IMPLEMENTATION OF PROTECTIVE ACTIONS FOR RADIOLOGICAL INCIDENTS AT OTHER THAN NUCLEAR POWER REACTORS

PROCEEDINGS OF A WORKSHOP

HELD AT THE
U.S. ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF RADIATION PROGRAMS
NATIONAL AIR AND RADIATION ENVIRONMENTAL LABORATORY
MONTGOMERY, ALABAMA

SEPTEMBER 25-26, 1991

Office of Radiation Programs
U.S. Environmental Protection Agency
Washington, D.C. 20460

PROCEEDINGS OF A WORKSHOP ON IMPLEMENTATION OF PROTECTIVE ACTIONS FOR RADIOLOGICAL INCIDENTS AT OTHER THAN NUCLEAR POWER REACTORS

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INTRODUCTION

The Workshop was held at the Environmental Protection Agency's (EPA) National Air and Radiation Environmental Laboratory in Montgomery, Alabama on September 25-26, 1991. Hosted by the EPA's Office of Radiation Programs, the Workshop was attended by State emergency response officials who have major nonreactor nuclear facilities in their State, and by Federal officials responsible for developing guidance on emergency preparedness.

The principal objective of the Workshop was to provide a forum for the States to identify and discuss issues regarding implementation of protective actions following a radiological accident involving a Federal or commercial nuclear facility, with emphasis on source terms other than power reactors. EPA's impending issuance of revised Protective Action Guides (PAGs) for evacuation and sheltering provided the key incentive for conducting the Workshop at this time. Previous PAGs, which were applicable only to reactor incidents, had been revised to be applicable to source terms from nonreactor incidents as well. The dose quantities for expressing the PAGs were also revised so that they would encompass all of the risk that may be avoided by the relevant protective action, and the accompanying text was clarified to provide more complete guidance on the factors that should or should not influence the choice between evacuation and sheltering.

The Workshop included two plenary sessions and one working group session in which four working groups met to address different issues. In the first plenary session a variety of speakers discussed State and Federal perspectives on the issues. This provided background information for the working group sessions. The second plenary session consisted of presentations and discussions from the four working groups. Although some key organizations were not represented at the workshop, a great deal of information was compiled that should be useful to those responsible for the development and exercising of emergency response plans.

The purpose of this document is to provide a summary of the key issues based on the formal presentations on specific topics, the associated discussions, and discussions of the work that went on in the four working groups. Separate reports that summarize the results of the deliberations of the working groups are provided later.

General Findings and Conclusions

Although several types of nuclear facilities other than power reactors were discussed, there was general consensus that the most significant source terms at nonreactor nuclear facilities for which detailed emergency planning is important are those associated with Federal facilities; primarily those operated by or for the Department of Energy (DOE) and Department of Defense (DOD).

It was pointed out that emergency planning had been conducted by State officials and facility operators at some of the Federal facilities, but in less detail than for nuclear power facilities. In some cases facility emergency response plans have been exercised with State participation. Also, Federal funds have been provided to some States to assist them in their planning efforts, and some State officials have received DOE "Q" clearances to reduce communication problems with facility operators.

Among the responsibilities of the Federal Emergency Management Agency (FEMA), as chair of the Federal Radiological Preparedness Coordinating Committee (FRPCC), is the following: "Establish policy and provide leadership via the FRPCC in the coordination of all Federal assistance and guidance to State and local governments for developing, reviewing, assessing and testing the State and local radiological emergency plans" (44 CFR Part 351.C.351.20). This same document requires the DOE and DOD to participate in these planning activities for their contractor-operated facilities. However, none of the planning activities mentioned above were carried out under the auspices of the FRPCC. Some attendees were aware of a major effort begun several years ago by DOE and FEMA to develop guidance for preparing and exercising State and local emergency response plans for Federal nuclear facilities. This guidance would have been parallel to the guidance developed for nuclear power plants. However, the effort was discontinued.

EPA discussed the proposed revisions to the "Manual of Protective Action Guides and Protective Actions for Nuclear Incidents" (PAG Manual). Considerable discussion centered around whether the revised PAGs for the early phase of response to a nuclear incident could be reasonably applied for all types of nuclear incidents. No circumstances (except nuclear war) could be identified that would require different PAG values, dose quantities, or time periods for calculation of projected dose in order for the PAGs to be applied to nonreactor incidents. It was concluded that the revised PAGs for the early phase could reasonably be applied to any type of nuclear incident except nuclear war.

There are some positive indicators that progress is being made regarding emergency response planning at Federal facilities. For example: 1) key officials in some states are getting security clearances, 2) some Federal facility officials are meeting with State officials regarding potential source term for incidents, and 3) some states are being funded temporarily for emergency planning by DOE. The following summarizes the major issues identified by attendees at the Workshop that require resolution with regard to planning for response to incidents at nonreactor nuclear facilities. Additional issues are identified in the individual reports of the four Working Groups.

Conclusions from Initial Presentations

1. The lack of regulatory oversight for planning at Federal facilities is a major problem. Regulatory oversight similar to that provided for emergency planning activities at commercial nuclear power facilities is needed for nonreactor nuclear facilities. Resolution of many of the other issues identified at the Workshop is dependent on resolving this issue.

2. A planning basis is needed for nonreactor facilities. The planning basis for nuclear power facilities dealt with size of the planning area, time frame for response, and radionuclides to plan for. Due to the variability among sites and source terms for Federal nuclear facilities, a different basis may be appropriate for each facility. Guidance is needed on how to develop a planning basis.

3. Nuclear power facilities are a source of stable long-term funding for emergency planning by State and local agencies. Similar funding is needed for State and local planning at Federal facilities. In some cases funding has been provided, but it is neither stable nor long-term.

4. At some facilities, arrangements are needed for communication between the facility operator and offsite officials regarding classified information. Clearances for key offsite individuals have been useful to facilitate communication in instances where they have been implemented.

5. After emergency response plans are developed, exercises and training programs are needed. Training programs already developed in support of response to nuclear power plant accidents and transportation accidents are not totally adequate for response to accidents at Federal nuclear facilities.

<u>Key Issues Identified During Exercises at Federal Facilities</u>

1. At some facilities, States were not considered to be an equal partner with the facility operator. For example:

    - Communications were generally ineffective. This was because communications at the facility were through a third party to a responsible party offsite.

    - No debate or justification of recommendations on protective actions was provided to offsite officials.

    - The technical expertise of the State was not recognized.

2. Accident classification was confusing because of the lack of a standard set of classifications.

3. Public information was ineffective. This was sometimes a result of facility rules that did not allow discussions of onsite activities with outsiders.

4. The distinction between recommendations and decisions on protective actions was sometimes not clear.

Key Lessons Learned from the Titan II Incident in 1980

1. The impossible can occur.

2. Emergency plans should allow for flexibility so that the response can be tailored to the situation.

3. Special monitoring equipment related to the potential source term is needed. This relates primarily to the need to monitor for alpha radiation.

4. Training programs are needed in relation to specific source terms applicable to nonreactor facilities.

5. An accident does a lot to improve emergency planning. Some results were:

   - Communication between State and Air Force was improved.

   - Emergency plans were developed.

   - Communication with citizens was improved.

Key Conclusions from Working Groups

1. Regardless of the nature of the tools to be used to assess offsite radiological consequences, it is an inherent responsibility of the facility operator to develop these tools and make them available to offsite agencies.

2. The absence of gamma-emitting radionuclides in releases from incidents at several categories of nuclear facilities will require acquisition of expensive field and laboratory instrumentation not currently available to offsite response organizations. Such instrumentation will be needed to verify the presence or absence of an airborne plume.

3. More important than the instrumentation itself, are the procedures and training required to prepare samples and use the equipment. The analysis of transuranics and mixed chemical/radiological sources were identified in particular as areas where training is needed.

4. Far too little information is currently available to offsite planning agencies regarding the nature of the hazards at many of the Federal facilities. Some may present mixed chemical/radiological hazards. It was concluded that the current implementation procedures for evacuation and sheltering will require expansion to address these different types of hazards. An assessment of the potential for accidental release of mixed source terms at Federal facilities was identified as a project that should be completed as soon as possible.

5. The responsibility for developing information and models for characterizing hazards of accidental releases should fall to the owner/operator of facilities, whereas the responsibility to expand current implementation procedures should rest with EPA, in coordination with FEMA, DOE, and NRC. The development of standards for alpha contamination was specifically identified as an area requiring the attention of EPA.

6. Due to the difficulty in collecting field monitoring data in a timely fashion, it will be necessary to make early decisions on the need for protective actions based on facility status. Emergency action levels and corresponding source terms in potential releases are needed to support these early decisions.

7. Agreements between nuclear facility operators and offsite response officials should be developed as needed for security clearances to facilitate communication during emergencies.

8. Concern was expressed that radiological professionals would tend to overlook chemical hazards during an event involving a mixed chemical/radiological release thus posing a threat to themselves and others. Cross training between the chemical and radiological personnel was recommended.

9. The Federal government should continue to streamline and consolidate authority to aid States in knowing who is in charge for incidents involving mixed releases.

10. The Federal agencies should participate realistically during exercises at Federal nuclear facilities by including all the resources that would actually be used in an emergency.

The consensus of attendees at the Workshop was that it was a success. They indicated that the information developed would be helpful to those preparing guidance for the development of emergency plans and exercises as well as to those required to develop such plans and exercises. EPA was encouraged to proceed with publication of the revised PAGs, and EPA and FEMA were encouraged to follow through on the development of additional guidance applicable to emergency preparedness at nonreactor nuclear facilities.

WORKSHOP ON IMPLEMENTATION OF PROTECTIVE ACTIONS FOR RADIOLOGICAL INCIDENTS AT OTHER THAN NUCLEAR POWER REACTORS

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WORKSHOP ON IMPLEMENTATION OF PROTECTIVE ACTIONS FOR RADIOLOGICAL INCIDENTS AT OTHER THAN NUCLEAR POWER REACTORS

U.S. Environmental Protection Agency
Office of Radiation Programs
National Air and Radiation Environmental Laboratory
1504 Avenue A
Montgomery, Alabama

September 25-26, 1991

AGENDA

Workshop Objective

The principal objective is to provide a forum for the States to identify and discuss issues regarding implementation of protective actions following a radiological accident involving a Federal or Commercial Facility, with emphasis on source terms other than power reactors. It is not expected that issues will be resolved or guidance developed at this workshop.

September 25, 1991

8:00 to 8:30 a.m. Registration
Cheryl L. Malina, Bradley Nelson, Thomas Reavey (EPA, ORP)

Plenary Session
Moderator: Allan C.B. Richardson (EPA, ORP)

8:30 a.m. Welcome and Introduction
Sam Windham (EPA, NAREL)
Welcome
Aubrey V. Godwin (AL)

8:50 a.m. Overview of the Workshop
Allan C.B. Richardson (EPA, ORP)

9:10 a.m. Lessons Learned From Emergency Planning at Hanford
Robert Mooney (WA)

9:30 a.m. Generic Nonreactor Source Terms: Transuranics, Tritium, Other Possibilities
To be Announced (DOE/DOD)

Agenda
September 25, 1991 (Continued)

9:50 a.m.	The Relationship Between Protective Action Guides and Emergency Planning Zones Robert Trojanowski (NRC, Region II)
10:10 a.m.	The Basis for Protective Action Guides and Their Application to Non-reactor Source Terms Allan C.B. Richardson (EPA, ORP)
10:30 a.m.	Break
10:45 a.m.	Implementation of Protection Action Guides at a Large Plutonium Processing Facility Philip C. Nyberg (EPA, Region VIII)
11:05 a.m.	Mixed Hazard Incidents (Chemical/Nuclear Incidents) William Klutz (EPA, Region IV)
11:25 a.m.	Arkansas' Titan II Experience Bernard Bevill (AR)
11:45 a.m.	Review on the Basis of Guidance for Sheltering as a Protective Action in a Plutonium Release Accident Bradley Nelson (EPA, ORP)
12:05 p.m.	Lunch
1:10 p.m.	Tour of Lab

Working Group Sessions

Working Group A Leader: James C. Hardeman Jr. (GA)
Working Group B Leader: Stanley R. Marshall (NV)
Working Group C Leader: Gary N. Wright (IL)
Working Group D Leader: Debra Shults (TN)

2:00 p.m.	Organization of Working Groups Allan C.B. Richardson (EPA, ORP)
2:15 p.m. to 5:30 p.m.	Working Group Discussions and Drafting of Summary Reports
8:30 a.m. to 10:00 a.m.	Working Groups Meet to Organize Presentations

Agenda
September 26, 1991

Plenary Session
Moderator: Aubrey V. Godwin (AL)

10:00 a.m.	Working Group A Presentation and Discussion
10:45 a.m.	Break
11:00 a.m.	Working Group B Presentation and Discussion
11:45 a.m.	Working Group C Presentation and Discussion
12:30 p.m.	Lunch
1:30 p.m.	Working Group D Presentation and Discussion
2:15 p.m.	Audience Discussion and Review of the Most Important Issues Aubrey V. Godwin (AL)
3:00 p.m.	Closing Remarks and Adjournment Allan C.B. Richardson (EPA, ORP)

SPEAKERS' PAPERS

WELCOME AND INTRODUCTION

Sam Windham

National Air and Radiation Environmental Laboratory
Office of Radiation Programs
U.S. Environmental Protection Agency
Montgomery, Alabama

As director of the National Air and Radiation Environmental Laboratory (NAREL), I would like to welcome you here for this important meeting. Cheryl Malina and Allan Richardson from the Office of Radiation Programs (ORP), and Dr. Charles Petko, from the laboratory, have worked to assure the meeting is a success and that the time you spend here is productive and pleasant.

For those of you who may not be familiar with the NAREL, we are an environmental radiation laboratory, a part of the ORP. The laboratory was first established in 1959 in support of the Bureau of Radiological Health, and when the Environmental Protection Agency (EPA) was formed in 1970, we were transferred to EPA. Not only do we work closely with our ORP headquarters organization, but we also support EPA regional offices and other federal and state government agencies in environmental radiation related projects. The laboratory has a staff of 39 federal employees and about 30 other employees who are contractors, co-op students, etc.

About 18 months ago, we moved into our new facility, a 65,000 square foot modern laboratory, of which we are very proud. We have set aside a time during this meeting to take you on a tour of the facility.

We have arranged to have lunch each day at the Gunter Air Force Base Club adjacent to the lab. There is a room reserved to accommodate our group. Our receptionist will handle messages for you during the meeting. Please check with her at the front desk at each break. Again, welcome to the NAREL, we are glad you are attending the PAG workshop. If there is anything the NAREL staff or I can do to assist you during your visit, please let us know.

WELCOME

Aubrey V. Godwin

Division of Radiation Control
Department of Public Health
Montgomery, Alabama

On behalf of Governor Hunt, welcome to Alabama. We anticipate a good meeting on the PAGs. I hope you found the accommodations in good order. This is a fine facility, and I am sure the Environmental Protection Agency (EPA) will want to show you around as their guests.

This workshop is to discuss the problems of implementing the PAGs for federal facilities. The Guides are out and are not being discussed at this workshop. The results of this workshop will be used by the federal agencies to identify problems and to develop policy regarding those problems. So, now is your opportunity to affect the National policies which may be developed.

OVERVIEW OF THE WORKSHOP

Allan C.B. Richardson

Guides and Criteria Branch
Office of Radiation Programs
U.S. Environmental Protection Agency
Washington, D.C.

Introduction

Welcome to this *Workshop on Implementation of Protective Actions for Radiological Incidents at Other Than Nuclear Power Reactors*. (I will elaborate on the slight change in emphasis represented by the current versus the previously announced title later.) The planning group has put forth considerable effort to bring this workshop together, and it is our hope that the information developed here will be of great value in identifying any new guidance needed for the host of different situations that the Protective Action Guides (PAGs) now address, in contrast to their original focus -- commercial nuclear power reactors.

We hosted a similar workshop two years ago on *Protective Action Guides for Accidentally Contaminated Food and Water* in Washington, D.C. The purpose of that workshop was to identify issues and relevant experience that should be considered in the development of PAGs for water and food. It was, I believe, a clear success and helpful to those responsible for the development of PAGs for ingestion. Several of you participated in that workshop and I want to thank you again for your assistance. You will be familiar with the process today and tomorrow, since it will be very similar.

We are also taking advantage of the opportunity provided by this workshop to show off our new laboratory, which has been open for less than two years. We believe this to be the best environmental radiation laboratory in the country, and possibly in the world, and are quite proud of it. The Environmental Protection Agency (EPA) is in great debt to Charlie Porter, whom I am sure many of you know, for conceiving the idea of a new laboratory and for pushing it through the bureaucracy to completion over a period of several decades. Charlie retired last year and Sam Windham, who has been involved in management at the EPA Radiation Facility in Montgomery for many years and who participated in the design of this new facility, is the new Laboratory Director. He has agreed to conduct a tour this afternoon for all of the workshop participants.

Participants and Roles

Co-sponsors of this workshop are the EPA, the Federal Emergency Management Agency (FEMA), the Department of Agriculture (USDA), the Food and Drug Administration (FDA), and the Conference of Radiation Control Program Directors, Inc., (CRCPD). Our

Planning Committee for the workshop included Aubrey Godwin (AL-CRCPD), Marlow Stangler (FEMA), Janet Quissel (USDA), Donald Thompson (FDA), Jim Rabb, Centers for Disease Control (CDC), Rosemary Hogan, Nuclear Regulatory Commission (NRC), Jim Fairobent, Department of Energy (DOE), Michael Schaeffer (DNA) and myself from EPA. We are responsible for the organization of the workshop, including development of the agenda. Cheryl Malina (EPA) has been responsible for the administrative effort required to make everything happen. Joe Logsdon, formerly of EPA, did most of the work on suggested issues for the working groups. The CRCPD arranged for invitations to State representatives who have major nonreactor nuclear facilities in their State. The CRCPD has also agreed to manage the publication of the proceedings document.

EPA recommended PAGs for the early phase in 1975 (and revised them in 1980). These PAGs applied to planning and carrying out radiological emergency response at commercial nuclear power facilities. The 1975 (and 1980) PAGs addressed the need for evacuation or sheltering, based on projected doses to the whole body from external gamma radiation and to the thyroid from inhalation of radioiodine. Inhalation of particulate materials and exposure of the skin to beta emitters were not considered. Thus, emergency response planners have had no PAGs for evacuation and sheltering for source terms where neither whole body exposure to gamma radiation nor inhalation of radioiodines are the leading exposure pathways.

