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A textbook for use in the study of

HAZARDOUS MATERIALS EMERGENCIES

Internet Edition

HAZARDOUS MATERIALS EMERGENCIES

TITLE PAGE

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HAZARDOUS MATERIALS EMERGENCIES

NOTES about this Internet Edition

This is a digitized reproduction of the publication HAZARDOUS MATERIALS EMERGENCIES, initiated in 1973 and first published in 1976 for use in a Fire Science Hazardous Materials course at Montgomery College in Rockville Maryland. During this period, numerous casualties were occurring annually to responders during accidents involving Hazamats. Investigations of those accident disclosed that many responders lost their lives doing what they were trained to do.. Hazmat accident responders were bearing risks in hazmat accidents about 10,000 times greater per hour of exposure than the second-ranked category of people - transportation employees. At that time, the training focus of hazardous materials emergency response instruction was on the classes and properties of hazardous materials.

This course was precipitated by the NTSB investigation findings. I was the Hazardous Materials Specialist at the Board, providing technical guidance on hazmat safety issues to the Board. One of those issues was then-current training.. Frank Brannigan, a friend who headed the Fire Service education program at Montgomery College was upset about the training criticisms. During one meeting, he laid down the gauntlet to me: "If you're so damn smart, YOU come up with something better!" When he heard some of my ideas, he invited me to teach the hazmat course for his Fire Science program. I accepted his challenge. With the patient and informed help of many active firefighter-students over a period of several years, we redefined hazmat response objectives, provided a new focus on the response decision process by which those objectives could be achieved, and developed technical aids required to support that decision process. The results were summarized in this short book, which reflects the course content.

Subsequently, the new objectives and approaches were picked up by the fire service and transportation communities. Several new response training programs, including a major initiative by the railroad industry which trained over 135,00 response-related personnel in the new approach. Its effect by 1979 was the elimination of fatal injuries to firefighters trained in with the new approaches during such emergencies.

That was almost a generation ago. This book is posted to make available these proven ideas to a new generation of individuals who may not otherwise have access to them.

Ludwig Benner, Jr.
April 24, 2000

PS: A system to measure the effectiveness of emergency responses of all kinds was developed not long afterward. It is called Time/Loss Analysis. You should read that document to reinforce what you find in this work. It is available on line at www.starlinesw.com/product/Y2kguides/Y2KGuide07.html

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HAZARDOUS MATERIALS EMERGENCIES

INTRODUCTION

This book contains ideas. Learning these ideas calls for thoughtful study on your part.

This textbook is designed to help you learn about emergencies involving certain materials and substances that, because of their nature, quantity or form, pose a threat to safety or health and property. By studying the ideas presented, and learning to apply them in your everyday work, you will be able to contribute to safer outcomes in such emergencies in the future.

The material is presented in a different format than you may be used to seeing. It is in outline form because you are expected to expand on the ideas presented as you study the subject of hazardous materials (HM) in your course. You are given the raw ideas and a structured learning situation; by discussing the ideas with classmates, doing the exercises in the companion workbook, and linking this to your experience, you should be able to improve your analytical skills and your ability to think through your problems.

Few "solutions" to the questions you face are presented, because HM incidents occur infrequently, and the specific incidents you need to deal with may involve any of several thousand HMs. The assumption that you can maintain a state of readiness for any such emergency seems unrealistic. Therefore, the emphasis of this text is on how to approach your problems and think your way through them, rather than on "cook book" instructions usually found in HM literature.

Each session has a purpose, explained at the beginning of the outline for the sessions. The purpose is coordinated with specific learning objectives described in the box at the beginning of the corresponding workbook session page. Concentrate on the purpose and learning objective during each session. You will find the contents have broad application, to pre-planning and post-incident critiques as well as to the handling of HM emergencies.

Finally, a word of caution: the field of HM emergencies is being subjected to increasing study. Many principles await discovery or much refinement. As they are discovered or improved, your ability to deal with such problems can be upgraded also. Study the ideas presented in this context; by analyzing them during class sessions or discussions with your co-workers, you can decide for yourself whether or not they have merit for your purposes. Sharpening your analytical skills is probably the most significant achievement you can strive for during your studies of HM. Don't hesitate to ask "why" and challenge unsupported opinions on which you may have to stake your life someday.

This introduction would be incomplete if it did not express gratitude to the students who participated in FS 205 at Montgomery College from 1973 to 1976. Without their patience, criticisms and encouragement, you would not be reading these materials.

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SESSION 1 UNLEARNING SOME TRADITIONAL APPROACHES

CONTENT AND PURPOSE

You are introduced to hazardous materials and the harm they can do, in general terms. Then you are introduced to a new way of thinking about emergencies and your role in them: you are there to try to produce a more favorable outcome, compared to the harm that would occur if you did nothing. Next, you are shown some different kinds of HM emergencies and why traditional "attack and extinguish" approaches do not work for all HM emergencies. You will be left with an awareness that the way you are now "programmed" will probably get you into trouble in the large emergencies, and hopefully you will have a desire to learn how to deal with HM emergencies in a better way.

POINTS TO REMEMBER

- You are expected to:
 - a. Attend or make up classes because each session builds on previous sessions.
 - b. Be able to do what is specified in the workbook objectives.
 - c. Demonstrate that you have mastered the objectives in open book tests.
- You should know what a hazardous material is.
 - a. Definition in Public Law 93-633 for transportation: any substance or material in a quantity or form which poses an unreasonable risk to safety or health and property.
 - b. EPA definition: EPA names those materials that harm the environment in specific ways. The lists are found in the Code of Federal Regulations.
 - c. Benner's definition: substance that jumps out at you when something goes wrong, and hurts or harms the things it touches when released.
 - d. Gerton's definition: any element, compound or combination thereof, which is flammable, corrosive, (etc.) and which, because of handling, storage, processing, packaging, may have detrimental effects upon operating and emergency personnel, the public, equipment and/or the environment.
- To study anything, you have to build a "fence" around the problem by
 - a. Definition, i. e. how you define what you will study.
 - b. "Scoping" your project and establishing limits or boundaries around it.
- For studying HM you are asked to adopt U. S. Department of Transportation (DOT) "operational" definitions temporarily (see DOT handout) for study.

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5. From DOT definitions, you can identify "classes" of HM, grouped by "hazard"
 - a. Each "class" of HM has its own labels and placards.
 - b. You should recognize that the word "hazard" is ambiguous, so focus on being concerned with the effects of the behavior of the HM or the container in emergencies.

6. HM are present in your community in many places:
 - homes: natural gas, insecticides, ammo, etc.
 - stores: all of the above plus portable tanks, refrigeration systems, etc.
 - warehouses: anything in transportation in any quantity
 - terminals where transportation begins or ends: anything may be present
 - highways and railroads: anything may be present
 - laboratories: etiologic agents, cylinders, solvents, anesthetics, etc.
 - gas bottlers: liquefied and compressed gases, all sizes; also gas generating units
 - hospitals: anesthetics, gases, solvents, etiologic agents, radioactive materials, etc.
 - construction sites: cutting gases, fuel, paints and solvents

(These lists are not exhaustive; you can add to them from your own experience).

7. HM exists in solid, gaseous and liquid forms, but the effects may include invisible forms of energy

8. Emergencies will eventually run their course even if emergency response personnel (ERP) do nothing. So, why should you intervene in an emergency????

9. Your purpose for intervention is to favorably change or influence the outcome.

10. Every emergency has an outcome, that is, it will produce some kind of result. The only justification you can give for being there and doing anything is that they will produce a less harmful outcome. Your actions will result in fewer casualties or reduced losses.

11. You need to try to figure out the expected outcomes before you
 - a. increase the amount of harm that occurs by getting hurt yourself, as happened in Oneonta, Waco, Philadelphia, and other past incidents
 - b. decide to intervene and how to do it.

12. Different HM emergencies require different approaches in emergency responses. By doing the first exercise in the workbook, you will see why traditional approaches are inappropriate for handling some HM emergencies (Workbook, p.1-2 and 1-3). You should be aware that by tradition firefighters have been "programmed" (you react in a specific way) to "attack and extinguish" and "protect exposures" in emergencies. That's what most firefighters were doing when they got hurt in HM emergencies.

13. If traditional approaches did not solve HM problems, what will? This is the question you will address in this course.

14. You are not being asked or encouraged to "run scared". Rather this course attempts to convey to you what to expect so you do not lay down your life inadvertently. This

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course attempts to help you improve your odds for a "successful" emergency response.

- At the conclusion of this session, you are probably questioning what you have been taught in the past about HM emergencies. By recognizing that you aren't well prepared, you will keep an open mind for what follows. Remember, the course tries to give you tools so you can approach these emergencies and think your way through them. It does not tell you what to do in specific emergencies. Only you can make those decisions when the specifics of the emergency are known.

15. After performing the Workbook exercise, you will be able to see that the way you are now programmed to respond to fires is not adequate for HM emergencies because:

- there may not always be a fire, and the size-up may involve invisible dangerous materials,
- rescue may require special protective gear that you do not have, and involve large geographic areas,
- confinement of gases or explosives often is impossible, protection of exposures may involve 3-4000 acres and several miles downwind or down stream,
- ventilation may release HM to do more widespread damage, extinguishment may produce violent reactions with water, or lethal runoff, or the growth of dangerous vapor clouds, or require you to go into the danger zone to reach an uncontrollable situation,
- salvage may expose personnel to lingering contamination dangers, explosions, or other HM threats, and
- overhaul may aggravate a stabilized HM or containment system.

HOW DO YOU KNOW WHAT TO EXPECT?

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SESSION 2 PREDICTING HM BEHAVIOR

CONTENT AND PURPOSE

An approach to the study of HM emergencies, based on visualization of events sequences in a "mental movie" framework is presented to you to establish the setting for further sessions. The need to think in terms of events is established, and then related to the prediction of the emergency events sequence that you will try to influence through preplanning, emergency responses and codes and standards activities. Techniques for selecting significant "actors" and "actions" are presented and practiced to develop your skills in producing mental movies of HM emergencies.

POINTS TO REMEMBER

1. One of the ways we communicate is by describing events. We describe or tell stories about past experiences in terms of
 - a. who or what did something
 - b. what happened next
 - c. in what setting

Consider a "happening" to be an event; an event is defined to be some actor + some action or deed = an event

3. In describing events, remember these rules to help you THINK EVENTS:
 - a. use a strong active voice, grammatically. ("heat stressed the tank")
 - b. use a singular subject.
 - c. use an action verb, past tense.
 - d. only one actor and one action per event.
 - e. events should be quantified whenever possible.
 - f. events must describe an action, not a condition, state, result, or circumstance.
4. Communications get confused when we cannot visualize a scenario, because:
 - a. There is a gap in the sequence of events being described that we have to fill with our imagination or from our personal experience.
 - b. Events are described in the incorrect sequence, and the actions get jumbled.
 - c. The setting is not easily visualized, and
 - d. We cannot fill in missing details because we cannot imagine them.
5. Usually we assume missing details on the basis of our experience. Therefore, we need to study to broaden our experiences, especially in studying HM with which you are not familiar.

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6. As we listen, our mind integrates the images coming to us into continuous moving patterns of visual events, or MENTAL MOVIES. We can use our normal method for communicating experiences as a method for structuring our study of HM emergencies.
7. The remainder of the study program depends on the "think events" principle, namely, communicate by transmitting and receiving ideas in terms of specific actors and actions (events) that can be readily visualized, in their proper sequence, without gaps.
8. In studying HM emergencies, it is impossible to include every actor in the mental movies we visualize; therefore, some way of selecting the significant actors to crank into the mental movie has to be identified. Possible "tests" by which to evaluate significance of actors that need to be considered can be:
 - a. Who or what is going to do something next in the emergency?
 - b. What is he or it going to do?
 - c. Will that action hurt or harm anyone or anything?

More and better tests will be developed in later sessions.

9. You need to focus on what the HM is going to do if you want to change the outcome of the emergency. Therefore, you need to develop skills in predicting what will happen during emergency so you can figure out what you might do to change the outcome for the better. This can be done by
 - a. building up your inventory of "past movies" where they exist.
 - b. studying every HM category and how it can behave in an emergency.
 - c. developing some general principles applicable to emergencies of various types.
 - d. practicing and hoping you guess well when the time comes.
10. The approach used in this course is to establish general methods for analyzing and thinking about HM emergencies so you can cope with a wide range of specific emergencies, rather than offering "cook book" solutions for every emergency you might encounter in the future
11. The method is based on mental movies concepts because they
 - a. provide a natural framework for studying past and future emergencies.
 - b. help structure your thinking into events sequencing channels.
 - c. force you to think in terms of beginning and end of "movies".
 - d. provide a basis for evaluating progress of action toward the intended outcome if you intervene.

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12. The course analysis is based on a second important principle: "break down events". To illustrate, consider the following example:

- 1 event: I had an accident
- 2 events: I was driving my car and ran into a tree. (conveys the picture of an accident)
- 3 events: I was driving my car, it- slid on an ice patch, and ran into a tree. (mental picture starting to form)
- 4 events: I was driving my car down Route 1 near the depot, it slid on an icy patch on the road, bounced over the curb, and ran into a tree.
- 5 events: I was driving my car down Route 1 near the depot, it slid on an icy patch on the road, bounced over the curb, ran into a tree, and my head hit the windshield. (note how each added event clarifies the mental movie being formed in the listener's mind)

When you want to try to understand a happening or emergency, study it by breaking down the event into increasingly more detailed actions.

13. Motion pictures consist of a series of still pictures (events) strung together into 24 frames per second so the mind sees them as a continuous motion picture.

The same concept applies to the formulation of mental movies for predicting HM behavior in emergencies and for testing effects if you elect to intervene. Put together a series of mental pictures to form a mental movie.

