public safety in the presence of nuclear power -- have, we believe, implications that bear on the broad question of energy. But the ultimate resolution of the question involves the kind of economic, environmental, and foreign policy considerations that can only be evaluated through the political process.

Our findings do not, standing alone, require the conclusion that nuclear power is inherently too dangerous to permit it to continue and expand as a form of power generation. Neither do they suggest that the nation should move forward aggressively to develop additional commercial nuclear power. They simply state that if the country wishes, for larger reasons, to confront the risks that are inherently associated with

nuclear power, fundamental changes are necessary if those risks are to be kept within tolerable limits.

We are very much aware that many other investigations into the accident are under way. There are several investigations by Congress, the NRC self-investigation, and a number of studies by the industry. Some will examine individual issues in much greater depth than we were able to do. And, no doubt, additional insights will emerge out of these various investigations. It is our hope that the results of our efforts may aid and accelerate the progress of the ongoing investigations, and help to bring about the required changes promptly.

ATTITUDES AND PRACTICES

Our investigation started out with an examination of the accident at Three Mile Island (TMI). This necessarily led us to look into the role played by the utility and its principal suppliers. With our in-depth investigation of the Nuclear Regulatory Commission (NRC), we gained a broader insight into the attitudes and practices that prevail in portions of the industry. However, we did not examine the industry in its totality.

Popular discussions of nuclear power plants tend to concentrate on questions of equipment safety. Equipment can and should be improved to add further safety to nuclear power plants, and some of our recommendations deal with this subject. But as the evidence accumulated, it became clear that the fundamental problems are people-related problems and not equipment problems.

When we say that the basic problems are people-related, we do not mean to limit this term to shortcomings of individual human beings -- although those do exist. We mean more generally that our investigation has revealed problems with the "system" that manufactures, operates, and regulates nuclear power plants. There are structural problems in the various organizations, there are deficiencies in various processes, and there is a lack of communication among key individuals and groups.

We are convinced that if the only problems were equipment problems, this Presidential Commission would never have been created. The equipment was sufficiently good that, except for human failures, the major accident at Three Mile Island would have been a minor incident. But, wherever we looked, we found problems with the human beings who operate the plant, with the management that runs the key organization, and with the agency that is charged with assuring the safety of nuclear power plants.

In the testimony we received, one word occurred over and over again. That word is "mindset." At one of our public hearings, Roger Mattson, director of NRC's Division of Systems Safety, used that word five times within a span of 10 minutes. For example: "I think [the] mindset [was] that the operator was a force for good, that if you discounted him, it was a measure of conservatism." In other words, they

concentrated on equipment, assuming that the presence of operators could only improve the situation -- they would not be part of the problem.

After many years of operation of nuclear power 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. One must recognize this to understand why many key steps that could have prevented the accident at Three Mile Island were not taken. The Commission is convinced that 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. A comprehensive system is required in which equipment and human beings are treated with equal importance.

We note a preoccupation with regulations. It is, of course, the responsibility of the Nuclear Regulatory Commission to issue regulations to assure the safety of nuclear power plants. However, we are convinced that regulations alone cannot assure safety. Indeed, once regulations become as voluminous and complex as those regulations now in place, they can serve as a negative factor in nuclear safety. The regulations are so complex that immense efforts are required by the utility, by its suppliers, and by the NRC to assure that regulations are complied with. The satisfication of regulatory requirements is equated with safety. This Commission believes that it is an absorbing concern with safety that will bring about safety -- not just the meeting of narrowly prescribed and complex regulations.

We find a fundamental fault even with the existing body of regulations. While scientists and engineers have worried for decades about the safety of nuclear equipment, we find that the approach to nuclear safety had a major flaw. It was natural for the regulators and the industry to ask: "What is the worst kind of equipment failure that can occur?" Some potentially serious scenarios, such as the break of a huge pipe that carries the water cooling the nuclear reactor, were studied extensively and diligently, and were used as a basis for the design of plants. A preoccupation developed with such large-break accidents as did the attitude that if they could be controlled, we need not worry about the analysis of "less important" accidents.

Large-break accidents require extremely fast reaction, which therefore must be automatically performed by the equipment. Lesser accidents may develop much more slowly and their control may be dependent on the appropriate actions of human beings. This was the tragedy of Three Mile Island, where the equipment failures in the accident were significantly less dramatic than those that had been thoroughly analyzed, but where the results confused those who managed the accident. A potentially insignificant incident grew into the TMI accident, with severe damage to the reactor. Since such combinations of minor equipment failures are likely to occur much more often than the huge accidents, they deserve extensive and thorough study. In addition, they require operators and supervisors who have a thorough understanding of the functioning of the plant and who can respond to combinations of small equipment failures.

OVERVIEW

The most serious "mindset" is the preoccupation of everyone with the safety of equipment, resulting in the down-playing 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.

CAUSES OF THE ACCIDENT

Other investigations have concluded that, while equipment failures initiated the event, the fundamental cause of the accident was "operator error." It is pointed out that if the operators (or those who supervised them) had kept the emergency cooling systems on through the early stages of the accident, Three Mile Island would have been limited to a relatively insignificant incident. While we agree that this statement is true, we also feel that it does not speak to the fundamental causes of the accident.

Let us consider some of the factors that significantly contributed to operator confusion.

First of all, it is our conclusion that the training of TMI operators was greatly deficient. While training may have been adequate for the operation of a plant under normal circumstances, insufficient attention was paid to possible serious accidents. And the depth of understanding, even of senior reactor operators, left them unprepared to deal with something as confusing as the circumstances in which they found themselves.

Second, we found that the specific operating procedures, which were applicable to this accident, are at least very confusing and could be read in such a way as to lead the operators to take the incorrect actions they did.

Third, the lessons from previous accidents did not result in new, clear instructions being passed on to the operators. Both points are illustrated in the following case history.

A senior engineer of the Babcock & Wilcox Company (suppliers of the nuclear steam system) noted in an earlier accident, bearing strong similarities to the one at Three Mile Island, that operators had mistakenly turned off the emergency cooling system. He pointed out that we were lucky that the circumstances under which this error was committed did not lead to a serious accident and warned that under other circumstances (like those that would later exist at Three Mile Island), a very serious accident could result. He urged, in the strongest terms, that clear instructions be passed on to the operators. This memorandum was written 13 months before the accident at Three Mile Island, but no new instructions resulted from it. The Commission's investigation of this incident, and other similar incidents within B&W and the NRC, indicates that the lack of understanding that led the operators to

incorrect action existed both within the Nuclear Regulatory Commission and within the utility and its suppliers.

We find that there is a lack of "closure" in the system -- that is, important safety issues are frequently raised and may be studied to some degree of depth, but are not carried through to resolution; and the lessons learned from these studies do not reach those individuals and agencies that most need to know about them. This was true in the B&W incident described above, it was true about various warnings within NRC that inappropriate operator actions could result in the case of certain small-break accidents, and it was true in several examples of questions raised in connection with licensing procedures that were not followed to their conclusion by the NRC staff.

There are many other examples mentioned in our report that indicate the lack of attention to the human factor in nuclear safety. We note only one more (a fourth) example. The control room, through which the operation of the TMI-2 plant is carried out, is lacking in many ways. The control panel is huge, with hundreds of alarms, and there are some key indicators placed in locations where the operators cannot see them. There is little evidence of the impact of modern information technology within the control room. In spite of this, this control room might be adequate for the normal operation of nuclear power plants.

However, it is seriously deficient under accident conditions. During the first few minutes of the accident, more than 100 alarms went off, and there was no system for suppressing the unimportant signals so that operators could concentrate on the significant alarms. Information was not presented in a clear and sufficiently understandable form; for example, although the pressure and temperature within the reactor coolant system were shown, there was no direct indication that the combination of pressure and temperature meant that the cooling water was turning into steam. Overall, little attention had been paid to the interaction between human beings and machines under the rapidly changing and confusing circumstances of an accident. Perhaps these design failures were due to a concentration on the large-break accidents -- which do not allow time for significant operator action -- and the design ignored the needs of operators during a slowly developing small-break (TMI-type) accident. While some of us may favor a complete modernization of control rooms, we are all agreed that a relatively few and not very expensive improvements in the control room could have significantly facilitated the management of the accident.

In conclusion, while the major factor that turned this incident into a serious accident was inappropriate operator action, many factors contributed to the action of the operators, such as deficiencies in their training, lack of clarity in their operating procedures, failure of organizations to learn the proper lessons from previous incidents, and deficiencies in the design of the control room. These shortcomings are attributable to the utility, to suppliers of equipment, and to the federal commission that regulates nuclear power. Therefore -- whether or not operator error "explains" this particular case -- given all the above deficiencies, we are convinced that an accident like Three Mile Island was eventually inevitable.

OVERVIEW

SEVERITY OF THE ACCIDENT

Just how serious was the accident? Based on our investigation of the health effects of the accident, we conclude that in spite of serious damage to the plant, most of the radiation was contained and the actual release will have a negligible effect on the physical health of individuals. The major health effect of the accident was found to be mental stress.

The amount of radiation received by any one individual outside the plant was very low. However, even low levels of radiation may result in the later development of cancer, genetic defects, or birth defects among children who are exposed in the womb. Since there is no direct way of measuring the danger of low-level radiation to health, the degree of danger must be estimated indirectly. Different scientists make different assumptions about how this estimate should be made and, therefore, estimates vary. Fortunately, in this case the radiation doses were so low that we conclude that the overall health effects will be minimal. There will either be no case of cancer or the number of cases will be so small that it will never be possible to detect them. The same conclusion applies to the other possible health effects. The reasons for these conclusions are as follows.

An example of a projection derived for the total number of radiation-induced cancers among the population affected by the accident at TMI was 0.7. This number is an estimate of an average, such as the one that appears in the statement: "The average American family has 2.3 children."

In the case of TMI, what it really means is that each of some 2 million individuals living within 50 miles has a miniscule additional chance of dying of cancer, and when all of these minute probabilities are added up, they total 0.7. In such a situation, a mathematical law known as a Poisson distribution (named after a famous French mathematician) applies. If the estimated average is 0.7, then the actual probabilities for cancer deaths due to the accident work out as follows: There is a roughly 50 percent chance that there will be no additional cancer deaths, a 35 percent chance that one individual will die of cancer, a 12 percent chance that two people will die of cancer, and it is practically certain that there will not be as many as five cancer deaths.

Similar probabilities can be calculated for our various estimates. All of them have in common the following: It is entirely possible that not a single extra cancer death will result. And for all our estimates, it is practically certain that the additional number of cancer deaths will be less than 10.

Since a cancer caused by nuclear radiation is no different from any other cancer, additional cancers can only be determined statistically. We know from statistics on cancer deaths that among the more than 2 million people living within 50 miles of TMI, eventually some 325,000 people will die of cancer, for reasons having nothing to do with the

nuclear power plant. Again, this number is only an estimate, and the actual figure could be as much as 1,000 higher or 1,000 lower. Therefore, there is no conceivable statistical method by which fewer than 10 additional deaths would ever be detected. Therefore, the accident may result in no additional cancer deaths or, if there were any, they would be so few that they could not be detected.

We found that the mental stress to which those living within the vicinity of Three Mile Island were subjected was quite severe. There were several factors that contributed to this stress. Throughout the first week of the accident, there was extensive speculation on just how serious the accident might turn out to be. At various times, senior officials of the NRC and the state government were considering the possibility of a major evacuation. There were a number of advisories recommending steps short of a full evacuation. Some significant fraction of the population in the immediate vicinity voluntarily left the region. NRC officials contributed to the raising of anxiety in the period from Friday to Sunday (March 30-April 1). On Friday, a mistaken interpretation of the release of a burst of radiation led some NRC officials to recommend immediate evacuation. And on Friday Governor Thornburgh advised pregnant women and preschool aged children within 5 miles of TMI to leave the area. On Saturday and Sunday, other NRC officials mistakenly believed that there was an imminent danger of an explosion of a hydrogen bubble within the reactor vessel, and evacuation was again a major subject of discussion.

We conclude that the most serious health effect of the accident was severe mental stress, which was short-lived. The highest levels of distress were found among those living within 5 miles of TMI and in families with preschool children.

There was very extensive damage to the plant. While the reactor itself has been brought to a "cold shutdown," there are vast amounts of radioactive material trapped within the containment and auxiliary buildings. The utility is therefore faced with a massive cleanup process that carries its own potential dangers to public health. The ongoing cleanup operation at TMI demonstrates that the plant was inadequately designed to cope with the cleanup of a damaged plant. The direct financial cost of the accident is enormous. Our best estimate puts it in a range of $1 to $2 billion, even if TMI-2 can be put back into operation. (The largest portion of this is for replacement power estimated for the next few years.) And since it may not be possible to put it back into operation, the cost could even be much larger.

The accident raised concerns all over the world and led to a lowering of public confidence in the nuclear industry and in the NRC.

From the beginning, we felt it important to determine not only how serious the actual impact of the accident was on public health, but whether we came close to a catastrophic accident in which a large number of people would have died. Issues that had to be examined were whether a chemical (hydrogen) or steam explosion could have ruptured the reactor vessel and containment building, and whether extremely hot molten fuel

could have caused severe damage to the containment. The danger was never -- and could not have been -- that of a nuclear explosion (bomb).

We have made a conscientious effort to get an answer to this difficult question. Since the accident was due to a complex combination of minor equipment failures and major inappropriate human actions, we have asked the question: "What if one more thing had gone wrong?"

We explored each of several different scenarios representing a change in the sequence of events that actually took place. The greatest concern during the accident was that significant amounts of radioactive material (especially radioactive iodine) trapped within the plant might be released. Therefore, in each case, we asked whether the amount released would have been smaller or greater, and whether large amounts could have been released.

Some of these scenarios lead to a more favorable outcome than what actually happened. Several other scenarios lead to increases in the amount of radioactive iodine released, but still at levels that would not have presented a danger to public health. But we have also explored two or three scenarios whose precise consequences are much more difficult to calculate. They lead to more severe damage to the core, with additional melting of fuel in the hottest regions. These consequences are, surprisingly, independent of the age of the fuel.