In response to this need, EPA has now developed revised PAGs for evacuation and sheltering that apply to all types of nuclear incidents (except, of course, nuclear war). Last year we issued similar PAGs for relocation. Since states are responsible for implementing PAGs, and have extensive experience in implementing them during exercises of emergency response plans for commercial nuclear power facilities, we thought it would be useful to provide an opportunity for the states to collectively identify and evaluate potential problems associated with implementation of these new PAGs at nonreactor nuclear facilities. We have, therefore, organized this workshop and invited emergency preparedness officials from all of the states that have major nonreactor nuclear facilities. We have also invited representatives from the Federal agencies that would provide assistance in the event of a radiological incident with potential offsite consequences.

I noted the change in the workshop title earlier. We have expanded the scope of this meeting from incidents at Federal facilities to any incident not caused by a commercial power reactor. We made this change, in response to suggestions from DOE, the Department of Defense (DOD), and FEMA, because we believe it makes good sense. The new PAGs now apply to any nonreactor source term, not just those at Federal facilities, the nonreactor sources that most readily come to mind. Other examples now covered by the PAGs include, among others, fuel cycle facilities licensed by the NRC, satellites using nuclear power sources, and radiopharmaceutical manufacturers. You may also have noticed the absence of DOE and DOD as co-sponsors. We regret this. They were invited. They have advised us that they do not feel comfortable with this sort of meeting at this time, and do not believe it would be productive. I hope we will prove their apprehensions wrong on both counts. It is not our intention to focus on possible past inadequacies, but on what we need to do in the future. In any case, the results of this workshop will be available to all in published form.

The purpose of this workshop, then, is to provide a forum for State and Federal officials to identify and evaluate the issues and problems associated with implementation of the new PAGs in the event of an incident at a nonreactor nuclear facility. However, since there is so much experience in planning and exercising of plans for incidents at commercial nuclear power plants, we should make a particular effort to evaluate the extent to which plans and procedures for nonreactor facilities can be the same as, as well as where they should differ from, those developed for power plants. For incidents at some of these facilities, it will also be appropriate to consider the issues and problems associated with response to incidents involving simultaneous releases of chemically toxic and radioactive materials (mixed releases), and we have included a special working group to focus on this problem.

Format for the Workshop

As you can see from the agenda, the workshop will consist of two plenary sessions and one working group session. This first plenary session is intended to provide background information that may stimulate you to identify issues or problems that should be discussed by the working groups. Each presentation in this session is scheduled for 15 minutes, with an additional 5 minutes for questions. Although there is limited time, I plan to be somewhat flexible with regard to individual presentations. In other words, we do not want to miss important information because of a time constraint, but, on the other hand, speakers, please do not feel obligated to use all of your allotted time. If questions and discussions tend to be lengthy, they will be deferred to the appropriate working group in the afternoon session. A second plenary session will be convened tomorrow morning to hear and discuss the deliberations of the working groups. Then, tomorrow afternoon, we will attempt to sum up what we have learned.

Working Groups

The planning group prepared a list of topics that included all of the relevant issues that we could identify. After categorizing them into four topic areas (one for each working group), they were sent to each of you with a request to identify your first, second, and third choices for working group assignments. We have reviewed your selections and have assigned each of you to a working group as shown on one of the handouts. Noone has been given his third choice, although a few of you did not get assigned to your first choice. I will make additional assignments, if necessary, and provide additional suggestions regarding operation of the working groups when they are convened this afternoon. If anyone is not happy with their assignment please see me during lunch.

Use of Workshop Results

We do not expect this workshop to produce consensus solutions or recommendations. However, we encourage individuals to express opinions or to make recommendations on any relevant issues. Also, if consensus opinions can be developed on what the outstanding needs are, we will welcome their presentation.

The proceedings of the workshop will include the papers that were presented in the plenary session plus any others that were submitted for use or consideration by the working groups. It will also include summaries prepared by each of the four working groups. The document will then be distributed to all of you, to relevant Federal agencies, and to any other interested parties. Most importantly, I hope it will be a useful resource for identifying any additional guidance and for identifying any special plans or procedures needed for emergency response based on these new PAGs.

Thank you for coming. I hope that when you leave you will feel that your time has been well spent. If you have any questions about the workshop, either now or later, please do not hesitate to ask either me or any of the other EPA staff members present.

LESSONS LEARNED FROM EMERGENCY PLANNING AT HANFORD

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Introduction

Thank you for the opportunity to speak at this workshop. My involvement with the Environmental Protection Agency (EPA) and Protective Action Guides (PAGs) dates back to the 1970's. I am pleased we are finally bringing federal facilities into the emergency planning process. My remarks will not cover the technical aspects of PAGs. The working groups provide the forum for us to do that. Instead I will deal with two main concepts which are poorly understood in emergency planning. Since they are so poorly understood, when it comes time to implement protective actions, the parties involved experience both grief and consternation. These two concepts are Guidance versus Legal Authority and Recommendations versus Decisions. Following a discussion of these two concepts, I will elaborate on lessons learned from our experience at Hanford.

Guidance versus Legal Authority

Usually overlooked in the application of PAGs is the fact that they are exactly that, Guides. Quoting from the *Federal Register* of October 22, 1982, "these recommendations are voluntary guidance to State and local agencies." (1) The legal authority for protecting public health and safety rests with the state and/or local government. Therefore, when federal guidance becomes "official," the process is not over. It has just begun. Failure to address this key point sets up recurring pitfalls in implementing PAGs.

Recommendations versus Decisions

The Legal Authority issue leads directly to the Recommendations versus Decision issue. Once an accident occurs at a nuclear facility, facility operators are responsible to provide **Recommendations** to the offsite agencies responsible for public health and safety. The agency with the legal authority then must make a **Decision** and implement it. Buried in the emergency planning trees, we often forget that the purpose of the forest is to make the process between the start of the accident and implementation of a protective action decision fast, smooth and effective. The offsite decisions must range from NO ACTION (minor accident) to AUTOMATIC EVACUATION (major accident).

There is a big gray area between these two extremes. For adequate public health protection to occur when we find ourselves in the gray area, trust and credibility must be strong and communications must be flawless. For nuclear power plants, over ten years of planning and exercises have brought us a long way down that road. For Federal exercises, we have barely begun the journey. Also, Federal facilities start with a major credibility problem. Because of this, one would expect Federal officials to spend major efforts on effective communications. Yet the opposite is happening.

At recent Federal exercises I have evaluated, the entire communications with offsite agencies is shunted to a third party "communicator." No one-to-one conversations occur between onsite and offsite decision makers. This problem of poor personal communications is well documented in a report titled, *Human Factors of an Emergency Response Center* by Moray, Sanderson, and Vicente. (2) The report identifies three inputs required for effective decision making:

(1) Status data from the facility.
(2) Data on meteorology and health physics.
(3) Data on the status of offsite agencies.

It is this third area where serious inertia exists. Progress cannot really begin until Federal officials see offsite agencies as equal partners in the joint mission of protecting public health and safety.

Once this equal partnership framework is established, major technical differences must be resolved. I call this the **Fix Fatal Flaws** process. The **Flaws** we are striving to fix at Hanford are:

- Planning Basis
- Planning Zones
- Long Term Stable Funding
- Independent Regulatory Oversight

Planning Basis

It is ironic that emergency planning at Hanford has begun after all major facilities have been shut down. At one time, Hanford included fuel fabrication, nine production reactors, plutonium extraction, and waste storage. Thus the entire nuclear fuel cycle, except for enrichment and uranium milling was represented at Hanford. Now the only operating facility is the FFTF breeder reactor, and it is expected to shut down soon. So what accidents are left that we might have to respond to? There are two major sources of significant radionuclide inventory: spent fuel from the last years of N reactor operations, and over 100 tanks of high level radioactive waste. The tanks have been identified as having potential for significant explosions due to ferrocyanide and hydrogen gas. What Safety Analysis Reports (SARs) do exist have been shown to be inadequate (3). Thus no technical basis exists that defines the maximum credible accidents which could occur at Hanford.

Planning Zones

In the absence of a sound technical basis for planning, the establishment of appropriate planning zones sits in limbo. The State's position has been to use the nuclear power plant 10- and 50-mile planning zones as a default until adequate SARs can justify something else. Rather than a 10 mile planning zone for the plume pathway, the U.S. Department of Energy (DOE) uses a 4.5 mile zone for their spent fuel storage facility. Ironically, the 4.5 mile zone magically stops just short of the Hanford boundary. DOE has been unresponsive to the State's efforts to resolve this issue.

Long Term Stable Funding

Washington's position on emergency response funding is that the facility pays the costs of state and local agency planning efforts. In 1981, Governor Spellman of Washington wrote to DOE requesting funding support for emergency planning at Hanford. Nine years later, in March 1990, the state received the first funds from DOE to begin emergency planning at Hanford. In accepting these funds, the state documented that the initial funding was inadequate, and laid out a three year budget that was consistent with our ten year old planning program for nuclear power plants. Eighteen months later, we are still negotiating with DOE for adequate funding.

Independent Regulatory Oversight

Presently, emergency planning at federal facilities is done on a voluntary basis. Thus the criteria at Hanford are established by DOE in a vacuum. The Conference of Radiation Control Program Directors, Inc. (CRCPD) went on record this year to bring federal facilities under the same regulatory umbrella as private industry. This is a key milestone in bringing credibility and a sound technical basis to emergency planning at Hanford.

The State of Washington has partial regulatory authority over Hanford operations. This includes authority over chemical and toxic wastes, waste clean-up operations, and air emissions of radionuclides. Neither Washington nor any other state or federal agency has authority to require emergency planning.

In closing, two conditions need to be established at Hanford to effectively implement PAGs:

Equal Partnership

Fix Fatal Flaws

These conditions require a major cultural change to occur on the part of DOE, and major state and federal legislative actions. In the meantime, state and local officials have begun the process of emergency planning. In the event the accident happens "today", we aim to be as prepared as resources allow.

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THE RELATIONSHIP BETWEEN PROTECTIVE ACTION GUIDES AND EMERGENCY PLANNING ZONES

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Introduction

Good morning. The Nuclear Regulatory Commission (NRC) is pleased to participate in this interesting and important workshop.

In order to discuss the relationship between the Protective Action Guides (PAGs) and the Emergency Planning Zones (EPZs), it is important to take a brief historical perspective as to the basis for the development of each of these concepts. The PAGs and the EPZs, which as you know, have been subsequently implemented as "guidance tools" and "planning mechanisms," respectively. Also, it is important to historically review the Federal regulations and guidance as related to emergency preparedness, both prior to and after the accident at the Three Mile Island (TMI) facility, in order to fully understand how we got to where we are from where we were in the early days of the commercial nuclear power industry.

These are some of the things I would like to discuss with you today, and then during the workshop phase of this program, we can hopefully have a thorough discussion of how these concepts can be applied to radiological incidents involving Federal facilities. Unfortunately, I understand that the representatives from the Department of Energy (DOE), Department of Defense (DOD), and the National Aeronautical and Space Administration (NASA) who were expected to participate in this workshop will not be joining us today.

The Period Before the Incident at TMI

Yankee Rowe, located in Western Massachusetts was the first licensed nuclear power reactor to go on-line and began commercial operation in July 1961. Others were licensed and came on-line shortly thereafter. During this early period of the commercial nuclear power industry, emergency planning considerations were initially set forth in Title 10, Department of Energy, Code of Federal Regulations, Part 100 (10 CFR 100), Reactor Siting Criteria, which was published in 1962. These 10 CFR 100 criteria specified that for each reactor site an exclusion zone (EZ), low population zone (LPZ), and a population center be established and identified. By definition, the utility operator was required to have total control over the EZ, which essentially meant that this area was company-owned property. Its exact size was determined through accident analyses consistent with the criteria specified in 10 CFR 100 which required that an individual located on any boundary point of the EZ for a two-hour period immediately following a fission product release from the reactor coolant would not receive a total radiation dose of 25 rem whole body or 300 rem to the thyroid from plume exposures.

The size of the LPZ was similarly defined such that an individual located on any point of its outer boundary continuously over a thirty day period would not receive a total radiation dose in excess of 25 rem whole body or 300 rem thyroid from fission product plume exposures. Additionally, the utility operator was required to demonstrate that there was a reasonable probability that appropriate protective measures, including evacuation, could be taken to protect the LPZ populace in the event of an accident. LPZs were generally defined at distances of two to three miles from the site. Regarding the designated population center, no dose guidance values were given, but were assumed to be lower than those values associated with the LPZ. Population centers were generally defined as the areas within fifty miles of the site, and the utility operator was required to demographically characterize these areas. Not a great deal of concern was given to the need for implementing protective measures in the designated population centers, since the dose criteria established for the EZ and LPZ were considered to be extremely conservative based on the site-specific calculated doses over a broad range of design-basis accidents.

This general philosophy prevailed during the decade, and although in a traditional sense the state and local governments are responsible for public health and safety, these entities did not play a large role in emergency planning around commercial nuclear power plants. The risks from these facilities were generally considered to be consistent with the risks associated with other industrial facilities such as steel making plants, chemical plants, etc., and the utility operators were bound by the regulations specified in 10 CFR 100. In this regard, engineered safeguards were designed and put in place to mitigate the consequences of all identified design-basis accidents. Hence, the general thinking was that the public domain was not at risk even for the class 9 accident, i.e., core melt or containment failure. While the occurrence of a class 9 accident was plausible, the probability of it happening was thought to be so small that no special emergency planning requirements were considered to be necessary.

In 1970, 10 CFR 50, Appendix E was published which did contain explicit requirements for dealing with emergencies; however, these requirements were again directed to the utility operators, and required them to include provisions in their emergency plans for participation of offsite governmental authorities or outside groups. The obvious dilemma which developed is that the Federal Government did not have statutory authority over the states and local governments with regard to emergency planning, yet the utility operators were required to incorporate governmental participation into their emergency planning process. At best, this could only be accomplished on a cooperative basis but raised questions of effectiveness and legal liability.

During the period of the early to mid seventies not only was there an increase in the number of power plants coming on-line commercially, but the reactor core inventories were being substantially increased. Consequently, both the states and Federal Government began to raise concerns regarding the potential offsite consequences to the general public as a result of a major accident. Additionally, the Federal Government also questioned the capability of state and local governments in responding to a major nuclear incident, particularly in light of the Federal regulations which required the utility operators to coordinate state and local government participation into the overall response effort. Consistent with these concerns, the NRC published the WASH-1400, *Reactor Safety Study*, in 1975; and, the Environmental Protection Agency (EPA) developed and published the *Manual of Protective Action Guides and Protective Actions for Nuclear Incidents*, also in 1975. In 1976, the Conference of Radiation Control Program Directors, Inc. (CRCPD) petitioned the Federal Government to identify the offsite threat, and to assist in the development of state and local emergency plans. In response to these requests, NRC published NUREG-75/111, *Guide and Checklist for Development and Evaluation of State and Local Government Radiological Emergency Response Plans in Support of Fixed Nuclear Facilities*. Regarding the identification of the offsite threat, a joint NRC/EPA Task Force on emergency planning was formed and its findings were published in NUREG-0396/ EPA-520/1-78-016, dated December 1978, *Planning Basis for the Development of State and Local Government Radiological Emergency Response Plans in Support of Light Water Nuclear Power Plants*. These actions gave rise to the Regional Advisory Committees (RACs) which were originally chaired by NRC, and the joint Task Force findings established the concept of the 10-mile plume EPZ and the 50-mile ingestion EPZ. Initially, the RAC program was strictly voluntary for the states and the Federal Committees assisted in the development of state emergency plans, to include testing these plans in exercises. The RACs had no statutory jurisdiction and consequently, the state plans were not "approved" by the RACs, but rather the Committee simply granted a statement of "concurrence." This statement of concurrence acknowledged that the plan was developed in accordance with the NUREG-75/111 guidance criteria, concurred in by the RAC, and successfully tested by means of a demonstration exercise.

The joint NRC/EPA findings concluded that the major threat for design-basis accidents to be in the range of 2 to 5 miles, and out to ten miles, and possibly beyond, for the class 9 accident. The relationship between EPA PAGs of 1 rem to 5 rem whole body, and 5 rem to 25 rem thyroid, and the establishment of a ten mile EPZ is an extremely conservative approach to emergency response. The Task Force concluded that incident response generally would not involve taking response actions in the entire ten mile EPZ, but if necessary, the detailed essential planning mechanisms would be in place.

The Period After the Incident at TMI

As you know, after the accident at the TMI facility, greater emphasis was placed on emergency preparedness concerns. The NUREG-75/111 guidance criteria became the foundation for NUREG-0654/FEMA-REP-1, which placed more emphasis on defining emergency organizations, communications, notifications, alert and notification systems, etc. Additionally, the ten and fifty mile EPZ concepts which were derived in the joint NRC/EPA Task Force study were also incorporated into NUREG-0654. Federal Emergency Management Agency (FEMA), through Executive order, was given responsibility for offsite emergency preparedness. Consequently, the Chair of the RACs was transferred to FEMA from NRC, while NRC retained regulatory jurisdiction for emergency preparedness onsite. NRC also revised its regulation in 10 CFR 50, Appendix E to incorporate the planning standards in NUREG-0654.

Although the NRC did not have statutory authority over the state and local governments, its regulations authorized the operation of commercial nuclear power plants only in those states which have implemented a FEMA-approved emergency plan. Hence, the RAC program which heretofore was advisory and voluntary, shifted to a more formal program and became somewhat regulatory. This basically brings us to where we are today, and I assume that most of you are familiar with FEMA's plan review and approval process, as well as their program for evaluating exercises.

Emergency Planning Requirements for Fuel Processing Facilities

In contrast to the emergency preparedness requirements for reactors, I want to briefly comment on the NRC regulations governing fuel processing facilities. These regulations are contained in 10 CFR 70.22. Based on worst case accident analyses, which show that 1 rem effective dose at the site boundary will not be exceeded, there are no established EPZs for NRC licensed fuel processing facilities. Also, the regulations were revised to eliminate the "Unusual Event" and "General Emergency" classifications. I only mention these regulations to show that the risk to the public is based on the source term activity and potential offsite effect, and that the concept of EPZs is really only a planning mechanism, i.e., worst case accident analyses may indicate that the delineation of a specific EPZ is not necessary to protect public health and safety.