14. Prepare the exercise of selecting actors in an emergency experienced by one of the class members. Focus on the HM, the HM container or containment systems, and the "targets" that experienced or were exposed to harm. Test for significance by asking:

Did this actor do something that directly determined the outcome of this emergency, or was it just along for the ride as the emergency progressed? Focus on the former actors, and consider them as candidates to influence if you expect to change the emergency outcome.

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SESSION 3 MODELING AND EVENTS ANALYSIS METHODS

CONTENT AND PURPOSE

Demonstrable shortcomings of presently available HM emergency guides are used to persuade you that you need to develop skills in analysis and criticism before studying HM emergencies. Different analytical methods are presented and assessed briefly. The general systems model is shown to be applicable to your study effort. A simple exercise in events modeling techniques provides practice in the modeling techniques. The model is then linked to the "mental movie" approach for structuring your thinking processes for analytical and decision making purposes.

POINTS TO REMEMBER

1. There are numerous "aids" available which purport to help firemen or other emergency response personnel handle HM emergencies.
 - a. NFPA guide
 - b. DOT Emergency Guide and training courses
 - c. IAC of Police emergency guide
 - d. Bureau of Explosives emergency guide
 - e. chemical companies and other trade association guides
 - f. regional groups (Rocky Mountain area)
 - g. transportation organizations
 - h. other
2. Most have a common problem - "nonspecificity" . For example,
 - a. "cool containers from maximum distance until well after fire is out" is found in one guide; how do you translate "maximum distance" or "well after" in terms of feet, yards, or minutes, etc. in a specific emergency?
 - b. Apply the same test of trying to interpret instructions against a past emergency and see if any consistency emerges.
3. This "nonspecificity" in the instructions leaves you with the problem of figuring out what actions to take in specific emergencies. Where do you start your response efforts? How do you go about figuring out what you should do first, what effects it will have, and how the final results will influence the outcome of the emergency?

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4. The answer is that you will turn to your own skills and experience. This means that you must develop and improve your analytical skills to
 - a. evaluate some of the advice received from others.
 - b. figure out how to improve on materials you are given if they are not O.K.
 - c. improve effectiveness of your efforts to learn from past experiences, and
 - d. do a better job of criticizing constructively your own and others' ideas and work.

5. There are lots of analytical methods to choose from when analysis of something is required for study purposes. These include:
 - a. statistical analysis methods
 - b. simulation by testing
 - c. mathematical analysis or modeling
 - c. network analysis
 - e. decision analysis
 - f. expert opinion gleaned from experience
 - g. serendipity
 - h. superstition or legends to explain phenomena
 - i. modeling
 - j. logic trees
 - k. others, like epidemiological, etc.

6. Problems exist with each method because of limitations in applicability, problems with assumptions, unclear understanding of phenomena being studied, etc. You must always consider limitations of observers.

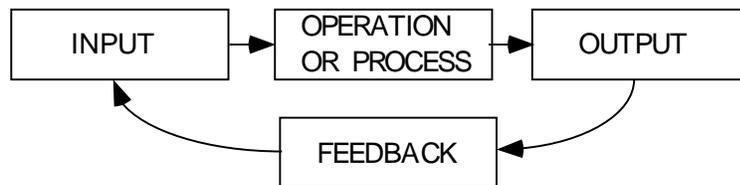
7. charting (a form of modeling) is a convenient way to study HM because the charts
 - a. give you a sequential mental picture of what is being represented.
 - b. are applicable to numerous operations or circumstances.
 - c. can be pulled out of the drawer later for refinement or other use.
 - d. can be manipulated to see what the effects would be.
 - e. can be scaled down less expensively than testing.
 - f. can be analyzed for predictive estimating purposes.
 - g. don't rely on memories for record of analysis logic.
 - h. can check logic for internal consistency of chronology of events.
 - i. are durable -- they aren't destroyed as in field testing.

In summary, charts can be seen, manipulated, criticized, tested, stored, and produced inexpensively.

8. Modeling is a useful way to study HM emergencies. A "model" is a **representation** of the real thing, usually a visual presentation of something that exists or is planned, usually presented on a smaller scale.
 - a. Models can be presented in two or three dimensions.
 - b. Two-dimensional models are usually found on paper or equivalent media.
 - c. Charts are often used to prepare and display something.

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9. There are lots of ways to study HM emergency problems, including
- reading references; narratives are usually hard to follow, remember, and apply and they are often not complete.
 - watching photos or movies; you see only what camera sees, you rely on the editor's interpretive judgment about what is pertinent, the movie starts late in emergency, and it is difficult to show everything that is going on at once in a complex emergency.
 - talking it over with others; you rely on incomplete memories, biases, and abilities of an observer.
 - living demonstrations; you learn only about that emergency, and then only under controlled conditions, they are expensive to stage, and usually only present one set of response options.
10. Charting of models originates in a basic general Systems model.



11. It is easiest to recognize when considered with computer operation:

- inputs = data + programs or applications
 - operation = computations performed by computer
 - outputs = printouts containing the display of the results of the operations performed on the data
 - feedback = observations that produce changes in inputs or operations
12. Relating this to HM emergencies,
- inputs = HM, containment system, ERP and equipment, (including the behavior instilled in ERP by their training or experience)
 - operation = what you do to influence the outcome of the emergency
 - outputs = the outcome, i.e. what got done, harmful or favorable results

Consider a system within a specific time frame; if the time frame shifts, the inputs, operations and outputs probably shift accordingly.

13. A system model can be used to focus on individual firefighters and their actions, on groups of "actors" constituting the "system", such as a fire department, or on the entire activity involving the ERP, HM and containers, and the exposed targets.

NOTE THAT GENERAL SYSTEMS MODEL USES ARROWS AND BLOCKS TO SHOW FLOW OR SEQUENCE: THE SIGNIFICANCE OF THE ARROW FLOWS MUST BE UNDERSTOOD!

14. To be able to follow the balance of the course, you must understand the flow charting method of presenting and analyzing models of HM emergency elements and their actions or functions.

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SESSION 4 ANALYZING AND MODELING HM EMERGENCIES

CONTENT AND PURPOSE

A model of the general pattern of events in HM emergencies is developed, to give you an insight into the nature of an emergency and to establish a framework for studying emergency responses. Stages of emergencies, and general approaches for influencing the events sequence are presented, to show you where your predictive MM efforts should begin and to establish a way of thinking of countermeasure options. Information and data sources for determining emergency stages are studied.

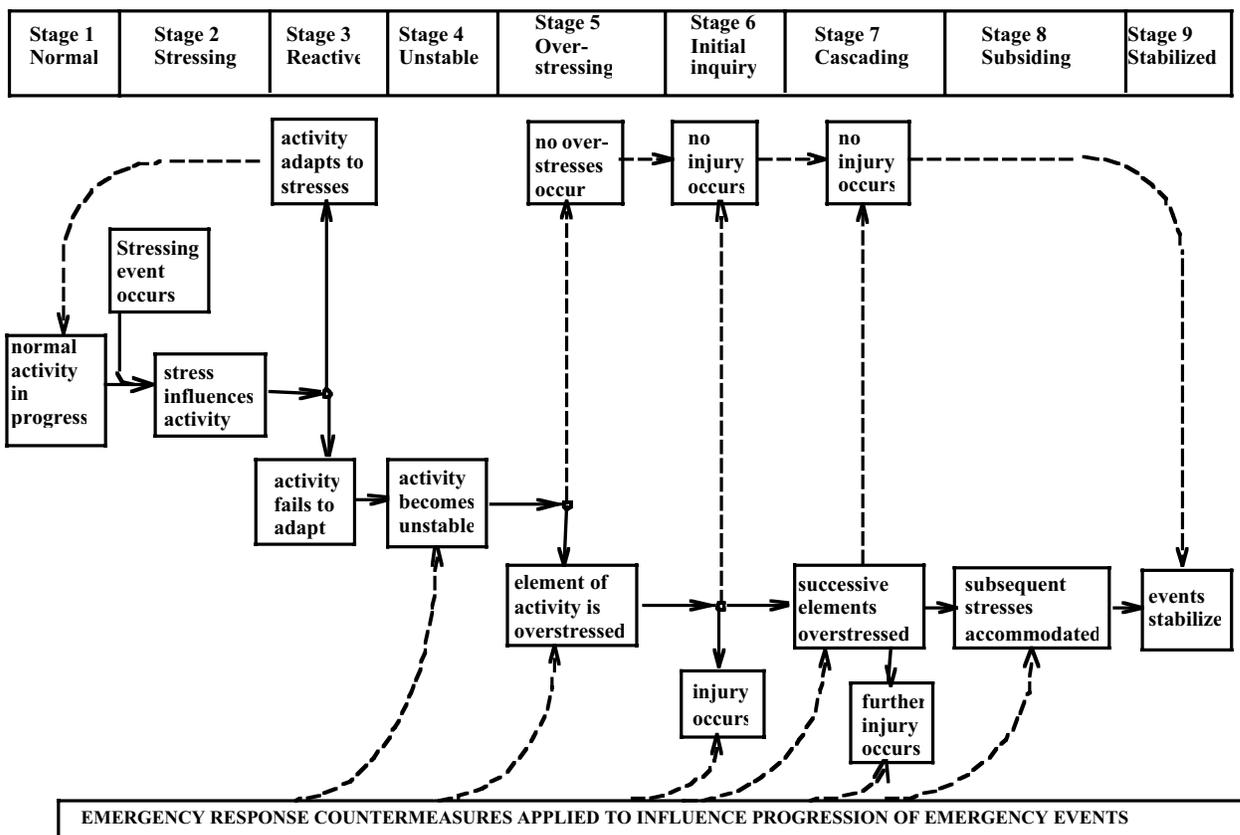
POINTS TO REMEMBER

1. Any emergency with HM follows a general pattern of events.
 - a. you can develop a general HM emergency model
 - b. HM differ because of cascading potential
2. This model serves as a framework for studying HM emergencies because
 - a. you can see, manipulate, criticize, test and store emergencies.
 - b. it gives an overview of what goes on in an HM emergency.
3. There is a logical way of finding opportunities to influence emergency outcomes with countermeasures.
 - a. You can influence total harm at numerous places between events.
 - b. You can see relationships on your model.
 - c. You can realize that the "attack and extinguish" philosophy is not applicable to HM.
4. Every emergency has common stages which can be nicknamed for convenience, speeding up the recognition of point of entry in specific HM emergencies.
5. Stages help identify what has already happened.
 - a. They suggest the possible harm for rescue purposes.
 - b. You can't influence what has already happened, or change that outcome.
6. Stages help in predicting what will happen next.
 - a. They identify the general pattern of events to look for.
 - b. They show where traditional guidelines fit into the model.
7. There are clues and signals for identifying each stage.
 - a. Certain indicators tell you what has happened.
 - b. Other indicators tell you what is likely to come next.
 - c. Some indicators do both.

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8. Many sources provide clues and signals for identifying stages. Walk through an example of an emergency and list the steps. Identify data available and sources for each step. You need to search for these data on emergency runs. The scope of an emergency may require lots of "eyes" to get all the data needed for handling the emergency.

9. Emergency stage determines when the MM has to begin.
 - a. Run the first MM to predict the outcome without intervention.
 - b. Start the MM at whatever stage is being encountered.
 - c. With HM involvement, HM danger lurks at every stage.



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SESSION 5 ANALYZING AND MODELING HM EMERGENCY DECISIONS

CONTENT AND PURPOSE

A model of the decision making in an HM emergency is developed, to show you the decision making process and its nature, and to provide a framework for studying HM emergencies from a command perspective. Implicit emergency response objectives are studied to focus your attention on the need for managing HM emergency responses to achieve a clear objective. Data needed to support decision making are explored, to show how DECIDE framework affects your search for data at the scene, with emphasis on the projected outcomes and outcome estimates.

POINTS TO REMEMBER

1. Numerous decisions have to be made in an HM emergency.
 - a. For example, Should I intervene? If so, what should I do? When?
 - b. List some of the specific decisions that must be made in your next HM emergency.
 - c. Note how disorganized (non-sequential) your thinking is under your present programming (training).
2. A different framework for studying HM emergency decisions is needed.
 - a. Review the DECIDE model of the HM decision making process. (below)
 - b. where does the goal-setting decision occur in the model?
 - c. Remember in any emergency-- YOU NEED TO THINK BEFORE ACTING
3. Your emphasis must be on setting objectives to be achieved by your response.
 - a. what am I going to try to accomplish and how should this be stated?
 - b. The "management by objectives" principles apply to your response actions.
4. Present Emergency Response guidelines have various implicit objectives.
 - a. You can spot implied objectives by looking for the word "to" (see CONTENT AND PURPOSE above) or "because", or similar phrases.
 - b. You need explicit rather than implicit response objectives for handling HM emergencies.
 - c. Existing implied objectives in emergency instructions are not structured for decision making.

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5. You must focus on producing "a more favorable outcome" with your response actions.
 - a. Favorable outcome means less harm than would occur naturally if you do not intervene.
 - b. Favorable outcome sets up useful objectives for an entire response team.
 - c. It may result in a "no intervention" decision.
6. It is important to get the community behind ERP now in supporting this approach.
 - a. Establish a consensus regarding HM emergency response objectives.
7. Data needed to support future HM emergency decisions are not available today in many instances.
 - a. ERP now don't know what data they need to make decisions.
 - b. Until they know what they want, they won't get it.
 - c. The problem is rooted in the lack of agreement about how to handle HM emergencies.
8. DECIDE framework structures questions to be answered during an emergency.
 - a. The questions guide the search for data to support predictions of estimate outcomes.
 - b. The data needed to support predictions depend on HM behavior programmed into the system by regulators, HM producers, etc.
9. The data for identifying the stage of emergency is related to but different from the data needed to support decision making and DECIDE steps.
 - a. stage identification looks backward - retrospective
 - b. DECIDE data looks forward - predictive
10. You need the most help in preparing predictions to arrive at your decisions.
 - a. Mental movies (MM) provide a method for structuring your predictive effort.
 - b. To make your MM, you need to recognize the HM behavior models which are programmed into the system.

