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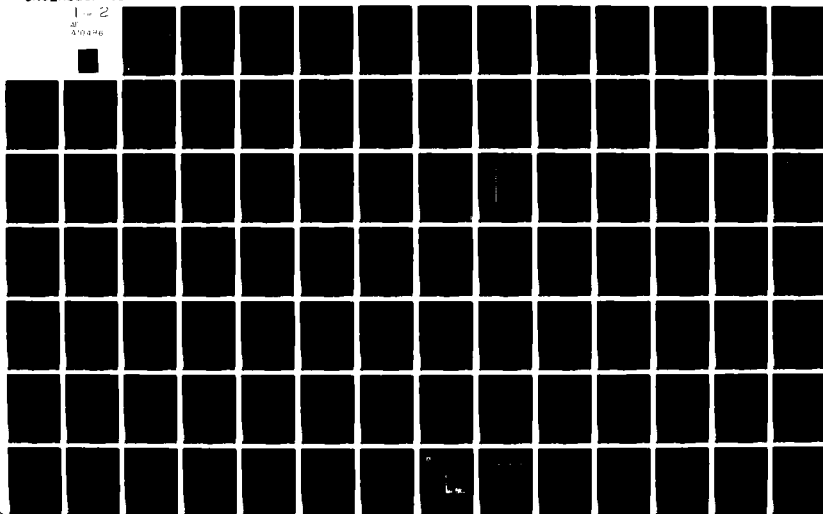
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An Approach to the Management of Hazardous Materials

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Information exchange media are examined and assessed for potential effectiveness in transferring the acquired and developed information to the area where information needs are greatest — the level of first responder. Test communities should be established to participate in information exchange programs.

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AN APPROACH TO THE MANAGEMENT OF HAZARDOUS MATERIALS

by

J. V. Zaccor, H. L. Hsu, and C. Wilton

for

Federal Emergency Management Agency
Washington, D.C. 20472

Contract No. EMW-C-0432, Work Unit 2321D
James W. Kerr, Project Officer

FEMA REVIEW NOTICE:

This report has been reviewed in the Federal Emergency Management Agency and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the Federal Emergency Management Agency.

Scientific Service, Inc.
517 East Bayshore, Redwood City, CA 94063

(DETACHABLE SUMMARY)

AN APPROACH TO THE MANAGEMENT OF HAZARDOUS MATERIALS

This report presents an approach to the management of hazardous materials. The work was sponsored by the Federal Emergency Management Agency and included study of current information, reports, and data on a variety of hazardous material problem areas, including manufacture, transportation, use, disposal, spills, etc. The major objective of this program was to analyze approaches that could be used by FEMA management to make program decisions. Emphasis was on identifying needs and research programs that would improve hazardous materials management and control and strengthen information and training available to the first responders at the site of an emergency. It involved consideration and assessment of decision information systems, data collection protocols, information exchange media, and other factors.

The conclusions reached in this study were that FEMA's role in the hazardous material area should be concentrated in the training of, and the supplying of information to, first responders for use in emergencies. To accomplish this role the agency should become the coordinating agency for research and data collection in the areas of importance to the first responder, be the leader in the development of interactive (self instructing) training courses, and initiate an information exchange medium (newsletter) specifically directed to the emergency community. Specific recommended program elements are as follows:

Programs and Technical Assessments

Compile a summary of ongoing programs in hazardous materials emergency management; develop assessments of these programs and identify specific applications pertinent at the community level.

Develop comparative study and assessments of available and affordable items such as: Protective clothing; materials identification instruments; breathing apparatus; hazardous materials response vans; and communications equipment/systems.

Develop a forecast of the above items in development expected to be available in the near future (items being field tested).

Develop flow diagram response protocols for well-established response procedures.

Develop comparative assessment of community preplanning methods.

Develop assessment of costs and benefits of community preplanning; develop emergency incident data to show improvement due to preplanning.

Information-Transfer Program Elements

Develop information transfer methods to provide the above developed information to first responders — and to emergency planners — at the local level:

- A. Explore a newsletter approach — with the above information targeted for first responders and emergency planners.
- B. Explore the use of interactive training options for supplying first responders with effective, realistic incident scenarios:
 - 1. Develop an initial program — consider use of scenarios developed from existing courses (e.g., Fire Academy) and from incident/response data of record.
 - 2. Test the program in a participating community.

Community Programs and Applications Assessments

Establish several test communities to participate in information exchange programs. (Some or all of the participants should be involved in community preplanning efforts.)

- A. Evaluate the use and application in each participating community of the information developed in the first program element.
- B. Initiate development of a uniform comprehensive data collection format for recording community emergency incidents as a collective effort among participating communities — with Federal representation and input.
- C. With this format develop emergency incident data in each participating community.
- D. Develop the data collected over one year for each community to show:
(1) Materials spilled - in order of spill frequency; (2) Materials spilled - in order of severity (to the general public and to first responders); (3) Locations of incidents (using zip codes to identify impacted regions, and combinations of zip codes to identify impacted transportation routes); (4) Spiller; (5) Principal cause; and (6) Response or outcome.
- E. Compare the data among communities to identify the problems held in common.
- F. Develop response protocols for common materials problems.

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Section 1
INTRODUCTION

This report presents an approach to the management of hazardous materials. The work was sponsored by the Federal Emergency Management Agency and included study of current information, reports, and data on a variety of hazardous material problem areas -- manufacture, transportation, use, disposal, spills, etc. The major objective of this program was to analyze approaches that could be used by FEMA management to make program decisions. Emphasis was on identifying needs and research programs that would improve hazardous materials management and control and strengthen information and training available to the first responders at the site of an emergency. It involved consideration and assessment of decision information systems, data collection protocols, information exchange media, and other factors.

Hazardous materials have been an integral part of the Comprehensive Emergency Management program at FEMA. Shortly after the agency's formation in 1979 the Defense Civil Preparedness Agency, now part of FEMA, sponsored a hazardous materials conference at the National Fire Academy in Emmitsburg, Maryland (Ref. 1). This conference was attended by 38 representatives of 21 Federal and local government agencies involved in various aspects of hazardous materials -- research, management, spill response, etc. DCPA's purpose in holding the conference was to obtain input from other interested agencies to help establish initial priorities for FEMA-sponsored research activities in the hazardous materials area. The results of this conference provided the basic input to a planning document that was distributed to all attendees (Ref. 2).

One of the major questions asked at the conference (and at subsequent meetings with the National Transportation Safety Board, the ASTM F-20 Committee and OSTP) was what role should FEMA play in the hazardous materials area. Other

agencies, such as EPA, DOT, NBS, were already heavily involved in this area, and the desire was not to compete and interfere with these efforts, but to complement and enhance them and possibly close some gaps that needed filling. A number of possible roles suggested included the following:

1. **Coordinating Agency** - Many people felt there was a need for a coordinating agency to deal with emergency management in hazardous materials, particularly with regard to research needs. For example, it was considered important to coordinate the research being done to ensure that what was being done was necessary, that it was not being duplicated, and that gaps were being filled. Another important facet was to ensure that the results of the research were being disseminated to the users in the field. This led to role No. 2.