Because of the uncertain physical condition of the fuel, cladding, and core, we have explored certain special and severe conditions that would, unequivocally, lead to a fuel-melting accident. In this sequence of events fuel melts, falls to the bottom of the vessel, melts through the steel reactor vessel, and finally, some fuel reaches the floor of the containment building below the reactor vessel where there is enough water to cover the molten fuel and remove some of the decay heat. To contain such an accident, it is necessary to continue removing decay heat for a period of many months.

At this stage we approach the limits of our engineering knowledge of the interactions of molten fuel, concrete, steel, and water, and even the best available calculations have a degree of uncertainty associated with them. Our calculations show that even if a meltdown occurred, there is a high probability that the containment building and the hard rock on which the TMI-2 containment building is built would have been able to prevent the escape of a large amount of radioactivity. These results derive from very careful calculations, which hold only insofar as our assumptions are valid. We cannot be absolutely certain of these results.

Some of the limits of this investigation were: (1) We have not examined possible consequences of operator error during or after the fuel melting process which might compromise the effectiveness of containment; (2) We have not examined the vulnerability of the various electrical and plumbing penetrations through the walls or the doorways for people and equipment; (3) The analysis was specific to the TMI-2 design and location (for example, the bedrock under the plant); (4) We

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recognize that we have only explored a limited number of alternatives to the question "What if . . .?" and, others may come up with a plausible scenario whose results would have been even more serious.

We strongly urge that research be carried out promptly to identify and analyze the possible consequences of accidents leading to severe core damage. Such knowledge is essential for coping with results of future accidents. It may also indicate weaknesses in present designs, whose correction would be important for the prevention of serious accidents.

These uncertainties have not prevented us from reaching an overwhelming consensus on corrective measures. Our reasoning is as follows: Whether in this particular case we came close to a catastrophic accident or not, this accident was too serious. Accidents as serious as TMI should not be allowed to occur in the future.

The accident got sufficiently out of hand so that those attempting to control it were operating somewhat in the dark. While today the causes are well understood, 6 months after the accident it is still difficult to know the precise state of the core and what the conditions are inside the reactor building. Once an accident reaches this stage, one that goes beyond well-understood principles, and puts those controlling the accident into an experimental mode (this happened during the first day), the uncertainty of whether an accident could result in major releases of radioactivity is too high. Adding to this the enormous damage to the plant, the expensive and potentially dangerous cleanup process that remains, and the great cost of the accident, we must conclude that -- whatever worse could have happened -- the accident had already gone too far to make it tolerable.

While throughout this entire document we emphasize that fundamental changes are necessary to prevent accidents as serious as TMI, we must not assume that an accident of this or greater seriousness cannot happen again, even if the changes we recommend are made. Therefore, in addition to doing everything to prevent such accidents, we must be fully prepared to minimize the potential impact of such an accident on public health and safety, should one occur in the future.

HANDLING OF THE EMERGENCY

Another area of our investigation dealt with the questions of whether various agencies made adequate preparations for an emergency and whether their responses to the emergency were satisfactory. Our finding is negative on both questions.

We are disturbed both by the highly uneven quality of emergency plans and by the problems created by multiple jurisdictions in the case of a radiation emergency. Most emergency plans rely on prompt action at the local level to initiate a needed evacuation or to take other protective action. We found an almost total lack of detailed plans in the local communities around Three Mile Island. It is one of the many ironies of this event that the most relevant planning by local

authorities took place during the accident. In an accident in which prompt defensive steps are necessary within a matter of hours, insufficient advance planning could prove extremely dangerous.

We favor the centralization of emergency planning and response in a single agency at the federal level with close coordination between it and state and local agencies. Such agencies would need expert input from many other organizations, but there should be a single agency that has the responsibility both for assuring that adequate planning takes place and for taking charge of the response to the emergency. This will require organizational changes, since the agencies now best organized to deal with emergencies tend to have most of their experience with such events as floods and storms, rather than with radiological events. And, insofar as radiological events require steps that go beyond those in a normal emergency, careful additional planning is needed.

A central concept in the current siting policy of the NRC is that reactors should be located in a "low population zone" (LPZ), an area around the plant in which appropriate protective action could be taken for the residents in the event of an accident. However, this concept is implemented in a strange, unnatural, and round-about manner. To determine the size of the LPZ, the utility calculates the amount of radiation released in a very serious hypothetical accident. Using geographical and meteorological data, the utility then calculates that area within which an individual would receive 25,000 millirems or more to the whole body, during the entire course of the accident. This area is the LPZ. The 25,000-millirem standard is an extremely large dose, many times more serious than that received by any individual during the entire TMI accident.

The LPZ approach has serious shortcomings. First, because of the extremely large dose by which its size is determined, the LPZs for many nuclear power plants are relatively small areas, 2 miles in the case of TMI. Second, if an accident as serious as the one used to calculate the LPZ were actually to occur, it is evident that many people living outside the LPZ would receive smaller, but still massive doses of radiation. Third, the TMI accident shows that the LPZ has little relevance to the protection of the public -- the NRC itself was considering evacuation distances as far as 20 miles, even though the accident was far less serious than those postulated during siting. We have therefore concluded that the entire concept is flawed.

We recommend that the LPZ concept be abandoned in siting and in emergency planning. A variety of possible accidents should be considered during siting, particularly "smaller" accidents which have a higher probability of occurring. For each such accident, one should calculate probable levels of radiation releases at a variety of distances to decide the kinds of protective action that are necessary and feasible. Such protective actions may range from evacuation of an area near the plant, to the distribution of potassium iodide to protect the thyroid gland from radioactive iodine, to a simple instruction to people several miles from the plant to stay indoors for a specified period of time. Only such an analysis can predict the true consequences

of a radiological incident and determine whether a particular site is suitable for a nuclear power plant. Similarly, emergency plans should have built into them a variety of responses to a variety of possible kinds of accidents. State and local agencies must be prepared with the appropriate response once information is available on the nature of an accident and its likely levels of releases.

The response to the emergency was dominated by an atmosphere of almost total confusion. There was lack of communication at all levels. Many key recommendations were made by individuals who were not in possession of accurate information, and those who managed the accident were slow to realize the significance and implications of the events that had taken place. While we have attempted to address these shortcomings in our recommendations, it is important to reiterate the fundamental philosophy we stated above: One must do everything possible to prevent accidents of this seriousness, but at the same time assume that such an accident may occur and be prepared for response to the resulting emergency. The fact that too many individuals and organizations were not aware of the dimensions of serious accidents at nuclear power plants accounts for a great deal of the lack of preparedness and the poor quality of the response.

PUBLIC AND WORKER HEALTH AND SAFETY

We have identified a number of inadequacies with respect to procedures and programs to prevent or minimize hazards to health from radiation exposure from the operations of nuclear power plants. In setting standards for permissible levels of worker exposure to radioactivity, in plant siting decisions, and in other areas related to health, the NRC is not required to, and does not regularly seek, advice or review of its health-related guidelines and regulations from other federal agencies with radiation-related responsibilities in the area of health, for example the Department of Health, Education, and Welfare (HEW) or the Environmental Protection Agency (EPA). There is inadequate knowledge of the effects of low levels of ionizing radiation, of strategies to mitigate the health hazards of exposure to radiation, and of other areas relating to regulation setting to protect worker and public health. In preparation for a possible emergency such as the accident at TMI-2, various federal agencies (NRC, Department of Energy, HEW, and EPA) have assigned responsibilities, but planning prior to the accident was so poor that ad hoc arrangements among these federal agencies had to be made to involve them and coordinate their activities.

The Commonwealth of Pennsylvania, its Bureau of Radiation Protection and Department of Health -- agencies with responsibilities for public health -- did not have adequate resources for dealing with radiation health programs related to the operation of TMI. The utility was not required to, and did not, keep a record on workers of the total work-related plus non-work-related (for example, medical or dental) radiation exposure.

We make recommendations with respect to improving the coordination and collaboration among federal and state agencies with radiation-related

responsibilities in the health area. We believe more emphasis is required on research on the health effects of radiation to provide a sounder basis for guidelines and regulations related to worker and public health and safety. We believe that both the state and the utility have an opportunity and an obligation to establish more rigorous programs for informing workers and the public on radiation health-related issues and procedures to prevent adverse health effects of radiation.

RIGHT TO INFORMATION

The President asked us to investigate whether the public's right to information during the emergency was well served. Our conclusion is again in the negative. However, here there were many different causes, and it is both harder to assign proper responsibility and more difficult to come up with appropriate recommendations. There were serious problems with the sources of information, with how this information was conveyed to the press, and also with the way the press reported what it heard.

We do not find that there was a systematic attempt at a "cover-up" by the sources of information. Some of the official news sources were themselves confused about the facts and there were major disagreements among officials. On the first day of the accident, there was an attempt by the utility to minimize its significance, in spite of substantial evidence that it was serious. Later that week, NRC was the source of exaggerated stories. Due to misinformation, and in one case (the hydrogen bubble) through the commission of scientific errors, official sources would make statements about radiation already released (or about the imminent likelihood of releases of major amounts of radiation) that were not justified by the facts -- at least not if the facts had been correctly understood. And NRC was slow in confirming good news about the hydrogen bubble. On the other hand, the estimated extent of the damage to the core was not fully revealed to the public.

A second set of problems arose from the manner in which the facts were presented to the press. Some of those who briefed the press lacked the technical expertise to explain the events and seemed to be cut off from those who could have provided this expertise. When those who did have the knowledge spoke, their statements were often couched in "jargon" that was very difficult for the press to understand. The press was further disturbed by the fact that, in order to cut down on the amount of confusion, a number of potential sources of information were instructed not to give out information. While this cut down on the amount of confusion, it flew in the face of the long tradition of the press of checking facts with multiple sources.

Many factors contributed to making this event one of the most heavily covered media events ever. Given these circumstances, the media generally attempted to give a balanced presentation which would not contribute to an escalation of panic. There were, however, a few notable examples of irresponsible reporting and some of the visual images used in the reporting tended to be sensational.

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Another severe problem was that even personnel representing the major national news media often did not have sufficient scientific and engineering background to understand thoroughly what they heard, and did not have available to them people to explain the information. This problem was most serious in the reporting of the various releases of radiation and the explanation of the severity (or lack of severity) of these releases. Many of the stories were so garbled as to make them useless as a source of information.

We therefore conclude that, while the extent of the coverage was justified, a combination of confusion and weakness in the sources of information and lack of understanding on the part of the media resulted in the public being poorly served.

In considering the handling of information during the nuclear accident, it is vitally important to remember the fear with respect to nuclear energy that exists in many human beings. The first application of nuclear energy was to atomic bombs which destroyed two major Japanese cities. The fear of radiation has been with us ever since and is made worse by the fact that, unlike floods or tornadoes, we can neither hear nor see nor smell radiation. Therefore, utilities engaged in the operation of nuclear power plants, and news media that may cover a possible nuclear accident, must make extraordinary preparation for the accurate and sensitive handling of information.

There is a natural conflict between the public's right to know and the need of disaster managers to concentrate on their vital tasks without distractions. There is no simple resolution for this conflict. But significant advance preparation can alleviate the problem. It is our judgment that in this case, neither the utility nor the NRC nor the media were sufficiently prepared to serve the public well.

THE NUCLEAR REGULATORY COMMISSION

We had a broad mandate from the President to investigate the Nuclear Regulatory Commission. When NRC was split off from the old Atomic Energy Commission, the purpose of the split was to separate the regulators from those who were promoting the peaceful uses of atomic energy. We recognize that the NRC has an assignment that would be difficult under any circumstances. But, we have seen evidence that some of the old promotional philosophy still influences the regulatory practices of the NRC. While some compromises between the needs of safety and the needs of an industry are inevitable, the evidence suggests that the NRC has sometimes erred on the side of the industry's convenience rather than carrying out its primary mission of assuring safety.

Two of the most important activities of NRC are its licensing function and its inspection and enforcement (I&E) activities. We found serious inadequacies in both.

In the licensing process, applications are only required to analyze "single-failure" accidents. They are not required to analyze what

happens when two systems fail independently of each other, such as the event that took place at TMI. There is a sharp delineation between those components in systems that are "safety-related" and those that are not. Strict reviews and requirements apply to the former; the latter are exempt from most requirements -- even though they can have an effect on the safety of the plant. We feel that this sharp either/or definition is inappropriate. Instead, there should be a system of priorities as to how significant various components and systems are for the overall safety of the plant. There seems to be a persistent assumption that plants can be made sufficiently safe to be "people-proof." Thus, not enough attention is paid to the training of operating personnel and operator procedures in the licensing process. And, finally, plants can receive an operating license with several safety issues still unresolved. This places such a plant into a regulatory "limbo" with jurisdiction divided between two different offices within NRC. TMI-2 was in this status at the time of the accident, 13 months after it received its operating license.

NRC's primary focus is on licensing and insufficient attention has been paid to the ongoing process of assuring nuclear safety. An important example of this is the case of "generic problems," that is, problems that apply to a number of different nuclear power plants. Once an issue is labeled "generic," the individual plant being licensed is not responsible for resolving the issue prior to licensing. That, in itself, would be acceptable, if there were a strict procedure within NRC to assure the timely resolution of generic problems, either by its own research staff, or by the utility and its suppliers. However, the evidence indicates that labeling of a problem as "generic" may provide a convenient way of postponing decision on a difficult question.

The old AEC attitude is also evident in reluctance to apply new safety standards to previously licensed plants. While we would accept a need for reasonable timetables for "backfitting," we did not find evidence that the need for improvement of older plants was systematically considered prior to Three Mile Island.

The existence of a vast body of regulations by NRC tends to focus industry attention narrowly on the meeting of regulations rather than on a systematic concern for safety. Furthermore, the nature of some of the regulations, in combination with the way rate bases are established for utilities, may in some instances have served as a deterrent for utilities or their suppliers to take the initiative in proposing measures for improved safety.

Previous studies of I&E have criticized this branch severely. Inspectors frequently fail to make independent evaluations or inspections. The manual according to which inspectors are supposed to operate is so voluminous that many inspectors do not understand precisely what they are supposed to do. There have been a number of incidents in which inspectors have had difficulty in getting their superiors to concentrate on serious safety issues. The analysis of reported incidents by licensees has tended to concentrate on equipment malfunction, and serious operator errors have not been focused on.

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Finally, while the statutory authority to impose fines is fairly limited, a previous study shows that I&E has made minimal use of even this authority.