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11. Decisions in HM emergencies deal with several outcomes.

- a. first MM outcome identifies what to try to "save"
- b. second set of MM outcomes identify outcomes from alternative actions available to ERP
- c. third MM provides basis for comparison of progress during implementation of response selected

DECIDE approach has application to other types of emergencies.

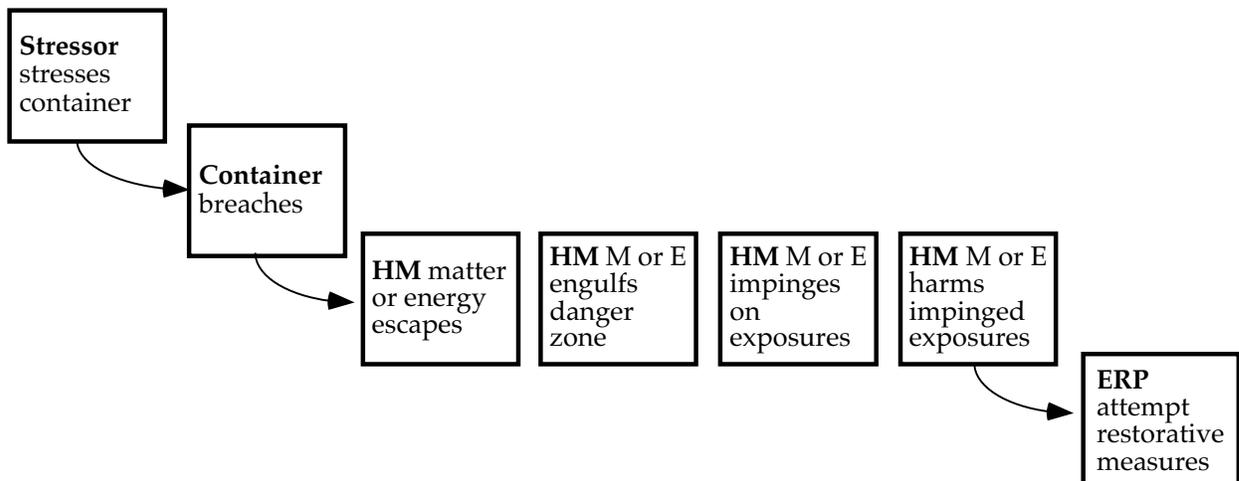
- a. redefining your objectives in terms of improving outcomes changes your thinking to a goal-oriented activity
- b. the general decision process is similar in most emergencies.

The 6-step decision making model (D.E.C.I.D.E.) is:



Memorize it now.

For the next six chapters, you will be referring to the GENERAL HM EMERGENCY BEHAVIOR MODEL. It forms the basis for predicting the behavior of HM that may be present in an emergency.



(Note for Internet Edition: this has been updated in HAZMAT INVESTIGATION GUIDE 3,. ISBN 0-87939-139-1 Available from Protection Publications, Oklahoma State University, Stillwell, OK. 1998)

HAZARDOUS MATERIALS EMERGENCIES

SESSION 6 HM BEHAVIOR PREDICTION MODELS

CONTENT AND PURPOSE

The harm that HM can add to an emergency is reviewed and outcome estimates needed for emergency decision making are analyzed, to show you the end points you need to develop from your mental movies, or predictive estimates. The need for predicting HM behavior "programmed" into existing HM systems is demonstrated. One general HM behavior model is then developed to show how to approach prediction problems. The model is expanded to illustrate some of the determinant factors to look for in emergencies, and to provide a form of "check list" to guide your data searches. A new perspective on exposures is presented to facilitate future discussion of possible response actions by ERP in subsequent sessions.

POINTS TO REMEMBER

1. Identifying your response objectives, you have to begin by figuring out what would happen if you do nothing.
 - a. need an estimate of harm still likely to occur
 - b. estimates of harm are the outcomes sought with mental movies (MM) development
 - c. outcome estimates indicate harm that might be influenced
2. Behavior of HM in emergencies is "programmed" into the system where it is present. Programs are determined by
 - a. the characteristics of HM involved
 - b. the natural laws of physics and chemistry
 - c. decisions of regulatory agencies and others
 - d. certain factors involved in the emergency, like terrain, weather, populations exposed, etc. that vary with each accident or emergency.
3. Each HM is programmed differently, but some behave enough like others that we can group them into manageable patterns for ERP.
4. ERP can identify likely behavior in emergencies if they can identify 1) the built-in programs, and 2) the influence of the surroundings.
 - a. you need to know "programs"
 - b. you need to know how to identify "programs" in emergency settings
 - c. you need to know the influence of settings on programs
5. If you know #4, you can figure out how to change the outcome of the natural course of events.
 - a. You need the framework to study.
 - b. Use the modeling analysis method as before.

HAZARDOUS MATERIALS EMERGENCIES

6. Present emergency guides consider only fragments of HM mental movies. Select a set of emergency guidelines for a hazardous material, and
 - a. compare a model of a guide with EMERGENCY, DECIDE models.
 - b. demonstrate implied events or conditions suggested by the guide (gaps)
 - c. decide what is needed to fill in the gaps.
7. HM BEHAVIOR models will fill the gaps; remember that HM is the principal actor of concern in an HM emergency, usually.
 - a. They will serve as general "scripts" for HM mental movies.
 - b. They can be further analyzed to identify determinant factors to look for in emergency analyses.
 - c. They can be linked to estimated harm likely to occur.
8. Models need to reflect events sequences that produce harm and
 - a. need to incorporate exposed "targets" affected by HM behavior.
 - b. need to accommodate how targets are likely to be' harmed.
9. Exposure concepts can help with modeling efforts by analyzing the three dimensions of exposure.
 - a. intensity (how much or how strong)
 - b. duration (how long)
 - c. frequency (how often)
10. Exposure considerations help define each "next event" in mental movies.
 - a. enabling conditions (exposures) permit the next event to occur.
 - b. exposure data constitutes these enabling conditions.
11. Approach involves some new concepts that will be developed with you during the next several sessions. All rely on the HM BEHAVIOR modeling you will be doing.

HAZARDOUS MATERIALS EMERGENCIES

SESSION 7 STRESSING PRINCIPLES FOR HM EMERGENCIES

CONTENT AND PURPOSE

The first general event in the HM BEHAVIOR models is analyzed in detail to give you practice in identifying and evaluating available input data in emergency situations. The nature and behavior of stressing events that lead to container or HM releases are explored so you can determine if you can influence these events. Potential countermeasures are formulated during the workbook exercise. You are also introduced to the variety of HM containment systems you may encounter, so you will recognize the types of threatening stress to be identified in emergencies.

POINTS TO REMEMBER

- The range of containment systems likely to be encountered depends on activity: The variety of systems encountered in transportation is most complicated. Examples include

Transportation

- a. carboys, jugs in tubs and rubber drums
- b. inside metal, paper, or plastic containers or linings
- c. cylinders
- d. metal barrels, drums, kegs, cases, trunks and boxes
- e. wooden barrels, kegs, boxes kits and drums
- f. fiberboard boxes, drums and mailing tubes
- g. cloth, burlap, paper or plastic bags
- h. portable tanks
- i. motor vehicle cargo tanks
- j. tank car tanks
- k. vessel tanks and barges

Manufacturing or distribution facilities examples include all of the above- plus

- a. piping
- b. open piles outdoors and indoors
- c. tanks and storage vessels
- d. reactors - chemical and nuclear
- e. storage bins, cabinets, or shelves
- f. machinery and others

Retail facilities usually involve relatively smaller quantities.

- a. cans, glass vials or bottles, cartons, etc.

Residential locations may contain

- a. bottles, cylinders, boxes, etc.

Construction sites may involve

- a. tanks
- b. cylinders
- c. add to the above others you know about

HAZARDOUS MATERIALS EMERGENCIES

2. Either the containment system or the HM within it can be stressed in an emergency.
 - a. sometimes containment system capability limits are reached before HM stress limits are reached, and containment system lets go,
 - b. sometimes HM stress limits are reached first, and HM reacts to be stressor
3. There are a limited number of types of stressing events in HM emergencies.
 - a. Fire emergencies are mostly thermally stressed events sequences.
 - b. Non-fire emergencies can also be thermally stressed (cryogenic, for example).
 - c. Stressing always involves some kind of energy transfer.
4. Energy transfer can take several forms. including:
(refer to workbook p. 7-2 TRACEM))
 - a. thermal energy flow (temperature differential, sparks, friction)
 - b. radiation from radioactive materials
 - c. asphyxiates (nitrogen, carbon dioxide)
 - d. chemical energy activation (pH differential, corrosion, exposure to oxygen for pyroforic substances, spontaneous combustion, etc.)
 - e. etiologic agents, sort of. (active "microorganisms" , pathogens move around)
 - f. mechanical energy transfer (impact, shock, velocity differential)
5. Break down stressing events and model them into
 - a. stressing actor or energy form: fire vs. non-fire emergency
 - b. stressed actor: containment system or HM
6. Intensity of energy being transferred is determined by
 - a. the amount of differential between "stressor" and "stressee" like temperature differential, velocity differential, pH differential, emission rate for isotopes, activity of etiologic agents.
 - b. proximity of stressor and stressee, i.e. how far apart are they
 - c. any barriers between stressor and stressee, like insulation, etc. offering resistance to transfer of energy
7. Duration of energy transfer is determined by
 - a. quantity of stressor available at the beginning of the emergency
 - b. the rate at which stressing energy is being transferred from source to target
 - c. the form of stressing agent involved (depletion of pressurized source material, for example)
8. Frequency of stressing events during emergency is usually once, but may be more often when dealing with
 - a. radioactive materials (rotating personnel to control emergency)
 - b. etiologic agents (when unaware of exposure)
 - c. toxic exposures (during successive rescue attempts)
 - d. note that all involve intervention of ERP

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9. Types of stressors can be grouped as shown in #4 through #8 by "classifying" the different stressors into the groups shown on p. 7-3 of your workbook.
 - a. classification categories should be mutually exclusive
 - b. classification categories should help ERP with a search for determinants at the scene of emergency, and provide framework for analyzing the role of the determinants
 - c. stressors in a class should be internally consistent with respect to characteristics and traits

10. "Break, bend or weaken the arrows" (between events) is the principle that helps you identify possible countermeasures to influence stressing events during the HM emergency, i.e., influence the events sequence.

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SESSION 8 CONTAINMENT SYSTEM BREACH/RELEASE PRINCIPLES

CONTENT AND PURPOSE

The breaching of HM containment Systems and the release of the HM during emergencies is analyzed, so you can recognize what types of breach/release behaviors to look for in emergencies. The factors determining these behaviors are explored, to guide your search for data and to aid the identification of possible countermeasures. The uncertainty of the timing of these events is considered in relation to escalating harm during emergencies. Types of breach/release behaviors are linked to HM classes, to give you practice in applying the principles presented.

POINTS TO REMEMBER

1. Problems with HM escalate when containment integrity is lost in an HM emergency situation, and HM capability to harm is unleashed.
2. This breach/release behavior varies with the type of containment system and the HM involved, but the behavior is predictable within workable limits, if we understand what is programmed into the system.
3. The timing of the behavior is not readily predictable.
 - a. It varies with stressors, i.e. kind, intensity, duration, differential.
 - b. It varies with programmed breach/release behavior type for containment system.
 - c. It may be influenced by countermeasures during stressing events.
4. You must distinguish between actions of stressed container and stressed HM in the container
 - a. containment system degradation occurs under stress
activation of HM occurs under stress and
 - 1/ can degrade the container system
 - 2/ can breach an undegraded container system

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- Containment system breach behavior (event) types include:
 - C catastrophic disintegration, like with glass bottles, brittle fracture
 - R runaway linear cracking, like with LPG tank car or truck tanks
 - A attachments open up, like safety valves opening, lines break
 - P punctures occur, like fork lift puncturing drum
 - S- splits and tears occur, like torn bags or boxes

LOOK FOR "CRAPS" IF CONTAINERS ARE STRESSED

6. Factors determining intensity of containment system breach behavior include:
 - a. stressing energy exchange rate vs. energy absorption capability of containment system
 - b. level of stored energy in containment system
 - c. programmed breach behavior of containers
 - d. proportion of containment system being stressed
7. Factors determining duration of breach behavior include:
 - a. energy dissipation rate within containment system materials
 - b. duration of stressing events (for safety valve operation)
8. HM behavior in containment system under stress includes:
 - a. boiling of liquids
 - b. combining chemically of HM + air, contaminants, contaminating materials, etc.
 - c. decomposition of HM, or chemical breakdown
 - d. melting of solids and liquid expansion
 - e. oxidation of HM when air is present
 - f. polymerization, or formation of molecular chains
9. Intensity of HM behavior is determined by factors including:
 - a. HM characteristics like reactivity, melting or boiling points, etc.
 - b. HM state
 - c. containment of reaction products after reaction
 - d. quantity of HM or other materials present
 - e. energy released by reactions
10. Influences on the duration of HM behavior in a container include:
 - a. the quantity of HM present
 - b. the reaction rate
 - c. the energy formation/ dissipation ratio; the higher this ratio is during stress build-up, the greater the danger from high energy releases

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11. Factors determining frequency of events are pertinent only to pulsating types of behaviors; then they relate to the duration determinants.
12. The containment system/ HM reaction behaviors can be combined into classes of breach/release behaviors that are meaningful to you. These four breach/release classes incorporate rough timing considerations.
 - a. Detonation breach/release behavior: includes catastrophic break-up of container and detonation of HM inside, occurring in a time interval of .01 seconds or less (order of magnitude).
 - b. Violent massive failure behavior: includes runaway cracking of container and rapidly acceleration polymerization or oxidizing HM reactions that burst container abruptly, but at subsonic velocities occurring in .01 to about 1 second.
 - c. Rapid relief behavior: includes pressure ruptures or safety valve operation, knocking valve of pressurized container, water stream into molten metal, etc. occurring over 1 second to 1 minute time.
 - d. Spill or leak behavior :includes gradual flow through attachment openings, tears or splits and punctures over a prolonged time span of minutes or hours.
13. Movements of HM through breached containment system involves one of a limited number of flow patterns:
 - a. puff (related to a, b, above)
 - b. steady flow (related to d)
 - c. diminishing flow (related to c)
 - d. pulsating flow (related to c,d)

These patterns describe the movement of the HM through the breach in the containment system; the patterns they form outside the containment system will be discussed in the next session.