2. **Information Transfer** - There seemed to be a need for rapid, efficient means for transferring practical research results to the users in the field. The primary research need seemed to be for better, understandable, and more usable information for the so-called "first responders"; i.e., the local fire, police, and emergency forces who are usually the first on the scene. This seemed to be a very logical role since the U.S. Fire Administration was part of FEMA and already had good rapport with the fire community.

3. **Training and Education** - As an integral part of the information transfer process it was observed that there was a need for training courses and training materials on tactics, equipment, contingency planning, etc., which could be most logically supplied by the National Fire Academy at Emmitsburg.

4. **Data Management** - Numerous agencies involved in the hazardous materials area were collecting data on manufacture, transportation, use, and spills of hazardous materials, there seemed to be little coordination of these data bases. Better coordination would allow the information from each to be integrated, applied, and used to develop a comprehensive management approach to hazardous materials.

Considering these factors, plus the general concerns with how FEMA could function to improve the management and control of hazardous materials, Scientific

Service, Inc., produced a "Planning Document for Hazardous Materials Research" (Ref.2), which outlined a preliminary five-year plan for a FEMA research program. Three funding levels were proposed -- minimal, intermediate, and comprehensive (some of the rationale for these recommended programs is presented in Section 2). Unfortunately, funding committed to the hazardous materials area since that time has not been sufficient to fund even the minimal program proposed in the Planning Document. SSI, however, under the program reported here, was directed to:

"A. Develop a decision information system and data collection protocol comprehensive management approach to hazardous materials. Data base and models must address limitation of risk, hardware considerations, setting of priorities, and evaluation of constraints such as legislation and regulations.

"B. Develop an approach, with prototype editions, of a hazardous materials information exchange medium. Candidate approaches should include but not be limited to newsletters, data sheets and research outputs; these should be analyzed so that FEMA can make program decisions.

"C. Provide on-call assistance to FEMA task forces and other study groups addressing hazardous materials, to include activities such as site visits, conference management and reporting, and quick-response ad hoc studies."

This report covers Tasks A and B.

The report is organized as follows: after the background review in Section 2, Section 3 discusses currently available data bases and models; Section 4 discusses various types of information exchange media; Section 5 presents an approach (or series of approaches) that FEMA could take with regard to future research programs in this area.

Section 2

BACKGROUND

The conference held at Emmitsburg, Maryland in June 1979 (Ref. 1) identified major national concerns relating to hazardous materials -- as viewed by 38 representatives selected from 21 Federal and local government agencies who met to discuss the issues. The conference was convened in recognition of two important factors; i.e., that, historically, hazardous materials management had been founded on a sequence of unrelated programs -- with little coordination and essentially no management overview -- and that FEMA had just been created, with an implied mandate to alter this trend as part of the agency's commitment to "comprehensive emergency management". Evidently, then, the major challenge for the new agency, insofar as hazardous materials were concerned, appeared to be the effective integration of programs and efforts conducted by agencies already playing major roles in the hazardous materials area into a comprehensive effort to mitigate the effect of these materials on the environment.

Effective integration of programs seemed logically to hinge on the development of a comprehensive overview of the various agency efforts and an assessment of their impact on the hazardous materials problem and its management. The rationale for this view was simply that it would be difficult to make sensible management decisions regarding the direction that a coordinated program should take without some idea of where the program pieces completed and being conducted by the many agencies might fit. It was suggested in the Planning Document (Ref. 2) that this be accomplished through (1) a **programs assessment** to define the direction, status, and schedule of research completed and in progress nationwide on the general subject of hazardous materials handling and disposal; (2) a **technical assessment** directed at defining the technical adequacy of, and gaps in, the overall program, with recommended remedial action. The intended objective and presumed end result would be a clear view, at a single agency, of all Federal emergency preparedness mitigation and response activities (a FEMA mandate, by executive order).

An alternative to the ad-hoc approach (where the "squeaky wheel gets the grease") is systematic attention to ranking of hazardous material problems as to their possible relative impact on society. To identify and establish rankings would require analysis and statistical summaries of hazardous materials experience, including manufacture, transportation, use, disposal, spills, etc. Some of these same data and data bases would also be needed to satisfy another requirement stated at the Emmitsburg conference as incumbent on FEMA "to provide a better basis for determining the cost effectiveness of spending for hazard mitigation, preparedness planning, relief operation and recovery assistance". Expenditures for hazard mitigation and preparedness planning may be the most effective way to avoid the cost of relief operations and recovery assistance after a disaster, but it would be difficult to assess such management tradeoffs without data. Moreover, the only effective way to measure the impact of management decisions is through "before" and "after" data. All these reasons considered, the **acquisition and development of data and data bases** was as important as the **program and technical assessments**.

There would be little point in working towards a better basis for measuring cost effectiveness of benefits (i.e., greater public safety from enlightened management choices) if no benefits were developed, so there is an implied requirement for **delivery** of such benefits through improved performance of operating personnel in the field. This touches on another important factor -- dissemination of information pertinent to improved performance of operating personnel (e.g., tactics, equipment innovation, contingency planning). This, in turn, will require effective information exchange with the appropriate end-users, as new techniques are discovered and proven.

The foregoing exposition briefly summarizes the underlying rationale for the management support requirements that were developed in the Planning Document (Ref. 2). How these requirements fit in the total proposed program can be seen in the outline of requirements that were discussed at length by all the participants at the Emmitsburg conference. This outline is presented in Table 1, which is reproduced from Ref. 2. Table 2 presents material that was extracted from Table 6 in Ref. 2; it covers the first two years of a strong five-year program to accomplish the objectives identified in Table 1 (without specific reference as to which agency,

TABLE 1: RESEARCH NEEDS

MANAGEMENT SUPPORT

Decision Information

- Program and Technical Assessments
- Data Base and Risk Analysis
- o Regulatory
Marking/Labeling; Classification;
Documentation; Siting; Mitigation Standards;
Re-entry/Reuse; Planning Requirements

Training and Education

- Dissemination of Available Information
- o Development of New Courses
Tactics; Recognition; Equipment Usage;
Contingency/Evacuation Plan; Prevention/
Mitigation/Standards

FIELD OPERATIONS SUPPORT

Instrumentation

- o Material Identification
- o Hazard Identification (risk alarm)
- o Site Conditions

Equipment

- o Protective Clothing
- o Breathing Apparatus
- o Response Vehicles
- o Sampling Equipment
- o Communication

Environmental

- o Response Protocols
- o Health Effects of Individual Materials
- o Health Effects of Mixtures
- o Hazard of Mixtures
- o Mitigation Requirements
- o Ultimate Disposal