Since in many cases NRC does not have the first-hand information necessary to enforce its regulations, it must rely heavily on the industry's own records for its inspection and enforcement activities. NRC accumulates vast amounts of information on the operating experience of plants. However, prior to the accident there was no systematic method of evaluating these experiences, and no systematic attempt to look for patterns that could serve as a warning of a basic problem.

NRC is vulnerable to the charge that it is heavily equipment-oriented, rather than people-oriented. Evidence for this exists in the weak and understaffed branch of NRC that monitors operator training, in the fact that inspectors who investigate accidents concentrate on what went wrong with the equipment and not on what operators may have done incorrectly, in the lack of attention to the quality of procedures provided for operators, and in an almost total lack of attention to the interaction between human beings and machines.

In addition to all the other problems with the NRC, we are extremely critical of the role the organization played in the response to the accident. There was a serious lack of communication among the commissioners, those who were attempting to make the decisions about the accident in Bethesda, the field offices, and those actually on site. This lack of communication contributed to the confusion of the accident. We are also skeptical whether the collegial mode of the five commissioners makes them a suitable body for the management of an emergency, and of the agency itself.

We found serious managerial problems within the organization. These problems start at the very top. It is not clear to us what the precise role of the five NRC commissioners is, and we have evidence that they themselves are not clear on what their role should be. The huge bureaucracy under the commissioners is highly compartmentalized with insufficient communication among the major offices. We do not see evidence of effective managerial guidance from the top, and we do see evidence of some of the old AEC promotional philosophy in key officers below the top. The management problems have been made much harder by adoption of strict rules that prohibit the commissioners from talking with some of their key staff on issues involved in the licensing process; we believe that these rules have been applied in an unnecessarily severe form within this particular agency. The geographic spread, which places top management in Washington and most of the staff in Bethesda and Silver Spring, Maryland (and in other parts of the country), also inhibits the easy exchange of ideas.

We therefore conclude that there is no well-thought-out, integrated system for the assurance of nuclear safety within the current NRC.

We have found evidence of repeated in-depth studies and criticisms both from within the agency and from without, but we found very little

evidence that these studies have resulted in significant improvement. This fact gives us particular concern for the future of the present NRC.

For all these reasons we recommend a total restructuring of the NRC. We recommend that it be an independent agency within the executive branch, headed by a single administrator, who is in every sense chief executive officer, to be chosen from outside NRC. The new administrator must be provided with the freedom to reorganize and to bring new blood into the restructured NRC's staff. This new blood could result in the change of attitudes that is vital for the solution of the problems of the nuclear industry.

We have also recommended a number of other organizational and procedural changes designed to make the new agency truly effective in assuring the safety of nuclear power plants. Included in these are an oversight committee to monitor the performance of the restructured NRC and mandatory review by HEW of radiation-related health issues.

THE UTILITY

When the decision was made to make nuclear power available for the commercial generation of energy, it was placed into the hands of the existing electric utilities. Nuclear power requires management qualifications and attitudes of a very special character as well as an extensive support system of scientists and engineers. We feel that insufficient attention was paid to this by the General Public Utilities Corporation (GPU).

There is a divided system of decision-making within GPU and its subsidiaries. While the utility has legal responsibility for a wide range of fundamental decisions, from plant design to operator training, some utilities have to rely heavily on the expertise of their suppliers and on the Nuclear Regulatory Commission. Our report contains a number of examples where this divided responsibility, in the case of TMI, may have led to less than optimal design and operating practices. For example, we have received contradictory testimony on how the criteria under which the containment building isolates were selected. Similarly, the design of the control room seems to have been a compromise among of the utility, its parent company, the architect-engineer, and the nuclear steam system supplier (with very little attention from the NRC). But the clearest example of the shortcomings of divided responsibility is the area of operator training.

The legal responsibility for training operators and supervisors for safe operation of nuclear power plants rests with the utility. However, Met Ed, the GPU subsidiary which operates TMI, did not have sufficient expertise to carry out this training program without outside help. They, therefore, contracted with Babcock & Wilcox, supplier of the nuclear steam system, for various portions of this training program. While B&W has substantial expertise, they had no responsibility for the quality of the total training program, only for carrying out the contracted portion. And coordination between the training programs of the two companies was extremely loose. For example, the B&W instructors were not aware of the precise operating procedures in effect at the plant.

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A key tool in the B&W training is a "simulator," which is a mock control console that can reproduce realistically events that happen within a power plant. The simulator differs in certain significant ways from the actual control console. Also, the simulator was not programmed, prior to March 28, to reproduce the conditions that confronted the operators during the accident.

We found that at both companies, those most knowledgeable about the workings of the nuclear power plant have little communication with those responsible for operator training, and therefore, the content of the instructional program does not lead to sufficient understanding of reactor systems.

It is our conclusion that the role that the NRC plays in monitoring operator training contributes little and may actually aggravate the problem. NRC has a limited staff for supervising operator licensing, and many of these do not have actual experience in power plants. Therefore, NRC activities are limited to the administration of fairly routine licensing examinations and the spotchecking of requalification exams and training programs. In evaluating the training of operators to carry out emergency procedures, NRC failed to recognize basic faults in the procedures in existence at TMI. Since the utility has the tendency of equating the passing of an NRC examination with the satisfactory training of operators, NRC may be perpetuating a level of mediocrity.

The way that NRC evaluates the safety of proposed plants during the licensing process has a most unfortunate impact on the way operators are trained. Since during the licensing process applicants for licenses concentrate on the consequences of single failures, there is no attempt in the training program to prepare operators for accidents in which two systems fail independently of each other.

There were significant deficiencies in the management of the TMI-2 plant. Shift foremen were burdened with paper work not relevant to supervision and could not adequately fulfill their supervisory roles. There was no systematic check on the status of the plant and the line-up of valves when shifts changed. Surveillance procedures were not adequately supervised. And there were weaknesses in the program of quality assurance and control.

We agree that the utility that operates a nuclear power plant must be held legally responsible for the fundamental design and procedures that assure nuclear safety. However, the analysis of this particular accident raises the serious question of whether all electric utilities automatically have the necessary technical expertise and managerial capabilities for administering such a dangerous high-technology plant. We, therefore, recommend the development of higher standards of organization and management that a company must meet before it is granted a license to operate a nuclear power plant.

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THE TRANSITION

We recognize that even with the most expeditious process for implementation, recommendations as sweeping as ours will take a significant amount of time to implement. Therefore, the Commission had to face the issue of what should be done in the interim with plants that are currently operating and those that are going through the licensing process.

The Commission unanimously voted:

> Because safety measures to afford better protection for the affected population can be drawn from the high standards for plant safety recommended in this report, the NRC or its successor should, on a case-by-case basis, before issuing a new construction permit or operating license: (a) assess the need to introduce new safety improvements recommended in this report, and in NRC and industry studies; (b) review, considering the recommendations set forth in this report, the competency of the prospective operating licensee to manage the plant and the adequacy of its training program for operating personnel; and (c) condition licensing upon review and approval of the state and local emergency plans.

A WARNING

During the time that our Commission conducted its investigation, a number of other reports appeared with recommendations for improved safety in nuclear power plants. While we are generally aware of the nature of these recommendations, we have not attempted a systematic analysis of them. Insofar as other agencies may have reached similar conclusions and proposed similar remedies, several groups arriving at the same conclusion should reinforce the weight of these conclusions.

But we have an overwhelming concern about some of the reports we have seen so far. While many of the proposed "fixes" seem totally appropriate, they do not come to grips with what we consider to be the basic problem. We have stated that fundamental changes must occur in organizations, procedures, and, above all, in the attitudes of people. No amount of technical "fixes" will cure this underlying problem. There have been many previous recommendations for greater safety for nuclear power plants, which have had limited impact. What we consider crucial is whether the proposed improvements are carried out by the same organizations (unchanged), with the same kinds of practices and the same attitudes that were prevalent prior to the accident. As long as proposed improvements are carried out in a "business as usual" atmosphere, the fundamental changes necessitated by the accident at Three Mile Island cannot be realized.

OVERVIEW

We believe that we have conscientiously carried out the mandate of the President of the United States, within our limits as human beings and within the limitations of the time allowed us. We have not found a magic formula that would guarantee that there will be no serious future nuclear accidents. Nor have we come up with a detailed blueprint for nuclear safety. And our recommendations will require great efforts by others to translate them into effective plans.

Nevertheless, we feel that our findings and recommendations are of vital importance for the future of nuclear power. We are convinced that, unless portions of the industry and its regulatory agency undergo fundamental changes, they will over time totally destroy public confidence and, hence, they will be responsible for the elimination of nuclear power as a viable source of energy.

A. Assessment of Significant Events

B. Health Effects

C. Public Health

D. Emergency Response

E. The Utility and Its Suppliers

F. Training of Operating Personnel

G. The Nuclear Regulatory Commission

H. The Public's Right to Information

COMMISSION FINDINGS

The President's Commission on the Accident at Three Mile Island, after conducting a study and investigation into the events of that accident and the conditions existing prior to the accident, finds and concludes*/:

> To prevent nuclear accidents as serious as Three Mile Island, fundamental changes will be necessary in the organization, procedures, and practices -- and above all -- in the attitudes of the Nuclear Regulatory Commission and, to the extent that the institutions we investigated are typical, of the nuclear industry.

A. ASSESSMENT OF SIGNIFICANT EVENTS

1. The accident at Three Mile Island (TMI) occurred as a result of a series of human, institutional, and mechanical failures.

2. Equipment failures initiated the events of March 28 and contributed to the failure of operating personnel (operators, engineers, and supervisors) to recognize the actual conditions of the plant. Their training was deficient and left them unprepared for the events that took place. (See finding F.) These operating personnel made some improper decisions, took some improper actions, and failed to take some correct actions, causing what should have been a minor incident to develop into the TMI-2 accident.

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*/ "Supplemental Views" from Commissioners are available and will be included in the permanent edition of the Commission's report.

COMMISSION FINDINGS

3. The pilot-operated relief valve (PORV) at the top of the pressurizer opened as expected when pressure rose but failed to close when pressure decreased, thereby creating an opening in the primary coolant system -- a small-break loss-of-coolant accident (LOCA).*/ The PORV indicator light in the control room showed only that the signal had been sent to close the PORV rather than the fact that the PORV remained open. The operators, relying on the indicator light and believing that the PORV had closed, did not heed other indications and were unaware of the PORV failure; the LOCA continued for over 2 hours. The TMI-2 emergency procedure for a stuck-open PORV did not state that unless the PORV block valve was closed, a LOCA would exist. Prior to TMI, the NRC had paid insufficient attention to LOCAs of this size and the probability of their occurrence in licensing reviews. Instead, the NRC focused most of its attention on large-break LOCAs.

4. The high pressure injection system (HPI) -- a major design safety system -- came on automatically. However, the operators were conditioned to maintain the specified water level in the pressurizer and were concerned that the plant was "going solid," that is, filled with water. Therefore, they cut back HPI from 1,000 gallons per minute to less than 100 gallons per minute. For extended periods on March 28, HPI was either not operating or operating at an insufficient rate. This led to much of the core being uncovered for extended periods on March 28 and resulted in severe damage to the core. If the HPI had not been throttled, core damage would have been prevented in spite of a stuck-open PORV.

5. TMI management and engineering personnel also had difficulty in analyzing events. Even after supervisory personnel took charge, significant delays occurred before core damage was fully recognized, and stable cooling of the core was achieved.

6. Some of the key TMI-2 operating and emergency procedures in use on March 28 were inadequate, including the procedures for a LOCA and for pressurizer operation. Deficiencies in these procedures could cause operator confusion or incorrect action.

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*/ For a definition of loss-of-coolant accident and other technical terms used in the Commission's report, see the Glossary at the back of this volume.

COMMISSION FINDINGS

7. Several earlier warnings that operators needed clear instructions for dealing with events like those during the TMI accident had been disregarded by Babcock & Wilcox (B&W) and the Nuclear Regulatory Commission (NRC).

a. In September 1977, an incident occured at the Davis-Besse plant, also equipped with a B&W reactor. During that incident, a PORV stuck open and pressurizer level increased, while pressure fell. Although there were no serious consequences of that incident, operators had improperly interfered with the HPI, apparently relying on rising pressurizer level. The Davis-Besse plant had been operating at only 9 percent power and the PORV block valve was closed approximately 20 minutes after the PORV stuck open. That incident was investigated by both B&W and the NRC, but no information calling attention to the correct operator actions was provided to utilities prior to the TMI accident. A B&W engineer had stated in an internal B&W memorandum written more than a year before the TMI accident that if the Davis-Besse event had occurred in a reactor operating at full power, "it is quite possible, perhaps probable, that core uncovery and possible fuel damage would have occurred."

b. An NRC official in January 1978 pointed out the likelihood for erroneous operator action in a TMI-type incident. The NRC did not notify utilities prior to the accident.

c. A Tennesse Valley Authority (TVA) engineer analyzed the problem of rising pressurizer level and falling pressure more than a year before the accident. His analysis was provided to B&W, NRC, and the Advisory Committee on Reactor Safeguards. Again no notification was given to utilities prior to the accident.

8. The control room was not adequately designed with the management of an accident in mind. (See also finding G.8.e.) For example:

a. Burns and Roe, the TMI-2 architect-engineer, had never systematically evaluated control room design in the context of a serious accident to see how well it would serve in emergency conditions.

b. The information was presented in a manner which could confuse operators:

(i) Over 100 alarms went off in the early stages of the accident with no way of suppressing the unimportant ones and identifying the important ones. The danger of having too many alarms was recognized by Burns and Roe during the design stage, but the problem was never resolved.

(ii) The arrangement of controls and indicators was not well thought out. Some key indicators relevant to the accident were on the back of the control panel.

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(iii) Several instruments went off-scale during the course of the accident, depriving the operators of highly significant diagnostic information. These instruments were not designed to follow the course of an accident.

(iv) The computer printer registering alarms was running more than 2-½ hours behind the events and at one point jammed, thereby losing valuable information.

c. After an April 1978 incident, a TMI-2 control room operator complained to his superiors about problems with the control room. No corrective action was taken by the utility.

9. In addition to the normal instrumentation present in the control room at the time of the accident, TMI-2 was equipped with a special data recorder that B&W had temporarily installed during the plant start-up and never removed. This data recorder, called a reactimeter, preserved a large amount of information useful in post-accident analysis. This type of data recorder was not required as standard equipment by the NRC.