Relationship Between PAGs and EPZs

The PAGs were developed and published by EPA in 1975. As you know, they are expressed over a range for whole body exposures and exposures to a child's thyroid. EPA intends that the PAGs be utilized as guidance for triggering appropriate protective actions in order to protect public health and safety and to minimize exposures to the general public and emergency workers. The PAGs should not be viewed as acceptable dose limits; and, although the PAGs and EPZs complement each other, they should not be utilized to determine the size of an EPZ, i.e., the boundary at which the whole body PAG is exceeded should not be the EPZ demarcation boundary.

EPZs are planning mechanisms which, for any given facility, are based on a whole range of accidents and other variables such as population demographics, meteorological data, terrain, ingress and egress routes, etc. They should be developed and defined in a conservative manner such that in the event of an accident, incident response will not involve the entire EPZ, but if necessary, appropriate emergency plans are in place. Incident response beyond the EPZ, if necessary, will have to be developed on an ad-hoc basis at the time; however, if the EPZ is properly defined, such actions will be unlikely.

As I previously mentioned during our discussion of NRC licensed fuel processing facilities, if an EPA PAG cannot be exceeded at the facility boundary, there should be no need to develop and define an EPZ for such a facility.

Before closing, I would like to briefly discuss the current philosophy within the NRC regarding evacuation relative to power reactor incidents. Presently, at the declaration of general emergency, the NRC regulatory scheme requires that, at a minimum, licensees recommend that sheltering be implemented in the area encompassing the 0 - 2 mile radius of the plant. However, the current thinking, as noted by some of you as expressed in NRC's Response Technical Manual 91 (RTM-91), calls for the automatic evacuation of the 0 - 2 mile sector at the declaration of a general emergency. Currently, actions are under way within the NRC to adapt this scheme as a regulatory requirement. Please note that this evacuation may be based solely on plant conditions in the absence of an actual radiological release, and obviously, prior to reaching an EPA PAG trigger level.

I would be happy to respond to any questions you may have.

THE BASIS FOR PROTECTIVE ACTION GUIDES AND THEIR APPLICATION TO NON-REACTOR SOURCE TERMS

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Overview

The Protective Action Guides (PAGs) for decisions on evacuation and sheltering (also known as the PAGs for the early phase) were first published in the Environmental Protection Agency (EPA) *Manual of Protective Action Guides and Protective Actions for Nuclear Incidents* in 1975, and were reissued in slightly revised form in 1980. In 1990, we added PAGs for relocation as well as the 1982 recommendations of the Food and Drug Administration (FDA) on PAGs for food. As you know, EPA has been in the process of revising the PAGs for the early phase since early in the 1980s. My discussion today will focus primarily on the reasons why the PAGs required revision and the considerations that have led to the new PAGs. I will also touch on implementation guidance that we have developed for these new PAGs, including examples of some recent situations to which they have been applied.

There are three types of problems that led to the decision to update the 1975 PAGs for the early phase of a nuclear incident. First, the scope of the PAGs was inadequate; e.g., some important exposure pathways were not covered and the source term did not include long-lived materials. Second, we needed to consider new radiation risk projections. Finally, implementing guidance for use of the range and the choice between evacuation and sheltering had been occasionally misinterpreted and required clarification.

The PAGs Were Limited in Scope

a) Limited Source Term

The old PAGs for the early phase were adequate for protection of the general public from a reactor accident, but they did not apply to other nuclear incidents, unless the principal exposure was from radioactive noble gases or radioiodines. This is the case because these PAGs were developed specifically for atmospheric releases from power reactors, for which the leading pathway, in terms of health effects, is either whole body exposure to gamma radiation from the plume (plume shine), or thyroid exposure from inhalation of radioiodines. The deficiency is most noticeable in planning for incidents involving releases of particulates when radioiodine is not a major component.

To put the matter succinctly, we needed to generalize the PAGs so they would apply to the dose from any combination of radionuclides. The new PAGs solve this problem simply; they are now expressed in terms of effective dose, rather than whole body or organ dose. This assures that dose to any organ is accounted for, regardless of the radionuclide or pathway. We have also developed dose conversion factors for 141 radionuclides that cover almost any conceivable incident; these have been added to the implementation guidance. However, there were other problems.

b) Long Term Exposure

Whole body dose from exposure to a plume only accumulates while the plume is present. And, due to the short half-lives of most radioiodines, thyroid dose from short-term inhalation of radioiodines also accumulates over a short period of time. However, inhalation of long-lived particulates results in doses that accumulate over a long period, in some cases for a lifetime. Similarly, surface deposits of long-lived particulate materials can result in long-term exposure due to inhalation of resuspended materials. Since, as we will see later, risk of delayed health effects from radiation dose is the primary basis for selection of the PAGs, all of these doses should be considered for decisions on protective actions.

The PAGs that have already been developed for relocation take into account long-term exposure to deposited materials during the intermediate phase, both direct whole body exposure and inhalation of resuspended materials, because they are expressed in terms of the committed dose, rather than annual dose. However, long-term internal dose from inhalation of particulate materials from the plume were not addressed by the 1975 PAGs for evacuation and sheltering. This deficiency has been solved by expressing these PAGs in terms of the committed dose as well.

Thus, we have now adopted, for emergency response, both of the improvements introduced by ICRP-26 in 1977 and in use now for a number of years in regulation of occupational exposure and exposure of the public to routine releases, the concepts of effective and of committed dose.

c) Additional Exposure Pathways

Two exposure pathways not included in the old PAGs were, (a) exposure of the skin from beta radiation from an airborne plume and from materials deposited on the skin, and (b) whole body exposure to gamma radiation from radioactive materials deposited on surfaces (ground shine). For an airborne plume of beta/gamma emitters, calculations indicate that the health risk from skin dose will almost always be secondary to the risk from other doses, but only if exposed persons wash and change clothes within several hours after exposure of the skin begins. Therefore, since skin dose is not included in the summation over organs represented by effective dose, there may be situations where guidance is needed for evacuation or sheltering based on skin dose. Likewise, whole body dose from ground shine could be a major exposure pathway if relocation PAGs are not implemented within a few days after exposure begins. These deficiencies were solved by adding separate guidance for skin and by adding short-term exposure to ground shine to the dose included in the PAG for evacuation and sheltering.

Risk Estimates Have Changed

In 1975, the International Commission on Radiation Protection (ICRP) assumed that the risk of fatal cancer from low level exposure was approximately 1×10^{-4} rem^{-1}. At that time, EPA assumed a risk of about 2×10^{-4} rem^{-1}. Now, fifteen years later; these risk estimates have increased approximately 5-fold. The 1991 risk estimates published by the National Academy of Sciences correspond, for total radiogenic cancer incidence to 5 to 10 x 10^{-4} rem^{-1}, depending on the rate at which the dose is delivered.

We have addressed these increased risk estimates in two ways. First, we have taken a new look at the PAGs in terms of the basic principles for their selection. Second, we have reviewed experience on how the old PAGs were implemented, to make sure that they are applied in a manner consistent with our judgments on risk.

The four principles that EPA has selected as the basis for choosing PAG values are shown in Table 1. Principles 1, 3, and 4 are similar to those recommended by the ICRP in Publication 40 and in the recently published Publication 60. We have added Principle 2 and a similar consideration has been recognized by the International Atomic Energy Agency in its recently re-issued Publication 72.

Principles 1 and 2 limit the risk to health of individuals from radiation independently of other considerations. The first calls for avoiding dose that exceeds the threshold for prompt health effects; the second calls for keeping the risk of delayed health effects to reasonably low levels.

We assume that there is a threshold dose below which prompt effects are not expected to occur, and that threshold is much higher (50 to 300 rads) than any PAG that would satisfy the remaining three principles. Thus, Principle 1 has no effect on the choice of the PAG level. However, there is no threshold associated with delayed effects, and, therefore, the choice of PAGs based on the second principle is not so simple.

a) Risk of Delayed Effects

Since there is no threshold dose for delayed health effects, the determination of a dose value that is "adequately protective of public health under emergency conditions" requires one to select an acceptable risk value and relate it to the corresponding dose. One approach is to compare risk levels commonly used by EPA in setting standards for other carcinogens. These levels fall in the range of lifetime risks of death of 10^{-4} to 10^{-6}; that is, EPA almost always chooses its standards to reduce the lifetime risk of fatal cancer to less than 1 in 10,000, and rarely establishes a standard requiring a risk level less than 1 in 1,000,000. This implies a maximum dose in the range of 100 to 200 millirem. This maximum risk applies to standards for normal releases. Although there is no clear precedent for choosing different acceptable risks for normal versus emergency conditions, we concluded that a factor of 5 to 10 is not unreasonable. This leads us to the conclusion that a projected dose of 1 rem would satisfy Principle 2.

b) Cost of a Protective Action

Principle 3 requires that we carry out any further reduction of risk that is achievable at acceptable cost, and thus it acts as a supplement to Principle 2. That is, if the risk level established under Principle 2 can be reduced by cost-effective measures, then the PAG should reflect this. A recent landmark court decision under the Clean Air Act directed EPA not to set environmental standards on the basis of cost unless the risks are lower than those found to be "safe" without consideration of cost. This criterion has since been applied to other standards set by EPA, including PAGs. Using our conclusion for Principle 2 of 1 rem as the definition of "safe," under this criterion cost of implementation cannot be used to justify a higher dose, but it can be used to drive the risk to a lower value. Our analyses of cost of evacuation for several combinations of reactor accident categories, meteorology, and evacuation models indicates that the cost-effectiveness of avoiding the risk associated with 1 rem by evacuation is well within the range considered acceptable by the EPA, but not so low as to warrant a further reduction in the PAG. Since power reactors probably represent the worst case we can reasonably conjecture, we take this as a general conclusion. Therefore, cost was not an influencing factor in establishing the PAGs for the early phase.

c) Risk from the Protective Action

Principle 4 is simply an exercise in the application of common sense. It says that one should never apply a protective action if the risk from the action itself is greater than the risk that would be avoided.

In evaluating the risk from evacuation, the principle risk, for the average member of the population under normal circumstances, is that from the associated transportation. An additional potentially significant, but unquantifiable, risk is the psychological risk from evacuation. However, this risk may be offset by the psychological risk to those who would be concerned about not being evacuated. The risk from transportation associated with evacuation for ambulatory persons and under normal environmental conditions was calculated to correspond to the risk associated with a dose of about 30 mrem. This is, of course, small compared to 1 rem. However, if evacuation involves persons who are at much more than the normal risk from evacuation, or if the environment is more risky than normal, then evacuation at a dose of 1 rem could result in more risk from the evacuation itself than would be caused by the radiation. To avoid this situation, sheltering provides an alternative to evacuation. The PAGs provide for substituting evacuation, therefore, up to a dose 5 times higher than the recommended level for evacuation under normal circumstances for situations where evacuation carries a high risk. There may be other reasons, such as physical constraints to evacuation, or special source term characteristics that argue for sheltering. The new guidance also provides that sheltering should be substituted for evacuation for any situation where sheltering will provide equal or greater protection. But, caution is advised regarding possible shelter failure mechanisms for situations where the projected dose exceeds 10 times the PAG level for evacuation under normal circumstances (1 rem).

TABLE 1

Principles for Establishing PAGs

1. Acute effects on health (those that would be observable within a short period of time and which have a dose threshold below which such effects are not likely to occur) should be avoided.

2. The risk of delayed effects on health (primarily cancer and genetic effects for which linear nonthreshold relationships to dose are assumed) should not exceed upper bounds that are judged to be adequately protective of public health under emergency conditions, and are reasonably achievable.

3. PAGs should not be higher than justified on the basis of optimization of cost and the collective risk of effects on health. That is, any reduction of risk to public health achievable at acceptable cost should be carried out.

4. Regardless of the above principles, the risk to health from a protective action should not itself exceed the risk to health from the dose that would be avoided.

PAGs Have Been Misinterpreted

An additional problem associated with the old PAGs for evacuation and sheltering was their frequent misinterpretation with regard to whether evacuation was the protective action of choice at 1 rem in the absence of other risk factors or constraints, or was only recommended for consideration at this level. The intent of the guidance was that evacuation was normally to be the protective action of choice at 1 rem, but some portions of the published guidance on implementation were capable of multiple interpretations. This was further complicated by the absence of a published rationale. Both of these problems have been corrected in the revised guidance through detailed explanations and examples of the intended implementation of the PAGs, and by including background information on the process used to develop them.

Implementation Guidance is Based on Postulated Source Terms

During the early phase of an incident when dose, or dose commitment, can be accumulated rapidly, there is an urgent need to implement decisions for protective action promptly. For reactor incidents, potential source terms have been defined for different combinations of emergency plant conditions and meteorological conditions so that recommendations for evacuation/sheltering can be made early for close-in populations, and generally prior to a major release. The new guidance encourages this process for all fixed nuclear facilities that require radiological emergency response plans.

a) Short-Term versus Long-Term Dose

Before getting into guidance on dose projection, I want to discuss a common misunderstanding regarding the period of time over which dose is calculated to evaluate risk of health effects. Since deterministic health effects occur within a short time (usually within two months), dose received after this period is of no importance for evaluating whether a threshold level of concern has been exceeded. Therefore, dose calculations for these effects usually include only prompt external exposure to plus the dose that would accumulate over about 30 days from long-term exposure pathways such as inhalation of particulate materials. Some dose models calculate these short-term doses, and some emergency planners make the mistake of comparing these doses to PAGs for purposes of decisions on protective actions. However, the primary risk of concern for PAGs is the risk of cancer, for which there is no threshold and for which the risk continues to accrue from chronic doses received over many years. Therefore, a dose model is required that takes these longer term doses into account. In short, the dose of relevance is the entire committed dose, not the annual, or any other shorter term dose.

b) Projection of Effective Dose

"Effective dose" is a new dose quantity for PAGs. This quantity allows us to include all of the significant exposure pathways: direct gamma, inhalation, and ground shine. The first two will generally predominate. The component from ground shine may continue over many years, depending on the half life of the deposited materials. However, since relocation PAGs may be implemented to protect the public from long-term exposure to ground shine following evacuation, the only dose from ground shine to be considered for decisions on evacuation is the portion that would be accrued prior to the implementation of relocation. Based on experience with exercises, we have concluded that 4 days is sufficient time, in most cases, to collect sufficient information to implement relocation, if necessary.

Some concern has been expressed regarding the difficulty in calculating effective dose, in comparison to calculating whole body dose, as required for the current PAGs. In fact, it is no more difficult to calculate effective dose. It is just a matter of using different dose conversion factors. Chapter Five of the new guidance includes a single dose conversion factor for each of 141 radionuclides that can be used to calculate effective dose from the three exposure pathways combined (plume shine, inhalation, and 4 days of ground shine). These 141 dose factors should accommodate any reasonably conceivable source term.

Application Experience

The revised PAGs for the early phase have been implemented successfully for some special applications. The most notable were for the standby emergency responses for the launch of Galileo and Ulysses spacecrafts, which carried large quantities of Pu-238 as an on-board power source. In these cases, the limited road system was inadequate for timely evacuation of the large temporary population that would be there to view the launch. For this reason sheltering was considered and, since it provided the greatest exposure reduction, and could be implemented within the guidelines, was the recommended protective action.

Another special application was developed for potential reentry into the atmosphere over the United States land mass of Cosmos 1900 in 1988. This spacecraft was powered by a fission reactor similar to one that crashed in a sparsely populated area of northern Canada in 1978 and contaminated a large area with widely dispersed, highly radioactive, small "hot particles." In preparation for possible similar consequences if Cosmos 1900 crashed in the United States, it was necessary to develop procedures for monitoring and for calculating projected dose from widely dispersed hot particles, so that the projected dose could be compared to the PAGs for purposes of decisions on evacuation and relocation. These procedures were on standby when reentry occurred (over the ocean, fortunately). These two examples provide an indication that the new PAGs are flexible and that it is possible to develop special implementation procedures for defined accident source terms and conditions.

In summary then, the new PAGs now apply to any source term, the dose units in which they are expressed encompass all of the risk that may be avoided by the relevant protective action, and the accompanying text has been clarified to provide more complete guidance on the factors that should or should not influence the choice between evacuation and sheltering.

I hope this discussion will be helpful to you in your workshop deliberations this afternoon and tomorrow. I will be around if needed to further discuss any of these points, as will Joe Logsdon who participated in development of the PAGs and the implementation procedures.

IMPLEMENTATION OF PROTECTIVE ACTION GUIDES AT A LARGE PLUTONIUM PROCESSING FACILITY

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Introduction

The State of Colorado, with the assistance of the U.S. Department of Energy (DOE), has developed a Radiological Emergency Response Plan for the DOE Rocky Flats Plant. Several serious accidents at the plant in the past caused the Governor of Colorado to require an emergency response plan equivalent to that required for a commercial nuclear power plant. That planning process began in 1977 and has continued to the present. The planning basis since 1980 has been the maximum credible accident (MCA), which was defined for the plant as the maximum airborne release of plutonium which could occur with a frequency of more than once in ten million years. The State chose to use the MCA as the bounding accident for planning purposes, although it acknowledges that this is different than the planning basis currently required by the Nuclear Regulatory Commission (NRC) for commercial nuclear power reactors. The State developed protective action guides (PAGs) based on the Environmental Protection Agency (EPA) guidance available in 1980 as well as other information relevant to limiting lung dose, believed to be the most serious hazard for an airborne release of plutonium particles. A review of the MCA and the emergency planning zones (EPZs) for the plant was initiated in 1988 and continues to the present. Phase II of that effort, the development of information to assist the State in revising its plan on an interim basis, was recently completed. The observations in this paper are drawn from the Phase II EPZ Project.

The Rocky Flats Plant is a major plutonium processing and fabrication facility owned by DOE and located on 384 acres of land about 16 miles from downtown Denver, Colorado, as shown in Figure 1. The facility itself is centered within a 6,550-acre buffer zone which extends to a radius of roughly 2 miles from the center of the plant site in all directions. EPZs have been established, and federal, state and local agencies have participated in exercises which have tested the efficacy of the offsite emergency plan.

Changes in the operations at the plant, particularly the cessation of transuranic radioactive waste shipments, caused the Governor of Colorado in 1988 to request a review of the plan to assure its continued validity in the face of increasing waste volumes stored on the site. DOE committed its operating contractor, then Rockwell International and now EG&G/Rocky Flats, Inc., to provide Task Teams that would develop the necessary technical information to validate the MCA and to update and improve the emergency plan. That information would be reviewed and evaluated by an oversight committee consisting of representatives from the Colorado Division of Disaster and Emergency Services (DODES), the Colorado Department of Health (CDH), DOE (Rocky Flats Area Office), and EPA (Region VIII Office).