TABLE 2: EXTRACT FROM REF.2, COMPREHENSIVE PROPOSED PROGRAM

Research Area	Sub Task	1980	1981
MANAGEMENT SUPPORT			
MANAGEMENT INFORMATION AND CONTROL	PROGRAMS AND TECHNICAL ASSESSMENTS	Compile summary of all ongoing programs; document objectives, methodologies, schedules; Assess merit; define overlaps, gaps, remedial action. \$ 175,000	Track and update; identify progress and new problems, priorities, new directions. Assess quality, transfer technology, publicize impact. \$ 200,000
	DATA BASE AND RISK ANALYSIS	Develop data acquisition format and compile data on incidents, causes, effects, response, economic and environmental impact, etc. \$ 100,000	Update data bases, develop management tools; integrate into tracking, forecasting HM problems. \$ 100,000
	REGULATORY	As management data are developed on manufacture, use, transportation, disposal, incidents, initiate development of appropriate regulations. \$ Steering Committee	→
TRAINING AND EDUCATION	PROGRAMS DEVELOPMENT AND TECHNOLOGY TRANSFER	Assess state of the art in tactics, recognition methods, equipment usage, contingency planning, HM release prevention. Update all response agencies. \$USFA Staff	Utilize incidents data base to develop better tactics. Identify innovative response using common equipment; develop contingency plans; transfer technology. \$ 75,000
FIELD OPERATIONS SUPPORT			
INSTRUMENTATION	MATERIAL IDENTIFICATION	Development program for four or five most promising instruments. * \$ 400,000	Field test -- evaluate -- and develop training/education program. \$ 450,000
	HAZARD IDENTIFICATION (RISK ALARM)	Study state of technology; Establish threshold limits; Define indicators for reactants to be measured. \$ 250,000	Implement R & D program three instrument types. \$ 300,000
	SITE CONDITIONS	Determine types of measurements and accuracy needed. Survey instruments available. \$ 30,000	Develop prototype kit; Field test and evaluate. \$ 100,000

TABLE 2: EXTRACT FROM REF. 2, COMPREHENSIVE PROPOSED PROGRAM (contd)

Research Area	Sub Task	1980	1981
EQUIPMENT	PROTECTIVE CLOTHING	Survey existing items -- costs, availability, limitations; Assess needs for 1) supersuit; 2) throwaway(one-use) suit. Establish standards. \$ 80,000	Develop prototype protective clothing. \$ 250,000
	BREATHING APPARATUS	Survey available equipment; assess need for interchangeability regulations. Assess need for new technology. \$ 40,000	Implement R & D program and field test. \$ 40,000
	SAMPLING EQUIPMENT	Survey currently available sampling equipment and technology. \$ 100,000	Develop field-type instrumentation for detecting trace quantities of HM. \$ 300,000
	RESPONSE VEHICLES	Survey existing response vehicles -- limitations, costs, and geographic distribution. Assess need for remote control & manned vehicles. \$ 100,000	Establish standards for improved vehicles and conduct R & D program. \$ 300,000
	COMMUNICATION EQUIPMENT	Evaluate existing technology Assess need for helmet radio -- satellite links -- scramble system. Establish equipment standards. \$ 200,000	Initiate two or three R & D programs. \$ 250,000
ENVIRONMENTAL	HEALTH EFFECTS OF INDIVIDUAL HAZARDOUS MATERIALS (EPIDEMIOLOGY)	Identify principal health hazards by material; cancer, cell deterioration, etc. Start with most hazardous material. \$ 300,000	Identify pathways into body -- ingestion, inhalation, absorption -- the statistics thereof, and organs affected. \$ 500,000
	HEALTH EFFECTS OF MIXTURES (EPIDEMIOLOGY)	Determine interaction effects of binary mixtures of common HM Identify disproportionate health effects; i.e., worsened or nullified. \$ 100,000	Identify and develop neutralizing techniques; Develop controlling regulations for proximities if hazardous pairs form. \$ 80,000
	NON-TOXIC HAZARDS OF MIXTURES	Determine mixtures of common chemicals that become flammable, combustible, explosive. \$ 200,000	Define common chemicals, materials, reagents that can and that cannot be safely mixed. \$ 80,000
	ULTIMATE DISPOSAL		Survey disposal techniques, materials, quantities, procedures. Assess cumulative effects. Evaluate neutralization. Identify optimum disposal. \$ 250,000

or even industry, should have primary responsibility). Also included in Table 2 are specific tasks and budget estimates (compiled by SSI) for that program.

Two other funding levels were presented in Ref. 2: intermediate and minimal or austere. The very austere program was considered to be support of just the first four items in Table 2; i.e. those listed under "Management Support." The basis for that cost estimate was that a review of existing programs would require the analysis and assessment of hundreds of program elements, reports, data summaries, etc.; i.e., billions of dollars worth of studies conducted by a variety of agencies, over years, on hazardous materials management and control research. An estimated two or three hundred thousand dollars committed annually would be little enough to get a grasp on this mushrooming problem — a problem wherein a single dump disaster can add millions of dollars in cost to the taxpayer bill. Nothing resembling a realistic budget — in relation to FEMA's responsibilities — has materialized. However, in view of the important role FEMA has been assigned, it was decided to continue the effort initiated, even if only on a minor level. For the present study, SSI was commissioned to initiate effort corresponding to those items in Table 1 identified by the solid markers. In Section 3, the program effort that relates to the first two items marked is discussed.

It is interesting to note, however, that progress by other agencies has been made in the interim since the conference on many of the items shown in Table 2. For example, the Department of Transportation, the Environmental Protection Agency, and industry have ongoing programs in the areas of data base development and analysis, training and education, instrumentation and equipment (particularly protective clothing) development and assessment, and environmental protection. It is doubtful that any of these research efforts is in direct response to the program as presented in Ref. 2, but they do indicate that the suggested program did recognize many of the important needs and issues. It also suggests that there is still a great need for a coordinating agency, such as FEMA, to oversee this research, to see that the right areas are being covered, that efforts are not being duplicated and that they complement one another and are compatible, and to assure that the results are being disseminated to those that need it.

Section 3
MANAGEMENT DECISION INFORMATION PROTOCOL

There are many types of data required in order to make management decisions with regard to hazardous materials: summaries of past and current research, with analysis of the usefulness and extent of the research; data on the quantities, both current and future, of hazardous materials that will be manufactured, transported, processed, spilled; information on spills that have occurred including type of material, quantity, how it was handled, and the effect on the environment; and environmental and health effects -- i.e., health effects of both individual and mixtures of hazardous materials, disposal and neutralization techniques,

Many data bases have already been developed. Taking into account the role of "Comprehensive Emergency Management" -- and FEMA'S primary responsibility to the first responder, field management support -- it was considered necessary to look at a number of these existing data bases to determine their adequacy, and also to determine if new or more comprehensive data bases were necessary. Based on this analysis it was determined that the following areas merit FEMA'S attention:

1. Coordinate the assessment and integration of data resources already available.
2. Coordinate the development of uniform requirements to report incidents.
3. Coordinate the acquisition of data on outcome severity.
4. Coordinate the development of data on response outcomes.
5. Analyze spill event causes.
6. Coordinate the acquisition of logistics data.
7. Perform simple analyses of catastrophic incidents.