10. Those managing the accident were unprepared for the significant amount of hydrogen generated during the accident. Indeed, during the TMI-2 licensing process which concentrated on large-break LOCAs, the utility represented and the NRC agreed that in the event of a large-break LOCA, the hydrogen concentration in containment would not be significant for a period of weeks. In the first 10 hours of the TMI accident (a small-break LOCA), enough hydrogen was produced in the core by a reaction between steam and the zirconium cladding and then released to containment to produce a burn or an explosion that caused pressure to increase by 28 pounds per square inch in the containment building. Thus, TMI illustrated a situation where NRC emphasis on large breaks did not cover the effects observed in a smaller accident.

11. Iodine filters in the auxiliary and fuel handling buildings did not perform as designed because the charcoal filtering capacity was apparently partially expended due to improper use before the accident. Required testing of filter effectiveness for the fuel handling building had been waived by the NRC. There were no testing requirements to verify auxiliary building filter effectiveness.

12. The nature and extent of damage to the core is not likely to be known with assurance until the core materials are recovered and carefully examined. However:

a. We estimate that there were failures in the cladding around 90 percent of the fuel rods. The interaction of the very hot cladding with water generated somewhere between 1,000 and 1,300 pounds of hydrogen gas and converted 44 to 63 percent of the zirconium to relatively weak zirconium oxide. As a result of oxidation and embrittlement of the fuel rod cladding, several feet

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of the upper part of the core fell into the gaps between the fuel rods, causing partial blocking of the flow of steam or water that could remove heat from the damaged fuel.

b. Fuel temperatures may have exceeded 4,000°F in the upper 30 to 40 percent of the core (approximately 30 to 40 tons of fuel). Temperatures in parts of the damaged fuel that were not effectively cooled by steam may have reached the melting point of the uranium oxide fuel, about 5,200°F.

c. An NRC study suggests that some of the fuel may have become liquid at temperatures above 3,500°F by dissolving in a zirconium-zirconium oxide mixture. The study estimates that the amount of fuel that may have melted by this process is from zero to a few tons. An independent analysis by Argonne National Laboratory suggests that the formation of such a mixture was unlikely.

d. Substantial fractions of the material in the reactor control rods melted.

e. There is no indication that any core material made contact with the steel pressure vessel at a temperature above the melting point of steel (2,800°F).

13. The total release of radioactivity to the environment from March 28 through April 27 has been established as 13 to 17 curies of iodine and 2.4 million to 13 million curies of noble gases. (The health effects of the radiation released are described in finding B.)

a. Five hundred thousand times as much radioactive iodine (7.5 million curies) was retained in the primary loop. On April 1, 10.6 million curies of iodine were retained in the containment building's water and about 36,000 curies in the containment atmosphere. Four million curies were in the auxiliary building tanks. Almost all of the radioactive iodine released from the fuel was retained in the primary system, containment, and the auxiliary building. Since the accident, most of the short-lived radioactive iodine has decayed and is no longer a danger.

b. No detectable amounts of the long-lived radioactive cesium and strontium escaped to the environment, although considerable quantities of each escaped from the fuel to the water of the primary system, the containment building, and the auxiliary building tanks.

c. Most radioactivity escaping to the environment was in the form of fission gases transported through the coolant let-down/make-up system into the auxiliary building and through the building filters and the vent header to the outside atmosphere.

d. The major release of radioactivity on the morning of March 30 was caused by the controlled, planned venting of the make-up tank into the vent header. The header was known to have a leak.

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14. The process of recovery, cleanup, and waste disposal will be lengthy, costly, and presents its own health dangers. Cleanup of the reactor and auxiliary buildings and disposal of approximately one million gallons of radioactive water, a substantial amount of radioactive gases, and the solid radioactive debris within the reactor vessel remain to be done.

15. The cost of the accident, including this cleanup and a portion of the waste disposal, will be between $1 billion and $1.86 billion, if the plant can be refurbished. If it cannot be refurbished, the total cost will be significantly higher. An independent study prepared for the Commission estimates these costs as follows:

	Low	Medium	High
		(Millions of dollars)	
Refurbish TMI-2			
Emergency Management	$ 120	$ 160	$ 225
Replacement Power*/	678	966	1,128
Plant Refurbishment	249	306	503
Total**/	$1,047	$1,432	$1,856

16. The 1974 WASH 1400 Reactor Safety Study (the Rasmussen Report) analyzed events, equipment failures, and human errors that could happen during reactor accidents, including those associated with the TMI accident. However, NRC has not made systematic use of WASH 1400, a major study commissioned by the Atomic Energy Commission (AEC), in its design review analyses. WASH 1400 showed that small-break LOCAs similar in size to the accident at TMI were much more likely to occur than the design basis large-break LOCAs, and can lead to the same consequences. Further, the probability of occurrence of an accident like that at Three Mile Island was high enough, based on WASH 1400, that since there had been more than 400 reactor years of nuclear power plant operation in the United States, such an accident should have been expected during that period.

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*/ The low case assumes TMI-2 will be returned to service in January 1983, the medium assumes January 1984, and the high assumes January 1985.

**/ The costs associated with health effects have been deleted from this table. The costs projected by the study had a minimal effect on the total costs projected. The Commission believes that the analysis of health effects costs was insufficent to reach the conclusion set out in the study.

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17. The Commission tried to determine what would have happened if certain additional events had occurred during the accident. For a discussion of these scenarios, see the Commission Overview and the technical staff analysis report on "Alternative Event Sequences."

B. HEALTH EFFECTS

1. Based on available dosimetric and demographic information:

a. It is estimated that between March 28 and April 15, the collective dose resulting from the radioactivity released to the population living within a 50-mile radius of the plant was approximately 2,000 person-rems. The estimated annual collective dose to this population from natural background radiation is about 240,000 person-rems. Thus, the increment of radiation dose to persons living within a 50-mile radius due to the accident was somewhat less than one percent of the annual background level. The average dose to a person living within 5 miles of the nuclear plant was calculated to be about 10 percent of annual background radiation and probably was less.

b. The maximum estimated radiation dose received by any one individual in the off-site general population (excluding the plant workers) during the accident was 70 millirems. On the basis of present scientific knowledge, the radiation doses received by the general population as a result of exposure to the radioactivity released during the accident were so small that there will be no detectable additional cases of cancer, developmental abnormalities, or genetic ill-health as a consequence of the accident at TMI.

c. During the period from March 28 to June 30, three TMI workers received radiation doses of about 3 to 4 rems; these levels exceeded the NRC maximum permissible quarterly dose of 3 rems.

d. The process of recovery and cleanup presents additional sources of possible radiation exposure to the workers and the general population.

2. There were deficiencies in instrumentation for measuring the radioactivity released, particularly during the early stages of the accident. However, these deficiencies did not affect the Commission staff's ability to estimate the radiation doses or health effects resulting from the accident.

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3. The health effects of radiation dose levels of a few rems or less are not known. Estimates of the potential health effects of the TMI accident are based on extrapolations from the known health effects of higher levels of radiation.

4. The major health effect of the accident appears to have been on the mental health of the people living in the region of Three Mile Island and of the workers at TMI. There was immediate, short-lived mental distress produced by the accident among certain groups of the general population living within 20 miles of TMI. The highest levels of distress were found among adults a) living within 5 miles of TMI, or b) with preschool children; and among teenagers a) living within 5 miles of TMI, b) with preschool siblings, or c) whose families left the area. Workers at TMI experienced more distress than workers at another plant studied for comparison purposes. This distress was higher among the nonsupervisory employees and continued in the months following the accident.

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C. PUBLIC HEALTH

1. The Nuclear Regulatory Commission has primary responsibility and regulatory authority for health and safety measures as they relate to the operation of commercial nuclear plants. While the NRC has certain requirements in connection with radiation exposure and medical monitoring of workers at nuclear plants, it has no requirements for medical examination of workers other than licensed reactor operators, and even those examinations are only performed to assure that the operators do not have physical or mental conditions that might impair their ability to perform their jobs safely. Metropolitan Edison's (Met Ed) administrative procedures go beyond this NRC requirement and provide that all radiation workers receive routine medical examinations to assess any possible radiation-related illnesses. The NRC only requires monitoring and reporting of radiation exposure for workers who, in the utility's view, are likely to receive doses beyond NRC-specified levels. Met Ed does not keep, and the NRC does not require it to report, a record of the total radiation exposure of workers from both occupational and nonoccupational (for example, medical and dental) sources.

2. The Public Health Service agencies of the U.S. Department of Health, Education, and Welfare (HEW),*/ whose sole mission is protection and promotion of the public health, have very limited responsibilities with respect to radiological health matters relating to the location, construction, and routine operation of commercial nuclear power plants.

3. Although there were designated channels of communication and specific responsibilities assigned for federal agencies responding to the radiological emergency at TMI (for example, Interagency Radiological Assistance Plan), the existence of these channels and responsibilities was generally unknown to many high-level federal officials. In several instances during the course of the accident, some federal agencies were unaware of what other federal agencies were doing in providing support personnel and resources.

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*/ Now the U.S. Department of Health and Human Services.

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4. Research on the biological effects of ionizing radiation is conducted and/or sponsored by a number of federal agencies. In fiscal year 1978, the federal government spent approximately $76.5 million on such research. More than 60 percent of this funding was provided by the U.S. Department of Energy. With the exception of potassium iodide, there are no drugs presently approved by the Food and Drug Administration for the prevention or mitigation of adverse effects of ionizing radiation.

5. States have primary responsibility for protecting the health and safety of their citizens. Pennsylvania public health officials and health-care providers in the TMI area did not have sufficient resources to respond to the potentially serious health consequences of the accident at TMI. Responsibility for radiological protection in Pennsylvania rests with the Department of Environmental Resources (DER). At the time of the accident, the Pennsylvania Department of Health was not organized to respond to radiological emergencies, and maintained no formal liaison with DER on radiological health matters.

6. During the accident, TMI-area hospital administrators found no one at the state level with authority to recommend when to evacuate patients and when to resume normal admitting procedures. The Pennsylvania Secretary of Health viewed his department's role with respect to area hospitals as informational, not advisory.

7. During the first days of the accident, Met Ed did not notify its physicians under contract who would have been responsible for the on-site treatment of injured, contaminated workers during the accident. The emergency radiological medical care training provided to these physicians to provide on-site emergency care to such workers was inadequate.

8. Met Ed experienced several radiation protection problems during the accident: a) the emergency control center for health physics operations and the analytical laboratory to be used in emergencies was located in an area that became uninhabitable in the early hours of the accident; b) there was a shortage of respirators; and c) there was an inadequate supply of uncontaminated air.

9. NRC regulations on health physics education of nuclear power plant workers leaves the details of such things as course content, frequency, and attendance to the discretion of the licensee, subject to NRC inspection. Similarly, NRC regulations for environmental radiological monitoring leaves the details and methods of how these requirements are to be implemented (for example, types of dosimeters, kind of sample analysis) to the discretion of the licensee, subject to NRC inspection and approval.

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D. EMERGENCY RESPONSE

1. Planning for the protection of the public in the event of a radiological release that extends beyond the boundary of TMI was highly complex. It involved the utility and government agencies at the local, state, and federal levels. That complexity posed problems in the case of the accident at Three Mile Island; some of the written plans that existed had not been coordinated and contained different systems for classifying accidents and different guidelines for notifying government officials.

2. In approving sites for reactors, the NRC has required licensees to plan for off-site consequences of radioactive releases only within the "low population zone" (LPZ), an area containing "residents, the total number and density of which are such that there is a reasonable probability that appropriate protective measures could be taken in their behalf in the event of a serious accident." As calculated for the design-basis accident for TMI-2, this zone was a 2-mile radius.

3. Emergency planning had a low priority in the NRC and the AEC before it. There is evidence that the reasons for this included their confidence in designed reactor safeguards and their desire to avoid raising public concern about the safety of nuclear power.

4. The NRC has not made the existence of a state emergency or evacuation plan a condition for plant licensing. A state may voluntarily submit a response plan to NRC for concurrence, and if the plan meets NRC guidelines -- which do not have the force of law -- the state receives a formal letter of concurrence. At the time of the accident, Pennsylvania did not have an NRC concurred-in plan. The NRC concurrence program has been called ineffective by federal and state emergency preparedness officials.

5. The utility has the responsibility to prevent or to mitigate off-site radiation releases and to notify the government agencies designated in its emergency plan in the event that an emergency is declared. Federal, state, and local agencies are responsible for off-site response to radiation releases. At the

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time of the TMI accident, the local and county governments had the primary action role once notified of the emergency. None of the local communities within the 5-mile radius of the plant had emergency plans, and the existing county plans did not include detailed evacuation plans.

6. At all levels of government, planning for the off-site consequences of radiological emergencies at nuclear power plants has been characterized by a lack of coordination and urgency. For example, a federal response plan in preparation since 1974 by federal emergency preparedness agencies was unfinished at the time of the accident because of an interagency jurisdictional dispute and lack of communication. Pennsylvania did not begin to develop a radiological emergency plan until 1975, even though nuclear power plants had been operating within its borders for at least a year prior to that time. People who attempted to generate interest in radiological emergency planning at the local level near TMI found local officials apathetic. Part of the reason for this was the attitude fostered by the NRC regulatory approach, and by Met Ed at the local level, that radiological accidents having off-site consequences beyond the LPZ were so unlikely as not to be of serious concern.

7. Interaction among NRC, Met Ed, and state and local emergency organizations in the development, review, and drill of emergency plans was insufficient to ensure an adequate level of preparedness for a serious radiological incident at TMI.

8. Although NRC personnel were on-site within hours of the declaration of a site emergency and were in constant contact with the utility, the NRC was not able to determine and to understand the true seriousness and nature of the accident for about 2 days, when the fact of extensive core damage and the existence of the hydrogen bubble were generally recognized within NRC.

9. During the first 2-½ days of the accident, communications between the NRC Incident Response Center in Bethesda, Maryland, where the senior management was located, and the site were such that senior management officials found it extremely difficult to obtain up-to-date information. Communications were so poor on Friday morning that the senior management could not and did not develop a clear understanding of conditions at the site. As a result, an evacuation was recommended to the state by the NRC senior staff on the basis of fragmentary and partially erroneous information. Communications did not improve until Harold Denton, designated the sole source of information, arrived on the site and communicated with NRC headquarters, the Governor's office, and the White House by White House communications line.