14. You need to study past accidents to build the number of stored experiences that can be drawn on in future HM emergencies. This gives you guidance for locating factors to be studied.

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SESSION 9 HM DISPERSION PRINCIPLES

CONTENT AND PURPOSE

HM behavior, after it gets out of the containment system, is analyzed so you can estimate where HM will threaten people, property, or systems. Both fire and non-fire dispersion behavior, for both energy and matter, are presented so you can identify danger zones and possible options for influencing dispersion patterns, as part of mental movie efforts.

POINTS TO REMEMBER

1. Breach/release behavior influences dispersion patterns and resultant danger zones in which targets may be harmed during an HM emergency.
2. Only two things "jump out" at you after breach/release events:
 - a. energy
 - b. matter
3. Each can occur by itself or in combination, depending on HM systems, and can occur in several forms:
 - a. energy can occur as infra-red rays, light rays, gamma rays or pressure waves (sound or air over-pressure)
 - b. matter can be in solid, liquid or gaseous states
4. Energy or matter has to get from containment systems to where targets are before harm to the targets can occur. It is moved by
 - a. self propulsion from stored and released energy of containment system.
 - b. being carried by something, like air currents, ERP, other persons or streams of water like runoff or waterways (buoyancy).
 - c. natural diffusion through water or air when mingled.
 - d. gravity.
5. Energy moves outward from its source in straight lines. Sources may be:
 - a. single point sources, like a leak in shielding of radioactive materials (RAM) or an exploding tank or breaking jar
 - b. linear sources, like ignition effects from a trail of burning gasoline
 - c. area sources, like a vapor cloud that ignites or explodes

HAZARDOUS MATERIALS EMERGENCIES

6. Matter moves outward in several different ways from point or linear sources, including:
 - a. radially, in a linear trajectory
 - b. randomly where people transport it
 - c. upward with air currents (windborne)
 - d. downhill in a stream-like flow along surface contours
 - e. radially in a circular pattern directly outward from the source, like a vapor cloud forms in still air.

7. Dispersing HM matter or energy will form predictable dispersion patterns:
 - a. hemispherical (or dome-shaped) as in an explosion
 - b. spherical, as with fireball rising after LPG tank rupture
 - c. conical, as with radiation of RAM through a shielding breach
 - d. plume, as with vapor cloud from point source
 - e. circular, as with gas cloud on a still day on level terrain
 - f. stream-shaped, as with runoff downhill
 - g. irregular, as with personal transport or runoff in sewers, etc.

8. Factors determining the intensity or size of encroached area in which dispersion pattern forms include:
 - a. strength of HM release
 - b. quantity of HM
 - c. terrain and atmospheric conditions
 - d. dissipation rate (gases, or liquids in streams)

9. Factors determining the duration of danger patterns include:
 - a. quantity of HM, as related to breach / release mechanism
 - b. dispersion mechanism
 - c. carrier velocities
 - d. secondary reactions

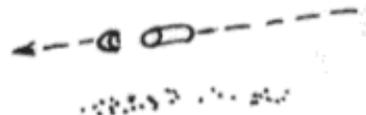
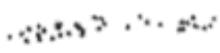
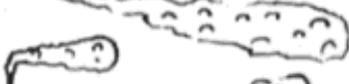
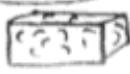
10. In preparing your mental movie, as yourself "What will I have to dodge, and where will I have to dodge it?"

11. Your ability to influence dispersion patterns is limited to dispersion mechanisms that form danger zones slowly or have extended duration.

12. When matter disperses, be prepared for secondary and sometimes even tertiary breach / release / dispersion events, especially with flammable gas cloud formations, or toxic runoff, etc.

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13. HM form patterns when they escape or react. Some of these dispersion patterns are shown below. As you study HM, add your own below.

HM form	Pattern	Associated with	Illustration
<i>ENERGY:</i>			
1. Infra-red rays	hemispherical	Fires, fireballs	 <p style="text-align: center;">see 1.</p>
2. Gamma rays	conical or hemispherical	Radioactive mtl.	
3. Pressure waves	hemispherical	Explosions	
<i>MATTER:</i>			
4. Solids (dusts)	airborne plume or puffs	bags or bulk transportation personal spills transport	 <p style="text-align: center;">see 1.</p>
5. Solids	hemispherical	explosions (chunks, fragments) linear traject.	 <p style="text-align: center;">see 1.</p>
	violent ruptures		 <p style="text-align: center;">see 2.</p>
6. Micro-spill or leak	irregular	contact with a organisms	
7. alpha/beta	conical or hemispherical	radioactive mtl.	 <p style="text-align: center;">see 2.</p>
8. Liquids	stream flow or pool	spills or leaks	
9. Liquid + cloud	contour stream vapor	spills or leaks flow + pool +	
10. Vapors	Plume	leaks or spills, or or open containers	
		contour chemical	
reactn			
11. Gases	Puff or plume	leaks, fires,	
or contour chemical reactions	Circular	leak, no wind, level terrain	
	Confined cloud	indoor leaks, fires	

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SESSION 10 HM INJURY AND OUTCOME ESTIMATES

CONTENT AND PURPOSE

The ways which HM can injure persons, systems and property are categorized and analyzed to help you estimate emergency "outcome" needed for establishing response objectives, by identifying the "targets" you will try to save by your actions if you intervene. Practice in making these estimates is included, and related to the mental movies framework for predictions. The need for mental movies without intervention, and for second and subsequent mental movie for estimating effects of intervention is shown.

POINTS TO REMEMBER

1. Establish firmly that to determine whether you can favorably influence the outcome of an HM emergency, you must estimate harm both without and with intervention, and compare gains by intervening.
2. Outcome estimates are expressed in terms of numbers of people harmed, system outage impact, and property dollar losses.
3. Targets in a mental movie include thinking about
 - a. people- with harm expressed in terms of number of people fatally injured, incapacitated and requiring help, or injury but ambulatory
 - b. systems- with harm expressed as days of lost services, threat to public health and safety, back-up supply sources capabilities, etc.
 - c. property- with harm expressed in rough dollar losses

MUCH EMPHASIS IS ON THE ORDER IN WHICH THESE TARGETS ARE LISTED; IT IS INTENDED TO REFLECT PRIORITIES

4. Outcome estimates need to consider primary, secondary, and tertiary events sequences that can produce harm.
 - a. primary = dynamite explosion in tunnel, no further harm
 - b. secondary = dynamite explosion that ignites secondary fires
 - c. tertiary = dynamite explosion that knocks over buildings that then catch fire
5. To estimate harm, you need to link breach/release mechanisms to dispersion patterns and visualize an "envelope" within which harm will occur.

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6. Think in terms of "targets" in danger zone "envelopes" because
 - a. "target" implies something to be hit by HM
 - b. "target" also implies the target of your "saving actions"
7. Develop types of injuries from worksheets and handout.

Using TRACEM list, establish links between dispersion patterns and injury types.
(T hermal, R adioactive, A sphyxiate, C hemical, E lectrical, M echanical)

9. Review end points of first mental movie of harm without intervention.
 - number fatally injured, number incapacitated requiring rescue, number injured but ambulatory needing only instructions; system outages and number of days public health and safety impaired; property loss in dollars
10. To summarize the process for arriving at an outcome estimate
 - a. locate the HM.
 - b. identify the stressors.
 - c. predict the breach / release mechanism.
 - d. predict the danger zone "envelope".
 - e. estimate the harm to people, system, and property "targets".
11. Factors determining intensity of harm include:
 - a. density of exposed and impinged targets
 - b. concentration of harming agents
 - c. quantity of HM present
 - d. form of impingement, or state
12. Factors determining duration of harm include
 - a. doses received by targets
 - b. ameliorating actions by targets, ERP, and others

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13. Impingement of targets is influenced by:

Intensity

- a. state of HM dispersing
- b. form of HM dispersing
- c. distance from source of harmful dispersing agent
- d. rate of dispersion
- e. reaction time to protect selves

Duration

- a. quantity of HM agent at source
- b. environmental changes
- c. degree of harm done by initial impingement

14. Remember this principle: you cannot make a good mental movie unless you have a picture of the entire scene:

- a. HM can spread out over very large danger zones
- b. HM can obscure behavior by cloud formations
- c. commander on scene needs all the eyes he can get - trained to look for stressing and other events clues relating to HM present

15 To sum up, the following matrix contains the "blanks" to be filled in by your outcome estimates from the mental movies:

%	1	2	3	4	5	6
%	Do nothin g	Type harm	Op1	Op2	Op3	Gain
		How many fatal injuries				
		How many incapacitated				
		\$ property damage (est.)				
		Critical systems disrupted				
		Environmental harm				

Column

Description of entry required

- % proportion of vulnerable targets already "lost" before your actions take effect
- 1 count of harm if no intervention is undertaken before emergency has run its course
- 2 type of harm that needs to be considered
- 3 count of harm if action option 1 is selected for implementation by ERP
- 4 count of harm if action option 2 is selected for implementation by ERP
- 5 count of harm if action option 3, etc., is selected for intervention (for each option considered feasible, count of harm should be estimated.)
- 6 the reduction (gain) in the net amount of harm for each type that will be achieved for the "best option" selected for implementation. This is

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the payoff expected for intervention, i.e. your response "objective"

<p><i>NOTE If the % column is already 100%, no gain is possible and intervention cannot influence the outcome!!!</i></p>

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SESSION 11 EVENTS INTERRUPTION PRINCIPLES FOR ACTION OPTIONS

CONTENT AND PURPOSE

Methods for establishing the emergency response objectives are presented to help you develop a rational purpose for your response efforts. General strategies and tactics for influencing the emergency events sequences are developed to show you a framework within which you can identify response options in specific emergencies. This is linked to the preparation of another set of mental movies for each option believed reasonable, so you will recognize alternative outcomes from which to choose the "best" option. Treatment of uncertainties is also examined.

POINTS TO REMEMBER

1. The ERP decision process covered thus far requires you to
 - a. detect presence of HM in an emergency
 - b. estimate harm without intervention (natural outcome)
2. Your response actions should have a clear objective or objectives
 - a. you should not act until you decide what you want to accomplish by your actions
 - b. the harmful outcome you try to change = your objective
 - c. think of the "outcome" matrix
3. Remember "triage" principle in figuring out whom to "save"¹¹
 - a. "targets" beyond help
 - b. "targets" ERP need to do something to help (rescue, evacuate)
 - c. "targets" that can help themselves if they know what's needed
4. The same principle applies to systems or property likely to be "saved"
 - a. HM containment system probably beyond saving in an accident
 - b. focus on things that can be helped
 - c. don't increase harm (watch runoff, damages to environment, personal exposure, etc.)
5. In setting your objectives, try to influence only who or what will get worse if you do nothing; don't risk life and limb for what is already lost; **LEARN TO TELL THE DIFFERENCE!**

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6. After you select what you are going to try to save, you have to figure out ways to achieve your objective, i.e. how the harm can be controlled.
 - a. You need to discover what choices are available to you, given your resources, the situation confronting you (scope, targets at risk, etc.), the time you think is available.
 - b. You need to run a mental movie of each to estimate the outcomes for each choice you think might work out to achieve your intended goals.
 - c. You need to think in terms of how the mental movie ends - i.e., how it is expected to come out after you have finished with your response.
 7. If you think in terms of events in a chronological sequence, you will be able to use some of the general strategies and tactics to figure out what response choices are available to you.
 8. The general strategies consist of influencing the
 - a. event now occurring, in terms of its intensity, duration or frequency
 - b. the next event in the sequence, in terms of its expected
 1. Magnitude: try to keep it as little as possible, i.e. minimize its intensity
 2. Occurrence: * try to keep it from happening at all by influencing event now occurring
 3. Timing: * try to change when it happens or how long it lasts
 4. Effects: * try to keep the next event confined so it is the last event in the cascading harmful sequence
 5. Location: * try to change where the next event occurs
- NOTE the acronym "M O T E L" may be useful for remembering the general strategies to look for in a specific emergency.
9. In any HM emergency, focus on influencing the actions of the stressors, the HM containment system, the HM itself, or the "targets" to be saved, considering the resources at your disposal.
 10. Among the tactical options that might be considered in HM emergencies are methods to influence the next event with
 - a. barriers: put something between the interacting or potentially interacting elements present
 - b. distance: separate the elements with space
 - c. absorbents: soak up or into some material you introduce
 - d. diluents: thin or reduce the strength or potency of HM
 - e. reactants: add some material that will react with the HM posing the risk
 - f. time: try to stretch out the duration, reduce duration or trade off or rotate persons exposed
 - g (note others you have used here)

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11. Water can be used to implement only a few of the above tactics in HM emergencies: recognize that water
 - a. can serve as a curtain or shield against heat, but may give you problems when used as a shield against other injury mechanisms like radiation, etiologic agents, some chemicals, etc.
 - b. can not buy you distance - may have to reduce distance to get water where you think you want it.
 - c. can soak up heat, and some radiation, but not many flammable and other liquids or solids: can absorb some gases, but runoff can then give you problems.
 - d. can serve as a diluent for some soluble gases and liquids, but once again run-off may be worse problem.
 - e. is chemically inert with most HM, but it can and does react vigorously with a few substances to create danger to ERP.
 - f. can help you stretch out the duration or shorten it if fire is involved, but doesn't help much with other circumstances to help you get time to work for you.

IN SUMMARY, water is NOT a do-all in HM emergencies!!