Recognizing the magnitude of the task, it was decided to divide it into four time-sequenced phases, each of which would provide the State with a summary of the technical information developed in that phase. Phase I was a revalidation of the MCA, while Phase II was an interim analysis of the EPZs for a radiological accident. Phases III and IV would develop more complete information on a spectrum of radiological and non-radioactive hazardous material accidents. The activities of Phase II form the basis for this paper.

Background

According to A.J. Hazle (Ref. 1), Colorado has used a MCA as its bounding accident for planning purposes. The assumption is that, by basing its plan on such a relatively improbable event, the State would be prepared to handle more probable but less severe events as well. It was not considered a prudent expenditure of State funds to develop a plan for more severe, less probable accidents, although the current plan certainly provides a sound basis for response in that unlikely event.

The MCA currently defined for the plant is the airborne release of 100 grams of plutonium (primarily Pu-239, -240 with some Am-241 ingrowth). The scenario developed in the Rocky Flats Plant Final Environmental Impact Statement (Ref. 2) was that of a large airliner crashing into a plutonium production building, with the resultant penetration of the building and jet-fueled fire providing the mechanism and driving energy for the release. Release fractions for burning plutonium were taken from the available literature, and worst-case meteorological conditions were assumed to maximize the off-site impact in the FEIS analysis.

When the current emergency plan was developed in 1977-80, the State considered the then-available EPA PAGs to be only partially appropriate for the Rocky Flats situation, as they recommended action based on either whole body or thyroid radiation dose. The doses expected from the Rocky Flats MCA would come primarily from inhalation of airborne plutonium particles. This would result in a dose to the lung that would have a relatively long commitment period because of the long half life of plutonium and its relative immobility when deposited in the lung (although the doses to the liver and gonads were also considered). The State chose to use the recommendations of the British Medical Research Council (Ref. 3) to take protective action to avoid doses exceeding twice the maximum permissible annual dose for radiation workers. By the standards of the day, this PAG translated to a projected lung dose of 30 rem, a bone dose of 10 rem, and a gonadal dose of 5 rem. Calculations quickly revealed that the lung dose would be the controlling factor, i.e., if the lung dose were maintained below the guideline, the other doses would also be well below their respective guides as well.

Using the expected worst-case meteorology, dose versus distance curves were developed for an airborne release of 100 grams of plutonium, and three zones were defined corresponding to the EPA Category I, II, and III protective actions. They were: Category I, projected dose greater than 30 rem (lung), consider evacuation/sheltering; Category II, projected dose between 6 and 30 rem (lung), sheltering; and Category III, projected dose less than 6 rem (lung), confirmatory sampling. The corresponding distances were 0 to 4 miles, 4 to 10 miles, and greater than 10 miles, as illustrated in Figure 1.

1988 Phase II Review

The current review, begun in late 1988, was conducted to ensure that the accumulation of transuranic waste at the Rocky Flats Plant had not created a situation in which the assumed MCA, i.e., the "credible" release of 100 grams of plutonium, could be exceeded, and to update and revise the existing EPZs by considering more recent developments in dosimetry and PAGs.

Dosimetry

Consistent with the recommendations in the International Commission on Radiological Protection (ICRP) Publications 26 and 30 (Ref. 4 and 5), the State had decided at the outset to use the "committed effective dose equivalent" concept as its primary measure of radiation risk. This necessitated substantial changes from the "organ dose" concept employed in the existing plan. Furthermore, the previous dose calculations had been based on an assumed particle size distribution of 0.3 μm (AMAD: activity median aerodynamic diameter) and a dose commitment period of 70 years. For consistency with national and international practice, it was agreed to change the assumptions to a particle size distribution of 1 μm (AMAD) and a dose commitment period of 50 years in the Phase II revision.

Protective Action Guides

PAGs are recommended levels of projected radiation dose at which actions to protect the public should be taken following an accident at a nuclear facility involving an actual or potential release of radioactive material. They are response guidelines, rather than mandatory levels at which actions must be taken. State or local government agencies may take actions at other projected doses or based upon conditions at the facility. They may also refrain from taking protective action if that action would result in a higher immediate risk to the public than the radiation risk avoided by the action.

PAGs have been issued by the EPA (Ref. 6 and 7) for the United States, and the ICRP has provided similar guidance internationally (Ref. 8). These two groups espouse similar, though not identical, principles for their recommendations, and the action levels are somewhat different. EPA recommendations are given in Table 1 while ICRP recommendations are given in Table 2. In reviewing the use of PAGs world wide, the task team found significant variations among facilities, states, and countries. The EPA recommendations employ the lowest action levels in common use, and are presented in units of "committed effective dose equivalent" (CEDE). The ICRP action levels are somewhat greater, and there is some ambiguity concerning which dosimetry units are intended. The task team noted five possible PAG options for the State's consideration, including:

* EPA PAGs, December 1990 draft
* EPA PAGs, 1980 (revised 1988) draft
* ICRP Publication 40 PAGs
* Modify current State PAGs for the Rocky Flats Plant to incorporate CEDE
* Develop new PAGs specifically for this site

TABLE 1
EPA PAGs FOR THE EARLY PHASE OF A NUCLEAR INCIDENT

Protective Action	PAG (Projected Dose)	Comments
Evacuation (or sheltering[a])	1-5 rem[b]	Evacuation (or, for some situations, sheltering[a]) should normally be initiated at 1 rem. For further guidance, see Ref. 7.
Administration of Stable Iodine	25 rem[c]	Requires approval of State Medical Officials.

[a]*Sheltering may be the preferred protective action when it will provide protection equal to or greater than evacuation, based on consideration of factors such as source term characteristics, and temporal or other site-specific conditions.*

[b]*The sum of the effective dose equivalent resulting from exposure to external sources and the committed effective dose equivalent incurred from all significant inhalation pathways during the early phase. Committed dose equivalents to the thyroid and to the skin may be 5 and 50 times larger, respectively.*

[c]*Committed dose equivalent to the thyroid from radioiodine.*

Emergency Planning Zones

EPZs are areas surrounding a nuclear facility within which local and state authorities have developed specific plans to protect the public in the event of an actual or potential release of radioactivity at that facility. For nuclear power reactors, the two zones are areas within a 10-mile radius of the plant (of greatest concern during the early phase of an accident) and areas from 10 to 50 miles in radial distance (of concern in the intermediate and late phases of an accident). At Rocky Flats, there are effectively three zones as previously indicated, differentiated by the maximum expected dose and type of protective action. These zones were originally defined by projected doses relative to the PAGs at various distances resulting from the MCA.

TABLE 2
ICRP GUIDANCE ON INTERVENTION LEVELS

Countermeasure	Critical Organ Dose Equivalent (rem)	
	Whole Body	Individual Organ (including lung & thyroid)
Sheltering and Stable Iodine Administration		
upper dose level	5	50
lower dose level	0.5	5
Evacuation		
upper dose level	50	500
lower dose level	5	50
Control of Foodstuffs		
upper dose limit	50	50
lower dose limit	5	5
Relocation		
upper dose limit	50	Not Anticipated
lower dose limit	5	

(Extracted from ICRP Publication 40 (Ref. 8), Tables C1 and C2)

Current thinking at both EPA and NRC disavows such a specific linkage between EPZs and PAGs. Both agencies agree that EPZs should be large enough to include all areas where the MCA might cause exposures sufficient to produce acute health effects, and also large enough to provide an adequate planning area for implementing the PAGs (plus a basis for expansion if doses are predicted to exceed the PAGs beyond the EPZ). The dilemma at Rocky Flats, as well as many other non-reactor nuclear facilities, is defining an EPZ large enough for protection and small enough for effective planning.

The distance from the plant to which a PAG would be exceeded in the event of a MCA is an important component of EPZ development. This protective action distance can be determined by comparing the dose versus distance relationship calculated for the MCA and some assumed meteorology to PAG thresholds. This distance can be highly variable, however, depending upon the selected wind speed and atmospheric stability. In the case of Rocky Flats, several years of meteorological observations are available from which to characterize these parameters in terms of their probability of occurrence, although only one year was used in this analysis in order to comply with strict data quality guidelines.

Three annual meteorological probabilities were chosen as illustrative of the complete distribution. The median meteorology was chosen to represent "typical" conditions at the plant, reflecting an annual meteorological probability of 0.5 (50% of the time it would be more favorable, 50% less favorable). A meteorological probability of 0.05 was chosen to represent the "worst case" - the level used in previous analyses at the Rocky Flats Plant. This level implies that only 5% of the time in one year would the conditions be less favorable than this. The third meteorological probability chosen for illustration was 0.005, corresponding to the "extreme worst case" conditions defined in NRC Regulatory Guide 1.145 (Ref. 9). This implies that only 0.5% of the time in one year would conditions be less favorable than this.

Figure 2 illustrates the effect of increasingly conservative meteorological assumptions on the distance at which any given PAG would be exceeded for the assumed MCA at the Rocky Flats Plant. For example, for the same accident scenario, a dose of 1 rem might be exceeded at distances ranging from less than 6 to greater than 80 kilometers (less than 4 to greater than 50 miles), depending on the chosen meteorology. What is an appropriate assumption in this case? As a guide, it may be appropriate to remember the compounding of probabilities. If the MCA has a probability of one in ten million (1×10^{-7}) per year, then the probability of achieving the dose-distance curve from the median meteorology is the product of the two probabilities, or 5×10^{-8} per year. Similarly, the probability of achieving the extreme worst case curve is 5×10^{-10} per year. Is it appropriate to utilize such extremely small probabilities in the emergency planning process? This is less a technical than a policy question for the particular planning agency.

Summary

A technical review of the information needed by the Colorado emergency planning agency to revise and update the radiological emergency response plan for the DOE Rocky Flats Plant was conducted by a multi-agency oversight committee. This information may be used by the State to redefine the EPZs. The choice of PAGs plays an important but not definitive role in determining the most appropriate EPZ boundaries. The assumptions underlying the MCA, the meteorological probability, and several other factors will also affect the EPZ determination. Future activities contemplated for this project include investigation of more realistic meteorological models than the straight-line Gaussian model used in this analysis, analysis of a spectrum of possible accident probabilities and outcomes, and the incorporation of procedures for coping with non-radioactive hazardous material accidents which could have off-site consequences.

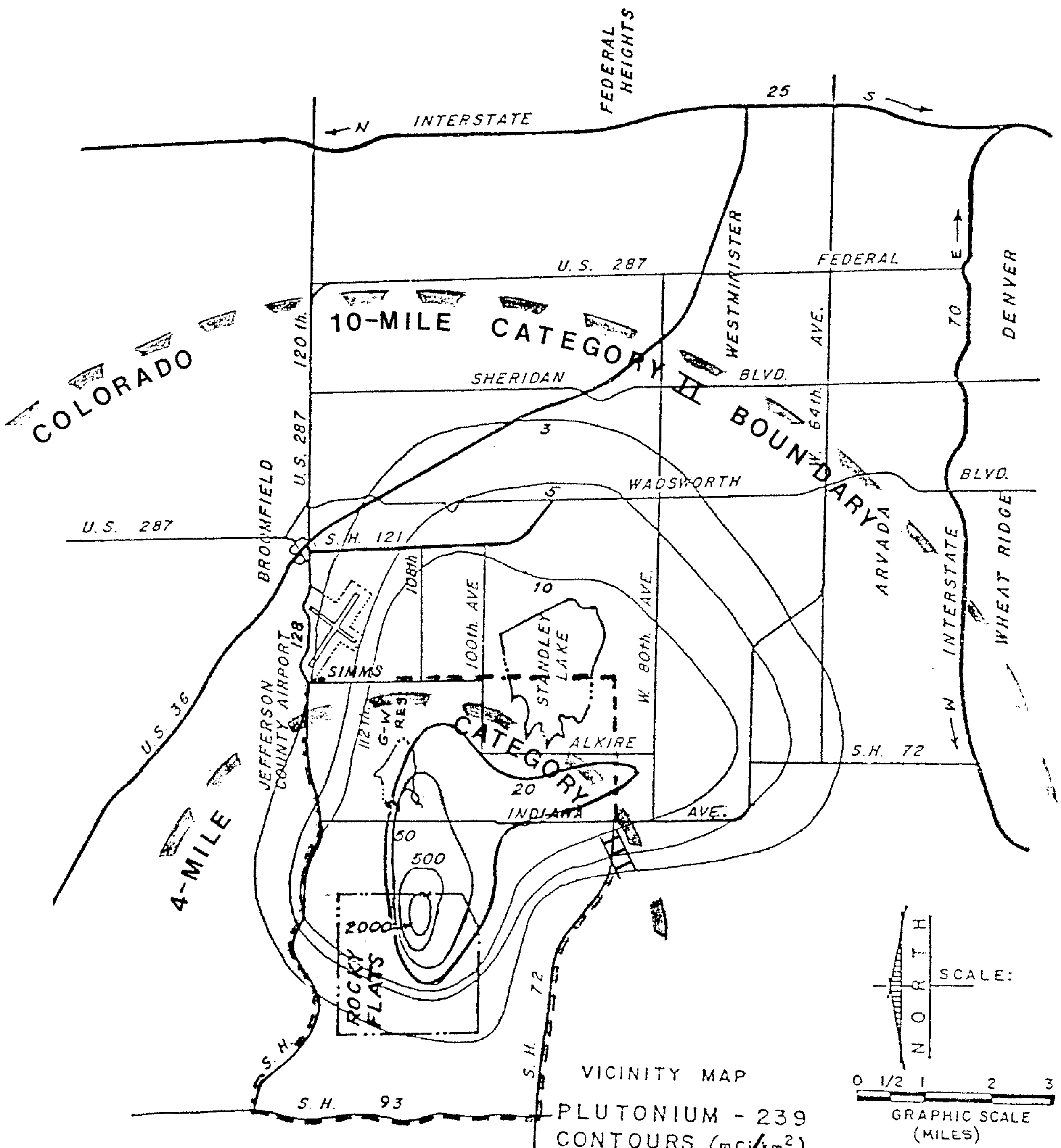
Acknowledgements

The effort described above is not mine but is the combined achievement of many individuals working together often under difficult circumstances and with short deadlines. Special acknowledgements go to the PAG Task Team, and to the entire Oversight Committee, who have furthered my education in the emergency planning process.

FIGURE 1
U.S. DOE Rocky Flats Plant and Vicinity

Approximate Boundaries for Colorado Emergency Response Plan and "Area of Concern for Housing"

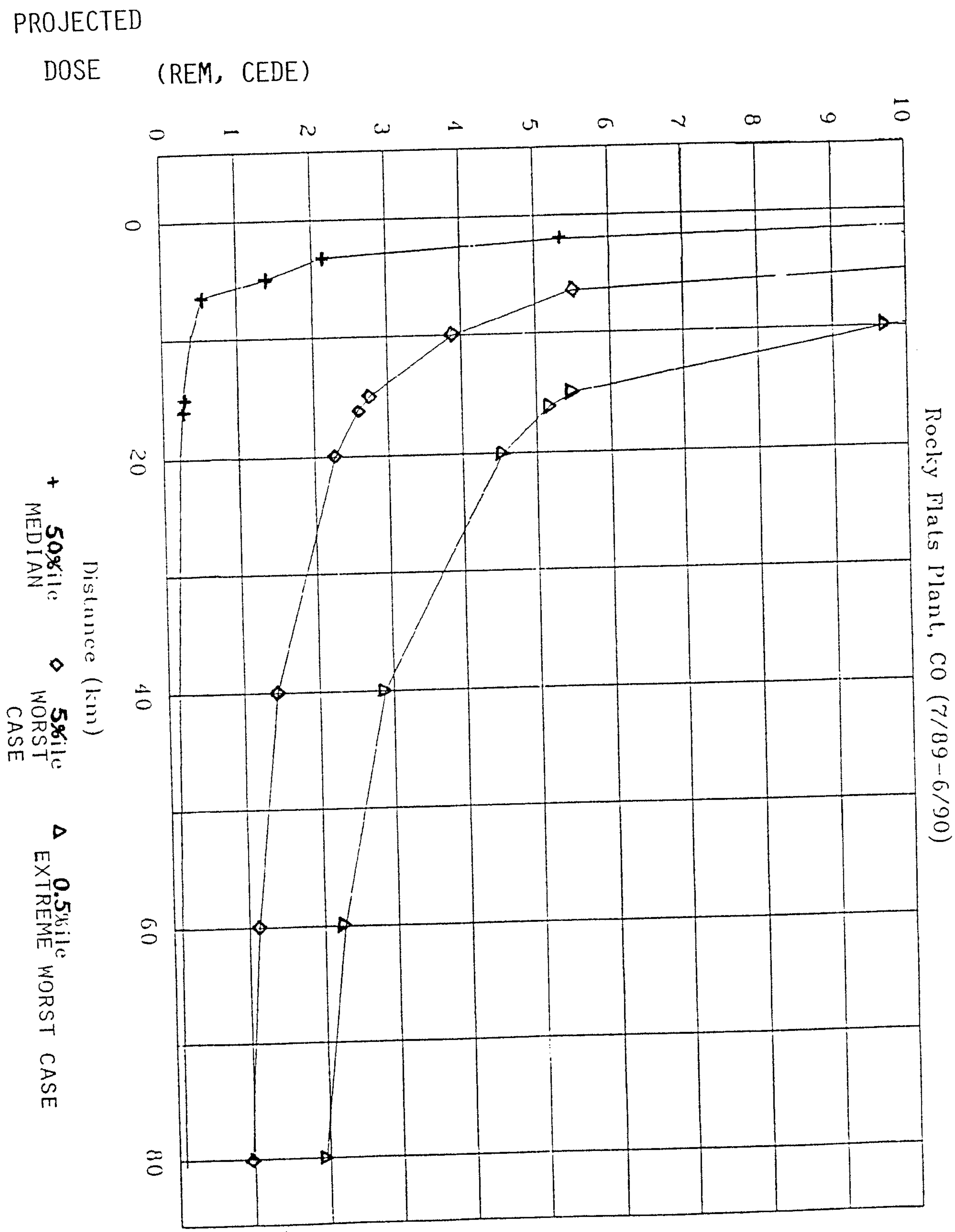
Adapted by EPA Region VIII Radiation Program - Revised 1985



Adapted from P.W. Krey and E.P. Hardy, Plutonium in soil around the Rocky Flats Plant, US AEC Report HASL-235, (1970)

FIGURE 2

NRC Guide 1.145 Dose Calculations



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MIXED HAZARD INCIDENTS (CHEMICAL/NUCLEAR INCIDENTS)

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Emergency Response Capabilities to an Incident Involving Radioactive Materials or Mixed Hazardous and Radioactive Materials

Emergency response to a release of radiation or a release of hazardous and radioactive materials will be the responsibility of the Environmental Protection Agency (EPA) Region IV, Emergency Response and Removal Branch. This Branch maintains a 24-hour duty officer who will receive the information directly and will determine whether the Regional first responder, an On-Scene Coordinator (OSC), should respond to the release. EPA receives notifications through the National Response Center (NRC) in Washington D.C., which is the national clearinghouse for reporting spills or releases of CERCLA 101 listed hazardous substances or the releases of oil. The listed hazardous substances includes hazardous waste, hazardous air pollutants, hazardous substances, and the Title III list of extremely hazardous substances as well as all radionuclides. All of the hazardous substances have an associated reportable quantities, which is the minimum quantity which determines whether the spill must be reported to either EPA or the Nuclear Regulatory Commission (NRC). The reportable quantities are reported in pounds for hazardous substances and in curies for radioactive materials.