1. Coordinate the Assessment and Integration of Data Resources Already Available.

This effort was part of a program proposed in Ref. 2 (i.e., to mount a Program Assessment and Technical Assessment effort to establish the status of past and present programs) to provide FEMA with quantitative rationale for management action. Such an effort is likely to be sizable (it must cover years of programs conducted by the EPA, DOT, NIOSH, NTSB, and others) and is quite beyond the scope of the present study. (It is estimated by EPA that there are more than 200 data bases offering information on chemicals alone.) However, as some kind of assessment is properly a **prerequisite** to both the organization and the development of a pertinent data base for management decision purposes, a small effort in this direction was necessary to the present program.

Some of the existing Federal, State, and local data bases assessed during this study are listed in Tables 3 and 4. To be comprehensive, an exhaustive list of Federal data sources, and an expanded list of State and local data sources should be compiled, and **program objectives, management models, and their application and effectiveness determined.**

In Tables 3 and 4, the data sources examined have been identified, catalogued according to type of information and source, described, and briefly assessed. A major problem with some of the data sources is the difficulty in retrieving information because it is filed chronologically. Crossfiling, and better and common coding at the local level, would provide a wealth of information on spill events and their outcomes. In the long run, data collected **at the local level** will be most useful because it is pertinent to the problem where the corrective action must be taken and contingency plans made, and it can be aggregated to make comparisons that could never be made if the data were not so disaggregated in the first place.

The main concerns underlying the management purposes in building a data base and information system are those inherent in the life hazards and the environmental hazards (long-term life hazards) resulting from exposure to hazardous material releases. For general programs management, the agency requires information that will, among other things, enable priorities to be established to reduce impact to an

TABLE 3: FEDERAL LEVEL DATA SOURCES

<u>Type & Source of Data</u>	<u>Description</u>	<u>Limitations</u>
A LOGISTICS		
1 U.S. Dept of Transportation Federal Highway Admin- istration	Partial list of hazardous material shippers and carriers Registers bulk compresses cargo tanks	Not compiled in a compre- hensive manner
U.S. Coast Guard	Registers 54,000 vessels, many of which transport hazardous materials	
Materials Transportation Bureau	Partial list of container suppliers	Manufacturers of some types of containers are not required to register.
Federal Railroad Administration 1% Waybill Sample	Each railroad sends FRA every hundredth waybill. Information available includes commodity, origin and destination, number of cars annually.	Sample size is very small.
2 U.S. Dept of Commerce Bureau of Census	Census of manufacturers conducted every five years. For each four-digit SIC number, the quantity and dollar value of products produced, and the quantity of materials consumed are presented. Specific chemicals are identified by name and by seven-digit product code.	Some data for small estab- lishments are estimated. Not all information is collected for all estab- lishments.

TABLE 3: FEDERAL LEVEL DATA SOURCES (contd)

<u>Type & Source of Data</u>	<u>Description</u>	<u>Limitations</u>
U.S. Dept. of Commerce Bureau of Census (contd)	"Current Industrial Reports" series For specific inorganic chemicals, identified by name and seven-digit product code, annual production quantity and value, and quantity shipped each year are reported.	Information is collected by sending forms to each establishment. Each estab- lishment classifies its products into the code, resulting in inconsistent replies.
3 U.S. International Trade Commission "Synthetical Organic Chemicals" Annual publication	For specific organic chemicals produced in the United States, production and sales value are reported.	Excludes chemicals produced by fewer than three companies.
8 SPILL EVENTS		
1 U.S. Dept of Transportation Materials Transportation Bureau Incident Reports	Carrier reports of unintentional haz- ardous materials releases related to transportation. Reports must be sub- mitted within 15 days of the incident.	Reporting not always done. Carriers not likely to be aware of incidents during handling. Only applies to <u>interstate</u> carriers. Information is frequently missing or incomplete.

TABLE 3: FEDERAL LEVEL DATA SOURCES (contd)

<u>Type & Source of Data</u>	<u>Description</u>	<u>Limitations</u>
U.S. Dept. of Transportation Federal Railroad Administration Accident/Incident Reports	Reports from each railroad on accidents/incidents that result in injuries or dollar damage to equipment greater than \$2,300 include the time, place, circumstances, and hazardous material cars (if any).	Presence of hazardous materials is not a criterion for reporting.
2 U.S. Environmental Protection Agency Incident Reports	Regional offices receive reports of oil and hazardous materials spills. Each region enters its own data into the system, then all other regions and headquarters can retrieve it. System includes canned management programs usable by the regions.	Quality of the data varies greatly among regions. Not all spills are reported.
3 National Fire Protection Association Fire Incidence Data Organization	Selected fires involving hazardous materials are followed up by examination of source documents from fire department reports and "high protective risk" insurers reports (e.g., Factory Mutual). Information includes: dollar loss, casualties, causal factors, equipment involved.	Only includes incidents involving fire.

TABLE 3: FEDERAL LEVEL DATA SOURCES (contd)

<u>Type & Source</u>	<u>Description</u>	<u>Limitations</u>
4 Chemical Manufacturers Association CHEMTREC	Records kept of calls for assistance include some or all of the following: Material, location, container, carrier, shipper, consignee. Kept on floppy disc.	May not be available to the public (CMA is a private organization). CHEMTREC is not notified of all spills.
5 U.S. Dept of Labor Bureau of Labor Statistics Worker Injury/Illness Reports	Thirty-five states participate with the Federal government in collecting statistics on causes and types of injury, including chemicals. States may collect the information in more detail, but combine the categories when reporting to Washington.	Fifteen states do not participate. At the Federal level, chemicals are not identified specifically, but by a dozen general categories.
C CLEANUP AND ULTIMATE DISPOSAL 1 U.S. Environmental Protection Agency. Uncontrolled site project	Each region compiles a list of suspected hazardous waste sites in the region, and sends it to headquarters. By June 9, 1981, all hazardous waste treatment, storage, and disposal facilities and transporters must report the location of hazardous waste sites used.	No comprehensive method for compiling the list.
Anticipated reports		

TABLE 3: FEDERAL LEVEL DATA SOURCES (contd)

<u>Type & Source of Data</u>	<u>Description</u>	<u>Limitations</u>
D RESPONSE vs OUTCOME		
1 National Transportation Safety Board	Detailed investigations of selected major accidents to establish probable cause, assess effectiveness or emergency response, and make recommendations for prevention.	Only about a dozen accidents are investigated each year.
NTSB Accident Investigations		
E TRAINING/EDUCATION		
1 U.S. Department of Transportation Materials Transportation Board	Identification of educational institutions, business organizations, and government agencies offering hazardous materials training. Lists are currently being updated.	No description of course contents. No evaluation of the usefulness of each class.
F LEGISLATION/REGULATION		
1 "Federal Legislation Affecting Transportation of Hazardous Material" National Strategies Conference.	A "legislative roadmap" detailing laws since 1966 pertinent to hazardous materials transportation.	Includes only transportation legislation.