12. Other ERP equipment also has limitations. For example,
 - a. air packs and turnout gear do not protect against radiation, etiologic, some chemical (especially toxic, corrosive, or solvent type chemicals) and mechanical injury mechanisms
 - b. water supply systems have limited capacity and ranges that may require ERP to remain in the HM danger zone
 - c. radios- properly utilized- can be lifesaving aids for gathering needed data in an HM emergency spread out over a large area
 - d. handbooks are subject to varying interpretations and applicability and often are not taken to the scene
13. In deciding whether tactics identified are practical or feasible, ERP need to decide whether above limitations + available manpower permit the option to be implemented: running the mental movie for each option helps screen out the impractical ones, if you follow the action of the ERR with the equipment they have available to the end of that movie.
14. Always look for at least two options in any emergency involving HM:
 - a. do nothing
 - b. try to influence the outcome
15. All the preceding steps involve uncertainties at each step. ERP have to make "best guesses" under stress in a very short time period at an HM emergency. The previous material is intended to decrease the degree of uncertainty in arriving at the predicted outcome estimates in individual emergencies.

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16. The most difficult uncertainties ERP must handle are those related to identifying injured targets or exposed targets. That is why the outcome estimates are so important in the whole decision making process:

the greater the risks the ERP will usually be prepared to undertake in formulating their response options. A corollary consideration in making the outcome estimates is that the worse the outcome you think likely, the greater the uncertainty you will tolerate in arriving at the estimates of harm and your objectives.

Risk taking factors in selection of the "best option" are explored in the next session.

General hazmat behavior stage	Examples of factors determining occurrence of event	Examples of response strategies	Examples of possible response Options
A Stressor stresses containment system	1 Type of Stress applied 2 Intensity of stress 3 Duration of stress	influence applied stresses	- redirect impingement - shield stressed system - move stressed system
B Container Breaches	1 HM characteristics 2 Nature of stresses 3 System failure mode	influence breach size	- Chill contents - limit stress levels - activate venting devices
C HM released Through breach	1 Location of breach 2 NM driving forces 3 NM flow characteristics	influence quantify escaping	- change Container position - minimize pressure differential cap off breach
D Escaping HM engulfs danger zone	1 HM quantity present 2 HM dispersion characteristics 3 meteorological conditions	influence size of danger zone	- initiate controlled ignition - erect dikes or barriers - dilute with fog sprays
E HM impinges on exposures	1 NM State 2 Warning/response times 3 Mobility of exposures	influence exposures impinged	- provide shielding measure - begin evacuation immediately - call in helicopters
F HM harms exposures	1 Duration of exposure 2 Intensity of NM impingement 3 Velocity of impingement	influence severity of injury provide shielding measure	- rinse off NM Contaminant - Increase distance from Source

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SESSION 12 WEIGHING ACTION OPTIONS

CONTENT AND PURPOSE

The factors weighed and the weighing process needed to arrive at the "best" HM emergency response decision in specific emergencies are described, so you will be aware of the way such decisions evolve. You will explore your own "value hierarchy" so you will recognize its influence when you are confronted by an emergency decision. Also included is the first exercise in constructive criticism of existing HM emergency guidelines, using the analytical methods and models developed previously, to give you practice in critical evaluations and to increase your confidence in your own judgment.

POINTS TO REMEMBER

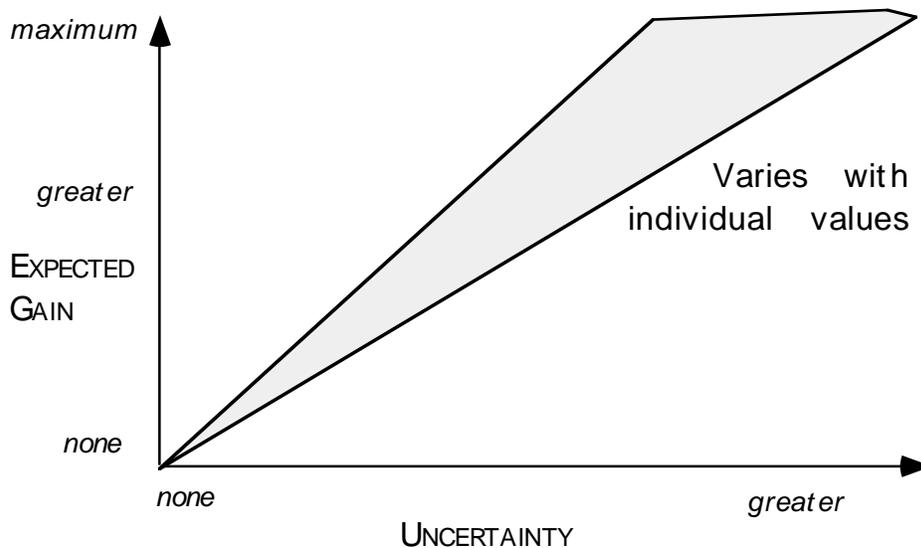
1. Every decision we make involves trade-offs between two or more factors that more often than not conflict
 - a. factors may involve conflicting or uncertain data or interpretations
 - b. factors may involve conflicting or competing values
 - c. factors may reflect differing predictions of expected outcomes
2. Uncertainties with data may result from factors like:
 - a. inability to acquire it at the scene, for any of several reasons
 - b. unfamiliarity about what to look for (adaptive learning situation)
 - c. conflicting indications from the same origins (like mismarking, two people saying different things)
 - d. lack of enough "eyes" in a large emergency
3. Uncertainties with interpretations of what data indicates may result from your prior experience or factors like:
 - a. your unfamiliarity with limitations of HM emergency action guidelines
 - b. problems with the guidelines for interpreting the data you collect
 - c. too many data to assimilate
 - d. inability to organize data available for interpretation

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4. Once the alternative outcomes of the mental movies for each of the options considered have been estimated, the "best" option needs to be selected. The ERP have to make a decision to do nothing or do something; both constitute a decision.
5. The selection of the "best" option involves weighing the "gains" to be achieved, against the "costs" of achieving those gains. Refer to p. 12-2 in the workbook and record "gains" and "costs".
6. "Gains" include many different factors:
 - a. "targets" to be saved or harm avoided or minimized
 - b. intangible factors affecting individual ERP
 - c. intangible factors affecting fire service
 - d. intangibles involved in economic, legal and other factors
7. "Costs" include all of the above factors plus any harm to ERP and equipment (injuries and damages)
8. Each individual ERP has a set of values that affect the decision of selecting the "best" response option. evident as the entries in the workbook exercise are compared in the class session.
9. In addition to different factors considered to be of value to an individual ERP the importance assigned to common factors varies from person to person, This can be illustrated by comparing the rankings for the same values listed in exercise 12-2 by different students during your class session.
10. Where life is involved, different persons can be expected to choose different options as the "best" one in their judgment at specific HM emergencies. The explanation for arriving at different decisions often lies in understanding the differences in individual value hierarchies.
11. If we understand our value hierarchy, we can rearrange our own rankings before we are faced with life-and-death decisions in hazmat emergencies, so these decisions will be made more quickly and in a more rational manner.

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12. Expected or hoped for gain influences the amount of uncertainty that individual ERP will tolerate before acting in an HM emergency. See graph below:



13. Since you may not have much personal experience with a lot of HM emergencies from which you can learn, study of past emergencies and of the training materials plus the emergency guidelines offered to ERP may be helpful in preparing you for HM emergency problems.
14. Perform exercise 12-3 using guidelines for HM emergency involving bulk gasoline or LPG, for which applicable models have been developed previously in class.

Objective is to link each instruction from the guideline to a specific person who is supposed to carry out the instruction during an HM emergency, and to make a mental movie of exactly what that person is to do in the sample emergency that was modeled.

15. You will probably find that
- guidelines are not directed toward a specific actor, or that actors to whom instructions are addressed vary from instruction to instruction in a given guideline;
 - guidelines actions are unspecific so they are often very difficult to try to follow or interpret;
 - guidelines do not indicate limitations on their applicability or the possibility of uncertainty of the outcomes from their application
 - guidelines have no underlying framework or logic to tie the instructions together;
 - guidelines do not recognize that behavior of HM must be predicted, or that programmed behavior for containment systems needs to be sought

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- f. guidelines do not contain a clearly stated objective or a way of establishing an objective for a specific emergency.

Other difficulties may emerge from discussions of results of class exercise.

16. Some way needs to be found to improve the guidelines to help you in the future.

How can this be accomplished?

- a. by applying analytical tools and using a systematic approach
- b. by testing the guidelines against past incidents using the analytical tools that are appropriate (go back to session 3)
- c. by trying to model future incidents and seeing how guidelines would affect their outcomes.

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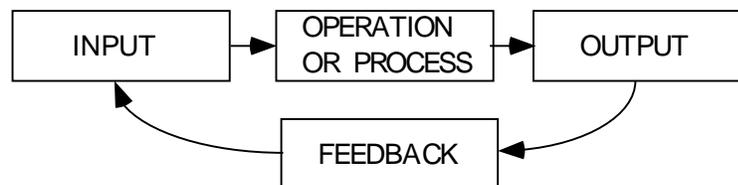
SESSION 13 EVENTS MONITORING AND FEEDBACK

CONTENT AND PURPOSE

The role of "feedback" data during implementation of the emergency response plan adopted is presented to assist you in monitoring progress during the emergency, and to help you identify when the response actions should be changed. The mental movie is shown to be a useful measurement test for evaluating progress in achieving intended outcomes. Factors indicating when danger no longer exists are presented to show the need for consultation and careful evaluation of actions by ER? during clean-up stages of emergencies. Practice in applying principles of the course is undertaken to sharpen your criticism skills.

POINTS TO REMEMBER

1. After a plan of intervention has been selected, ER? must monitor subsequent actions to assure that events are progressing as intended.
2. General systems model explains monitoring function with "feedback" concept:
 - a. INPUT - operation - OUTPUT model describes single action by ER?
 - b. Adding "feedback" to model enables you to describe a continuous process, like monitoring response actions:



c. Note how feedback creates sequential inputs to monitoring function

3. Monitoring involves a continuing series of YES/NO decisions as emergency events sequences progress during intervention efforts.
 - a. events are proceeding as planned and intended (YES)
 - b. events are not proceeding as planned and intended (NO)
 - c. if YES continue
 - d. if NO, change something

HAZARDOUS MATERIALS EMERGENCIES

4. As each new bit of information comes in, it needs to be fit into place in the mental movie describing how the response is expected to progress.
5. Monitoring progress requires you to SEEK OUT data that will tell you events are progressing satisfactorily; this requires watching the behavior of stressors, stressees, ER?, targets and other principal actors, if any, to determine if they are playing their role correctly.
6. As events progress, data they emit (to ER? receiver) may indicate a change in plan is required: This can be indicated by
 - a. events happening out of sequence.
 - b. events happening sooner than expected.
 - c. different, unexpected events occurring.
 - d. expected events not occurring.
7. When monitoring indicates a "NO" answer, you need to rerun the mental movie programs over again and review
 - a. prior assumptions about HM present, or HM or container behavior
 - b. prior assumptions about training in procedures
 - c. assumptions about degree of certainty of data on which decisions are based, including what people on the scene provide
 - d. assumptions about your capabilities
 - e. assumptions about your intervention objectives
8. Be aware that search for data to validate assumptions must be a continuous search to increase confidence level throughout the course of the emergency when HM are present. Don't take any assumptions for granted without further attempts to verify them.
9. You must never make your response decision and quit looking around!!
10. What are some of the problems you might discover?
 - a. additional HM are present
 - b. HM are present in different places
 - c. additional stressors or stressees are present
 - d. targets did not get out of range
 - e. mostly, dangers of further cascading harm

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11. Each new data input during feedback cycle requires another decision about whether events are proceeding as expected toward the intended outcome.
12. Even after fires are out or clouds have dispersed or HM has stabilized as the result of your efforts, danger may still be lurking for the cleanup and overhaul activities.
 - a. cleanup may involve energy transfers as containment systems are moved or otherwise stressed
 - b. contained energy from prior stressing' of HM may be triggered by a minor energy input
 - c. watch for new kinds of stressors being introduced during cleanup.
13. You should not assume role of expert during cleanup operations if HM are present in the emergency because
 - a. you usually lack experience with HM behavior during this stage.
 - b. experts from owner, shippers or carriers should be providing expert advice because they are responsible for the HM risks being there in the first place.
 - c. parties in b. should be responsible for the results of the HM behavior during this stage of operations if anything goes wrong, so you can respond if needed and not be decimated by the unexpected.
 - d. sometimes these operations can last a long time - and you are usually going to be needed elsewhere.
14. Threat is over when HM have been safely removed from the scene, or any possibility of further stressors has been removed from the scene of the emergency. Not before.
15. Briefly summarize the steps required to achieve the "best" outcome in future HM emergencies with on-scene responses.

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SESSION 14 PREPLANNING FOR HM EMERGENCIES

CONTENT AND PURPOSE

Application of the analytical methods presented in the course to pre-planning tasks is practiced in this session, to give you an opportunity to demonstrate and apply your analytical skill and to provide you an opportunity to present constructive criticism based on a persuasive analysis of problems with HM in emergencies. The role of pre-planning in improving responses through adaptive behavior is reviewed, to reinforce the value of the analytical approaches for your future activities.