After notification of a spill or release, the regional duty officer assesses the quantity and hazard, and then determines whether to send an EPA OSC, or to utilize the capabilities of our Technical Assistance Team (TAT) contractor, or in the case of major spills, both EPA and TAT. Response to a spill of radioactive or mixed material would, at a minimum, require the use of TAT for immediate monitoring for radiation. If additional radiation monitoring is necessary or an extensive cleanup was required, the OSC has the capability and contracting authority to utilize the Emergency Response Contract Services (ERCS) contractor to perform a cleanup. Through either TAT or ERCS contractor, specialty contractors for radiation monitoring, health physics and radioactive materials emergency response cleanup could be obtained within 24 hours in an extreme emergency. In the case where a viable responsible party is present, EPA OSC has the authority to issue immediate cleanup orders.

Region IV has used the services of Chem-Nuclear, Westinghouse, and Numanco as subcontractors on removal actions which involved the removal or stabilization of radioactive or mixed waste. Through TAT, EPA could procure all the necessary laboratory services for both mixed waste or radioactive materials. The capability of EPA to respond is also enhanced by being able to use the services of the EPA Emergency Response Team (ERT) and its contractor services. The ERT has the capability for radiation monitoring or would be able to procure specialized equipment.

In addition to the ability to procure contractor services, Region IV has a mobile command post, satellite and cellular communications capabilities, which can be mobilized immediately. We also have the ability to use the services of the U. S. Coast Guard Strike Team and all of their resources, including level A personnel protection.

EPA Region IV OSC has the ability to procure up to $50,000 on-scene during an emergency. If additional funds are necessary for a response action, the regional contracting officer could approve an additional $200,000, and in the case of a catastrophic release up to $2,000,000 in funds could be made available.

In summary, in the case of a radioactive or mixed waste release, EPA Region IV or any Region could and would have the necessary funds, equipment and necessary personnel on-scene within minimal time. We would have available the latest in communication equipment, monitoring equipment and would be able to procure any needed specialty services or equipment.

ARKANSAS' TITAN II EXPERIENCE

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Introduction

A Flash....a deafening Blast ushered in a dawn of a new Day. The unplanned, the unthinkable, the IMPOSSIBLE had occurred. An American nuclear warhead had been propelled from an underground missile silo. Its final target was not a Russian city or a Soviet military complex thousands of miles away. It was on American soil within 1000 feet from its Titan II silo. As the warhead lay near the edge of the silo complex grounds in the dark of the early morning, state and local government officials were also in the dark. Due to U.S. Air Force policy, the existence of this nuclear device and its final destination could not be discussed with civilians. This, of course, lead to political and public relation nightmares for all. Without adequate coordination with the Department of Defense (DOD), state and local governments each worked separately. In some cases, alarming false data surfaced, creating panic among our major administrators. I will in my talk today:

* Review the specific details of this Titan II missile incident near Damascus, Arkansas, and

* Discuss an overview of activities that came after this incident to better protect the health and safety of the citizens.

Background

In 1980, the American land based Intercontinental Ballistic Missile (ICBM) nuclear arsenal consisted of 1000, what was then considered, "Modern" Minuteman missiles and a few aged Titan II missiles. At that time, 54 Titans were sited in underground silos within Arkansas, Kansas, and Arizona.

As their name implied these were large missiles capable of delivering large megaton warheads. (In fact, these 54 made ⅓ of the land based U.S. megatonage). They had been deployed in 1963. Seventeen years later their existence may have been poker chips in the Arms reduction game.

These "geriatric giants" began to create problems for the Air Force in the field. As they aged, liquid fuel leakage problems became more numerous, dangerous and on occasion fatal. Between 1975 and 1980, 125 leaks had been reported with the Titans. In 1978, two leaks had occurred where two airmen had been killed. Another 29 were injured.

One such Titan II missile and its nine megaton thermonuclear warhead was sited in a 146 foot underground silo near Damascus, Arkansas. This is a small town approximately 60 miles north - northeast of Little Rock. Two years earlier (in 1978) problems with leakage at the silo had occurred. Liquid vapors had leaked into the air and seven people from the Damascus area required hospitalization.

The Incident

On Thursday, September 18, 1980, routine maintenance was being performed on the 103 foot Titan missile. An Air Force technician dropped a 3 pound wrench socket. After falling 70 feet it punctured the first stage fuel tank (The missile's skin was thin.). Fuel (Aerozine-5O) vapors began to escape. The workmen evacuated the silo.

The automatic sprinkler system was activated once a fire had started. With 100,000 gallons of water the fire was put out. Yet, the leak continued. Vapor concentrations continued to rise. A two mile evacuation was ordered by the missile crew on site.

Approximately 6½ hours after the initial accident a two member emergency team entered the silo's access chamber to plug the leak. They found at that time vapor concentrations were continuing to increase. As these concentrations increased so did the probability of spontaneous combustion. Just as the team was leaving the access chamber the vapor, and air mixture exploded. This ignited the remaining fuel. The 750 ton concrete roof was demolished. It was hurled across the country side as aluminum foil discarded from the weekend picnic. The nine megaton warhead was catapulted out of the silo approximately 200 yards.

One airman died of chemical pneumonia from inhaling fumes. Another was critically injured. Twenty more were hurt. Approximately 1,400 people were evacuated from the area.

ADH's Response

In September 1980, the Department's Division of Environmental Health Protection (now named Division of Radiation Control and Emergency Management) had a hazardous Chemical Response group. This section was staffed with chemists who responded to a wide range of hazardous material mishaps within the State of Arkansas. A variety of chemical test equipment could be taken on to a Hazmat scene and preliminary measurements could be made to assess the impact of the incident.

On Thursday September 18, 1980, at approximately 8 p.m., our director, E.F. (Frank) Wilson, received notification that there was a fire at the missile silo complex near Damascus.

The supervisor of our Hazardous Material Chemists was contacted and instructed to obtain test equipment and proceed to the missile complex. At the same time, the Department's Mobile Command Headquarters was activated.

This Mobile Command Post is a refurbished Kentucky trailer that years earlier had been used as an x-ray van for the Tuberculous Examination Program. At that time, it was pulled by a two-ton Dodge tractor.

Mr. Wilson arrived on the scene at 10:30 p.m. Upon arrival, he was briefed by the local Office of Emergency Services (OES) coordinator who informed him that there was no fire in the complex. However, there was a leak.

At 12:15 a.m., on the next morning (September 19) our Field Headquarters van arrived on the scene. A briefing was provided. Then, the normal routine long wait as with many responses began. But, at 3:01 a.m., the normal waiting was interrupted by the explosion.

In world class speed and with physical feats of herculean magnitude, the mobile van was loaded up. The Department personnel jumped in the Dodge tractor and their personal vehicles. They floorboarded the accelerators. A mad dash similar to the land rush in the movie "Oklahoma" was in progress. We were racing away from the site following blue Air Force pickup trucks.

Minutes and miles later contact with our director was made. The van was directed to go to Damascus. Meanwhile, Mr. Wilson went to the State Emergency Operations Center in Conway, Arkansas (30 miles northwest of Little Rock). Notification of our Medical Director, other state officials and our emergency radiation monitoring teams (Health Physicists (HP)) were made.

By 6 a.m., our HP teams had arrived in Conway. One team was directed to go to the Conway Memorial Hospital to monitor the Air Force personnel being treated for burns and wounds. No alpha contamination was detected.

At 6:30 a.m., Mr. Wilson contacted the Department of Energy (DOE) to activate the IRAP team. He was informed that the Air Force had already alerted the system via another method. Since the Air Force had alerted them they could not respond to the Arkansas request. However, later that day they did.

Mr. Wilson was referred to the Albuquerque Operations Office for further information.

Upon contact with that Operations Office, we were informed that a DOE team had been initiated. From these discussions, it was indicated that the high explosives had gone off or burned in a reported mushroom shaped cloud. It was thought that it was possible that the warhead could be involved. The area should be monitored. (Keep in mind that at this time the Air Force was not talking to civilians about this incident. Thus, we were in a near vacuum desperate for any information).

By 7 a.m., two ADH monitoring teams were dispatched to the Damascus area.

One team was deployed to a paved county road a few miles west of the silo. While traveling down the road one of the novice HP's stuck his Eberline alpha probe out of the window of the vehicle. Due to internal instrument noise and perhaps faulty connections a reading was obtained. Before followup readings and a plausible explanation could be made, the erroneous reading was called in.

A pound of lead sunk through the GI tract of those within the State Emergency Operations Center. (This report became one of our Medical Health Officer's most unforgettable moments in his brief career with the Department).

The other HP team was quickly deployed to this area. Both teams were able to confirm the existence of no alpha contamination. The EOC staff was informed of these findings. Relieved, this staff was able to coordinate activities between the various state agencies, answer questions and talk on the telephone.

Around 11:30 a.m., members of the DOE IRAP team arrived. They toured the area around the silo. By early afternoon it was apparent that the Air Force had found their wayward child and had safely secured it. No alpha contamination had been detected.

Finally, we were stationed at the missile complex gate. The remainder of the afternoon was spent standing and sitting in the late summer sun discussing the days events, speculating and watching a wide variety of military helicopters fly over.

By 5 p.m., we were sent back to our duty stations in Little Rock. Meanwhile, Damascus, Arkansas enjoyed it's brief moment of fame as the lead-in story for all the major networks and print media.

The Aftermath

From this Titan experience a new Dawn was figuratively ushered in. Better communications between the Military (DOD), and the state and local government was established.

From the standpoint of relationships between Arkansas officials and DOD, it was a major catalyst in the Titan program. The following were results of this event:

* A Memorandum of Understanding between the U.S. Air Force and the State of Arkansas was negotiated.

* Detailed emergency plans were developed.

* Canister masks could be made available for personnel protection.

* Periodic exercises of the Emergency Plans were performed with the Air Force.

State agencies were kept informed of movement of missile propellants. This was especially true as the Titan II's were phased out within the next 6 years.

Lessons Learned

Of course, many lessons were learned.

* First we must continually realize that the unplanned, the unthinkable and even the impossible can and will occur. Our mode of thinking must not rule these out. Here, we do not necessarily have to plan for the possibility of every potential event. Yet, our response policies and procedures must not be rigid. Flexibility must be the standing order of the day.

* Adequate monitoring equipment must be available. After this event, the Division was able to vastly update and upgrade it's radiation detection equipment inventory.

* Adequate staff training must also be provided. A routine training program was established. Both in-house and outside training is now provided to our staff. Even today, various survey equipment and techniques not normally encountered are covered in the rare event they must be employed.

Conclusions

Today, I have reviewed with you what I hope was a very interesting chapter in American Emergency Response history. Hopefully, we have gleaned lessons as to how we may respond to the unplanned. The need for communication between DOD and the state and local officials can not be over emphasized.

I believe that this workshop is a giant step toward a mutual working partnership.

I will be glad to answer any questions.

REVIEW ON THE BASIS OF GUIDANCE FOR SHELTERING AS A PROTECTIVE ACTION IN A PLUTONIUM RELEASE ACCIDENT

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Introduction

Hazard

Briefly, I'll review the hazard from plutonium. For Pu-239, inhalation of contamination in a cloud gives a dose of 5.2×10^8 rem per µCi cm^{-3} h. Ground shine from deposited contamination is 1.5×10^0, and direct skin exposure from immersion in a cloud is 4.7×10^{-2}. Clearly, inhalation is the pathway of concern.[1]

Air Exchange

Protective action is based on the inhalation pathway. Evacuation removes the public from the plume, breathing uncontaminated air at another location. Sheltering keeps the public indoors breathing air which does not reach equilibrium with the plume.

In this discussion shelter means any building: a home, a school, a factory, an office building, a hospital, or any other building of opportunity. The discussion is weighted toward homes because, on average, only 40 hours of a 168 hour week are spent at work. The effectiveness of a shelter is a function of the number of exchanges of clean inside air with contaminated outside air. Shelter, in this case, is unrelated to shielding. Please note that this is very different than Civil Defense (CD) fallout sheltering. Shelter here means air-tight.

Three Areas of Consideration

The number of contaminated air exchanges depends on three things: (1) the tightness or air exchange rate of the shelter, (2) the nature of the plume at the shelter, and (3) the understanding of the public in sheltering techniques.

Tightness of the Shelter

Typical Exchange Rates

Typical air exchange rates vary from 0.07 to 4.0 complete air changes per hour.[2] Even for a specific building, air exchange rate or tightness varies with a number of factors, one of the largest being the weather.

Weather Variance

Indoor/outdoor temperature differences cause density differences which cause pressure differences that drive infiltration.[3] Wind also causes a driving pressure that produces natural ventilation.[4] Exchange rate more than doubles for a doubling of wind speed above 6 mph.

Figures 1 and 2 show comparable wind driven and temperature driven infiltration rates. One graph shows a "tight" house and the other shows a "loose" house.

Filtration

Air infiltrates through open windows and doors, cracks, and directly through solid walls. These pathways essentially do not filter the incoming air. An entrained 2 μm particle of plutonium will not be removed.[5]

Dose Reduction Factor (DRF) is the ratio of the time-integrated concentration of contaminants inside the shelter to that outdoors. This means that a DRF close to zero is desired and that a DRF of 1.0 offers no protection. The graph of the DRF of a shelter immersed in a plume takes the form of $1 - e^{-Rt}$. This is shown in Figure 3.

Some buildings draw in outside air directly and filter it as it comes in, other buildings filter recirculating air, and some do neither. If air is filtered at any step of the process, the equilibrium contamination ratio of indoor to outdoor air will be less than one.

The types of heating and cooling systems also affect the tightness of the building. For instance a radiant heating system such as hydronic will affect infiltration differently than a forced air system. A combustion based heating system will cause more infiltration than an electric based system. An air conditioning system which uses evaporative coolers rather than refrigerant coolers may have an indoor/outdoor equilibrium contamination ratio of greater than one.[6]

Overall Estimate

There really is not a good ballpark number to use for air-exchange rate or DRF in an emergency. If sheltering is to be considered as a protective action, emergency response plans must evaluate buildings on a case-by-case basis. In very general terms, modern homes built since the energy-conscious mid 70's seem to offer the most protection. Industrial buildings offer the least protection and other buildings fall somewhere in between. Again, for any real sense of sheltering effectiveness, specific buildings in the area must be evaluated in advance.

Plume Considerations

Duration

The nature of the plume itself also obviously affects indoor air contamination concentration. For a long duration release, a shelter's indoor air contamination concentration value will more closely approach equilibrium. A shelter subject to five air changes inside the plume has nearly achieved equilibrium. Based on a range of 0.07 - 4.0 air changes per hour this is anywhere from 1.25 to 71 hours. The Environmental Protection Agency (EPA) guidance on implementing Protective Action Guides (PAGs) is that sheltering is usually not appropriate for exposure lasting more than two air exchanges of the shelter.[7] This translates to 1/2 to 29 hours.

Concentration

The shelter's location in the plume is a self evident concern. What is the concentration? Is it low enough that the increment of protection afforded by sheltering reduces projected concentration below the PAG Derived Response Levels?

Sheltering Technique

Sealing the Shelter

The third area of concern is public understanding. A shelter is a device which must be operated properly to be effective.

Ventilation must be secured. Heating and air conditioning (HAC) in general is worth 0.33 ± 0.37 air changes per hour.[8] Note that Figures 1 and 2 are given with the assumption that HAC is turned off.

Operation of kitchen and bathroom exhaust fans will also increase infiltration by the amount of air being exhausted. This makes sense intuitively. If air is being removed from the house at one point, then air must be coming into the house at another. Otherwise the exhaust fans would draw a vacuum on the house and a person's ears would pop as they walked outside (or they would pass out as all the air was removed from the house.) Attic fans also greatly increase infiltration by creating pressure differences. See Figure 4.

Post Plume Ventilation

Not to be overlooked is the dose received from contaminated air trapped indoors after the plume has passed. A shelter must be aired-out. Otherwise, the indoor contamination concentration will be an exponential die-off (e^{-Rt}) based on the same air exchange rate.

Summary

Highlights have been presented here. For planning purposes, thorough discussions should be consulted in the EPA PAG Manual, Chapter 5 and the Department of Energy (DOE) publication *Effectiveness of Sheltering in Buildings and Vehicles for Plutonium* DOE/EH-0159T UC-160. Experienced Heating, Ventilation and Air Conditioning (HVAC) engineers familiar with American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE) Fundamentals and local building customs should be consulted about building tightness and infiltration.

CD sheltering considerations are very different than those presented here. Reliance on CD plans and techniques could very well be worse than useless in a plutonium release accident.

Three Areas of Concern

In a plutonium release accident, sheltering does provide some protection for the airborne pathway, the pathway of concern. To rely on sheltering as a protective action, three major considerations must be evaluated in advance: 1) air-tightness of available shelters, 2) duration and concentration of the plume, and 3) public understanding of sheltering technique.

[1]U.S. Environmental Protection Agency (EPA); *Manual of Protective Actions for Nuclear Incidents*. Draft. Tables 5-3, 5-4, and 5-5; 1991.

[2]Engelmann, R.; *Effectiveness of Sheltering in Buildings and Vehicles for Plutonium.* DOE/EH-0159T UC-160. U.S. Department of Energy (DOE). p.23; 1990.

[3]American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE); Fundamentals. p.22-3; 1985.

[4]Ibid., p.22.2.

[5]Engelmann; p.8.

[6]Ibid., p.9.

[7]EPA; p.5-29.