TABLE 3: FEDERAL LEVEL DATA SOURCES (contd)

<u>Type & Source of Data</u>	<u>Description</u>	<u>Limitations</u>
G RESEARCH		
1 "Hazardous Materials Spills: A Documentation and Analysis of Historical Data," Factory Mutual Research for EPA, 1978.	Analysis of data to identify priority spill causes, which would reflect the quantity and hazardous potential of the material spilled.	
2 "Effect of Hazardous Material Spills on Biological Treatment Processes," Environmental Quality Systems, Inc., for EPA, 1977.	The effects of over 250 chemical substances on biological treatment processes are presented in an operations handbook format.	
3 "Instrumentation for Detecting Hazardous Materials," LOCUS, for FEMA, 1980.	An assessment of material sensing technology for detection and identification of hazardous materials.	
4. "Chemical Information Resource Handbook," Koba Associates, Inc., for EPA 1980	Scope, access, and cost of 89 chemical information resources.	

TABLE 4: EXAMPLES OF STATE AND LOCAL DATA SOURCES

<u>Type & Source of Data</u>	<u>Description</u>	<u>Limitations</u>
A LOGISTICS		
1 Puget Sound Council of Governments (Interim Report) Seattle, WA	Inventory of hazardous material storage and transportation in major industrial areas and along prominent roadway corridors of the Central Puget Sound Region	Information was collected only once - no continuing input.
2 Multnomah County, Oregon Office of Emergency Management	Survey of quantities and locations of general hazard classes of hazardous materials stored in and transported through the county.	Information was collected only once - no continuing input.
3 San Mateo County, CA Department of Environmental Health	Survey of general type and quantities of hazardous waste generated in the county.	Information was collected only once - no continuing input.
4. Santa Clara, CA Fire Department	Periodic inventory of hazardous material storage in every commercial occupancy in the city.	Transportation was not included.
5 California State Dept. of Health Services Hazardous Materials Management Section	Data from hazardous waste manifests are collected continuously and organized into an annual report to show waste streams by generating facility SIC code.	Accounting is not exhaustive Most reporters estimate rather than analyze the chemical composition of the waste.
B SPILL EVENTS		
1 California State Dept. of Fish and Game	Reports of hazardous material and oil spills are received.	Reports are kept chronologically - data not easily retrieved.

TABLE 4: EXAMPLES OF STATE AND LOCAL DATA SOURCES (contd)

<u>Type & Source of Data</u>	<u>Description</u>	<u>Limitations</u>
SPILL EVENTS (contd)		
2 Maryland State Dept. of Natural Resources, Dept. of Environmental Programs	Spill incidents are recorded in a log book, in order of occurrence.	Data retrievable only by date of incident
3 San Francisco, CA Fire Department	All calls, including hazardous mate- rials incidents, are logged into a computer by incident number and date.	Data are retrievable only by date of incident.
4 Redwood City, CA Fire Department	All incident reports, including hazardous materials incidents, are kept chronologically.	Data are retrievable only by date of incident.
5 Oakland, CA Fire Department	Hazardous materials incident reports are kept chronologically in files.	Data are retrievable only by date and address of incident.

acceptable level. In most instances, these priorities will correspond to where emergencies have been of greatest magnitude, or have occurred with greatest frequency (in short, where risks appear greatest). Underlying these risks are causes that, when identified, may be mitigated by management attention through research, regulation, training, equipment, or some other option. All these aspects of hazardous materials management and control need to be treated — yet, many are outside the purview of field operations managers. Treatment, therefore, becomes an agency problem. Nevertheless, data that are obtained for agency management purposes may also be useful to the field operations manager. Such information should be organized for practical application in the field, and passed along systematically. A finite effort should be committed to this latter task and to development of information specifically to support safer operations in the field.

At present, there is a great deal of data and information available to sort and consider (see Appendix A). What is needed is some way to organize it so that it remains easy to assimilate. A pragmatic methodology is suggested here that has been used in similar situations. To organize the information it is proposed it be arranged initially into a first tier matrix of **operational areas vs problem magnitude and mitigation and control factors** (see Figure 1). This is a simple, but pragmatic approach that will identify general areas of major interest where data have (and have not) been developed, and the data collection protocol will be to acquire some data pertinent to each primary node, or coordinate intersection, as a first requirement (see Figure 2). The objective is to acquire enough data to make a decision about priorities now, to provide insight into the next logical management step and to provide a simple format for keeping track of data. The procedure is best appreciated by an example.

Operational areas in which hazardous materials and their waste products are involved are:

- o Processing, manufacturing, and end use
- o Storage
- o Transport
- o Disposal

PROGRAM MAGNITUDE & CONTROL FACTORS	MAGNITUDE FACTORS			MITIGATION AND CONTROL FACTORS					
	SPILL EVENTS	LOGISTICS	HISTORICAL / POTENTIAL	RESPONSE vs OUTCOMES	CLEAN UP in ULTIMATE DISPOSAL	LEGISLATION	TRAINING EDUCATION	RESEARCH	
OPERATIONAL AREAS									
TRANSPORT									
PROCESSING MANUFACTURING & END USE									
STORAGE									
DISPOSAL									

Fig. 1. Matrix of Operating Sectors versus Magnitude and Control Factors Affecting Hazardous Materials Risks and Exposures.

PROGRAM MAGNITUDE & CONTROL FACTORS	MAGNITUDE FACTORS		CONTROL FACTORS				
	EVENTS #	LOGISTICS	HISTORICAL / POTENTIAL		MITIGATION AND PREVENTION		
			RESPONSE	CLEAN UP	LEGISLATION	TRAINING & EDUCATION	RESEARCH
OPERATIONAL AREAS	1. MTB-M.M. Incident Reports 2. FRA Accident Reports 3. CHEMTREC	1. DOT - FHWA - USCG - MTB - FRA 2. PSLOS 3. Multnomah County	1. NTSB Investigations		Williamsburg Report "Federal Legislation Attaching Trans- portion of Hazardous Materials."	DOT / MTB Hazardous Materials Training Course List	1. "Instrumentation", FEMA 2. "Spills", EPA
TRANSPORT							
PROCESSING MANUFACTURING & END USE	Bureau of Labor Statistics - Worker Injury/ Illness Reports 2. NFPA	1. Bureau of Census 2. USITZ					1. "Chemical Information Resource Handbook", EPA 2. "Instrumentation", FEMA 3. "Spills", EPA
STORAGE	1. NFPA	1. Santa Clara F.D. 2. PSLOS 3. Multnomah County					1. "Instrumentation", FEMA 2. "Spills", EPA
DISPOSAL	EPA	1. California Dept. of Health Services 2. San Mateo County		1. EPA Uncontrolled Site Project 2. EPA anticipated Reports.			1. "Effects of Hazardous Materials", EPA 2. Chemical Info. Resource Handbook, EPA 3. "Instrumentation", FEMA

EPA Incident Reports and State and Local Spill Event Data Sources includes reports from all operational areas.