POINTS TO REMEMBER

1. Identify your expectations of a preplan for an occupancy in which HM are involved;
 - a. why bother with a preplan? The usual answers are
 - help with your size-up
 - guide firefighting
 - help with rescue
 - b. what is the philosophy behind a preplan document? The strategy is
 - to control fires
2. Note how your views of the preplan for responders vary when HM are involved:
 - a. generally, you want preplan to tell them what is involved
 - b. generally, you want preplan to tell them what to do in an emergency
 - c. generally, you think a preplan will do both
 - d. philosophy behind preplan is often obscure
 - e. quality of preplan varies with jurisdictions
3. How do you determine whether or not a preplan involving HM is acceptable?
 - a. what are criteria for evaluation
 - b. how are criteria applied
 - d. preplan should set forth likely response objectives in terms of the outcome gains or reduction in losses, relative to the 100% method from session 11
 - e. note other points suggested by classmates during your discussions
4. Preplans have several forms:
 - a. preplan documents (look at example from a local jurisdiction)
 - b. training exercises (consider pit fires with gasoline)
 - c. training films (you have viewed examples)
 - d. training aids, books, textbooks, and other printed words

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5. Criteria for evaluation of preplan include following:
 - a. preplan identifies operation objectives
 - b. preplan describes decision factors
 - c. provides data required to support decision processes
 - d. identifies factors to monitor during response actions for feedback
 - e. aids in prediction of HM behavior for mental movie efforts
 - f. identifies limitations for operational plans presented
 - g. considers more than just fire situations for HM
 - h. facilitates adaptive behavior vs. adaptive learning in an emergency
6. Preparation of preplan for a facility should take into account the anticipated behavior of HM if stressed by fire or otherwise, and the ways injury is likely to occur, via either
 - a. events modeling for HM if stressed or released, i.e. where will it go and whom will it harm, or what will it harm?
 - b. mental movies of these events sequences
7. Get help with the "what if" exercises from the occupants or experts who know what to expect of the HM; if they don't know, get outside advice, and ask them to help you make a mental movie of the HM behavior under reasonably foreseeable circumstances.
8. Using the mental movies of the behaviors of the HM, work out the alternative action options that might be available and see how the outcome would be changed by each, i.e. make outcome estimates of the options and see how much would be gained.
9. Take a typical preplan and walk through an emergency response using the DECIDE process; as this is done, show how each bit of data on the preplan fits or does not fit the preplan. Establish these needs:
 - a. preplan needs to consider events and perhaps describe events scenarios to be expected in various circumstances
 - b. preplan should reflect the sequence of the decisions that will be made during the course of the emergency, and provide data in that order, showing several columns where necessary when branched decision network may be involved.
 - c. preplan should identify more than one action option and HOW TO SELECT AN ACTION PLAN FROM AMONG THEM
10. Keep in mind that your preplans, like training, are based on the principle that you are trying to maximize adaptive behavior and minimize adaptive learning. Therefore, the preplan should reflect the behavior that you think will probably be needed when emergencies arise. The mental movies approach is intended to help you visualize and predict your behavior.

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11. Here are some additional hints for your HM emergency preplanning.

- Get some U S Geological Survey maps for your area, and on these maps place an overlay containing the outline of the danger zones formed by HM in some past emergencies to see what the affected areas in your community would be. These maps also can help you predict where run-off would go, what the danger zones would be for different wind directions if gases are involved, (as with pipelines, which are shown on many of the maps) and what your evacuation problems might be if an accident occurs.
- Don't overlook planning for removal and treatment of injured victims in HM emergencies. Hospitals may or may not be ready to treat victims of some of the HM you might encounter in transport incidents, and they may be able to help with your preplanning. Accessibility, rescue and movement of victims to hospitals may require special gear or techniques. Utilization of medical experts and local hazardous materials emergency specialists for developing these scenarios could be productive.
- Consider recruiting local hazardous materials technical experts to form a sort of local or regional "hazmat squad" to help you preplan emergencies, and to help you diagnose HM threats in emergencies during the earliest stages. They should be accessible around the clock on short notice by radio if possible. Local hazardous materials suppliers and users are becoming increasingly receptive to requests for such support. Before you train any of your firemen to become chemical experts, consider the option of asking the people who are responsible for the HM being in your community in the first place to provide expertise in emergencies.
- Plan for and get agreement on the expectations of your organization during the cleanup and disposal of HM after emergencies. This is a dangerous period, frequently, for all concerned with these operations. Before assuming the responsibility for these tasks, determine that it is really your responsibility and then if it is, make sure you prepare for this stage of HM emergencies.
- Don't overlook communications. HM can create large danger zones, covering areas in more than one jurisdiction. Preplanning should include establishment of communications for such events. A gas cloud is no respecter of jurisdictional boundaries.
- Test your preplans, at least with table-top exercises.

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SESSION 15 HM CODES AND STANDARDS DEVELOPMENT

CONTENT AND PURPOSE

The numerous kinds of public safety regulations are presented to you to show you the many ways safety can be influenced. Processes for determining and demonstrating a need to change a safety rule are analyzed and methods for bringing about needed changes are explored so you will be able to recognize and fix safety problems through these processes when you encounter them in your career. Areas where ERP need new data and knowledge are reviewed, so your expectations of future improvements are imaginative but realistic.

POINTS TO REMEMBER

1. Safety rules serve many purposes. Among others, they
 - a. describe expected behavior and norms against which behavior can be measured after-the-fact.
 - b. provide a vehicle for conveying lessons learned from past experiences or incidents.
 - c. prevent or minimize the possibility of private actions endangering others.
 - d. provide an instructional tool for new entrants into a field like firefighting.
 - e. establish levels of risk of harm that are acceptable to the community being governed.

2. There are many different kinds of rules affecting public safety
 - a. privately drawn rules include personal rules of conduct, codes of ethics, organizational procedures and policies, multi-organization codes and standards, emergency response guidelines
 - b. publicly drawn rules include international, Federal, State and local regulations codes and standards
international = UN Dangerous Goods Regulations, IMCO (maritime)
Federal = DOT regulations, OSHA, DHHS, Nuclear Regulatory Commission, EPA
State = Public Service Commission, DOT, Fire Marshall's codes
local = ordinances, building or occupancy codes, fire codes, etc.

3. Regulations have several sources. These include
 - a. trying to prevent a past problem or harm from recurring.
 - b. satisfying someone's opinion about an 'unsafe' condition.
 - c. implementing the perceived intent of some legislation.
 - d. outputs of systematic analysis.
 - e. legal disputes about responsibility for safeguards.

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4. Enforcement of regulations is rarely 100% effective because of the
 - a. overwhelming mass of requirements, both private and public.
 - b. limited number of "enforcers .
 - c. perception of "major" and "minor violations, i.e. perception of variations in importance by either "ruler" or "rulee".
 - d. person is ignorant of rules.
 - e. price or cost of breaking the rules if you get caught is less than the cost for complying with it.
 - f. perceived threat, especially with respect to safety rules, is too remote.
5. The net result is mixed effectiveness and perceived benefits of rules.
 - a. sense of fairness among rulees, also a sense of some degree of protection, i.e. someone is trying to do something about that problem
 - b. for private companies, rules provide a legal shield (although this benefit is rapidly diminishing through recent litigation); also removal of safety as a competitive element is doing business; crutch for disciplining employees; guidelines for new ventures
 - c. for regulators, rules are evidence that they are trying to do their job of protecting the public safety; also a standard for judging their behavior in legal actions.
6. As public servants, you need to look for signals that the rules y-'Y.' establish need to be changed. These signals include
 - a. signs of general disregard for rules
 - b. apparent lack of impact on problem supposedly being attacked
 - c. quantity of regulation is very large
 - d. frequent interpretations are requested
 - e. frequent litigation over rules
 - f. difficulties in teaching rules to new employees
 - g. personal difficulty in understanding the meaning or intent of rules
 - h. large staff required to enforce rules
 - i. signs of general lack of awareness of their existence
 - j. frequent disputes about jurisdiction of rules
7. The two biggest problems in bringing about changes in rules are
 - a. inability to clearly demonstrate the need for and/or effects of rule being proposed
 - b. lack of understanding of process by which changes are made

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8. To "sell" a change, one must be able to demonstrate why it is in the best interests of the people who will have to spend money to implement the rule, or that fairness requires it.
 - a. you must demonstrate that there is a genuine problem that merits change to achieve one of the following objectives:
 1. social responsibility of person creating the risk
 2. risk of financial loss to person creating the risk
 3. threat to venture itself
 4. costs less to fix than to leave uncorrected
 - b. you must persuade decision maker that change will produce the intended results, and identify undesired results if it is adopted
 - c. you must persuade person who bears the expense of the change that he should be responsible for these expenses
 - d. you must demonstrate that this is not just a "whim" of the regulator
9. Analytical methods and modeling you have studied can be used to produce the supporting problem statement, display optional corrections and their expected effects, and give an indication of the urgency for making the needed corrections with regulation or code action.
 - a. all the benefits of analytical methods discussed in Session 3 are applicable to this activity
10. Anyone who proposes to regulate or who holds himself out as an advocate of a change in a code, standard, procedure, rule, regulation, or any other requirement governing the conduct of an activity in the name of public safety owes it to himself, the public he serves, and his profession to do the very best job he can, and to apply the most effective tools he can bring to the job.
11. You can make your own list of outstanding problems in the HM emergency field. This list is long, including,
 - a. difficulties in identifying the "programmed behavior" of the HM or its containment system
 - b. difficulties in predicting when actions by HM or its container will occur in an emergency (an events "clock")
 - c. difficulties in recognizing when traditional firefighting approaches must be abandoned because they do not apply to the HM emergency involved.
12. In summary, keep alert for opportunities to improve responses.. Don't stop here.

HAZARDOUS MATERIALS EMERGENCIES

GUIDELINES FOR WORKBOOK EXERCISES

(Note: the accompanying workbook has not been reproduced on line.)

In this section, you will find instructions that assist you in the preparation of your Workbook exercises. These aids should enable you to prepare most of the exercises without help, if necessary. They should also help you achieve the session objectives, and improve your analytical skills.

Prepare your exercises in pencil. Then you can erase and change entries freely if you change your mind as your work progresses. Try to do the exercises before they are discussed in class. That way, you will discover what you don't understand, so you can ask your instructor during the class sessions.

You will probably find it helpful to work under the "buddy" system. Try to find someone who is taking the course or is interested in the HM emergency field. Arrange to discuss your workbook exercises and entries with your "buddy" during your preparations. You will find the exchange of ideas more rewarding than if you try to do the exercises yourself.

Notice that there frequently are no "right" or "wrong" answers to many of the entries in the exercises. So, don't worry about making mistakes. It is your thinking that is important - especially how you arrive at your answers. If you feel you have not achieved the session objectives, ask your instructor for help! Almost without exception, if you don't understand something, there is someone else in the class that is having the same problem. So, speak out.

Lastly, be patient. You can not communicate with someone unless you are both speaking the same language. The same is true of the words and ideas presented in this course. Make sure you understand both. The ideas in one session are used to build up the ideas in the following sessions. It takes a while for you to feel comfortable with the new words and ideas. The approaches should begin to fit together about the time you are halfway through the course. So, stay with it.

HAZARDOUS MATERIALS EMERGENCIES

SESSION 1.

Exercise 1-2. In this exercise, you first set up a "standard" (or criteria) for comparison during your analysis of the problem. That standard is a description of actions you would take at a residential fire, with no HM present. Those actions are guided by the traditional fire fighting instructions.

First, visualize a fire you have observed or fought. In the column "fire, no HM present" list what you would do in carrying out the traditional firefighting operations. Place each action next to the block containing the traditional steps you have been taught. For example, in the block next to "size-up" you are trained to "check for rescues₁ check water supply, evaluate fire load," etc. Those are the entries you would make, in that column.

When you have completed that column, visualize an emergency that involves no fire, but a toxic gas leak. For example, try to visualize a tank semi-trailer containing anhydrous ammonia falling off a bridge onto an expressway, bursting open, and spilling ammonia fumes over a large area of the community. This happened in Houston in May, 1976. Going by the traditional firefighting steps, list the actions that you would take to handle that emergency.

Next, visualize an emergency that involves a fire around a truck transporting explosives. Picture a Volkswagen sedan being struck by the truck, fuel spilling, catching on fire, igniting the truck which came to rest across the highway, and the driver trying to warn passers by away from the wreckage. Then you arrive on scene. List what you would do, following the traditional steps. (The truck exploded 4-5 minutes after the firemen arrived at the scene. Waco, Ga., 1971.)

Next visualize an emergency that involves a train wreck with some LPG tank cars, and fire. A train wrecks in a rural area. During the derailment, an LPG tank car is punctured, and the LPG catches fire. The nearest water supply is over 500 yards away. No one is injured. You arrive about 4-5 minutes after the derailment. List what you would do, following the traditional steps. (The Oneonta, NY accident, 1974.)

After you have completed this exercise, you will recognize that the traditional steps are not always applicable in HM emergencies.

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SESSION 2

Exercise 2-2. This exercise will help identify ACTORS and ACTIONS more precisely in studying HM emergencies. A actor, remember, is someone or something that does something. What that actor does is considered the action.

Study these examples. "The fireman laid 1000 feet of 3" hose." Underline the actor and action. If you didn't underline fireman and laid then try again.

"The fireman got burned." What are the actor and action? If you said fireman, try again. The fireman didn't do anything - he had something done TO him. The actor in that example was probably "radiant heat" because the radiant heat burned the fireman. This example is the kind you will usually trip over.

Try this one. "The fireman was struck on the head by a falling roof beam." Who or what did what? Again, the fireman had something done to him, so he is not the actor in that scenario. The actor is the roof beam, and the action is "struck"(the fireman.) If you are still unclear, check with your instructor. You must understand how you identify both an actor and action for the rest of the course.

Use the following rules for preparing exercise 2-2:

1. Never show more than one actor and action in a block.
2. Use the 'past tense' to describe all actions.
3. Show each actor and its actions on a separate line.

For the exercise, select an incident that you can visualize in a lot of detail. Develop the actor/action descriptions that describe what happened during the emergency.

Let the instructor review your entries before you begin the next workbook exercises.