[8]Engelmann; p.26.

SHELTERING CONSIDERATIONS

1. Building Tightness

2. Plume Concentration and Duration

3. Sheltering Technique

FIGURE 1

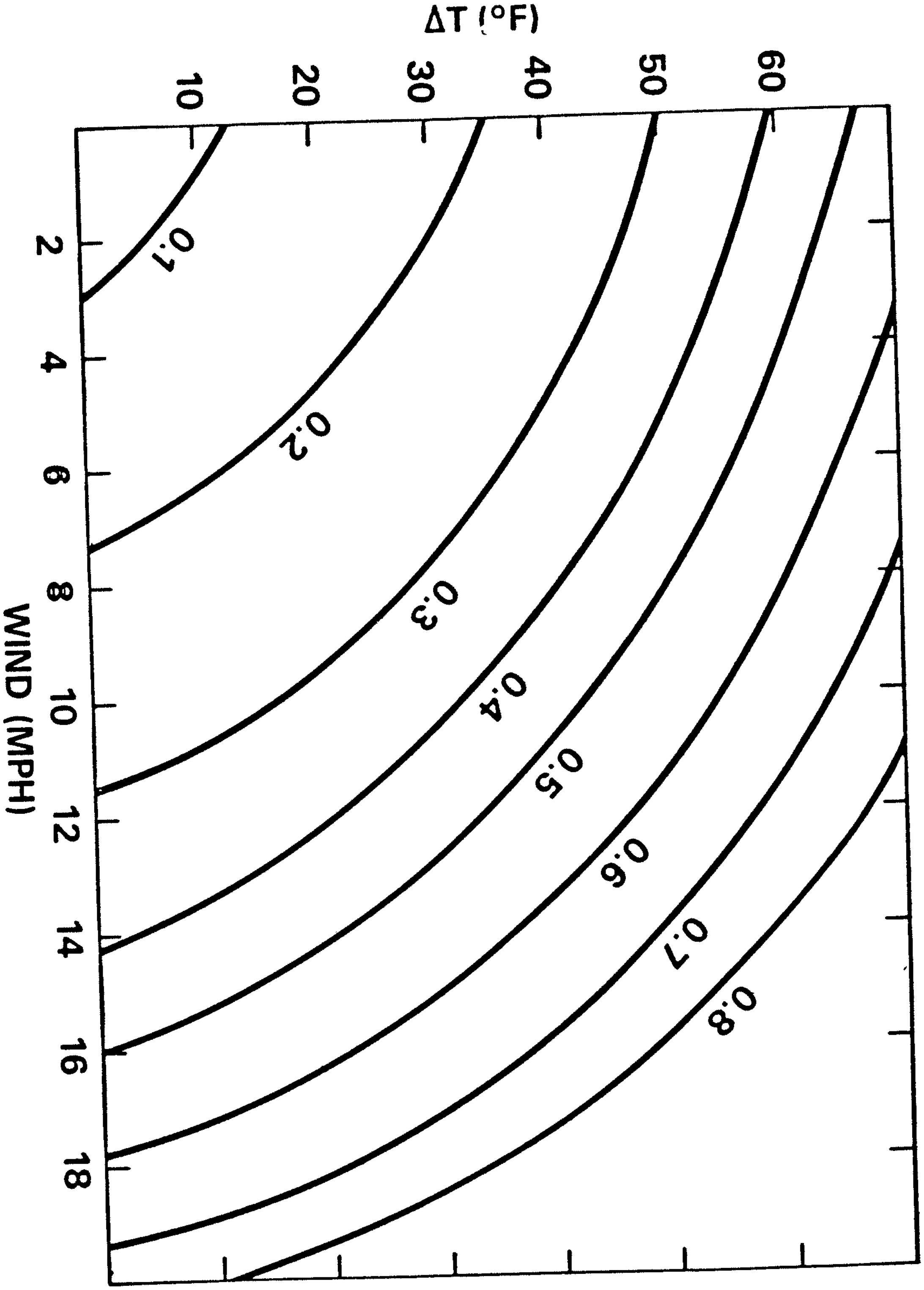

Fig. 1 Exchange rate for closed homes of modern construction and good insulation, with furnace and fans off. The number of air exchanges per hour are presented as a function of the indoor-outdoor temperature difference and the wind speed.

FIGURE 2

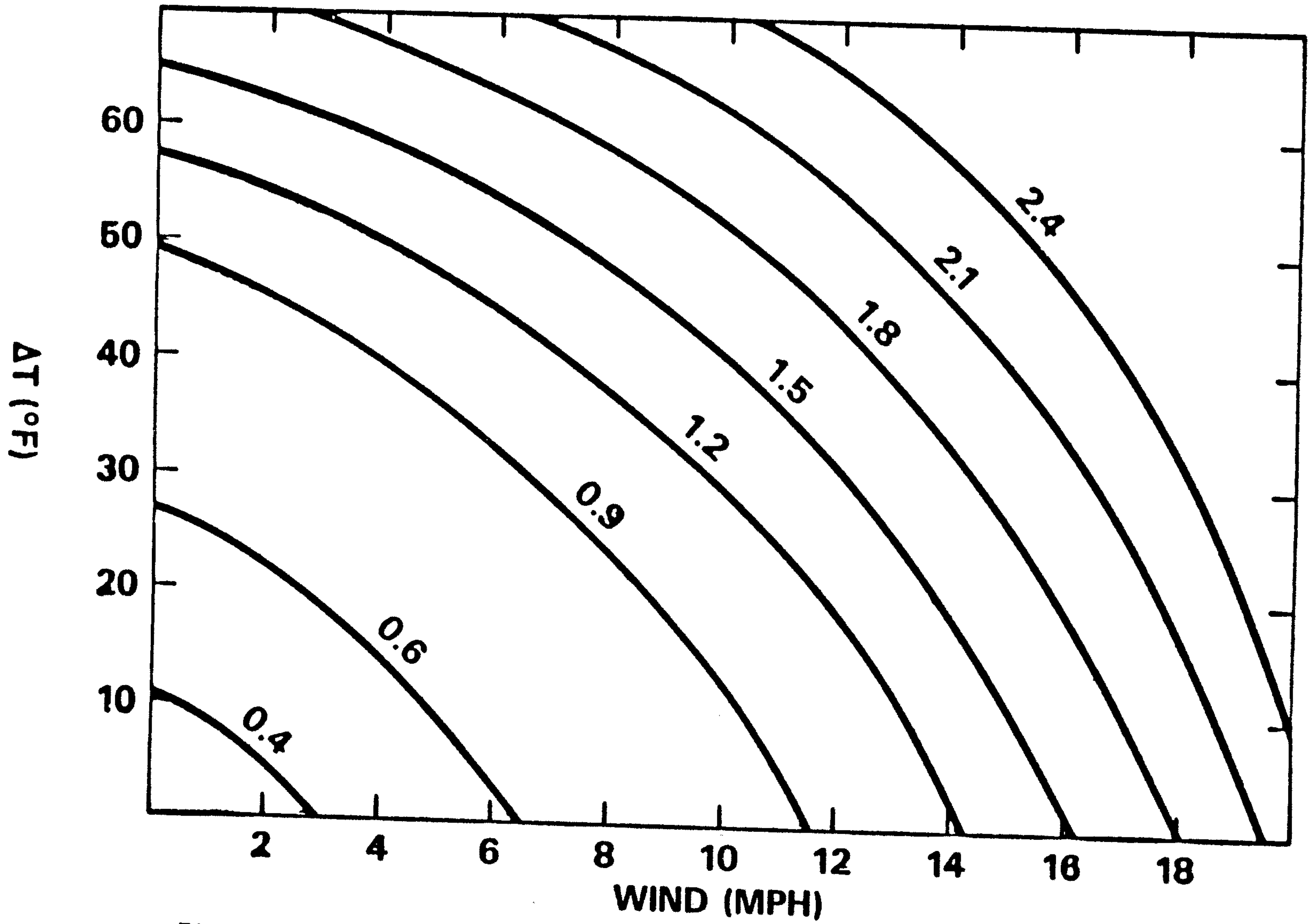

Fig. 2 **Exchange rate for closed homes of older construction and poor insulation with furnace and fans off. The number of air exchanges per hour are presented as a function of the indoor-outdoor temperature difference and the wind speed.**

FIGURE 3

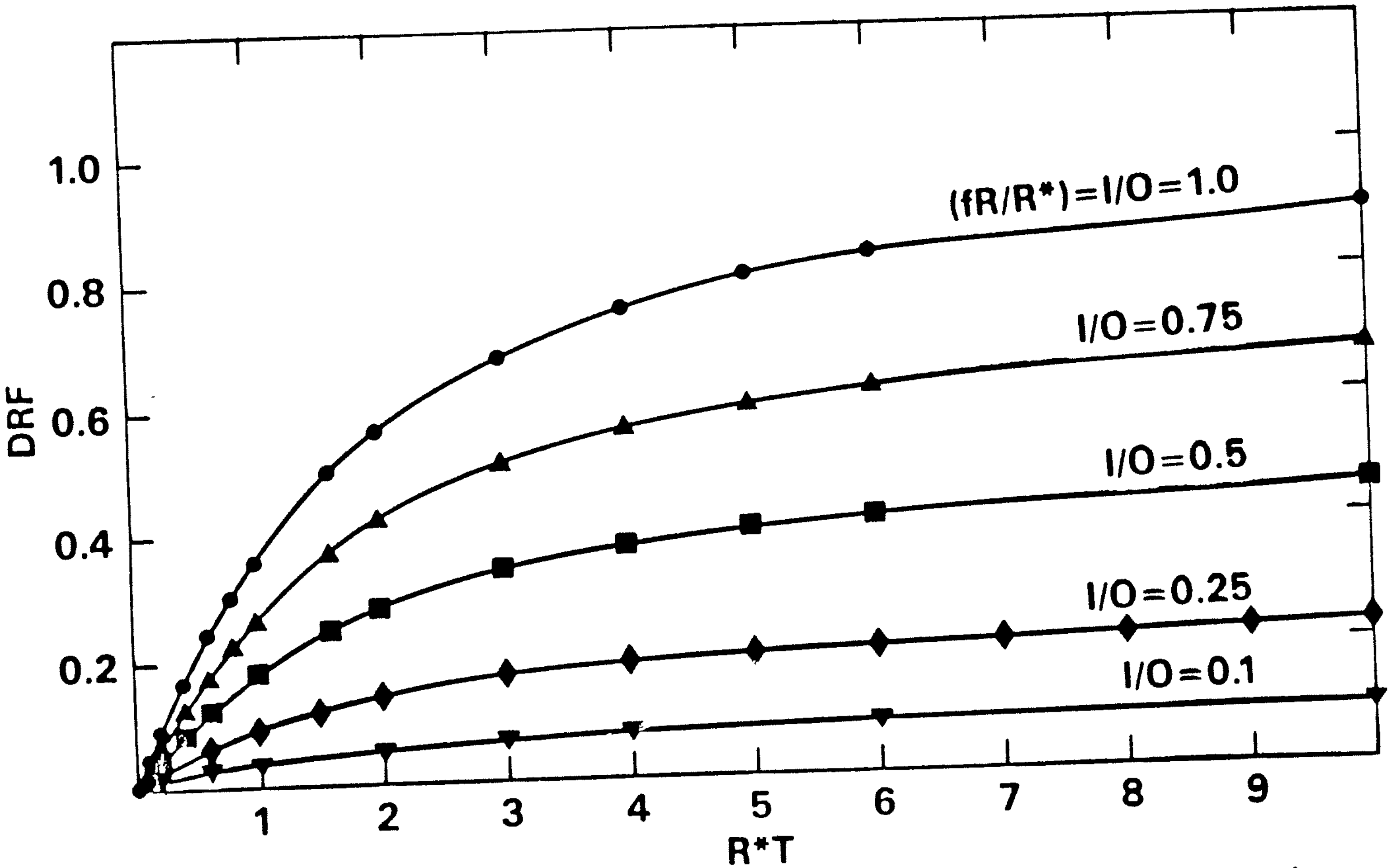

Fig. 3 The Dose Reduction Factor (DRF) as a function of the air exchange rate, R, time, T, fraction of the contaminant that penetrates the shelter's structure, f, and the virtual air exchange rate, R^*. At large values of R^*T, the DRF approaches the equilibrium ratio of indoor and outdoor concentrations, I/O.

FIGURE 4

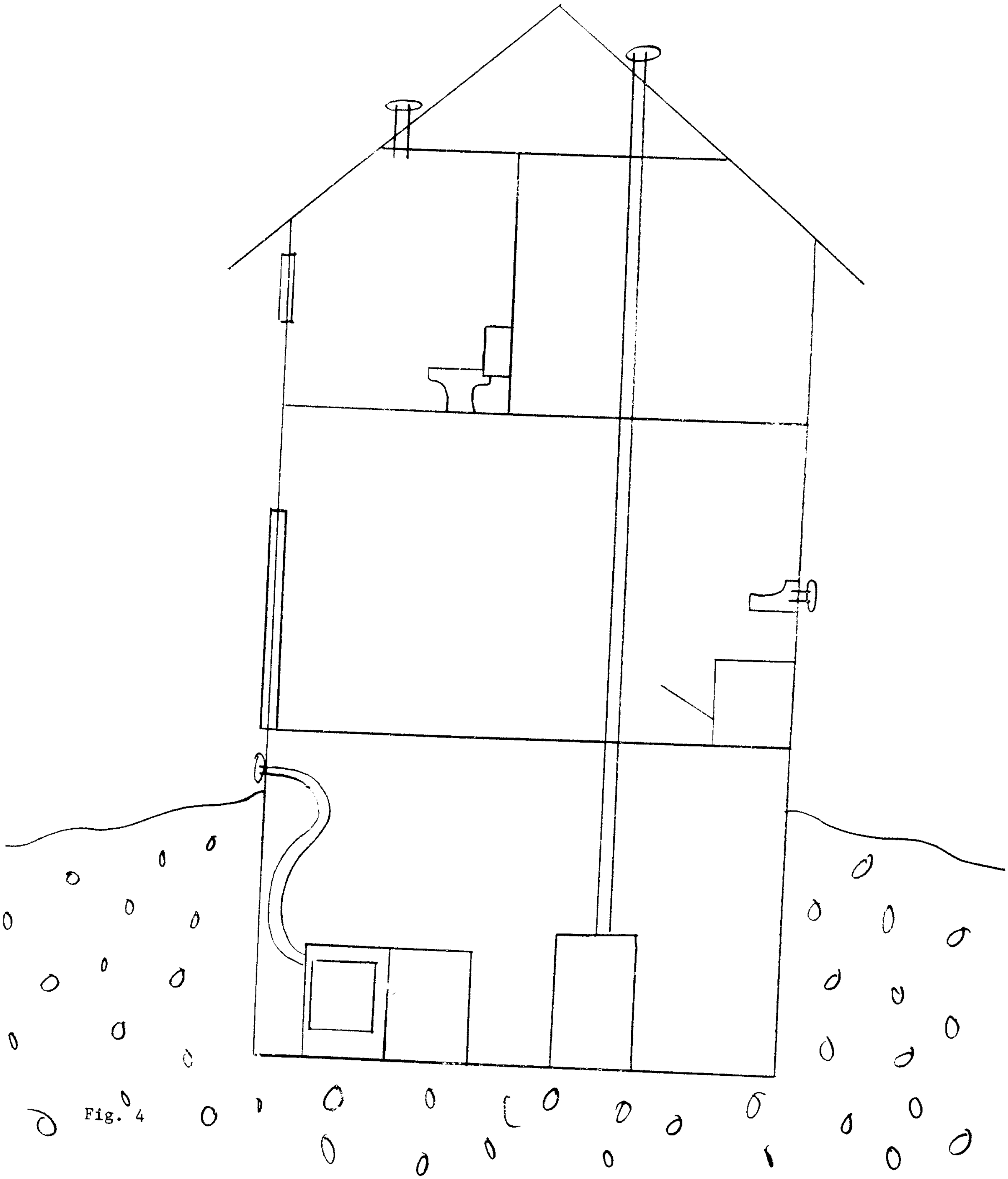

Fig. 4

SUBMITTED PAPERS

LESSONS LEARNED BY THE ILLINOIS DEPARTMENT OF NUCLEAR SAFETY FROM PARTICIPATION IN FFE-2

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The second Federal Radiological Emergency Response Plan (FRERP) (Ref. 1) Federal Field Exercise (FFE-2) was conducted June 23-25, 1987, at the Commonwealth Edison Company's (CECo) Zion Nuclear Power Station (NPS) in Zion, Illinois. The first day of this three-day exercise was the biennial regulatory exercise involving CECo, the States of Illinois and Wisconsin, the U.S. Nuclear Regulatory Commission (NRC), and Lake (IL) and Kenosha (WI) counties. On the second day, these participants were joined by the Federal Emergency Management Agency (FEMA), the U.S. Department of Energy (DOE), the U.S. Environmental Protection Agency (EPA), and other Federal agencies. The time line of the exercise was advanced seven days at the end of day two, so that day three of the exercise corresponded to day ten of the simulated accident. Altogether, over 1,000 players at 30 different locations and over 150 controller/evaluators took part in FFE-2. In addition, there were 130 foreign visitors from 17 countries, and 126 official U.S. visitors who visited the exercise emergency response facilities in the Zion area.

The Illinois Department of Nuclear Safety (IDNS) played a key role in FFE-2. Under the Illinois Plan for Radiological Accidents (IPRA), IDNS is responsible for providing technical support for emergency response activities in the event of a nuclear power plant accident in the State of Illinois. During FFE-2, IDNS activated approximately 100 persons during day one, and then maintained the level of activity in cooperation with Federal personnel during days two and three. IDNS shifted its primary technical functions from Springfield on day one to the Federal Radiological Monitoring and Assessment Center (FRMAC) for days two and three. IDNS also participated in the management leadership of the FRMAC to ensure that it supported the needs of the states.

All agencies involved in FFE-2 learned many valuable lessons as a result of their participation in this exercise. The purpose of this paper is to present some of the major lessons learned by IDNS as a result of participating in FFE-2.

The lessons learned from an activity usually refer to actions that need to be taken in the future to improve what is being done. While that is certainly the case with FFE-2, it is important to begin by pointing out an important general conclusion; that is, the State of Illinois did demonstrate an ability to protect the health and safety of its citizens in the event of a nuclear reactor accident similar in scope to the accident simulated for FFE-2. If an actual release had occurred under the conditions of the exercise, no members of the general public would have received significant doses from this accident. State and local government agencies worked together closely and effectively to implement IPRA, and there was good coordination with the key Federal agencies.