10. The reality of possible evacuation was quite different from the theoretical planning requirements imposed by the NRC and Pennsylvania before the accident. The 5-mile emergency plans were developed according to a Pennsylvania requirement for emergency planning within a 5-mile radius of nuclear power plants. The Pennsylvania requirement was stricter than that prescribed by NRC,

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which only required TMI to have a plan for a radius to 2 miles. (See finding D.2.) It is known that the consequences of a postulated major release to the atmosphere from a reactor accident could lead to significant doses of radiation being received many tens of miles from the site of the accident. At TMI-2, although the radiation releases were significantly lower than the design-basis accident, evacuation was being considered for distances much greater than 2 miles. During the TMI accident, NRC believed that the consequences of the accident might extend far beyond the 2- or 5-mile radius. As a result, evacuation plans were hurriedly developed for distances of 10 and 20 miles from the plant.

11. During the most critical phase of the accident, the NRC was working under extreme pressure in an atmosphere of uncertainty. The NRC staff was confronted with problems it had never analyzed before and for which it had no immediate solutions. One result of these conditions was the calculational errors concerning the hydrogen bubble, which caused the NRC to misunderstand the true conditions in the reactor for nearly 3 days.

12. On Friday and Saturday, certain NRC officials incorrectly concluded that a hydrogen bubble in the reactor vessel would soon contain enough oxygen to burn or explode. Ignoring correct information supplied by a B&W employee and certain members of its own staff, NRC relied instead upon incorrect information supplied by other members of its staff and by others that sufficient oxygen was being formed from water radiolysis to reach a concentration sufficient for a burn or explosion. Based on this information, the NRC commissioners began formulating new recommendations for evacuation. On Sunday, NRC staffers obtained information from several national laboratories and from General Electric and Westinghouse that sufficient oxygen could not form. The Sunday information ended the concern about oxygen formation and evacuation. This incident suggests that NRC lacks sufficient knowledge and expertise in water radiolysis.

13. The role of the NRC commissioners and their decision-making process during the accident were ill-defined. Although the commissioners on Friday assumed responsibility for making recommendations to the Governor concerning protective action, there was no apparent procedure by which issues and staff recommendations were explored and resolved. The commissioners were preoccupied with matters such as the details of evacuation planning and the drafting of a press release.

14. Existing emergency plans were not designed to meet the demands of a protracted crisis. The plans had no mechanisms for establishing reliable communications among the on-site and the several off-site organizations responsible for various aspects of the emergency response.

15. There were no hospitals within 5 miles of TMI, but there were several hospitals within the expanded, proposed evacuation zones. The NRC estimated that it would be able to give officials a few hours "lead time" for evacuation. But hospital administrators

estimated they would need substantially more time to evacuate patients.

16. During the TMI accident, the actual radiation levels outside the plant were low, but there was uncertainty about the possibility of serious releases on short notice. Federal and state officials disagreed about the nature of the information on which to base evacuation decisions and other protective actions during the emergency. Some officials based their decisions on actual radiation exposure levels, while others based their decisions on concerns about potential releases of large amounts of radioactivity. For example, the Pennsylvania Bureau of Radiation Protection told the Governor on Friday that radiation levels indicated that no protective action of any kind was required; on that same morning, NRC Chairman Hendrie recommended that pregnant women and young children be advised to leave the area near the plant because of his concern about possible releases of radioactivity.

17. At approximately 12:30 p.m., March 30, Governor Thornburgh advised pregnant women and preschool aged children to leave the area within a 5-mile radius of TMI until further notice. A substantial number of other persons, including health professionals, voluntarily left the area around the plant during the weekend of March 30 through April 1. The advisory to pregnant women and preschool children was lifted on April 9.

18. Throughout the accident, the Pennsylvania Emergency Management Agency (PEMA) received reports concerning conditions at the site from the Bureau of Radiation Protection. During the first 2 days of the accident, however, the director of PEMA also received background information on the status of the plant from the Governor's office by attending meetings and press conferences and relayed that information to county organizations, which, in turn, informed the local civil defense directors. Starting Saturday, the PEMA director was no longer included in these meetings with the result that PEMA and county and local civil defense organizations had to rely primarily on the news media for information about conditions at the site. They found this an unsatisfactory source of information and believed that this arrangement compromised their effectiveness in responding to the accident.

19. The TMI emergency plan did not require the utility to notify state or local health authorities in the event of a radiological accident. (See also finding C.7.)

20. For over 25 years, the use of blocking agents such as potassium iodide to prevent the accumulation of radioiodine in the thyroid gland has been known. The effectiveness of potassium iodide administration for thyroid gland protection in the event of releases of radioiodine was recognized by the National Council on Radiation Protection and Measurement in 1977. The Food and Drug Administration authorized use of potassium iodide as a thyroid-blocking agent for the general public in December 1978. However, at the time of the TMI accident, potassium iodide for this use was not commercially available in the United States in

quantities sufficient for the population within a 20-mile radius of TMI. At the time of the accident, Met Ed had no supply of potassium iodide on-site. A crash effort by the federal government and private industry resulted in delivery of substantial supplies of potassium iodide to Pennsylvania within 2 days of the decision to obtain such supplies.

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E. THE UTILITY AND ITS SUPPLIERS

1. In a number of important cases, General Public Utilities Corporation (GPU), Met Ed, and B&W failed to acquire enough information about safety problems, failed to analyze adequately what information they did acquire, or failed to act on that information. Thus, there was a serious lack of communication about several critical safety matters within and among the companies involved in the building and operation of the TMI-2 plant. A similar problem existed in the NRC. (See finding G.)

a. The September 1977 incident at Davis-Besse, another plant with a B&W reactor, foreshadowed several aspects of the TMI-2 accident. A serious warning by a senior engineer at B&W that more precise instructions be given to operators "fell between the cracks." This warning, issued 13 months before the TMI-2 accident, if heeded, could have prevented the accident. (See also finding A.7.a.)

b. Nine times before the TMI accident, PORVs stuck open at B&W plants. B&W did not inform its customers of these failures, nor did it highlight them in its own training program so that operators would be aware that such a failure causes a small-break LOCA.

c. A report by an engineer at TVA questioning how operators might respond to rising pressurizer level and falling pressure was sent to B&W in April 1978. B&W took 9 months to respond and never advised its utility customers of the concern expressed in the report. The concern was similar to the one which B&W itself had identified from the Davis-Besse incident.

d. TMI-2 had repeated problems with the condensate polishers. During the 18-month period before the accident, no effective steps were taken to correct these problems. These polishers probably initiated the March 28 sequence of events.

e. The TMI-2 operators had never had specific training about the dangers of saturation conditions in the core, although they were generally familiar with the concept. Although Met Ed

believed saturation had occurred in an incident a year before the accident that could have led to core uncovery, its hazards were not emphasized to the operators. When saturation occurred again on March 28, operators did not recognize the significance of that fact and take corrective action promptly.

f. After an incident at TMI-2 a year earlier during which the PORV stuck open, an indicator light was installed in the control room. That light showed only that a signal had been sent to close the valve -- it did not show whether the valve was actually closed -- and this contributed to the confusion during the accident. (See finding A.3.)

Timely attention to all of these factors probably would have prevented the accident.

2. The GPU Service Corporation (GPUSC) had final responsibility for design of the plant. However, by its own account, it lacked the staff or expertise in certain areas to discharge that responsibility. Once construction was complete, GPUSC turned the plant over to Met Ed to run, but Met Ed did not have sufficient knowledge, expertise, and personnel to operate the plant or maintain it adequately.

3. Responsibility for management decisions was divided among the TMI site, Met Ed, and GPU. GPU recognized in early 1977 that integration of operating responsibility into one organization was desirable. A management audit by Booz, Allen, and Hamilton completed in the spring of 1977 recommended clarifying and reevaluating the roles of GPUSC and Met Ed in the design and construction of new facilities; strengthening communications between GPUSC and Met Ed; and establishing minimum standards for the safe operation of GPU's nuclear plants. However, integration of management did not occur until after the accident.

4. The Met Ed management systems, procedures, and practices did not provide Met Ed a firm understanding of TMI's operations, nor were effective systems of checks and balances in use.

a. Met Ed had a plan for a quality assurance program that met NRC requirements. The NRC requirements, however, were inadequate because they did not require quality assurance programs to be applied to the plant as a whole, but rather only to systems classified as "safety-related." Neither the PORV nor the condensate polishers were classified as "safety-related." In addition, the NRC did not require the level of independent review (i.e., outside of line management) normally found in the quality assurance programs of safety-critical industries.

b. There was no requirement for an independent (i.e., outside of line management) safety assessment of operating procedures. Independent audit of the performance of surveillance procedures was required only every 2 years.

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c. Met Ed's implementation of its own quality assurance plan was found to contain significant deficiencies by the Commission staff and in an NRC post-accident audit of TMI-2. For example:

(i) There were not enough inspectors to do the inspections required under the Met Ed plan.

(ii) The NRC audit reported deficiencies in maintaining "as built" drawings and in the purchasing of "safety-related" equipment without quality controls.

(iii) Although all plant procedures were required to be reviewed every 2 years, there was no plan for such a review and no review had in fact been made of those TMI-2 procedures that were more than 2 years old.

(iv) Although such inspections were required, Met Ed had not scheduled or conducted any inspections of materials, components, or equipment in storage.

(v) There were deficiencies in the reporting, analysis, and resolution of problems in "safety-related" equipment and other events required to be reported to the NRC.

(vi) Independent assessment of general plant operations was minimal.

d. Met Ed did not go beyond NRC requirements in such areas as:

(i) Requiring reporting, resolution, and trending of problems in plant equipment and procedures which were not "safety-related."

(ii) Applying its quality assurance program to the operation of non-"safety-related" equipment and systems vital to plant operation, consistent with the importance of those systems to safety. For example, no quality assurance review was given to radiation monitoring equipment, control rod drive mechanisms, hydrogen recombiners, the PORV, or condensate polishers. In addition, Met Ed's quality assurance program was not applied to the maintenance or the procedures associated with such non-"safety-related" equipment.

As a result of these deficiencies, the safe operation of the TMI-2 plant was impaired.

5. Utility management did not require attention to detail as a way of life at Three Mile Island. For example:

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a. Management permitted operation of the plant with a number of poor control room practices:

(i) A shift supervisor testified that there had never been less than 52 alarms lit in the control room.

(ii) TMI Commission staff and NRC inspections noted a large number of control room instruments out of calibration and tags hanging on the instrument panel indicating equipment out of service. Operators testified that one of these tags obscured one of the emergency feedwater block control valve indicator lights.

(iii) When shifts changed in the control room, there was no systematic check on the status of the plant and the line-up of valves.

b. There were deficiencies in the review, approval, and implementation of TMI-2 plant procedures.

(i) Although Met Ed procedures required closing the PORV block valve when temperatures in the tailpipe exceeded 130°F, the block valve had not been closed at the time of the accident even though temperatures had been well above 130°F in the tailpipe for weeks.

(ii) Operators were not given adequate information about temperatures to be expected in the PORV tailpipe after the PORV opened.

(iii) A 1978 B&W analysis of a certain kind of small-break LOCA was misinterpreted by Met Ed. That misinterpretation was incorporated by Met Ed into the LOCA emergency procedure available at the time of the accident.

(iv) Operating and emergency procedures that had been approved by Met Ed and were in use at the time of the accident contained many minor substantive errors, typographical errors, and imprecise or sloppy terminology. Some were inadequate. (See finding A.6.)

(v) A 1978 revision in the TMI-2 surveillance procedure for the emergency feedwater block valves violated TMI-2's technical specifications, but no one realized it at the time. The approval of the revision in the surveillance procedure was not done according to Met Ed's own administrative procedures.

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(vi) Performance of surveillance tests was not adequately verified to be sure that the procedures were followed correctly. On the day of the accident, emergency feedwater block valves which should have been open were closed. They may have been left closed during a surveillance test 2 days earlier.

c. There were deficiencies in maintenance:

(i) After the accident, valves in the TMI-1 containment building exhibited long-term lack of maintenance. Boron stalactites more than a foot long hung from the valves and stalagmites had built up from the floor.

(ii) Review of equipment history for the 6 months prior to the accident showed that a number of equipment items that figured in the accident had had a poor maintenance history without adequate corrective action. These included the pressurizer level transmitter, the hydrogen recombiner, pressurizer heaters, make-up pump switches, and the condensate polishers.

(iii) Despite a history of problems with the condensate polishers, procedures were not changed to ensure that operators would bypass the polishers during maintenance operations to protect the plant from a possible malfunction of the polisher.

d. After the accident, radiological control practices were observed to be deficient. Contaminated and potentially contaminated equipment was found in uncontrolled areas of the auxiliary building.

e. Training of operators and supervisors did not give sufficient emphasis to a fundamental understanding of the reactor. There was no comprehensive evaluation of operator performance on the job to meet the requalification requirements of 10 CFR 55. (See finding F.)

f. Reports of operating experience at other plants were screened by technical analysts who did not have nuclear backgrounds. They were given no instruction in how to screen such operating reports, according to Station Manager Gary Miller. The technical analysts routed experience summaries to designated people at TMI. The routing sometimes took several months. The person in the training department who was assigned to review these summaries often did not get to them for several months after he received them because of the press of other work. The training department held only one 2-hour class per year on operating experience at other plants.

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g. There was no group with special responsibility for receiving and acting upon potential safety concerns raised by employees.

h. Management did not assure adequate identification of piping and valves throughout the plant. The Commission staff noted that pipe and valve identification practices were significantly below standard industrial practices. Eight hours into the accident, Met Ed personnel spent 10 minutes trying unsuccessfully to locate three decay heat valves in a high radiation field in the auxiliary building.

i. Management did not assure that Licensee Event Reports (LER) met basic NRC requirements. A review of TMI-2's LERs disclosed repeated omissions, inadequate failure analyses, and inadequate corrective actions.

j. Met Ed did not correct deficiencies in radiation monitoring equipment, although the deficiencies were pointed out by an NRC audit months before the accident.

k. On November 3, 1978, a mechanic caused a complete shutdown of the plant, including exercising of emergency systems, when he tripped a switch on the polisher electrical panel, thinking he was turning on a light. The only corrective action was to put a guard on the switch.

l. Sensitive areas of the plant were accessible to large numbers of people. On the day before the accident, as many as 750 people had access to the auxiliary building.

m. The manual control station of the polisher bypass valve was nearly inaccessible and took great effort, in a physically awkward position, to operate.

n. Iodine filters were left in continuous use rather than being preserved to filter air in the event of radioactive contamination. As a result, they did not have full capacity on the day of the accident. (See finding A.11.).