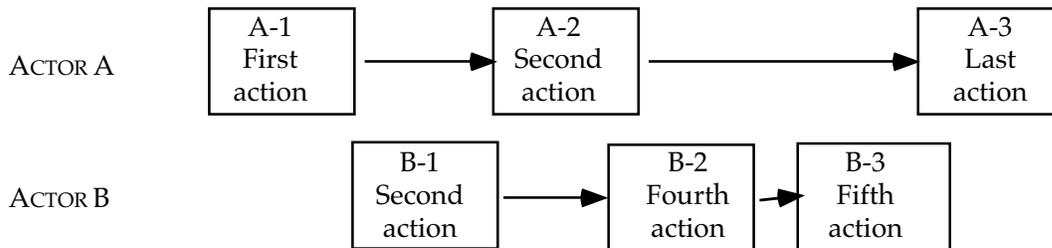
HAZARDOUS MATERIALS EMERGENCIES

SESSION 3.

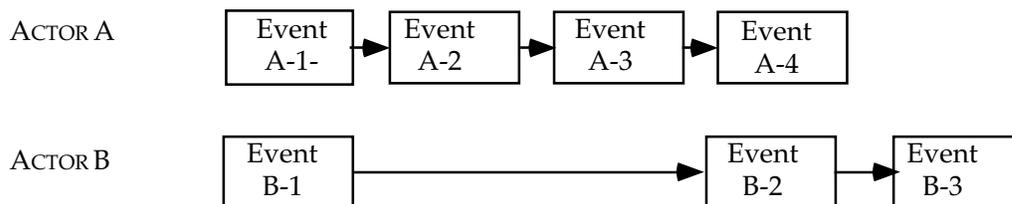
Exercise 3-2. The objective of this exercise is to display the events that occur during an emergency. Block diagrams of events are placed on a chart. The blocks are then connected with arrows to show the flow of the events (events sequence.) The flow moves from left to right. The first event is on the left, and the last event is on the right. The actions of an actor are placed on a single horizontal line, from left to right in the sequence they occurred. When you finish a chart, it will look like the following examples.



If you have more than one actor, it may look like this:



If both actors do something at the same time, it may look like this:



Notice how you can "see" or visualize the flow of events on the charts.

Using the events recorded in exercise 2-2, prepare a chart of the events in the above format. When you finish, you should have a chart describing or "modeling" the incident.

Get your instructor to approve your finished chart. This is the most crucial exercise in the series; it builds a crucial response management skill - visualizing events so you can act on what is coming next. If you don't grasp it, get help from your instructor.

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SESSION 4.

Exercise 4-2. This exercise requires you to visualize your trip to the scene of an HM emergency. You are to identify the sources of information about the emergency while you are enroute. As you search out these sources, ask yourself where they are and what information they can give you. You want any data that will help you make your mental movies, either sooner or better. Look for any data sources that you can use to get helpful information.

For example, when a caller reports the emergency, he is a source of data for you. He can describe what he saw or is seeing, like smoke, containers, signs or placards, gas clouds, injured people, etc. But he probably won't report much detail unless you ask him. Therefore, you would enter "caller" as the source of information, and the data entry would be "observations or "casualties."

Try to make a general outline, in chart form, of all the sources and data you can look for enroute to an HM emergency. This outline can guide your search efforts on runs to future emergencies.

HAZARDOUS MATERIALS EMERGENCIES

SESSION 5.

Exercise 5-2. In this exercise, focus on decision making, and on locating the facts you need for your decisions. Decision analysis is a powerful tool for study purposes. In this exercise you examine decisions needed during an HM emergency. Note that a decision can be viewed as an event. Actor = the decision maker, and action = the decision made.

Select an HM emergency involving some sort of injury. Make a mental movie of the emergency. Run the movie, looking for decisions that were made while coping with the emergency. List each decision that you can identify. Watch for hidden decisions, like conclusions that must be made before taking action. For example, "firemen apply water to cool the tanks" implies a hidden decision by the officer-in-charge to take that action. A decision generally precedes an order by an officer, or action by any of the firemen. Look for the decision maker, and the decisions made. Look especially hard for the decisions that led to actions by the responding personnel.

Exercise 5-3. The next portion of the exercise is designed to help you recognize the facts you need for emergency decisions. For example, if the officer-in-charge decides that full protective clothing is to be put on, that decision was probably based on certain facts. Those facts probably included strange odors, or a visible gas cloud, or data about what is stored in the facility, or observed injuries to others, or other such data. Write down the data that you would need to make each of the decisions you listed in 5-2. Use input/output (data/decision) methods.

Then listen closely to the views of classmates during the next discussion of this exercise.

HAZARDOUS MATERIALS EMERGENCIES

SESSION 6.

Exercise 6-2. This exercise **uses** your events modeling skill. Focus on the HM container system, the HM behavior, and the interaction between the HM and the "targets" exposed to injury.

Select a modest HM emergency. Visualize it as a mental movie, that ends with the occurrence of injury. For example, consider a chlorine mishap at a swimming pool. The released chlorine gas (Cl₂) injures some

- Event 1 container valve stressed
- Event 2 valve broke off
- Event 3 Cl₂ flowed through opening
- Event 4 = Cl₂ dispersed among crowd
- Event 5 = Cl₂ impinged victims
- Event 6 Victims inhaled Cl₂

Set up two models for the two emergencies you are to select. Then list one or more typical events you might look for under each block on the charts. For example, under container valve stressed, you might look for a falling cylinder, or something falling on the cylinder, or someone twisting the valve too hard with a wrench. Do the same for each entry.

When you finish, you should be aware of several types of actions that you might have to look for during emergencies. You should also realize that more than one possibility may need consideration for each successive stage of your mental movie.

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SESSION 7.

Exercise 7-2. Stressing events are the beginning of troubles in any emergency. Sequential stressing may produce cascading harm in an HM emergency. In this exercise, focus on the relatively few different types of stressing events that you have to look for. Remember, stressing events can trigger or enlarge your emergency. Stressing events also can occur in non-fire emergencies involving HM. Finally, during the cascading stage of emergencies, different types of stresses may occur at different times.

As you go through this and succeeding exercises, group your entries under the different sections you can link related entries as you go from section to section. For example, if you list "vehicle collision" as one of the stressing events, mark it number 1, and list any related entries under the intensity, duration or frequency sections with the same number. If you want to tie them together another way, that will be all right, too.

Exercise 7-3. This "classification" exercise is an attempt to help you develop your reasoning skills. Examine the entries under the different types of stressing events. Then try to figure out some way to group them into just a few categories.. Each category should be a general description that covers several similar events. For example, an HM container exposed to collision forces in a crash, a valve on a falling container, and the twisting of a wrench on a valve are all "mechanical" stresses. All the events are described by the "mechanical" stressing description. At the same time, none of your other entries can be so described, probably. This is a way of reducing the variety of events you have to look for in emergencies. Try to classify the intensity and duration factors in the same way.

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SESSION 8.

Exercise 8-2. HM must get outside its container (usually) to do harm. The exception is when you enter the container and get hurt. For this exercise, visualize the different types of containers and try to find ways they lose their integrity. For example, a glass container may shatter when stressed. Among the factors determining the intensity of the shattering are the "programmed" characteristics of the bottle. It happens quickly because of the characteristics of glass (duration.) It can only shatter once (frequency.) Now, think about the other kinds of containers and how they fail and release their contents.

Next visualize what can pass through the breached containers. For example, a powder or gas may pass through the breach in the package in the form of a "puff" or "plume." Focus on what flows through the breach, and the factors that determine what happens.

Exercise 8-3. In this exercise, you are to take each Department of Transportation HM classification, and indicate which of the breach/ release mechanisms can occur. For example, an orange label explosive, like dynamite, can detonate. So can a red label flammable solid, like monoethylamine nitrate. So can a yellow label material, like ammonium nitrate. So can a flammable compressed gas, like LPG. Get a good reference book, and review the HM listed to see the different ways the various classes of HM can behave, in terms of the breach/releases. Some of the Emergency Handling Guides referenced at the end of this book will help you with this exercise. The complete list will help you predict HM behavior for your mental movies in the future.

SESSION 9.

Exercise 9-2. Answer the questions at the tops of the columns, keeping related answers on the same line. For example, after energy, visualize a radioactive materials package that leaks or spills some RAM. The form of the energy that escapes is gamma rays. They are self-propelled by nuclear disintegration. The rays move away from the source in a straight line, or path. The dispersion pattern, if the RAM gets out of the packaging, would be hemispherical in shape, i.e., the rays would spread out in all directions, radially from the source.

Next, visualize other types of HM forms that escaped in some of the incidents you have discussed or read about. Consider also the data you put together in exercise 8-3, and some of the examples you thought of for that exercise. Visualize all the different ways HM can move about after it leaves its container or the container is breached.

Note the dispersion patterns you will have to look for when you have finished the exercise.

Exercise 9-4. Referring to Session 9 in the text of this book, note the types of events and factors requested. Try to list an example under each of your entries.

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SESSION 10.

Exercise 10-2. For this exercise, include in your list of injury those that could occur to personnel responding to the emergency and to any other victims who might be injured during the emergency.

The second part of the exercise is another classification exercise. Try to group the various types of injuries you have listed into 6 groups. Do not consider electrical injuries in connection with HM injuries. This exercise in classification can probably best be done during a class session.

Exercise 10-3. This exercise is self explanatory if done in connection with handouts from previous sessions. For types of impingement, visualize the different forms of HM that move around, and then picture how they give the "targets" the "dose⁹" of HM. For example, one type of impingement is to be splashed by a liquid HM. Another way is to step into the run-off and get a dose of HM. Try to identify all the ways HM can impinge on you and get into position to harm you.

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SESSION 11.

Exercise 11-3. (Note: do exercise 11-3 before 11-2.) Working from the general behavior model, develop strategies described in paragraph 11.8 of this book. For Part II, cover the duration and intensity factors by linking them to the M and T in the MOTEL strategy acronym.

For Part III, using MOTEL, select events to influence. Using the HM behavior model will help you develop specific tactical options. Try for at least two for each strategy. Visualize past or hypothetical emergency situations of your choice. Focus on use of tactics a through f under paragraph II.1e.

Exercise 11-2. Use the MOTEL strategies, and tactical options in paragraph 11.10 of this text for this exercise. Select an emergency described in a reference book like Meidl or Bahme, or use one from the class's experience. Pick out the targets that were harmed during the emergency. List the injuries in the order in which they occurred. The exercise is intended to show you that often when HM are involved, the harm occurs during the cascading stage of the emergency. The cascading stage involves successive cycles of stress/dispersion/harm, usually.

To illustrate, consider the Gretna Florida highway accident and toxic gas release: your entries would look something like this.

<u>Stressed targets</u>	<u>Stage of emergency</u>	<u>Strategy for responding personnel</u>
truck(in collision)	5	not there to act
tanks (when punctured)	7	not there to act
car passengers (gassed)	7	influence timing - remove victims fast, 11.10 f

Try to link your tactics or strategies to the paragraph number in this test in Session 11.

SESSION 12.

Exercise 12-2. This exercise is intended to expose the hidden factors you think about when you decide how to handle an HM emergency. First list the factors that concern you when you make a "do something" decision. Example might include "it's a child's life" or "pride" of "reputation", etc. Try to think about all the thoughts you weigh in arriving at your decisions.

Next, list the factors involved in a "do nothing" decision. Note that a factor may be in the "gain" column in one case, and in the "cost" column in the other case. Next, using a scale from 1 to 10, assign a "weight" to each factor you listed. This "weight" number should reflect how important the factor is to you. 10 means it is one of the most important. 1 means that you do not think it is very important. The other

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numbers indicate that you think their importance falls somewhere between the most and least important.

When you finish, average the weights you assigned each section of the worksheet. Record your average weight number.

Finally, rank the entries in each column and section of the work sheet. Place a 1 by the entry you consider most important, a 2 by the next most important one, and so on.

Be prepared to discuss the results in class. The discussion will help you understand your value differences, and how they might influence your decisions in HM emergencies, or for planning or post-emergency critiques.

Exercise 12-3. This is an analytical exercise to study emergency response instructions critically. Pick out some emergency handling instructions from a reference publication. Try to pick different ones than your class mates pick, so you all will benefit more from each other's work.

For the first step, translate each instruction into an event description (actor + action = event.) For example, on page 114 of Meidl, (reference 52) the following firefighter instructions are given:

Instruction	Actor/action(s)	EM	BEH	DEC
Be careful about moving a heated cylinder.	Firefighter/be careful	7	A	5
Acetylene fire should not be extinguished except to shut off gas flow	Several are implied: 1-firefighter/shut off gas flow 2-firefighter/extinguish fire 3-firefighter/don't extinguish fire	7,8	D	4
Stop flow in some manner	firefighter/stop flow	7	B	4

NOTE: For entries in last three columns, refer to stage number in HM emergency model; refer to letters A through D in HM behavior model: and refer to Steps 1 through 6 in the D.E.C.I.D.E. model. See reference 11.

By doing this exercise, you will note that criteria for selecting actions are not usually provided. Your attention is also directed to the usual lack of an operational objective in the sense presented in this course.

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SESSION 13.

Exercise 13-2. This is an extension of the exercise 12-3, using other aids and attempting to suggest improvements developed by the use of the principles learned in this course. Use one fire and one non-fire example. Entries should contain the following materials.

INSTRUCTION - write out the instruction in this column.

STRATEGIC OBJECTIVE - note the explicit or implicit objective(s) contained in the instruction.

TACTICS SUGGESTED - note the tactics (traditional or D.E.C.I.D.E.) that are contained in the instruction.

CRITERIA FOR EVALUATION - list the principles, models or other standards by which you judge the acceptability of the instruction. List only; explain your reasoning in the next column.

PROBLEMS WITH TREATMENT - list here the reasons why you think the instruction is satisfactory or in need of improvement. Relate your reasons to the criteria listed above. Note that before you can claim they are good or not satisfactory, you must have some standards against which to compare the instruction. Next you must decide whether or not the standards are met by the instruction. In other words, you have to measure the instructions against the standards for acceptability to determine whether or not they are acceptable.