An important factor in the success of FFE-2 was the extensive planning that took place prior to the actual exercise. This planning began 18 months before the June 1987 exercise. It included two practice drills that took place before the full exercise: a Tabletop exercise in January, 1987; and in May, about six weeks before the exercise, a Dry Run at Zion where many of the players assembled and participated in a dress rehearsal. In addition, there were many smaller groups of players that held extensive planning meetings. For example, the field monitoring staff of the FRMAC held meetings to identify potential problems and solve them before they could occur during the exercise.

The reason these meetings and all this planning were so important was that Federal agencies seldom participated fully in normal regulatory exercises. As a result, the meetings that were held prior to FFE-2 were important for improving communication links and settling questions of responsibility and capability. "What do you do?" was the typical kind of question that was asked and answered. Recently, NRC has participated more frequently in exercises, and we feel that is a very positive sign.

One of the insights gained from this exercise and planning process is that Federal guidance with regard to protective action recommendations is currently in a period of transition. The official guidance from the NRC suggests that dose assessment be used to evaluate various protective action decisions such as sheltering versus evacuation (Ref. 2). During the Dry Run, however, the staff of the NRC Incident Response Center demonstrated a different approach to decision making. Their procedure calls for making protective action decisions on the basis of in-plant parameters wherever possible, not dose assessments, and evacuation before a release starts is the preferred protective action (Ref. 3). Although this is an approach preferred by IDNS, it represents a change in philosophy on the part of NRC, and it initially caused some confusion between CECo, state and local officials, and NRC. Discussions prior to FFE-2 removed this confusion from the exercise itself. However, it is interesting to point out that this philosophy has neither been universally accepted by the technical community nor formally promulgated as NRC guidance to licensees. Further, the two licensees in the State of Illinois and IDNS are still concerned about just what would happen in the event of a real accident, despite NRC's position that there is no conflict.

The integration of the capabilities of IDNS with those of the various Federal agencies also needs further studying. In a large-scale radiological emergency, the Federal government would be asked to augment the technical capabilities of the state. During FFE-2, Federal agencies did supply extensive resources, including equipment, technical manpower, and facilities. However, the integration of the state's and Federal resources was not always smooth. For example, during FFE-2 the start-up of the various facilities was often unrealistically staged. At the end of day one, the Federal facilities were not yet operational. At the beginning of day two, however, they were suddenly all in place and fully functional. Expectations from the Federal facilities were not always realized either. For example, dose assessments were not produced at the FRMAC as rapidly as many expected. This led to delays in production of useful information from the FRMAC. Finally, the management of the Federal facilities to meet the state's needs was not always as effective as it should have been.

An important conclusion from FFE-2 is that realistic exercises involving Federal capabilities need to be continued and must be frequent enough to retain the joint capabilities developed during FFE-2 (Ref. 4). For example, recovery and re-entry following the release were important considerations during the third day of the exercise. As the Chernobyl accident illustrated, these would be important concerns following a severe nuclear reactor accident. Time does not allow sufficient demonstration of these activities during normal regulatory exercises, which generally run from 8:00 in the morning until 3:00 or so in the afternoon. During FFE-2, a multi-agency re-entry and recovery group was formed to support the states. Staff from IDNS provided direction for this group, and the output of the group was in fact very useful to decision makers, but more work needs to be done in this area. The recovery and re-entry group needs to be better defined and formalized, and special exercises to consider decontamination and re-entry questions need to be conducted. Furthermore, if these re-entry exercises are going to be effective, they must include Federal participation.

FFE-2 also served as a proving ground for many of the technical tools that have been developed by IDNS. For example, IDNS normally receives about 1,000 operating parameters from each of the 13 nuclear reactors in Illinois on a near real-time basis. Simulated parameters for Zion NPS were provided during FFE-2. A full set for Zion was not available, but enough data were provided to test IDNS's computerized analysis software under simulated accident conditions. Such data are desirable for all exercises, but they are not always available during regulatory exercises because of the time, money, and effort required to develop consistent values for all of these parameters.

A new PC-based radiological dose assessment model was used for the first time during FFE-2 (Ref. 5). This model allows for very rapid dose projections to be performed. It can also generate a picture of the radioactive plume and the pattern of the ground deposition, and can incorporate radiological dose measurements gathered by the field teams to augment model calculations. These and other IDNS tools have been modified and improved as a result of the experience gained from FFE-2.

Finally, one of the most important lessons confirmed by IDNS from FFE-2 is the fact that final protective action recommendations are based on more than technical and operational considerations. Under IPRA, the Governor of the State of Illinois is the final decision maker with regard to protective action recommendations for the general public. The Governor or his designee makes this decision on the basis of a variety of considerations. There are technical considerations such as the plant conditions, and operational factors such as the availability of evacuation routes. However, there are also other concerns to be taken into account. During the Chernobyl accident, for example, governmental agencies in Europe often made protective action recommendations that were more conservative than the recommendations of the technical experts they consulted. During FFE-2, the Governor's designee recommended evacuation of certain areas before receiving such a recommendation from IDNS. It is clear that in a severe nuclear reactor incident political considerations would likely play a key role in protective action decision making. Those involved in the technical aspects of emergency planning need to remain aware of this fact at all times.

In conclusion, FFE-2 was a good learning experience for IDNS. IDNS also firmly believes that Federal agencies need to participate in emergency exercises on a more regular basis, and some of the Federal agencies seem to concur (Ref. 4). Most importantly, however, Illinois did demonstrate the ability to carry out its responsibilities to protect the health and safety of its citizens in the event of a nuclear power plant accident similar in scope to the accident simulated in this exercise.

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THE USEFULNESS OF INFORMATION PROVIDED BY FIELD MEASUREMENTS DURING UNPLANNED RELEASES INTO THE ENVIRONMENT

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The emergency response manager is required to rapidly evaluate minimal amounts of information in order to decide whether or not to implement protective measures as an incident develops. Alarming effluent monitors will likely provide the only measurements of material actually released into the environment. For hours, or even days, after a release event it may be impossible to obtain good information about the quantities and concentrations of material at receptor locations. Therefore, the emergency response manager will place heavy reliance on modeling of releases. In preparing for unplanned releases, emphasis should be placed on realistic expectations of survey instrument measurements, of the time required to collect and analyze samples from the field, and of the type of information that can be provided. This report provides specific examples that illustrate both the limitations and strengths of measurement information in managing an emergency response.

Decision making under uncertain conditions is a difficult challenge, and emergency situations that can affect the immediate or future well-being of a large segment of the population present challenges that only a few people have the temperament to accept. Good, thorough planning can help to achieve the best outcomes for such unfavorable situations, and may even lead to design or procedure modifications that keep hazards to a minimum.

Basic Preparation for Unplanned Releases

The time required to evaluate a release of material into the environment, to make decisions regarding protective actions, and to implement those decisions, will usually determine the effectiveness of the response. Environmental sample collection can only evaluate releases after they have reached their receptor locations; therefore, they will be useless to the emergency response manager in the initial stages of the response.

The emergency response manager will rely primarily on modeling techniques to project the seriousness of the hazard to the public and make decisions regarding protective actions. Ordinarily, models should be incorporated into computer programs as part of the planning and preparation processes, in order to assure that calculations are made as rapidly, and accurately, as possible.

The computer programs should be interactive and friendly, with default values clearly provided to users as an option. In this way, if the first experts who are available to evaluate releases lack proficiency with the specific models employed, useful information can still be obtained.

Primary responsibility for developing the models should lie with the facility, but state and local government personnel will participate in their development and should be skilled in their use and interpretation. In the event that a release does occur, diversity of opinion among experts should be encouraged -- provided that the cadre of experts who advise the emergency response manager will produce a succinct consensus opinion, with a realistic assessment of their uncertainty.

All models must be based on site-specific information; default values for the models will be based on worst-case scenarios for design-based releases. The site-specific information will be used to project off-site concentrations and radiation doses. Relevant information about target organs will follow naturally from the dosimetry calculations. All other things being equal, reactor releases will require the most complicated models because the relative quantities of the various radionuclides will depend heavily on the recent operating history of the reactor.

Releases to the Air and the Inhalation Pathway

The fastest pathway to receptors is the airborne release. Airborne releases can reach the downwind population in a matter of minutes. Protective actions will invariably be initiated before monitoring teams can even reach the field.

Since the uncertainty about the on-site situation, together with the uncertainty in the model projections, is so great, extreme caution should be exercised when deploying monitoring teams to the field.

Consider the release of 100 grams (6.13 curies, or 227 GBq) of Pu-239 into the air and assume that it all falls to the ground, evenly distributed over a 25 square mile (65 km^2) area. The resulting surface contamination would be about 2000 dpm/100 cm^2. Of course, not all of the material will fall on the ground in such a small area, and it will not be evenly distributed. At the facility boundary it is unlikely, even in the event of such a catastrophe, that any measurable radioactivity will be found on the ground with a survey meter, assuming a detection limit of 20 dpm/100 cm^2.

Air sampling poses equally intractable problems for both gross alpha and gross beta analysis. Both alpha- and beta-emitting decay products of radon and thoron in outdoor air pose a sufficiently great interference in the measurement that the sample will have to be held for five to 24 hours before an accurate measurement can be made. Sample preparation for alpha spectrometric analysis would delay the measurement even more. Gamma spectrometric analysis is also time-consuming and will also be subject to interference from short-lived naturally-occurring material. Nonradioactive contaminants will typically require elaborate and time-consuming sample preparation prior to measurement, as well.

Air sampling can provide a very accurate evaluation of airborne contaminant concentrations, but *only after the fact of the release*. Therefore, air sampling will be useful only for reconstruction of the incident's impact after the initial and most critical phase of the incident has passed.

If airborne concentrations are to be accurately evaluated, reliance will have to be placed on continuous air samplers that are used for routine surveillance. Placement of air sampling devices after an incident has begun probably will not be timely and creates an unnecessary hazard for field personnel.

The best short-term evaluation of the airborne release will rely on monitoring outbound vehicles at traffic control points, coupled with preprinted questionnaires about the passengers' traverse of the plume, that can be filled out and mailed in at leisure. Law enforcement personnel cannot be expected to carry survey meters and questionnaires in their cars in anticipation of an unlikely event; however, this activity may be the most effective use of field teams in the early stages of airborne release event.

Releases to the air, which result in deposition on the ground, will also result in deposition on the surface of open reservoirs, lakes and rivers. While the ingestion pathway through drinking water and fisheries from an airborne plume will ordinarily be a relatively minor hazard to the public, it will require evaluation; protective actions should not be overlooked. The techniques for coping with this hazard will be similar to those for releases directly into the water, with the exception that the reservoir cannot be closed off from the source.

Releases to Surface Water and the Ingestion Pathway

With a little bit of luck, downstream reservoirs usually can be closed off before contaminated water reaches them, provided a mechanism is in place to warn the affected water supplies *immediately*, and that plants have adequate control over the intakes to stop the flow into the reservoir. In many locations reservoir intakes are several miles downstream from the release point, but at the Rocky Flats Plant in Colorado one large municipal water system has an intake directly across the street from the Plant, only about one mile from the release point.

The Rocky Flats Plant experience also points out another problem. In 1973 a release of tritium into the stream, and subsequently into the water supply, occurred for several weeks before it was discovered by state public health personnel; it was actually several months before Rocky Flats Plant personnel accepted the validity of the measurements and identified the cause. Fortunately, the radiation dose to the affected population was only about five millirem (0.05 mSv), but experiences of this type should emphasize that even a well-developed emergency response program can be thoroughly defeated if the operating conditions at the subject facility are not adequately monitored.

Initially, both the intake to the reservoir and the intake to the water treatment plant should be closed off, until good information about the release can support a decision to reopen them with confidence.

Analysis of alpha emitters will require very elaborate and time-consuming analysis; considering sample preparation time, a minimum of eight hours will be required to obtain the first gross alpha/gross beta radioactivity measurement. Alpha spectrometric, liquid scintillation, and gamma spectrometric analysis will require still more time, *even before the first sample analysis is complete.*

Contamination of Crops, Feed, and Livestock, and the Ingestion Pathway

Contamination of crops, feed, and livestock will ordinarily follow an airborne release. The Workshop on Protective Action Guides (PAGs) for Contaminated Water and Food, held in Washington, D.C., on September 13-14, 1989, resulted in several helpful recommendations for establishing PAGs and implementing protective actions. The Codex Alimentarius Commission, a joint body of the World Health Organization (WHO) and the Food and Agriculture Organization (FAO), held in Geneva, Switzerland, from July 3-12, 1989, resulted in several recommendations based on lessons learned from the Chernobyl incident.

Both of these groups focussed primarily on the Chernobyl experience, a disaster that produced off-site contamination on such an enormous scale that extreme actions, and extreme compromises to the quality of food as well, had to be considered.

Most of the scenarios that are likely to occur will not produce such widespread and extreme contamination.

The most perishable agricultural products, dairy products, will require the highest priority for assessment. Emergency response managers should always consider isolation of dairy products in the affected areas until conclusive measurements can be performed.

If a release occurs immediately before planting time, or immediately before harvesting time, the priority for evaluation of pathways through crops should be elevated.

Ranchers and herdsmen will consider moving their livestock out of the area, or substituting feed. Public health and agricultural experts should be prepared to quickly provide accurate and authoritative information to this group. Plans should also be made to assist in the orderly removal of livestock if ranchers and herdsmen so desire, whether or not the situation warrants such action.

Contamination of fisheries is another issue, but is only mentioned here as an item that warrants additional planning.

Public Expectation and Measurement and Surveillance Requirements

PAGs generally are based on the assumption that evacuation or other protective measures will affect large populations, or that such a large portion of the food and water supplies will be affected that alternative supplies will not be adequate to meet the population's needs.

As experts in this area we have a fairly realistic understanding of the hazards involved, and realistic estimates of the effect that intermediate radiation doses will produce.

Ordinary, reasonable citizens have rather different expectations. They will ordinarily wish to leave an affected area, no matter how small the actual hazard, unless they can be highly motivated to stay in place. And in this country of bountiful resources, tainted food and water, no matter how small the contaminant concentration is, will be unacceptable, particularly where alternative sources are available. The marketability of agricultural produce can be destroyed unless there is public confidence that every item in the grocery store is absolutely free of contamination from industrial releases.

We, therefore, should consider emergency response plans that are based on a realistic evaluation of public expectation. Law enforcement agencies should be prepared to facilitate *citizen-initiated* evacuation. Water supplies should make every effort to keep their reservoirs isolated until the quality of their product can be confirmed. Similarly, all food sources should be held in quarantine after a release event until confirmation is obtained that they are absolutely free of contamination.

By "free of contamination" we must agree that the laboratory must measure contamination with extreme sensitivity, not just to the concentrations established by PAGs. Good surveillance programs at each facility should consolidate preoperational measurements into a complete and thorough summary, and should evaluate contamination during normal operations. This evaluation should not be made to meet minimum regulatory requirements that are established by standards for protection under ordinary circumstances; this evaluation should exploit all available detector time and other excess capacity in the laboratory, after basic regulatory requirements have been met. Then, in the aftermath of a release to the environment, every effort should be made to duplicate the sensitivity of the baseline measurements.

Continuous air sampling devices should be placed at each point of the compass, and maintained to evaluate plumes in the event that releases do occur. Streams, lakes and every conceivable food pathway should be measured. All coefficients that are used in dosimetry analysis should be reviewed and updated as insight is gained into their site-specific application.

Measurement Equipment Needs

The TABLETOP Exercise in Baton Rouge, Louisiana, conducted on August 28 and September 18, 1990, concluded, among other things, that on-site, state, and local personnel have the expertise to address the problems of implementing PAGs, but that physical resources are limited. The report of lessons learned from that exercise recommended that the Federal government should keep available large amounts of equipment that can be deployed on short notice. While there are limitations on the usefulness of such equipment, anything will be a help.

Conclusions and Recommendations

The greatest obstacle to measurement of contamination following a release event is the quantity of very expensive and sophisticated equipment that is required. A good gamma spectrometry system, employing a single detector, costs a minimum of $75,000. A single detector system can only analyze one sample at a time.

Following a release event the demands for detailed analysis will consume all the capacity of an analytical laboratory, no matter how well equipped it is. Effective emergency planning will consider a variety of release scenarios and establish a sampling plan that will provide optimum use of scarce, identifiable resources. Some allowance should be made for discretionary analysis, but strict discipline should be enforced to adhere to the analysis priorities that are established in advance. In that way the emergency response manager can follow a realistic timetable for the receipt of measurement reports.

Finally, the models employed in making projections of hazards from releases should use reasonable coefficients. Models should *not* build conservatism into projections. Every effort should be made to make the most accurate estimates possible, and then provide the emergency response manager with a clear understanding of the uncertainty involved. It is, after all, the emergency response manager's responsibility to exercise caution when needed. If the projected hazards lack credibility, decisions will place little or no reliance on information that *could have been* the best basis for a decision available. And if the projected hazards are overly cautious, resources may be squandered at a time when they can never be adequate to meet all the demands of the situation.

WORKING GROUP SUMMARIES

SUMMARY REPORT OF WORKING GROUP A

Leader: James C. Hardeman Jr., Georgia

ISSUE: Differences in Modeling of Releases, Exposure Pathways, and Field Monitoring, in REP at Nonreactor Nuclear Facilities Compared to REP for Nuclear Power Plants

1. **Are State REP officials aware of the potential source terms that may require offsite monitoring capability at nonreactor nuclear facilities in their State? What additional source term information is needed?**

In addressing this question, the working group members outlined categories of facilities and/or potential incidents which would meet the above criterion. Facilities considered by the working group include: DOE production and/or test reactors; other DOE facilities, DOD facilities; research reactors; NASA facilities; transportation incidents; and the general category of NRC & state licensees, which specifically includes nuclear fuel cycle facilities and nuclear laundries.

The working group indicated a general knowledge of the radionuclides present in possible source terms from facilities in each of these categories. The working group members had lesser knowledge concerning the quantities of these materials available for release.

2. **What release scenarios, if any, could require early lifesaving efforts?**

The working group was unable to conclude that radiological releases from any of the facilities outlined above would require early lifesaving efforts. The working group did note, however, that non-radiological aspects of incidents at certain types of facilities (e.g., enrichment facilities, weapons-related incidents, etc.) might require lifesaving efforts.