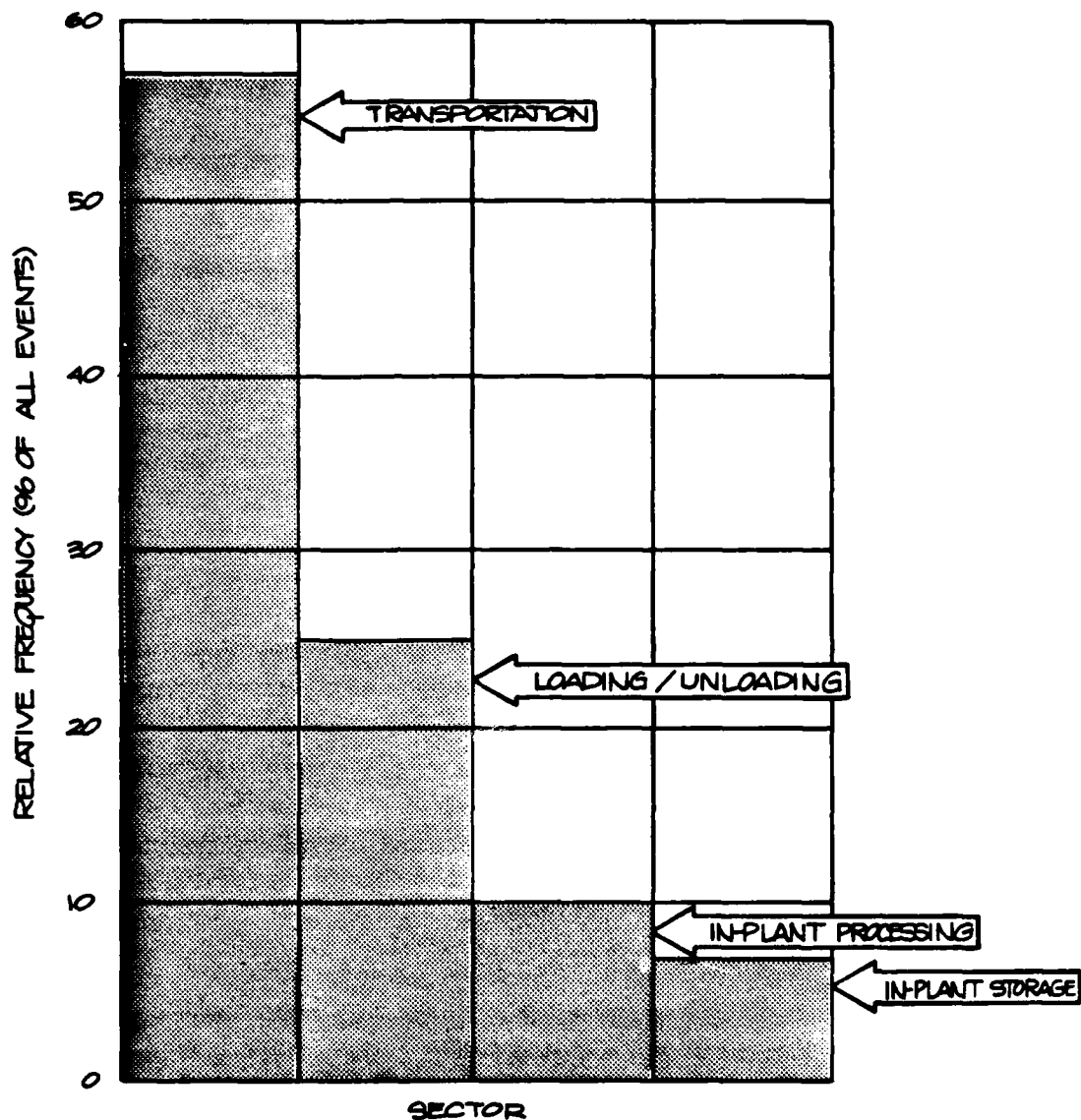
Fig. 2. First Tier Organizational Matrix of Data Sources in Tables 3 and 4.

The major factors that relate to the establishment of problem magnitude are spill and release events and logistic data. The event data provide historical (statistical) information on what has happened, and the logistic data identify bounds for prediction of what can happen. Mitigation and control factors consist of actions to preclude and to alleviate hazards. Legislation, regulation, education/training, and research can be used to preclude, or to alleviate, adverse effects, while response, cleanup, and disposal are principally for alleviation.

The first tier matrix of Figure 1 enables what information is available to be organized to show priorities, as well as where data are needed to confirm them, and to give insight into the next data requirement. This procedure was applied so that the operational sectors in Figure 1 have been listed in order of frequency of spill, according to event data provided in Ref. 3. The referenced event data have been developed into the histogram in Figure 3 to show this frequency as a percentage of total events recorded. (Note that only one incident out of 1,441 was a disposal incident, too small a percentage to show on the figure.)

2. Coordinate the Development of Uniform Requirements to Report Incidents

The authors of Ref. 3 caution that the data are biased because of the more stringent requirements to report incidents in the transportation sector, so that its appearance as the predominant sector for frequent spills may be artificial. Despite this identified shortcoming, the data represent the best information that is available on incident frequency by sector. Other comments with regard to non-uniformity of data come from Ref. 4, which discusses the new EPA Chemical Substances Information Network, CSIN. Both industry and academic observers are troubled about the quality of data. They contend that some of the information available is not good data, and with CSIN there will be no way to tell what is good and what is not. There is an obligation in compiling and in applying data to ensure information is not misapplied. It has been commented that the CSIN data should be tagged to include information such as the source of the data (so that knowledgeable users might judge for themselves). The vast majority of those in need of information, however, are not this knowledgeable. CSIN does not appear, therefore, to have widespread utility.



* Note: Disposal Sector is not Represented.

Fig. 3. Hazardous Materials Spill Frequency by Sector (according to Ref. 3.).

3. Coordinate the Acquisition of Data on Outcome Severity

If the priority for management attention were to be shifted from frequency of incidents to potential magnitude of a single incident, the order in Figure 1 would change. Again, in Ref. 3, data were organized to provide a measure of the "hazard potential" (a combination of the quantity involved in recorded spills and the corresponding toxicity). Using this new measure, the authors reported the rankings for hazard concern became Storage, Processing, Transport — just the reverse of the ranking for hazard concern based on frequency of incidents. (Disposal or dump site events were not included in this assessment.) It should not be construed that the hazard potential artifice developed in Ref. 3 implies anything that has been related to severity of the actual spills (destruction, injuries, property damage, etc.). Data are not now available on relative severity levels (actual outcomes) in the different sectors.