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F. TRAINING OF OPERATING PERSONNEL

1. Training of Met Ed operators and supervisors was inadequate and contributed significantly to the seriousness of the accident. The training program gave insufficient emphasis to principles of reactor safety.

2. The TMI training program conformed to the NRC standard for training. Moreover, TMI operator license candidates had higher scores than the national average on NRC licensing examinations and operating tests. Nevertheless, the training of the operators proved to be inadequate for responding to the accident.

3. NRC standards allowed a shallow level of operator training.

a. The Operator Licensing Branch activities were principally restricted to preparing and giving initial licensing examinations and occasional visits to vendors for an informal spot check of start-up certification tests. The branch was heavily involved in the initial start-up of the B&W cold licensing program in the early 1970s. A paper review of B&W's course for new plant operator training was performed without comment in 1976.

b. NRC prescribed only minimal requirements for operator training. There were no minimum educational requirements for operators; there was no requirement for checks to be made on the psychological fitness of candidates or whether they had criminal records.

c. An individual could fail parts of either the NRC licensing examination or the utility requalification examination, including sections on emergency procedures and equipment, and still pass the overall examination by getting a passing average score, and qualify to operate the reactor.

d. The NRC had no criteria for the qualifications of those individuals who carry out the operator training program. It also did not conduct regular in-depth reviews of the training programs.

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4. Met Ed had primary responsibility for the training of operators. The quality of the training program at TMI was low.

a. The training program was quantitatively and qualitatively understaffed as well as conceptually weak; emphasis was not given to fundamental understanding of the reactor and little time was devoted to instruction in the biological hazards of radiation. The content was left to the instructors, who had no greater formal educational qualifications than those of their students.

b. TMI-2's station manager, unit superintendent, and supervisor of operations were not involved in operator training.

c. With NRC approval, the unit superintendent and the station manager at TMI were only required to acquire the experience and training necessary to be examined for a senior reactor operator license, but were not required to hold such a license.

d. Although auxiliary operators performed tasks that could affect reactor power level or involve the handling of radioactive material, there was no formally defined training program for them.

e. Met Ed did not request waivers from employees with naval reactor experience to allow examination of their Navy records.

5. TMI contracted with B&W to carry out a portion of the TMI operator training. B&W performed only those functions specifically required under the agreement.

a. There was little interaction in B&W between those who conducted training and those responsible for nuclear plant design. Course content and conduct of courses were made up by the B&W training department, entirely on its own. There were no formal syllabi or training manuals.

b. The simulator at B&W was a key tool in the training of operators. Simulator training did not include preparation of the operators for multiple-failure accidents. Indeed, the B&W simulator was not, prior to March 28, programmed to reproduce the conditions that confronted the operators during the accident. It was unable to simulate increasing pressurizer level at the same time that reactor coolant pressure was dropping.

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G. THE NUCLEAR REGULATORY COMMISSION

1. A purpose of the Energy Reorganization Act of 1974 was to divorce the newly created NRC from promotion of nuclear power. According to one of the present NRC commissioners, "I still think it [the NRC] is fundamentally geared to trying to nurture a growing industry." We find that the NRC is so preoccupied with the licensing of plants that it has not given primary consideration to overall safety issues.

2. NRC labels safety problems that apply to a number of plants as "generic." Once a problem is labeled "generic," the licensing of an individual plant can be completed without resolving the problem. NRC has a history of leaving generic safety problems unresolved for periods of many years -- for example, the problem of anticipated transients without scram. In 1976 during the TMI-2 operating license (OL) review, the Advisory Committee on Reactor Safeguards recommended, as they did in at least one other OL review, that prior to commercial operation further evaluations be done of various possible accidents, including low-probability accidents. NRC staff designated this as a "generic issue." TMI-2 received its OL 2 years later without the resolution of the issue.

3. Although NRC accumulates an enormous amount of information on the operating experience of plants, there was no systematic method of evaluating these experiences and looking for danger signals of possible generic safety problems. In 1978, the General Accounting Office criticized NRC for this failure, but no corrective action had been taken as of the TMI-2 accident.

4. The NRC commissioners have largely isolated themselves from the licensing process. Although the commissioners have adopted unnecessarily stringent ex parte rules to preserve their adjudicative impartiality, they have also delegated most of their adjudicative duties to the Atomic Safety and Licensing Appeal Board and actually adjudicate approximately 25 percent of all licensing decisions. That figure is misleadingly high, in part because a number of the decisions do not represent significant adjudicatory events and include decisions on exports. The commissioners have also isolated themselves from the overall management of the NRC.

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One of the present NRC commissioners, testifying before Congress, said, "There has, I think, been too little Commission involvement in the setting of safety policy in this agency and too little Commission guidance on safety matters to the staff and to the board."

5. The major offices within the NRC operate independently with little evidence of exchange of information or experience. For example, the fact that operators could be confused due to reliance on pressurizer level had been raised at various levels within the NRC organization. Yet, the matter "fell between the cracks" and never worked its way out of the system prior to the TMI-2 accident.

6. Licensing of a nuclear plant is a two-step process. First, the company must obtain a construction permit (CP) and several years later must obtain an operating license (OL). The CP stage does not require complete design plans, and therefore the full safety review does not occur until the OL stage. By then, hundreds of millions of dollars have been spent or committed in the construction process. Therefore, the ultimate safety review may be influenced by economic considerations that can lead to a reluctance to order major changes at the OL stage.

7. The Advisory Committee on Reactor Safeguards (ACRS) reviews all applications for licenses and poses whatever questions it deems appropriate. The ACRS is the only body independent of the NRC staff which regularly reviews safety questions. However, it has established no firm guidelines or procedures, and generally has only monthly meetings of limited duration. ACRS members are part-time and have a very small staff, thus they must rely heavily on the NRC staff for follow-up of their concerns. ACRS members tend to concentrate on their own particular areas of expertise, thereby resulting in a fragmented licensing review.

8. There are serious inadequacies in the NRC licensing process.

a. Applicants for licenses are only required to analyze "single-failure" accidents; they are not required to analyze what happens when two systems or components fail independently of each other. The accident at TMI-2 was a multiple-failure accident.

b. NRC's design safety review places primary emphasis on those items labeled "safety-related." This designation is crucial since items not labeled "safety-related" need not be reviewed in the licensing process, are not required to meet NRC design criteria, need not be testable, do not require redundancy, and are ordinarily not subject to NRC inspection. There are no precise criteria as to which components and systems are to be labeled "safety-related;" the utility makes the initial determination subject to NRC approval. For example, at TMI-2, the PORV was not a "safety-related" item because it had a block valve behind it. On the other hand, the block valve was not "safety-related" because it had a PORV in front of it.

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c. NRC's reliance upon artificial categories of "safety-related" items has caused it to miss important safety issues and has led the nuclear industry to merely comply with NRC regulations and to equate that compliance with operational safety. Thus, over-emphasis by the NRC process on specific categories of items labeled "safety-related" appears to interfere with the development, throughout the nuclear industry, of a comprehensive safety consciousness, that is, a dynamic day-to-day process for operating safely.

d. There is no identifiable office within NRC responsibile for systems engineering examination of overall plant design and performance, including interactions between major systems.

e. There is no office within NRC that specifically examines the interface between machines and human beings. There seems to be a persistent assumption that plant safety is assured by engineered equipment, and a concommitant neglect of the human beings who could defeat it if they do not have adequate training, operating procedures, information about plant conditions, and manageable monitors and controls. For example, despite recognition within NRC and various industrial groups that outdated technology in the control room could seriously handicap operators during an accident, NRC continues to license new plants with similarly deficient control rooms. As noted before, problems with the control room contributed to the confusion during the TMI accident. (See also finding A.8.)

f. The requirement of additional instrumentation to aid in accident diagnosis and control was considered by NRC as early as 1975, but its implementation was delayed by industry opposition as expressed by the Atomic Industrial Forum (AIF). AIF opposition was based on, among other things, the belief that the instrumentation required would cover "Class 9" accidents, and therefore, would extend beyond design-basis requirements. The lack of instrumentation to display in the control room the full range of temperatures from the core thermocouples contributed to the confusion involved in the attempt to rapidly depressurize the primary system on March 28.

g. It is common to issue operating licenses to plants when there are still "open safety items." When a plant is licensed with many open items, the Division of Operating Reactors, which has the technical expertise to supervise operating plants, may refuse to accept jurisdiction from the Division of Project Management. In effect, the plant then ends up in a regulatory "limbo," receiving insufficient attention from either division. TMI-2 was in this "limbo" at the time of the accident, 13 months after its OL had been issued.

h. When NRC issues new guidelines concerning safety, there is usually no systematic review, on a plant-by-plant basis, of operating plants and plants under construction for possible "backfitting." For example, Chairman Hendrie explained to a Congressional committee that stricter requirements for on- and

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off-site emergency plans had not been imposed on any already operating plants because of the need to balance costs against safety. The committee, however, found no significant cost burden in requiring utilities to upgrade and implement emergency plans. Similarly, NRC determined not to backfit the 1975 Standard Review Plan (SRP) to those plants, such as TMI-2, that received construction permits prior to September 1, 1975. According to Roger Mattson, director of the Division of Systems Safety, if individual SRP requirements had been reviewed for possible backfitting, the SRP requirement of diverse containment isolation actuation would probably have been backfitted to plants such as TMI-2. Instead, TMI-2 containment was isolated only when the pressure in the building exceeded 4 pounds per square inch. Thus, containment isolation did not occur until several hours after the start of the accident. However, this delay had little effect on the actual small releases of radioactive material during the accident.

i. Although decisions of significant public health impact are considered in the licensing process, NRC has no specific mechanism for interactions with public health agencies in the licensing process, other than the U.S. Environmental Protection Agency (EPA) which does review Environmental Impact Statements filed by applicants for CPs and OLs.

9. The Office of Inspection and Enforcement (I&E) is charged with determining whether licensees are complying with NRC regulations, rules, and licensing conditions. Some serious deficiences in this office are:

a. A 1978 General Accounting Office report found that I&E inspectors did little independent testing of construction work, relied heavily on the utility's self-evaluation, spent little time observing ongoing construction work, and did not communicate routinely with people who did the actual construction work. Similar problems exist in I&E inspections of operating plants. For example, the principal I&E inspector for TMI-2 completed an inspection shortly before the accident by examining utility records and interviewing plant personnel, but without physically examining any equipment.

b. A 1978 survey of I&E commissioned by the NRC determined that the majority of inspectors felt their procedures were unclear and lacking in sufficient technical guidance.

c. Of crucial significance to I&E's system of inspection and enforcement are the Licensee Event Reports (LER) in which utilities report and evaluate important incidents. However, both licensees and vendors often have a strong financial disincentive to evaluate and report safety problems that may result in more stringent regulations, at least in part because it is uncertain which entity will ultimately bear the cost of increased safety. I&E makes little effort to systematically review the LERs, has no formal review mechanism for them, and hence, must rely on individuals to remember events and to identify generic concerns.

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d. I&E inspectors at various times have had difficulties having safety issues that they have raised seriously considered within the office. For example, in 1978 one I&E inspector raised the issue of operator termination of HPI during the September 1977 incident at Davis-Besse. For some 5 months, none of his efforts produced any action. He then took advantage of the "open-door policy" of NRC and went directly to two of the commissioners. These commissioners considered his complaint serious enough to merit further exploration. Unfortunately, this meeting with the commissioners did not take place until one week before the TMI-2 accident.

e. Early this year, the General Accounting Office concluded that NRC had not made effective use of its authority to assess monetary penalties for significant violations. The report cited cases where I&E consolidated continuing violations into one violation, took too long to impose penalties, and sometimes reduced the penalties to avoid financial hardship for the licensee.

f. In its investigative report on the TMI-2 accident (NUREG 0600), I&E came to the unequivocal conclusion that if the operators had followed their procedures for loss-of-coolant accidents, there would have been no accident. However, for more than 2 hours on March 28, the operators at TMI did not recognize that they had a loss-of-coolant accident and did not consider the LOCA procedure relevant. In any event, the TMI-2 procedures were inconsistent and misleading in this regard.

10. There is an absence throughout the NRC of any overall system to measure and improve the quality of safety regulations. There are inadequate management and internal quality assurance systems, an inadequate research program, and the absence of any systematic effort to obtain and use the public health-related research of such federal agencies as HEW and EPA.

11. The information and direction issued by NRC to licensees based on operating experience was, at times, fragmented and misleading. For example:

a. An NRC publication describing the September 1977 Davis-Besse incident made no mention of the fact that operators interrupted HPI. The incident appeared under the heading of "valve malfunction" not "operator error."

b. In the weeks following the accident, NRC apparently was confused as to what emergency procedures plant operators should follow. Thus, within a short span of time, NRC issued and then either modified or contradicted its post-TMI emergency instructions.

(i) Immediately after the TMI accident, NRC directed operators not to override automatic engineered safety features under any circumstances and to operate high pressure injection without regard for reactor vessel pressure/temperature

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limits. NRC modified this directive within a short time.

(ii) On April 5, NRC required all licensees operating B&W-designed reactors to revise their procedures so that in the event of HPI initiation with reactor coolant pumps (RCP) operating, at least two RCPs would remain operating. On July 26, NRC took the opposite position and directed licensees to shut down its pumps when HPI initiated. I&E, in its August 1979 report on the TMI accident, stated that the failure of the TMI operators to shut down the RCPs sooner than they did was a potential item of noncompliance.

12. With its present organization, staff, and attitudes, the NRC is unable to fullfill its responsibility for providing an acceptable level of safety for nuclear power plants.

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H. THE PUBLIC'S RIGHT TO PUBLIC INFORMATION

1. The quality of information provided to the public in the event of a nuclear plant accident has a significant bearing on the capacity of people to respond to the accident, on their mental health, and on their willingness to accept guidance from responsible public officials.