SUGGESTIONS FOR IMPROVEMENT - if there is a problem, use the principles you have learned to develop a way to correct your problem with the instruction. This is the most important step in criticism -don't just make accusations, but offer suggested improvements.

NOTE: you may wish to refer to SUGGESTED STUDENT PROJECTS section, Group III projects, for the TIME, GAP, LIMITS and PURPOSE tests or criteria.

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SESSION 14.

Exercise 14-2. You need to acquire a preplan where HM may become involved to do this exercise. Do your analysis in the following order.

- a. describe the occupancy.
- b. select one of the HM present, if more than one HM could be involved.
- c. agree on a hypothetical emergency to be analyzed, focusing on the HM behavior for this study.
- d. chart the emergency events sequence you are predicting, focusing on the HM, its containment system, and the targets; model it in the blocks provided.
- e. under each block of the model, list the preplan data that are found in the preplan and that are determinant factors for that event (see worksheets prepared in previous exercises.)
- f. under preplan analysis, list additional data that you think you should have to support your emergency handling decisions.
- g. review an emergency response guide, and list under the appropriate event in your model all the instructions for influencing that event or the next event. Bunching or gaps in the instructions may be noted as this is done.
- h. develop strategies and tactics you would recommend for each event in your model, based on principles from this course. Focus on ways to influence the events sequence and the outcome, in terms of reducing the harm. Visualizing your actions and their effects should be routine for you by the conclusion of this exercise. If not, clear up any remaining difficulties with your instructor!

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SESSION 15.

Exercise 15-2. For this exercise, select an organization that issues HM safety regulations, codes or standards. Get a copy of that organization's procedures. With these procedures in hand, prepare a model of the process (who does what, and the expected sequence.) Start with the identification of a need for change, and finish with the regulation, code or standard being adopted officially.

To complete the exercise, under organization list the name of the outfit that publishes the regulation, code or standard. For example, such rules are published by the Department of Labor, NFPA, your county or municipal council, etc. Next, show the type of rules established by the organization. For example, the rules might be voluntary standards, or Federal regulations, or ordinances, or tariffs, etc.

When you have finished, you should know how to bring about a change in any of the rules you studied if you think a change is ever needed. These processes change from time to time, and the outputs of these organizations may also change in the future. This is one worksheet you should try to keep up-to-date for your future use.

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WORKBOOK APPENDIX, PART I: INSTRUCTIONS

This section contains general instructions for the preparation of the records system which will contain your operational information about HM emergencies. By preparing these records, you will accomplish several things. First, you will think through what happens in different kinds of emergencies so they will not be a complete surprise to you when you encounter one. Secondly, you will have a detailed understanding of the models you prepare. Third, you will have some appreciation for when they will apply and when they don't. Also, you will have your information organized for use in a structured way if you need it.

The following steps are suggested for the orderly preparation of this section of the workbook. Each set of models follows these steps.

1. Select an HM class from among the DOT or other classifications, and enter the classification name. Then enter the name of the organization whose classification you are using after "by:"
2. Locate the organization's definition for that classification of HM and enter a reference to the source after "Reference" and enter the definition after "Definition."
3. After "Examples" enter the names of some of the substances or materials in that classification. For example, if the class is Explosives A, you might enter dynamite, bombs, etc. Use your references freely for this task. Try to get a wide variety of examples.
4. After "Identifiers" list identifying signals that materials in this class may be present in an emergency. Cover equipment or operating clues, code requirements, isolated storage areas, dikes, vent stacks and the like.
5. After "containment systems" list any distinguishing features of the systems that hold HM, such as tank head shapes, piping characteristics, silhouettes, etc., that give you clues that this class of HM may be present at the scene of an emergency.
6. Under "mfg. plant" enter any distinguishing characteristics that will give you clues that HM in this class are present at a facility, like rubber lined or plastic piping, dikes, special firefighting apparatus or equipment, etc.
7. Above "Rail" sketch in the placard or tags that identify this class of HM in a railroad car. Below "Rail" list any distinguishing characteristics that will give you clues about the presence of this class of HM in a railroad emergency.
8. Above "truck", sketch the placards that would indicate this class of HM is in a truck involved in an emergency. Below "truck" list any distinguishing characteristics that will give you clues about the presence of this class of HM in a highway or off-road emergency.
9. Above "package", sketch the labels that are supposed to be on packages containing this class of HM. Make sure you are working with the UN pictographic labels. It is helpful to show them in color. Below "package" list any distinguishing characteristics that will give you clues that this class of HM may be involved in your emergency.
10. Select one of the HM in this class, and visualize its behavior in an emergency. Make a mental movie of how it would probably behave in the emergency you picked, starting with a stressing event. To have a complete set of models for this

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class, you should develop models of the HM behavior for package size quantities, for truck loads, for rail car loads, and for stored quantities in a local facility.

11. In the "behavior model" column, you code them with the United Nations serial number for the HM you are modeling, or use the UN class number, or use your own numbering system. Since the UN system will probably become standard in the US in the future, that system would probably be most valuable to you in the long run. Assign each model a different number.
12. Next construct your models, using the blocks provided to guide you. For these purposes, it is all right to show more than one actor on a line. Try to make your models similar to the general HM Behavior Model. Break down the events into general terms,, remembering that you are trying to prepare records that will help you estimate the outcomes in such emergencies.
13. Above each model, list any limiting conditions in which the model would not apply. For example, rainy weather, rough terrain or an urban Vs rural setting might affect the course of events. Note such conditions immediately above the event they would affect.
14. Check the arrows in the model to be sure the events sequence is portrayed correctly. Use branched events diagrams if necessary.
15. Below each event, list examples of factors ~ look for that will help you predict the outcomes, or help you visualize what will probably occur next in an emergency.
16. Alternatively, you might wish to indicate below each event or between successive events, the possible countermeasures that might be used to improve the outcome. Check these entries against the ideas presented in this and other text books.

After you have completed the models and notes for one HM class, go on to the next class, until you have modeled all the classes to your satisfaction.

Some of these models will be discussed in class sessions, so watch for ways to make yours better, or for different models of materials in the individual HM classes.

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SUGGESTED STUDENT PROJECTS

This section contains suggestions for projects that can be done as homework, self-study to improve or maintain your skills, or as team projects during the course. They are designed for use with any reference books that may be available to you. They are relevant to the generalized approaches presented in this textbook, and support the skill development expected of the students.

GROUP I. Incident Histories

Purpose: This group of projects is designed to give you experience to

- 1) help visualize selected kinds of HM emergencies,
- 2) "skim" written materials to search for desired information, and
- 3) set up records for ready retrieval of your findings.

Projects: When you study, you should always have your objective in mind to help you concentrate your study effort. The outputs (your objective in these projects) will be a reference sheet to which you can refer for practicing "mental movies" of emergencies. Therefore, set up a piece of paper with columns to record 1) the page number of the reference you are using; 2) the city and state in which the incident occurred; 3) the year it occurred; 4) the activity underway when the emergency started (such as maintenance, transportation, manufacturing, etc.) 5) the HM involved; and 6) remarks.

Then, take your reference book and skim through it to find descriptions of incidents in which HM were released or reacted, note the items called for on your reference sheet, and try to visualize what happened from the description you are given. Strive to arrive at a fairly complete mental movie of each incident. Try to get at least 10 incidents in each of the following categories. Each category can serve as one project.

1. toxic chemicals incidents
2. halogen and halogenated hydrocarbon incidents
3. radioactive materials incidents
4. unstable chemicals incidents
5. corrosive, cryogenic and propellant incidents
6. oxidizing chemicals incidents
7. explosives incidents
8. water reactive chemicals incidents
9. combustible chemicals and fuels incidents

Feedback: After completing each project, review your entries and run a "mental movie" for each of the incidents you have referenced. If you have difficulties, add some "key reminder words" in the "remarks" column to help you improve your recollections.

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GROUP II. HM Injury Mechanisms

Purpose: This group of projects is designed to help you make estimates of the number of people "targets" that will be injured by HM in an emergency.

Projects: The outputs of these projects will be reference sheets that show you how HM produce injury to people in various types of emergencies. Set up a piece of paper with columns to record

- 1) the page number of the reference you are using
- 2) the city and state in which the incident occurred
- 3) the name of the HM involved
- 4) the DOT classification of the HM involved
- 5) the steps by which the activated HM injured people
- 6) remarks

Then, skim through your reference book to locate descriptions of incidents in which HM harmed people, and note the items called for on your reference sheet. Focus on how the HM injured the people, not on how the HM or the container acted in the emergency. For example, TNT can detonate but it is the overpressure and shrapnel from the explosion that impinge on people to injure them: focus on what impinges and injures, and how it does the damage to the people. List at least 10 chemicals for each category that follows. Each category can serve as a project.

1. toxic chemicals
2. radioactive materials
3. oxidizing materials
4. flammable gases
5. non-flammable compressed gases
6. flammable liquids
7. flammable solids
8. etiologic agents
9. explosives A and B
10. corrosive materials
11. organic peroxides
12. explosive C

Feedback: After completing each project, review your entries and run a "mental movie" of each injury mechanism you have referenced. If you have difficulties visualizing the fatal, incapacitating, or other injuries to be expected, add some "key reminder words" in the "remarks" column to help you improve your recollections.

Note: this will help you see the different injury mechanisms that can occur with a single classification of HM.

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GROUP III. HM Emergency Action Instructions

Purpose: This group of projects is designed to

- 1) give you a partial inventory of conventional HM emergency handling instructions for possible future use,
- 2) improve your analytical modeling skills, and
- 3) help you produce better "critiques" of material you read.

Projects: The outputs of these projects will be marked-up models of some of the typical emergency handling instructions you are offered, showing their strengths and weaknesses. Prepare a set of up to three models for each project. Assume you are the officer-in-charge at the scene of the emergency. Locate and review an emergency handling guide or instruction for the type of HM emergency you select. Identify the actions you are instructed to take. On a sheet of paper, after noting the source and the page number containing the instructions, prepare an events model of the actions you think you are expected to take according to the instructions. If you are uncertain about how to interpret an instruction, record your best guess. Don't overlook implied instructions suggested by the source. Prepare models for examples in each of the following HM classes:

1. toxic chemicals
2. radioactive materials
3. explosives
4. etiologic agents
5. corrosives
6. flammables
7. oxidizing materials
8. non-flammable gases

Feedback: After completing each model, review it and analyze it to identify gaps, out-of-sequence instructions, limits to its applicability, and clarity of purposes and objectives. This can be aided by comparing the actions with the outputs from Group I or II projects. "test" each model against the following criteria:

- a. TIMING test: do the instructions as modeled reflect the sequence in which the emergency progresses, and in which the instructions must be carried out during the emergency?
- b. PURPOSE test: do the instructions tell you what each action is intended to achieve so you know whether or not you are successfully accomplishing what needs to get done?
- c. GAP test: does each instruction logically follow the previous instruction, step by step, or are there gaps where you will have to guess what to do next?
- d. LIMITS test: are there situations in which the instructions are not applicable, and do they tell you what these situations are? (If not, beware, because you may be testing the instructions the first time when you try to follow them in handling an emergency!)

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 - e. Materials Transportation Bureau
4. Energy Research and Development Administration, Washington, D.C.

(Note for Internet Edition: These sources have changed. See www.iprr.org for links to accident reports by above agencies, their successors and others)

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GLOSSARY

actor:	who or what does or did something. action - what the actor does or did.
activity:	a set of actions directed toward a particular intended outcome.
accident:	the process by which a normal activity is transformed into a harmful outcome.
combustion:	a chemical oxidation reaction characterized by visible flame and heat evolution.
condition -	a particular state of being of a person or thing (actor) or set of persons or things.
emergency -	a course of events with the potential for disruption of an activity or for harm, and calling for attention or action.
energy -	the work a system is capable of doing to something else, i.e., producing a physical change of state (such as transfer of energy to a body by application of a force producing displacement, etc.)
energy transfer:	the doing of the work that is event - one action by one actor.
events sequence:	a series of related events in a logical proceed/follow order in time.
force:	a vector quantity of energy that tends to produce an acceleration in the direction of its application.
harm:	injury or damage to an actor.
hazard:	this term is not used because of its unclear meaning in general usage in the field.
injury :	the disruption of the intended functional continuity of an animate or inanimate actor; may range from negligible to fatal.
injury mechanism:	the step-by-step events by which a hazardous material injures an actor.
kinetic energy	energy available due to motion.
label:	a small piece of paper, cloth or other flat material attached to an article.
marking:	a sign, inscription, symbol or visible impression on an article like a container or containment system.
outcome:	a condition produced by a course of events or event.
overstress:	to stress an actor beyond recoverable limits, disrupting the functioning of that actor in its intended way.

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perturbation:	an event or unexpectedly encountered condition capable of throwing an activity into disorder if no adaptive response is undertaken.
placard:	a poster-type sign affixed to provide "public" notice. potential energy - energy derived from position rather than motion.
reaction,	the combining of two or more materials into another, or the chemical
chemical:	breakdown of a chemical material, or the combining of a chemical into a polymer or chemical chain. physical - the response to a stressing force.
shipment:	goods or cargo being transported; includes a hazardous substance and its container or packaging and markings.
stress (noun):	the condition of being strained or subjected to a force that tends to strain or deform or otherwise change a body or mass; a potentially disturbing or disruptive influence.
stress (verb):	to apply a form of force or energy or system of forces that tends to strain or deform or otherwise change a body or mass; disruptively influence.
stressee:	the actor whose state is being changed by stress. stressor - the actor applying the force or energy being transferred. unstable - a state immediately preceding erratic or unwanted behavior.
stressor:	the actor applying the force or energy being transferred.
unstable:	a state immediately preceding erratic or unwanted behavior.
The symbol Δ	(delta) is used to denote a differential between one state and another.
The symbol 	is used to indicate an event (actor +action).
The symbol 	is used to represent a direct chronological proceed/follow relationship between events. The earliest event is always on the left and the following event is always to the right, to represent the passage of time from left to right on the models.