Organizing severity data would enable plots of "worst case" (by category, a combination thereof, or total of all categories to reflect total cost) annually for a period of years to be used to provide the best estimate of probability that any similar event will exceed a given severity. This can be done by applying the statistics of extremes (Ref. 5) to historical data. This procedure is simpler and preferable to a risk assessment built on scenario development and fault-tree analysis of possible outcomes and their relative probabilities because the latter, though perhaps useful for research, is too sophisticated for management control, whereas the former essentially integrates a mass of data without, necessarily, any detailed understanding. Clearly many factors can affect trends in the historical data — changes in technology, commercial practice, regulations, etc., all could affect "worst case" incidence. It is precisely the deviation from the expected pattern of events (by some amount that exceeds a statistical limit) that tell management that new technology, regulation, etc., has caused a change.

As an adjunct to compiling the data identifying worst cases, the management information on what constitutes a "worst case" (i.e., how they appear to develop) will be inherent in the data, and by sector. This can be used to analyze the factors common to the worst cases to deliver improved safety. That is, the data would

provide insight into an appropriate mix of legislative and regulatory control, training and education, and research, to reduce the magnitude and/or frequency of these incidents in all sectors. This might be as simple as limiting tank size according to material toxicity and demographic factors, for certain materials, much like the quantity-distance requirements developed to establish safe distances from inhabited and uninhabited buildings for stored explosives (as Ref. 6 did for new chemicals). The net effect would be to reduce the severity of incidents, and this would appear in the monitoring of subsequent data (provided it is kept on a current basis) as a change in the historical trend of severities associated with "traditional" worst case incidents. If the severities are also compiled and plotted in terms of the total social cost, then the product of the average improvement (i.e., the reduced severity, or social cost) and the number of incidents is the benefit that can be measured against appropriate elements of the management program and regulatory impact cost, to assess the point where marginal costs and benefits are equal.

Not only will priorities be identified, but every effective option of management can be better orchestrated with data of the sort just discussed, including preparing, allocating, and deploying resources to prevent and/or deal with incidents, and measuring the effectiveness of control actions taken.

From the basic two-dimensional matrix, each intersection or node can be expanded in turn (creating a three-dimensional matrix). As the process is repeated, priorities, insights, and direction can, again, be obtained at each succeeding level. As an example of the matrix expansion, the transport sector can be expanded by mode -- rail, highway, ship and barge, pipeline, air -- and ranked for importance, by frequency of incident (see Figure 4), and/or by severity of incident (or worst case). By frequency of incident, the rank sequence is highway (90%), rail (9%), air (0.8%), water (0.2%) according to Ref. 7, for 1976, and virtually the same according to Ref. 8, for 1977 (but with a 33% increase in total number of incidents). However, these data are incomplete, as neither reference mentions pipeline incidents (though Ref. 4 indicates pipelines carry over 20% of the ton miles moved). Here, then, is another gap that needs filling if priorities are to be set properly -- a procedure to record and integrate pipeline incidents with the other transport modes must be established (and data relating to transport mode that provide incident

TRANSPORT SECTOR		MAGNITUDE FACTORS		MITIGATION AND CONTROL FACTORS					
		SPILL EVENTS	HISTORICAL POTENTIAL	LOGISTICS	RESPONSE vs OUTCOMES	CLEAN UP vs ULTIMATE DISPOSAL	LEGISLATION	TRAINING & EDUCATION	RESEARCH
MODES		90 %							
HIGHWAY									
RAIL		9 %							
AIR		0.8 %							
WATER		0.2 %							
PIPELINE									

Fig. 4. Disaggregation of Figure 1 Matrix by Transport Mode. (Spill Frequencies by Mode according to Refs. 7 and 8. Note: Pipeline Mode is not Represented.)

severities and worst case severities should be collected and/or sorted as well). In the meantime, the combination of 57% of incidents occurring in the transport sector (Figure 3), with 90% in the highway mode (Figure 4), indicates the majority; i.e., **over half, of all incidents** involving hazardous materials occur on the nation's highways. In lieu of data to rank consequences/severities, versus sectors (so that magnitudes of incidents can be ranked), available data would indicate highway transport of hazardous materials deserves a major portion of management attention.

4. Develop Data on Response Outcomes

When the matrix is expanded into the next tier, the logical priorities for attention are response vs outcomes and spill incident causes. So little data were found compiled on response outcomes (in the cursory search) that the immediate conclusion drawn is that there is a critical need for a study to develop a pertinent data base on response outcomes, including a suitable methodology for coding and comparing information.

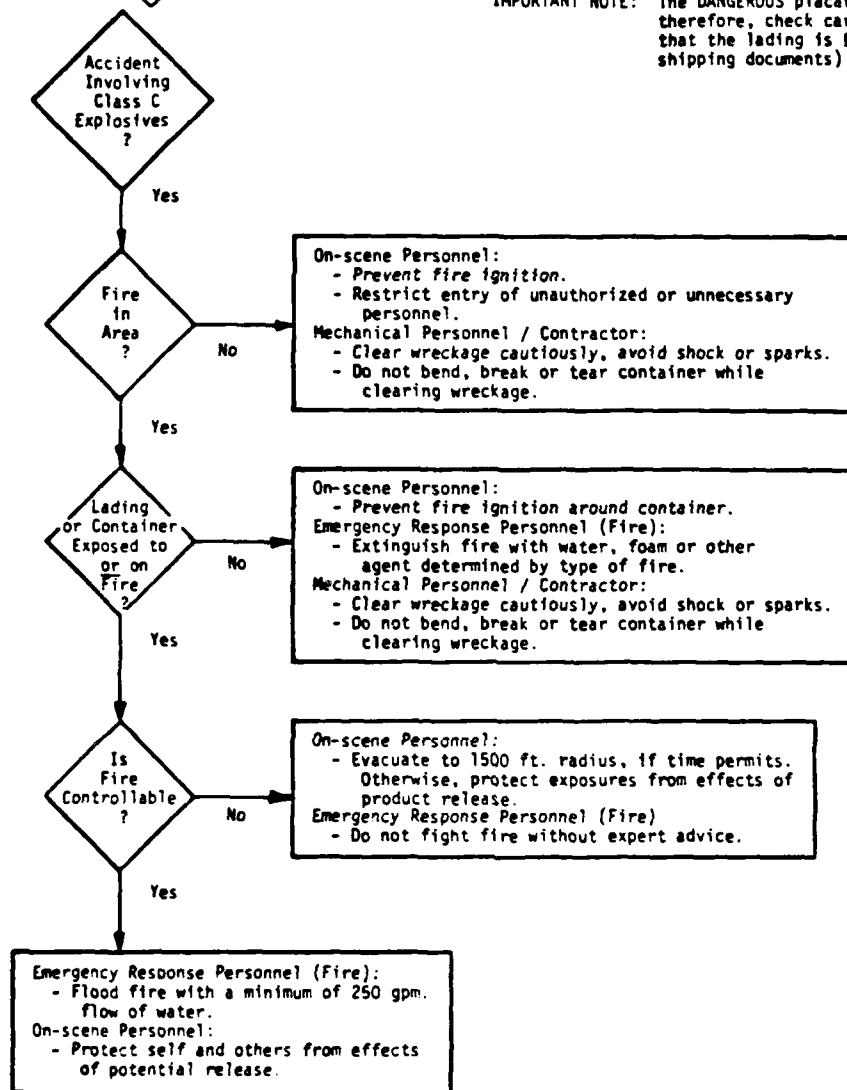
This effort will require careful consideration because the important aspects of outcomes may be totally determined in the initial minutes of an event, in many cases, and before any response is made. On the other hand, timely and competent response may succeed in containing an event to the extent that a very significant reduction in consequences is achieved. Among the kinds of management information that need to be developed here is that which will **identify equipment and training and education minimums for response personnel, as well as effective response protocols.**