2. Before the accident, Met Ed had consistently asserted the overall safety of the plant, although the company had made information concerning difficulties at TMI-2 public in weekly press releases. This information was not pursued, and often not understood, by the local news media in the area; and the local news media generally failed to publish or broadcast investigative stories on the safety of the plant.

3. Neither Met Ed nor the NRC had specific plans for providing accident information to the public and the news media.

4. During the accident, official sources of information were often confused or ignorant of the facts. News media coverage often reflected this confusion and ignorance.

5. Met Ed's handling of information during the first 3 days of the accident resulted in loss of its credibility as an information source with state and local officials, as well as with the news media. Part of the problem was that the utility was slow to confirm "pessimistic" news about the accident.

6. In accordance with an informal agreement worked out between Governor Thornburgh and the White House, the release of information was centralized beginning on the third day of the accident. Under the agreement, Harold Denton of the NRC would issue all statements from the site on plant status; the Governor's office would be the sole source of comment on protective action and evacuation; and the White House would coordinate comment on the federal emergency relief effort. This agreement limited the number of sources available to the news media and while it brought some

order out of the chaos in public information, it raised two problems. First, information on off-site radiation releases was not centralized in any source so that it would be readily available to the news media and the public; and second, the plan provided no specific public information role for the utility.

7. During the first days of the accident, B&W made a conscious decision not to comment on the accident, even when company officials believed that misinformation was being made available to the public by others.

8. The reporters who covered the accident had widely divergent skills and backgrounds. Many had no scientific background. Because too few technical briefers were supplied by NRC and the utility, and because many reporters were unfamiliar with the technology and the limits of scientific knowledge, they had difficulty understanding fully the information that was given to them. In turn, the news media had difficulty presenting this information to the public in a form that would be understandable.

a. This difficulty was particularly acute in the reporting of information on radiation releases.

b. They also experienced difficulty interpreting language expressing the probability of such events as a meltdown or a hydrogen explosion; this was made even more difficult when the sources of information were themselves uncertain about the probabilities.

9. The impression exists that in news coverage of the accident, the news media presented a more alarming than reassuring view of events. Without attempting to assess how alarming the accident may in fact have been, an analysis of the sources quoted in the news media reveals, overall, a larger proportion of reassuring than alarming statements in the coverage concerning the status of the accident. In choosing quotations from both official and unofficial sources, the news media did not present only "alarming" views, but rather views on both sides of issues related to the accident.

10. A qualitative survey of 42 newspapers from around the country showed that the vast majority covered the accident in much the same way as the major suppliers of news, such as the wire services, the broadcast networks, The New York Times, and The Washington Post. A few newspapers, however, did present a more frightening and misleading impression of the accident. This impression was created through headlines and graphics, and in the selection of material to print.

COMMISSION RECOMMENDATIONS

A. THE NUCLEAR REGULATORY COMMISSION

The Commission found a number of inadequacies in the NRC and, therefore, proposes a restructuring of the agency. Because there is insufficient direction in the present statute, the President and Congress should consider incorporating many of the following measures in statutory form.

Agency Organization and Management

The Commission believes that as presently constituted, the NRC does not possess the organizational and management capabilities necessary for the effective pursuit of safety goals. The Commission recommends:

1. The Nuclear Regulatory Commission should be restructured as a new independent agency in the executive branch.

a. The present five-member commission should be abolished.

b. The new agency should be headed by a single administrator appointed by the President, subject to the advice and consent of the Senate, to serve a substantial term (not coterminous with that of the President) in order to provide an expectation of continuity, but at the pleasure of the President to allow removal when the President deems it necessary. The administrator should be a person from outside the present agency.

c. The administrator should have substantial discretionary authority over the internal organization and management of the new agency, and over personnel transfers from the existing NRC. Unlike the present NRC arrangement, the administrator and major staff components should be located in the same building or group of buildings.

d. A major role of the administrator should be assuring that offices within the agency communicate sufficiently so that research, operating experience, and inspection and enforcement affect the overall performance of the agency.

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2. An oversight committee on nuclear reactor safety should be established. Its purpose would be to examine, on a continuing basis, the performance of the agency and of the nuclear industry in addressing and resolving important public safety issues associated with the construction and operation of nuclear power plants, and in exploring the overall risks of nuclear power.

a. The members of the committee, not to exceed 15 in number, should be appointed by the President and should include: persons conversant with public health, environmental protection, emergency planning, energy technology and policy, nuclear power generation, and nuclear safety; one or more state governors; and members of the general public.

b. The committee, assisted by its own staff, should report to the President and to Congress at least annually.

3. The Advisory Committee on Reactor Safeguards (ACRS) should be retained, in a strengthened role, to continue providing an independent technical check on safety matters. The members of the committee should continue to be part-time appointees; the Commission believes that the independence and high quality of the members might be compromised by making them full-time federal employees. The Commission recommends the following changes:

a. The staff of ACRS should be strengthened to provide increased capacity for independent analysis. Special consideration should be given to improving ACRS' capabilities in the field of public health.

b. The ACRS should not be required to review each license application. When ACRS chooses to review a license application, it should have the statutory right to intervene in hearings as a party. In particular, ACRS should be authorized to raise any safety issue in licensing proceedings, to give reasons and arguments for its views, and to require formal response by the agency to any submission it makes. Any member of ACRS should be authorized to appear and testify in hearings, but should be exempt from subpoena in any proceedings in which he has not previously appeared voluntarily or made an individual written submission.

c. ACRS should have similar rights in rulemaking proceedings. In particular, it should have the power to initiate a rulemaking proceeding before the agency to resolve any generic safety issue it identifies.

The Agency's Substantive Mandate

The new agency's primary statutory mission and first operating priority must be the assurance of safety in the generation of nuclear power, including safeguards of nuclear materials from theft, diversion, or loss. Accordingly, the Commission recommends the following:

COMMISSION RECOMMENDATIONS

4. Included in the agency's general substantive charge should be the requirement to establish and explain safety-cost trade-offs; where additional safety improvements are not clearly outweighed by cost considerations, there should be a presumption in favor of the safety change. Transfers of statutory jurisdiction from the NRC should be preceded by a review to identify and remove any unnecessary responsibilities that are not germane to safety. There should also be emphasis on the relationship of the new agency's safety activities to related activities of other agencies. (See recommendations E.2 and F.1.b.)

a. The agency should be directed to upgrade its operator and supervisor licensing functions. These should include the accreditation of training institutions from which candidates for a license must graduate. Such institutions should be required to employ qualified instructors, to perform emergency and simulator training, and to include instruction in basic principles of reactor science, reactor safety, and the hazards of radiation. The agency should also set criteria for operator qualifications and background investigations, and strictly test license candidates for the particular power plant they will operate. The agency should periodically review and reaccredit all training programs and relicense individuals on the basis of current information on experience in reactor operations. (See recommendations C.1 and C.2.)

b. The agency should be directed to employ a broader definition of matters relating to safety that considers thoroughly the full range of safety matters, including, but not limited to, those now identified as "safety-related" items, which currently receive special attention.

c. Other safety emphases should include:

(i) a systems engineering examination of overall plant design and performance, including interaction among major systems and increased attention to the possibility of multiple failures;

(ii) review and approval of control room design; the agency should consider the need for additional instrumentation and for changes in overall design to aid understanding of plant status, particularly for response to emergencies; (see recommendation D.1) and

(iii) an increased safety research capacity with a broadly defined scope that includes issues relevant to public health. It is particularly necessary to coordinate research with the regulatory process in an effort to assure the maximum application of scientific knowledge in the nuclear power industry.

5. Responsibility and accountability for safe power plant operations, including the management of a plant during an accident,

should be placed on the licensee in all circumstances. It is therefore necessary to assure that licensees are competent to discharge this responsibility. To assure this competency, and in light of our findings regarding Metropolitan Edison, we recommend that the agency establish and enforce higher organizational and management standards for licensees. Particular attention should be given to such matters as the following: integration of decision-making in any organization licensed to construct or operate a plant; kinds of expertise that must be within the organization; financial capability; quality assurance programs; operator and supervisor practices and their periodic reevaluation; plant surveillance and maintenance practices; and requirements for the analysis and reporting of unusual events.

6. In order to provide an added contribution to safety, the agency should be required, to the maximum extent feasible, to locate new power plants in areas remote from concentrations of population. Siting determinations should be based on technical assessments of various classes of accidents that can take place, including those involving releases of low doses of radiation. (See recommendation F.2.)

7. The agency should be directed to include, as part of its licensing requirements, plans for the mitigation of the consequences of accidents, including the cleanup and recovery of the contaminated plant. The agency should be directed to review existing licenses and to set deadlines for accomplishing any necessary modifications. (See recommendations D.2 and D.4.)

8. Because safety measures to afford better protection for the affected population can be drawn from the high standards for plant safety recommended in this report, the NRC or its successor should, on a case-by-case basis, before issuing a new construction permit or operating license:

a. assess the need to introduce new safety improvements recommended in this report, and in NRC and industry studies;

b. review, considering the recommendations set forth in this report, the competency of the prospective operating licensee to manage the plant and the adequacy of its training program for operating personnel; and

c. condition licensing upon review and approval of the state and local emergency plans.

Agency Procedures

The Commission believes that the agency must improve on prior performance in resolving generic and specific safety issues. Generic safety issues are considered in rulemaking proceedings that formulate new standards for categories of plants. Specific safety issues are considered in adjudicative proceedings that determine whether a particular plant should receive a license. Both kinds of safety issues

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are then dealt with in inspection and enforcement processes. The Commission believes that all of these agency functions need improvement, and accordingly recommends the following measures:

9. The agency's authorization to make general rules affecting safety should:

a. require the development of a public agenda according to which rules will be formulated;

b. require the agency to set deadlines for resolving generic safety issues;

c. require a periodic and systematic reevaluation of the agency's existing rules; and

d. define rulemaking procedures designed to create a process that provides a meaningful opportunity for participation by interested persons, that ensures careful consideration and explanation of rules adopted by the agency, and that includes appropriate provision for the application of new rules to existing plants. In particular, the agency should: accompany newly proposed rules with an analysis of the issues they raise and provide an indication of the technical materials that are relevant; provide a sufficient opportunity for interested persons to evaluate and rebut materials relied on by the agency or submitted by others; explain its final rules fully, including responses to principal comments by the public, the ACRS, and other agencies on proposed rules; impose when necessary special interim safeguards for operating plants affected by generic safety rulemaking; and conduct systematic reviews of operating plants to assess the need for retroactive application of new safety requirements.

10. Licensing procedures should foster early and meaningful resolution of safety issues before major financial commitments in construction can occur. In order to ensure that safety receives primary emphasis in licensing, and to eliminate repetitive consideration of some issues in that process, the Commission recommends the following:

a. Duplicative consideration of issues in several stages of one plant's licensing should, wherever possible, be reduced by allocating particular issues (such as the need for power) to a single stage of the proceedings.

b. Issues that recur in many licensings should be resolved by rulemaking.

c. The agency should be authorized to conduct a combined construction permit and operating license hearing whenever plans can be made sufficiently complete at the construction permit stage.

d. There should be provision for the initial adjudication of license applications and for appeal to a board whose decisions would not

be subject to further appeal to the administrator. Both initial adjudicators and appeal boards should have a clear mandate to pursue any safety issue, whether or not it is raised by a party.

e. An Office of Hearing Counsel should be established in the agency. This office would not engage in the informal negotiations between other staff and applicants that typically precede formal hearings on construction permits. Instead, it would participate in the formal hearings as an objective party, seeking to assure that vital safety issues are addressed and resolved. The office should report directly to the administrator and should be empowered to appeal any adverse licensing board determination to the appeal board.

f. Any specific safety issue left open in licensing proceedings should be resolved by a deadline.

11. The agency's inspection and enforcement functions must receive increased emphasis and improved management, including the following elements:

a. There should be an improved program for the systematic safety evaluation of currently operating plants, in order to assess compliance with current requirements, to assess the need to make new requirements retroactive to older plants, and to identify new safety issues.

b. There should be a program for the systematic assessment of experience in operating reactors, with special emphasis on discovering patterns in abnormal occurrences. An overall quality assurance measurement and reporting system based on this systematic assessment shall be developed to provide: 1) a measure of the overall improvement or decline in safety, and 2) a base for specific programs aimed at curing deficiencies and improving safety. Licensees must receive clear instructions on reporting requirements and clear communications summarizing the lessons of experience at other reactors.

c. The agency should be authorized and directed to assess substantial penalties for licensee failure to report new "safety-related" information or for violations of rules defining practices or conditions already known to be unsafe.

d. The agency should be directed to require its enforcement personnel to perform improved inspection and auditing of licensee compliance with regulations and to conduct major and unannounced on-site inspections of particular plants.

e. Each operating licensee should be subject periodically to intensive and open review of its performance according to the requirements of its license and applicable regulations.

COMMISSION RECOMMENDATIONS

f. The agency should be directed to adopt criteria for revocation of licenses, sanctions short of revocation such as probationary status, and kinds of safety violations requiring immediate plant shutdown or other operational safeguards.

B. THE UTILITY AND ITS SUPPLIERS

1. To the extent that the industrial institutions we have examined are representative of the nuclear industry, the nuclear industry must dramatically change its attitudes toward safety and regulations. The Commission has recommended that the new regulatory agency prescribe strict standards. At the same time, the Commission recognizes that merely meeting the requirements of a government regulation does not guarantee safety. Therefore, the industry must also set and police its own standards of excellence to ensure the effective management and safe operation of nuclear power plants.

a. The 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. The recently created Institute of Nuclear Power Operations, or some similar organization, may be an appropriate vehicle for establishing and implementing this program.

b. 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 the speedy flow of this information to affected parties. If such experiences indicate the need for modifications in design or operation, such changes should be implemented according to realistic deadlines.

2. Although the Commission considers the responsibility for safety to be with the total organization of the plant, we recommend that each nuclear power plant company have a separate safety group that reports to high-level management. Its assignment would be to evaluate regularly procedures and general plant operations from a safety perspective; to assess quality assurance programs; and to develop continuing safety programs.