3. **What computer codes or other standard formats (e.g., predetermined isopleths) are needed to project dose for incidents at nonreactor nuclear facilities? Who should develop them?**

The working group unanimously agreed that regardless of the nature of the tools to be used to assess offsite radiological consequences, it is an inherent responsibility of the facility operator to develop these tools and to make them available to offsite agencies. The working group discussed this matter at some length, and arrived at no clear consensus as to the "ideal" tool to be used to consequence assessment. The members of the working group did display a preference for the use of computer codes, given sufficient meteorological and effluent monitoring data to permit their use.

Several of the group members drew attention to the NRC Response Technical Manual (RTM-91), and particularly to the accompanying pocket cards. Among other information related to commercial reactor incidents, these cards present "order of magnitude" dose estimates for 1 curie releases of a variety of radioactive materials, and also for releases from 1 curie quantities of radioactive materials involved in a fire. The presentation of this data in the pocket card format appears to be very useful.

4. **What important differences are there between monitoring the ingestion exposure pathway for incidents at nonreactor nuclear facilities compared to similar monitoring at nuclear power plants?**

Working group members noted that releases from several categories of facilities may consist only of beta-emitting or alpha-emitting radionuclides. The absence of gamma-emitting radionuclides will require both different field instrumentation and laboratory instrumentation to assess the concentrations of radionuclides in food and water. DOE airborne monitoring resources, which will be critical to the rapid assessment of deposited radionuclides as a result of a reactor accident, appear to have limited utility for releases from certain nonreactor facilities. The consensus among the working group members was that more time would be required to monitor such releases than releases from reactor facilities.

5. **What important lessons regarding exposure pathways and field monitoring have been learned from exercises at nonreactor nuclear facilities?**

The working group members had little experience in exercises with nonreactor facilities, and thus few "lessons learned" could be gleaned from this source. Based on previous presentations and other experiences of the working group members, it was agreed that airborne pathways would almost always be dose-dominant, and that at least in the short term, inhalation would be the controlling pathway.

6. **What problems would be encountered in monitoring an airborne plume of pure alpha emitters or pure beta emitters? Is time a serious constraint for choosing protective actions? What effect, if any, should the time required to verify such airborne plumes have on the choice of the basis for taking protective actions?**

The working group members agreed that current equipment available to offsite agencies would not permit a "real-time" indication of airborne concentrations of alpha- and beta-emitting radionuclides, as a Geiger counter or a pressurized ion chamber would for gamma-emitting radionuclides. Current technology would be limited to collection of an air sample and subsequent analysis either in the field or at a radiochemical laboratory, yielding monitoring results minutes to hours after collection of a sample.

Members of the working group noted a trend among operators of commercial nuclear facilities and offsite agencies to recommend and implement measures for the protection of the general public based solely on plant status - regardless of the existence of a radioactive materials release. In these instances, the protective measures are based on the potential for a release of radioactive materials. Working group members urged the use of facility status in the determination of protective measures, particularly for those facilities where "real-time" monitoring of released radioactive materials would be difficult or impossible.

Several members of the working group indicated that an instrument such as a field-portable continuous air monitor (CAM) would be useful in providing a limited real-time indication of airborne plumes of alpha- and/or beta-emitting radionuclides. Fixed CAM systems are used in a variety of facilities to continuously sample and analyze air for the presence of radioactive materials.

Members of the working group also noted that field monitoring and laboratory procedures and laboratory equipment may not be adequate to verify the presence of an airborne plume of alpha- and/or beta-emitting radionuclides. The working group indicated a need for guidance and training in this area.

7. **What additional monitoring equipment will be needed by state and local responders for incidents at nonreactor nuclear facilities? Consider:**
   * **emergency response teams**
   * **off-site personnel**
   * **contamination on food and other surfaces**
   * **minimum detection levels compared to derived response levels**

As mentioned above, the working group recognized a need for field-portable instrumentation to provide a real-time indication of the presence of airborne alpha- and/or beta-emitting radionuclides. For contamination monitoring, the working group indicated that alpha scintillators and Fidler probes would probably be adequate for alpha-emitters, and that existing beta-gamma instruments may be adequate for high-energy beta-emitters.

Monitoring for the presence of low-energy beta-emitters (e.g., H-3, C-14, etc.) would require either additional equipment or the services of a radiochemical laboratory.

8. **What early monitoring services can be implemented by nonreactor nuclear facility operators? Should a list of these services and methods for accessing them be identified in state plans?**

The members of the working group recognized that facility operators are uniquely qualified and equipped to deal with radionuclides used at their facilities. More importantly, they are familiar with the systems in use at their facilities to detect the presence of abnormal conditions. At major facilities, these systems may include real-time effluent or environmental radiation monitoring systems and/or vehicles specifically equipped to monitor for radioactive materials. The facility operators should provide for, and the state plan should identify the methods for state personnel to obtain access to monitoring data gathered by the facility operator. This system should also allow for the facility operator to access monitoring data gathered by offsite response agencies.

9. **Are there any types of special laboratory analytical equipment that are not available to states that would be necessary for monitoring in the event of an accident at a nonreactor nuclear facility?**

The major laboratory analytical systems required for monitoring releases from nonreactor facilities (i.e., liquid scintillation (LS) counters, alpha-beta counters, alpha spectrometry systems) are likely to be already in place and in use by state radiochemical laboratories, with the possible exception of alpha spectrometry capability. The working group members did note, however, that most states would be ill-equipped to handle a large number of samples under "emergency" conditions with these systems. More important than the equipment itself are the procedures and training required to prepare samples for analysis by these systems. Working group members identified a specific need for training, particularly in the area of analysis for transuranics.

10. **What problems can be identified regarding the use of the dose limits for workers performing emergency services as prescribed in the revised PAG manual?**

The most obvious problem identified by the working group is the inability to monitor radiation doses delivered to radiation workers in real time when dealing only with alpha- and beta-emitting radionuclides. This problem led the members of the working group to conclude that the performance of monitoring activities would likely require the use of respiratory protection. In order to conclusively determine internal radiation doses, offsite agencies would need a bioassay program, including baseline bioassay data.

11. **How should the inability to accurately project dose from an accident at a nonreactor nuclear facility affect decisions to take protective actions?**

The language of the question implies that we have the ability to "accurately project" dose from accidents at reactor facilities. Members of the working group suggested replacing the phrase "accurate project" with "estimate," highlighting the inherent uncertainties in the assessment of offsite consequences from releases of radioactive materials.

The inability to estimate offsite radiation doses, coupled with the inability to monitor for airborne alpha- and beta-emitting radionuclides in real time, should drive facility operators and offsite responders to base protective action decisions on the status of systems required for the protection of the public (plant status). The inability to rapidly confirm radiological status may cause offsite agencies to "err on the side of public health and safety," basing protective action decisions on assumptions which may later prove to be substantially conservative.

SUMMARY REPORT OF WORKSHOP B

Leader: Stanley R. Marshall, Nevada

TOPIC: The Planning Basis and the Roles of Planning and Response Authorities

As a result of the group discussions, group consensus supported a general discussion with the full group, addressing the general questions when appropriate but without specifically using the questions to deliver our summary to the full group.

The group members also voted that I should lead the Group B discussion with the full group so I entitled the Group B discussion remarks, *Raindrops, Dogpaddling and PAGs: What Do They Have In Common?*. The title, with some qualification, seemed appropriate to me because the general emergency planning issue must also be qualified to describe parameters by which emergency response planning is conducted. You may recall that I referenced Aubrey Godwin's story about a 6-inch rain. Was the rain 6 inches deep or were the raindrops 6 inches apart? Whether discussing rain or PAGs, perspective is important.

I have attempted to organize the group comments in order of the questions for purposes of similar reporting by the other groups:

1. What should be the basis for the size and shape of the Emergency Planning Zones (EPZs)?

The group decided that the following minimum issues should be addressed in order to develop appropriate nonreactor EPZ size and shape:

1. characterize the radiation source term.
2. characterize EPZs and other pathways.
3. identify population demographics.
4. characterize maximum "credible" accident (do not devote resources to "incredible" accident scenario).

2. How should probability of incident severity figure into selecting the size of the EPZ?

The group again agreed that the parameters in Issue 1 must be considered to determine emergency action levels (EALs).

3. How would the time frame of release, notification, or response for incidents at Federal facilities differ from those at nuclear power plants?

Release time, notification and response time will differ by significance of the parameters in Issue 1.

Education of planning agencies and obligation by a facility operator to provide information allows planning agencies to develop response plans.

4. **How should size of the site affect the size of the EPZ?**

Group B participants agreed that onsite circumstances might not translate well to offsite areas. Issue 1 answer indicates onsite parameters that have to be addressed in the effort to determine size of EPZ and degree of implementation of PAG activities. Some may not be appropriate based on onsite parameters.

5. **What conditions at a Federal facility would indicate that an offsite emergency response plan or an EPZ is not needed?**

Again, Issue 1 answer parameters provide the minimum conditions to determine whether an EPZ is needed.

1. characterize the radiation source term.
2. characterize EPZs and other pathways.
3. identify population demographics.
4. characterize maximum "credible" accident (do not devote resources to "incredible" accident scenario).

6. **How much information is available to State REP officials regarding source term type, magnitude, and probability of occurrence: Is it adequate? What (if any) additional information is needed?**

The group recognized that some Federal information restrictions would prevent some information from being available to state and local planners. Available onsite information may also not be in a form that is directly usable by state or local planners. It is essential that state and local planners be provided opportunities to meet with onsite personnel to understand information that is pertinent to emergency planning.

7. **What revisions to NUREG-0654 are necessary to make it a satisfactory outline for the development of State and local REP plans for Federal facilities?**

Revision of NUREG-0654 should require development of a well defined source term to make it a satisfactory outline for state and local nonreactor plans.

8. **To what degree should the Regional Advisory Committee (RAC) be used for Federal facility REP plans and exercises?**

Group B did not believe that RACs have any authority for peacetime response activities. Typically, state legislation provides for state and/or local agency response designation without regard to federal agency organization or resources that may stand ready to respond.

9. What roles should FEMA and other Federal agencies have in revising State and local plans to include response to incidents at Federal facilities?

Group B did not believe that FEMA has authority for peacetime response activities. Typically, state legislation provides for state and/or local agency response designation without regard to federal agency organization or resources that may stand ready to respond.

10. What role should FEMA and other Federal agencies play in exercising at Federal facilities?

Consider planning, scheduling, scenario development, controlling, playing, evaluating, documenting findings, and concurring in the adequacy of response. Group B did not believe that FEMA has authority for peacetime response activities, therefore, FEMA should play only a supporting role to state and local agencies in exercise scenarios at state and local request.

11. What agreements for planning, exercising and/or response need to be made between Federal facility operators and state and local officials?

Consider site access, classified areas, data, etc. Again, the degree of agreements between facilities and state/local agencies will be dependent on the parameters in Issue 1. The agreements will also depend on facility operation restrictions that may exist that provide state and local leverage for obtaining information, assistance and cooperation from the facility management/ownership.

12. What restrictions are appropriate for public information releases from other Federal agencies and state and local governments? Are pre-prepared news releases appropriate?

The Federal government should never provide any press release unless the response information concerns a Federal facility. State and local government press releases are usually dependent on state/local administrative procedures that are developed. Issues concerning terrorism or national security would require coordinated press releases from federal, state and local agencies.

13. How will security restrictions at nonreactor facilities affect state and local officials in planning, exercising, training and response? What are potential solutions?

Group B participants who represented state agencies did not think that security restrictions at nonreactor facilities were a problem. Comments during some open discussion indicated that states felt they needed clearance for Federal facilities; others indicated they could implement adequate emergency plans without any level of Federal clearance.

SUMMARY REPORT OF WORKING GROUP C

Leader: Gary N. Wright, Illinois

ISSUE: The Need for Specific Guidance on Dose Projection, Protective Actions, Training, and Exercises for Implementing PAGs for Nuclear Incidents at Nonreactor Nuclear Facilities

1. **Do implementation procedures in the PAG manual for evacuation and relocation (Chapters 5 and 7) require expansion to apply to nuclear incidents at nonreactor nuclear facilities? If so, who should develop them?**

The group recognized that far too little information is currently available to offsite planning agencies regarding the nature of the hazards at many of these facilities. However, based on what is known, many of these facilities may present hazards somewhat different in nature than those presented by commercial nuclear reactor facilities. For example, some may present mixed chemical/radiological hazards. Therefore, the group felt that it is likely that the current implementation procedures for evacuation and relocation will likely require expansion to address these different types of hazards.

The group felt that the responsibility for developing the necessary information and models to characterize hazards should fall to the owner/operator of these facilities. The responsibility to expand current implementation procedures should likely rest with the U.S. Environmental Protection Agency (EPA), in coordination with FEMA, U.S. Department of Energy (DOE), and U.S. Nuclear Regulatory Commission (NRC).

2. **What important lessons regarding dose projection, protective actions, training, and exercises have been learned from exercises at nonreactor nuclear facilities?**

Although the group's experience in such exercises was limited, the group felt strongly that the level of planning, training, and exercises for some facilities should be at a level equivalent to that for commercial nuclear power plants. However, they felt that dose projection may be different in some cases than those for power reactors. The level of knowledge and training for offsite responders for such facilities should be similar to that for power reactors. All hazards at such facilities should be fully evaluated and exercises should include combinations of such hazards, e.g. mixed chemical/radiological hazards.

3. **How will security restrictions affect planning, exercises, training, and response? What agreements are appropriate during the planning phase to avoid problems during response?**

The group felt that any security restrictions which limit offsite planner's and responder's knowledge of source term, dispersion characteristics, and site access could severely hamper response. Therefore, the group felt that agreements should be developed to alleviate such problems. A generic format for such agreements should be negotiated at the highest levels, e.g. the National Governor's Association and appropriate federal agencies, to ensure some degree of uniformity throughout the U.S. These agreements might very well include provisions for key offsite planning and response personnel to obtain security clearances to ensure access to necessary information and the site.

4. **What special planning in the areas of dose projection, protective actions, and training is needed to deal with possible broken arrows?**

The group decided that some training is needed for all States since such an event could occur anywhere. The unique nature of such devices requires training on the nature of the source term, possible dispersal characteristics, and monitoring instrumentation and techniques.

5. **What special training will be needed by offsite responders to nuclear incidents at nonreactor nuclear facilities that is different from the training currently offered for planners and responders to incidents at nuclear power plants?**

Information regarding source term and dispersal modes for many of these facilities is not readily available to offsite responders, which makes it difficult to fully address this question. However, the group agreed that most States have limited capabilities for field monitoring for alpha contamination. In addition, the need for training in dealing with mixed hazards will be necessary for response to some facilities.

6. **What additional guidance is needed regarding deposited radioactive material on persons and other surfaces from nuclear incidents at nonreactor nuclear facilities? Who should develop it?**

The group decided that the EPA should give additional attention to alpha surface contamination levels.

7. **How does the State's responsibility to protect its citizens relate to the sometimes large, onsite, non-worker populations at some nonreactor nuclear facilities? Is it different from its responsibility at commercial nuclear power plants?**

The group decided that the owner/operators of such facilities has the primary responsibility for protection of non-worker populations. However, their procedures should be developed in consultation with state and local governments.

8. **What substantive revisions to State and local REP plans, if any, are necessary to accommodate response to nuclear incidents at nonreactor nuclear facilities?**

The group felt that for some facilities detailed site specific planning, similar to that for power reactors, will be necessary.

9. What additional guidance is needed on planning and conducting exercises for nuclear incidents at nonreactor nuclear facilities?

Additional guidance will be needed to deal with the different nature of some of the source terms and modes of dispersal presented by some nonreactor facilities.

10. Can circumstances be identified in which telephone drills or table-top exercises could be used to reduce the magnitude and cost of field exercises at nonreactor nuclear facilities without reducing preparedness? If so, who should develop and implement such drills or exercises?

The group could not identify any specific circumstances. However, they felt that there are probably instances where telephone drills and tabletops could be used. However, these should not be used to eliminate full exercises which will be needed at some agreed-upon frequency.

SUMMARY REPORT OF WORKING GROUP D

Leader: Debra Shults, Tennessee

ISSUE: Integration of Emergency Response for Incidents in Which the Release Includes Both Hazardous Chemical and Radiological Contaminants (Mixed Incidents)

Eleven issues under this topic were provided to the group for discussion. Although there were differing opinions on almost all the issues, the consensus of the group was that the basic planning criteria and fundamental guidance needed for mixed incidents were so closely related to those of a radiation incident that planning and exercising for these mixed incidents could be accomplished.

The group's discussions can be outlined in four major areas:
1. Risk Evaluation
2. Planning
3. Exercising
4. Federal Assistance

1. Risk Evaluation

Our experience involving mixed incidents to date has indicated that the chemical hazard is usually the greatest hazard involved but not necessarily the one that receives the most attention from the media or those involved in responding to the incident. There should be a mechanism in place to compare risk levels between chemicals and radioactive materials. If there were a philosophy or structure in place to compare the two, it would need to be placed into a guidance document. In comparing these risks, studies should be performed concerning the synergistic effects of the combinations of chemicals and radioactive materials. An assessment of the actual mixed source terms at Federal facilities should be made as soon as possible.

2. Planning

Most states are aware of the potential for mixed incidents at facilities which they or the NRC regulate. However, most states are not aware of the potential at Federal facilities which they do not regulate. In planning for these incidents, expertise from all areas involved should be considered. At both the state and Federal level, different response structures are often used for chemical versus radiological response. In order to provide adequate response, it is essential that there be communication between these groups, an understanding of the command structure, and as much integration of the systems as possible.

There is no need to write a separate plan for every possible mixed incident. Planning should be done for the concept, not to each mixed hazard. Many states have separate written procedures for chemical and radiological incidents. These states might reference a "mixed" incident in their existing plans.

3. Exercising

There was a real division among the group regarding the need for exercising mixed incidents. Most believed states should exercise a mixed incident scenario if there is a possibility that one may occur at a facility within their state or in transit within their state's borders. Several states have included a chemical incident during a nuclear power plant exercise, but did not actually incorporate a mixed incident during these scenarios. There was concern expressed by the group that radiological professionals would tend to overlook chemical hazards during a real event thus posing a threat to themselves and others. The group believed that more cross training between the chemical and radiological personnel should occur.

4. Federal Assistance

The Federal government should continue to streamline and consolidate authority to aid states in knowing "who's in charge?" during a mixed incident. The responsible parties could compare the relative risks of both hazards and advise the decision makers. The Federal agencies also should participate realistically during these exercises by including all the resources that would actually be used in an emergency.

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