3. Integration of management responsibility at all levels must be achieved consistently throughout this industry. Although there may not be a single optimal management structure for nuclear power plant operation, there must be a single accountable organization with the requisite expertise to take responsibility for the integrated management

of the design, construction, operation, and emergency response functions, and the organizational entities that carry them out. Without such demonstrated competence, a power plant operating company should not qualify to receive an operating license.

a. These goals may be obtained at the design stage by 1) contracting for a "turn-key" plant in which the vendor or architect-engineer contracts to supply a fully operational plant and supervises all planning, construction, and modification; or 2) assembling expertise capable of integrating the design process. In either case, it is critical that the knowledge and expertise gained during design and construction of the plant be effectively transferred to those responsible for operating the plant.

b. Clearly defined roles and responsibilities for operating procedures and practices must be established to ensure accountability and smooth communication.

c. Since, under our recommendations, accountability for operations during an emergency would rest on the licensee, the licensee must prepare clear procedures defining management roles and responsibilities in the event of a crisis.

4. It is important to attract highly qualified candidates for the positions of senior operator and operator supervisor. Pay scales should be high enough to attract such candidates.

5. Substantially more attention and care must be devoted to the writing, reviewing, and monitoring of plant procedures.

a. The wording of procedures must be clear and concise.

b. The content of procedures must reflect both engineering thinking and operating practicalities.

c. The format of procedures, particularly those that deal with abnormal conditions and emergencies, must be especially clear, including clear diagnostic instructions for identifying the particular abnormal conditions confronting the operators.

d. Management of both utilities and suppliers must insist on the early diagnosis and resolution of safety questions that arise in plant operations. They must also establish deadlines, impose sanctions for the failure to observe such deadlines, and make certain that the results of the diagnoses and any proposed procedural changes based on them are disseminated to those who need to know them.

6. Utility rate-making agencies should recognize that implementation of new safety measures can be inhibited by delay or failure to include the costs of such measures in the utility rate base. The Commission, therefore, recommends that state rate-making agencies give explicit attention to the safety implications of rate-making when they consider costs based on "safety-related" changes.

C. TRAINING OF OPERATING PERSONNEL

1. The Commission recommends the establishment of agency-accredited training institutions for operators and immediate supervisors of operators. These institutions should have highly qualified instructors, who will maintain high standards, stress understanding of the fundamentals of nuclear power plants and the possible health effects of nuclear power, and who will train operators to respond to emergencies. (See recommendation A.4.a.)

a. These institutions could be national, regional, or specific to individual nuclear steam systems.

b. Reactor operators should be required to graduate from an accredited training institution. Exemption should be made only in cases where there is clear, documentary evidence that the candidate already has the equivalent training.

c. The training institutions should be subject to periodic review and reaccreditation by the restructured NRC.

d. Candidates for the training institute must meet entrance requirements geared to the curriculum.

2. Individual utilities should be responsible for training operators who are graduates of accredited institutions in the specifics of operating a particular plant. These operators should be examined and licensed by the restructured NRC, both at their initial licensing and at the relicensing stage. In order to be licensed, operators must pass every portion of the examination. Supervisors of operators, at a minimum, should have the same training as operators.

3. Training should not end when operators are given their licenses.

a. Comprehensive ongoing training must be given on a regular basis to maintain operators' level of knowledge.

b. Such training must be continuously integrated with operating experience.

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c. Emphasis must be placed on diagnosing and controlling complex transients and on the fundamental understanding of reactor safety.

d. Each utility should have ready access to a control room simulator. Operators and supervisors should be required to train regularly on the simulator. The holding of operator licenses should be contingent on performance on the simulator.

4. Research and development should be carried out on improving simulation and simulation systems: a) to establish and sustain a higher level of realism in the training of operators, including dealing with transients; and b) to improve the diagnostics and general knowledge of nuclear power plant systems.

D. TECHNICAL ASSESSMENT

1. Equipment should be reviewed from the point of view of providing information to operators to help them prevent accidents and to cope with accidents when they occur. Included might be instruments that can provide proper warning and diagnostic information; for example, the measurement of the full range of temperatures within the reactor vessel under normal and abnormal conditions, and indication of the actual position of valves. Computer technology should be used for the clear display for operators and shift supervisors of key measurements relevant to accident conditions, together with diagnostic warnings of conditions.

In the interim, consideration should be given to requiring, at TMI and similar plants, the grouping of these key measurements, including distinct warning signals on a single panel available to a specified operator and the providing of a duplicate panel of these key measurements and warnings in the shift supervisor's office.

2. Equipment design and maintenance inadequacies noted at TMI should be reviewed from the point of view of mitigating the consequences of accidents. Inadequacies noted in the following should be corrected: iodine filters, the hydrogen recombiner, the vent gas system, containment isolation, reading of water levels in the containment isolation, reading of water levels in the containment area, radiation monitoring in the containment building, and the capability to take and quickly analyze samples of containment atmosphere and water in various places. (See recommendation A.7.)

3. Monitoring instruments and recording equipment should be provided to record continuously all critical plant measurements and conditions.

4. The Commission recommends that continuing in-depth studies should be initiated on the probabilities and consequences (on-site and off-site) of nuclear power plant accidents, including the consequences of meltdown.

a. These studies should include a variety of small-break loss-of-coolant accidents and multiple-failure accidents, with particular attention to human failures.

b. Results of these studies should be used to help plan for recovery and cleanup following a major accident.

c. From these studies may emerge desirable modifications in the design of plants that will help prevent accidents and mitigate their consequences. For example:

(i) Consideration should be given to equipment that would facilitate the controlled safe venting of hydrogen gas from the reactor cooling system.

(ii) Consideration should be given to overall gas-tight enclosure of the let-down/make-up system with the option of returning gases to the containment building.

d. Such studies should be conducted by the industry and other qualified organizations and may be sponsored by the restructured NRC and other federal agencies.

5. A study should be made of the chemical behavior and the extensive retention of radioactive iodine in water, which resulted in the very low release of radioiodine to the atmosphere in the TMI-2 accident. This information should be taken into account in the studies of the consequences of other small-break accidents.

6. Since there are still health hazards associated with the cleanup and disposal process, which is being carried out for the first time in a commercial nuclear power plant, the Commission recommends close monitoring of the cleanup process at TMI and of the transportation and disposal of the large amount of radioactive material. As much data as possible should be preserved and recorded about the conditions within the containment building so that these may be used for future safety analyses.

7. The Commission recommends that as a part of the formal safety assurance program, every accident or every new abnormal event be carefully screened, and where appropriate be rigorously investigated, to assess its implications for the existing system design, computer models of the system, equipment design and quality, operations, operator training, operator training simulators, plant procedures, safety systems, emergency measures, management, and regulatory requirements.

E. WORKER AND PUBLIC HEALTH AND SAFETY

1. The Commission recommends the establishment of expanded and better coordinated health-related radiation effects research. This research should include, but not be limited to:

a. biological effects of low levels of ionizing radiation;

b. acceptable levels of exposure to ionizing radiation for the general population and for workers;

c. development of methods of monitoring and surveillance, including epidemiologic surveillance to monitor and determine the consequences of exposure to radiation of various population groups, including workers;

d. development of approaches to mitigate adverse health effects of exposure to ionizing radiation; and

e. genetic or environmental factors that predispose individuals to increased susceptibility to adverse effects.

This effort should be coordinated under the National Institutes of Health -- with an interagency committee of relevant federal agencies to establish the agenda for research efforts -- including the commitment of a portion of the research budget to meet the specific needs of the restructured NRC.

2. To ensure the best available review of radiation-related health issues, including reactor siting issues, policy statements or regulations in that area of the restructured NRC should be subject to mandatory review and comment by the Secretary of the Department of Health and Human Services. A time limit for the review should be established to assure such review is performed in an expeditious manner.

3. The Commission recommends, as a state and local responsibility, an increased program for educating health professionals and emergency response personnel in the vicinity of nuclear power plants.

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4. Utilities must make sufficient advance preparation for the mitigation of emergencies:

a. Radiation monitors should be available for monitoring of routine operations as well as accident levels.

b. The emergency control center for health-physics operations and the analytical laboratory to be used in emergencies should be located in a well-shielded area supplied with uncontaminated air.

c. There must be a sufficient health-related supply of instruments, respirators, and other necessary equipment for both routine and emergency conditions.

d. There should be an adequate maintenance program for all such health-related equipment.

5. An adequate supply of the radiation protective (thyroid blocking) agent, potassium iodide for human use, should be available regionally for distribution to the general population and workers affected by a radiological emergency.

F. EMERGENCY PLANNING AND RESPONSE

1. Emergency plans must detail clearly and consistently the actions public officials and utilities should take in the event of off-site radiation doses resulting from release of radioactivity. Therefore, the Commission recommends that:

a. Before a utility is granted an operating license for a new nuclear power plant, the state within which that plant is to be sited must have an emergency response plan reviewed and approved by the Federal Emergency Management Agency (FEMA). The agency should assess the criteria and procedures now used for evaluating state and local government plans and for determining their ability to activate the plans. FEMA must assure adequate provision, where necessary, for multi-state planning.

b. The responsibility at the federal level for radiological emergency planning, including planning for coping with radiological releases, should rest with FEMA. In this process, FEMA should consult with other agencies, including the restructured NRC and the appropriate health and environmental agencies. (See recommendation A.4.)

c. The state must effectively coordinate its planning with the utility and with local officials in the area where the plant is to be located.

d. States with plants already operating must upgrade their plans to the requirements to be set by FEMA. Strict deadlines must be established to accomplish this goal.

2. Plans for protecting the public in the event of off-site radiation releases should be based on technical assessment of various classes of accidents that can take place at a given plant.

a. No single plan based on a fixed set of distances and a fixed set of responses can be adequate. Planning should involve the identification of several different kinds of accidents with different possible radiation consequences. For each such scenario, there should be clearly identified criteria for the appropriate responses at various

distances, including instructing individuals to stay indoors for a period of time, providing special medication, or ordering an evacuation.

b. Similarly, response plans should be keyed to various possible scenarios and activated when the nature and potential hazard of a given accident has been identified.

c. Plans should exist for protecting the public at radiation levels lower than those currently used in NRC-prescribed plans.

d. All local communities should have funds and technical support adequate for preparing the kinds of plans described above.

3. Research should be expanded on medical means of protecting the public against various levels and types of radiation. This research should include exploration of appropriate medications that can protect against or counteract radiation.

4. If emergency planning and response to a radiation-related emergency is to be effective, the public must be better informed about nuclear power. The Commission recommends a program to educate the public on how nuclear power plants operate, on radiation and its health effects, and on protective actions against radiation. Those who would be affected by such emergency planning must have clear information on actions they would be required to take in an emergency.

5. Commission studies suggest that decision-makers may have over-estimated the human costs, in injury and loss of life, in many mass evacuation situations. The Commission recommends study into the human costs of radiation-related mass evacuation and the extent, if any, to which the risks in radiation-related evacuations differ from other types of evacuations. Such studies should take into account the effects of improving emergency planning, public awareness of such planning, and costs involved in mass evacuations.

6. Plans for providing federal technical support, such as radiological monitoring, should clearly specify the responsibilities of the various support agencies and the procedures by which those agencies provide assistance. Existing plans for the provision of federal assistance, particularly the Interagency Radiological Assistance Plan and the various memoranda of understanding among the agencies, should be reexamined and revised by the appropriate federal authorities in the light of the experience of the TMI accident, to provide for better coordination and more efficient federal support capability.

G. THE PUBLIC'S RIGHT TO INFORMATION

1. Federal and state agencies, as well as the utility, should make adequate preparation for a systematic public information program so that in time of a radiation-related emergency, they can provide timely and accurate information to the news media and the public in a form that is understandable. There should be sufficient division of briefing responsibilities as well as availability of informed sources to reduce confused and inaccurate information. The Commission therefore recommends:

a. Since the utility must be responsible for the management of the accident, it should also be primarily responsible for providing information on the status of the plant to the news media and to the public; but the restructured NRC should also play a supporting role and be available to provide background information and technical briefings.

b. Since the state government is responsible for decisions concerning protective actions, including evacuations, a designated state agency should be charged with issuing all information on this subject. This agency is also charged with the development of and dissemination of accurate and timely information on off-site radiation doses resulting from releases of radioactivity. This information should be derived from appropriate sources. (See recommendation F.1.) This agency should also set up the machinery to keep local officials fully informed of developments and to coordinate briefings to discuss any federal involvement in evacuation matters.

2. The provision of accurate and timely information places special responsibilities on the official sources of this information. The effort must meet the needs of the news media for information but without compromising the ability of operational personnel to manage the accident. The Commission therefore recommends that:

a. Those who brief the news media must have direct access to informed sources of information.

b. Technical liaison people should be designated to inform the briefers and to serve as a resource for the news media.

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c. The primary official news sources should have plans for the prompt establishment of press centers reasonably close to the site. These must be properly equipped, have appropriate visual aids and reference materials, and be staffed with individuals who are knowledgeable in dealing with the news media. These press centers must be operational promptly upon the declaration of a general emergency or its equivalent.

3. The coverage of nuclear emergencies places special responsibilities on the news media to provide accurate and timely information. The Commission therefore recommends that:

a. All major media outlets (wire services, broadcast networks, news magazines, and metropolitan daily newspapers) hire and train specialists who have more than a passing familiarity with reactors and the language of radiation. All other news media, regardless of their size, located near nuclear power plants should attempt to acquire similar knowledge or make plans to secure it during an emergency.

b. Reporters discipline themselves to place complex information in a context that is understandable to the public and that allows members of the public to make decisions regarding their health and safety.

c. Reporters educate themselves to understand the pitfalls in interpreting answers to "what if" questions. Those covering an accident should have the ability to understand uncertainties expressed by sources of information and probabilities assigned to various possible dangers.

4. State emergency plans should include provision for creation of local broadcast media networks for emergencies that will supply timely and accurate information. Arrangements should be made to make available knowledgeable briefers to go on the air to clear up rumors and explain conditions at the plant. Communications between state officials, the utility, and the network should be prearranged to handle the possibility of an evacuation announcement.

5. The Commission recommends that the public in the vicinity of a nuclear power plant be routinely informed of local radiation measurements that depart appreciably from normal background radiation, whether from normal or abnormal operation of the nuclear power plant, from a radioactivity cleanup operation such as that at TMI-2, or from other sources.