In response protocol development, considerable effort has been made in the transportation sector in the rail transport mode, where flow diagrams have been developed for decision purposes (see Figure 5). These flow diagrams comprise historical data on experience vs outcomes translated into a training and educational format. Work on this subject is in committee in the ASTM at present, and the Union Pacific railroad (Ref. 9) is using some of these flow charts developed in their own training courses. Similar decision flow charts should be developed for application to other transport modes and other sectors, **starting with highway incidents.** Based on



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IMPORTANT NOTE: The DANGEROUS placard has various uses, therefore, check carefully to insure that the lading is EXPLOSIVE C (use the shipping documents)



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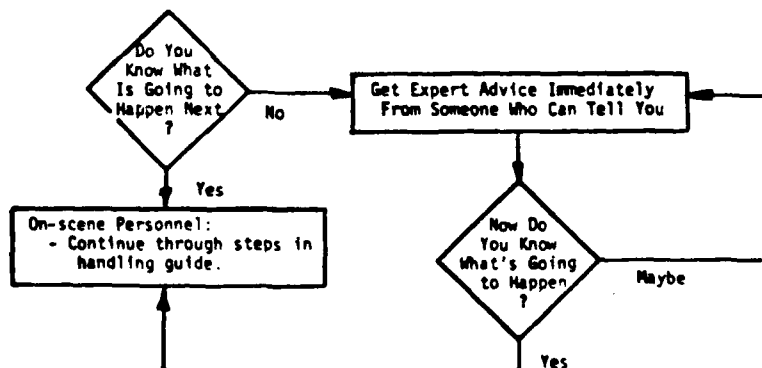


Fig. 5. Typical Management-Decision Flow Chart Applicable to Railroad Incidents (extracted from Ref. 9).

the data in Figure 4, development and organization of this kind of information expressly for use by field response personnel is one of the more valuable contributions FEMA could make to field management support.

5. Analyze Spill Event Causes

Figure 6 expands the matrix approach into spill event causes, by sector. The information in the figure was **inherent** in the **raw data** published in Ref. 3. (The example in Figure 6 is incomplete, however; only the first 100 of the 1,441 spill events in the listing were used, but it serves to demonstrate a management application.) The 100 datum have been organized, by sector, so that adding the center figures in each horizontal row totals 100% (excepting for rounding errors). Note that the corner figures entered in the matrix are a result of applying the available data on distribution of the hazardous materials problem **by sector** (i.e., that in Figure 3), to these sector percentage distributions **by cause**. Clearly, the two darkened boxes identify the causes and sector where the largest part of the spill event problem lies. (If the loading/unloading data of Figure 3 are lumped with the transport mode, they account for the majority (two-thirds) of the entire spill event problem insofar as frequency is concerned.) Further, the data in Figure 4 (Refs. 7 and 8) show that 90% of the transport spill events occur in the highway transport mode. Thus, 60% of **all** spill events of record relate either to container rupture or puncture, or to container leakage or overflow, associated with highway transportation and loading and unloading of vehicles.

The analysis (albeit based on incomplete data limited to incident frequency) has identified where, and on what, considerable management attention might profitably focus (i.e., where the most events occur). It also pinpoints where additional data should be developed (i.e., to better define why most events occur here). Based on the existing data developed in Ref. 3, the authors of that study concluded that the most promising mitigation program would be the development of a better overflow sensor and shutoff control system, and such a program was initiated. If this has been successfully brought to market and is effective, **current spill data should show it** -- as a decline in spill events caused by overflow (this will be necessarily relative to other spill causes, as the absolute number of spill events

SPILL EVENT CAUSES		SECTORS				
		NON-TANK CONTAINER RUPTURE OR PUNCTURE	TANK CONTAINER RUPTURE OR PUNCTURE	TANK OVERFLOW OR OTHER LEAKAGE	HOSE OR TRANSFER SYSTEM FAILURE	OTHER
TRANSPORT		7.7	40.2 * 26.3	34.6 * 19.7	11.5	—
PROCESSING		9.5	5.0 * .5	64.0 * 6.4	12.0	9.5
STORAGE		—	53.3 * 3.7	26.7 * 1.9	6.7	13.3
DISPOSAL				100		

* Percentage of All Hazardous Materials Incidents (per Fig. 3.)

Fig. 6. Spill Events Disaggregated in Each Sector by Cause as Percent of Sector Total (Summary is for the First 100 of 1441 Spill Events Compiled in Ref. 3.)

may show an increase because of growth in use and/or shipments of hazardous materials). If the new shutoff controller design has not been successfully brought to market, data can indicate that too, and perhaps consideration could be given to rigorous testing of the device in the field and mandating its use, if it is successful.

As with each of the other factors discussed, management attention should also be given to the development of spill event data that characterize worst cases, by cause, with as much detail as possible. The objective would be to assess what options might be available to selectively change the frequency with which very large spills exceeding some threshold severity are caused by puncture or tank rupture. Then any options identified should be subjected to field tests to determine adequacy. These field tests should be conducted selectively, choosing worst performance records in different operating sectors as the basis to select test candidates (so that conclusive results could be expected from field tests at the earliest possible date). As worst performance records will also be inherent in the spill event data base, here is another potential management decision application for these data.

As an example, among the data available in Ref. 10 is information on the number of incidents involving hazardous materials per train mile, by specific railroad, for Class I railroads in the year 1979. The number of accidents per train mile in which hazardous materials are in the consist (the assemblage of cars that make up a train) has been developed out of the published data and organized in Figure 7. Each number along the abscissa identifies a specific railroad. Those railroads with exemplary safety records are to the right of the average, and those with worst performance records are to the left. Those railroads with the most incidents per million train miles would be good candidates for testing options to reduce incidents, and for those specific railroads with more incidents than the average, additional data on causes (available from FRA accident reports, but aggregated in Ref. 10) should be compared with the averages to show specifically where the safety problem(s) may lie.*

* Note: An assumption was made, in this case, because data on the portion of the consist miles involving hazardous materials was not immediately available for each railroad. For present purposes it was assumed that the ratio of hazardous materials carrying cars in the consists involved in incidents — a figure reported for each railroad — was representative of the ratio of those consists with hazardous materials to all consists. (Before such data are used to make management decisions, all assumptions would need to be validated.)

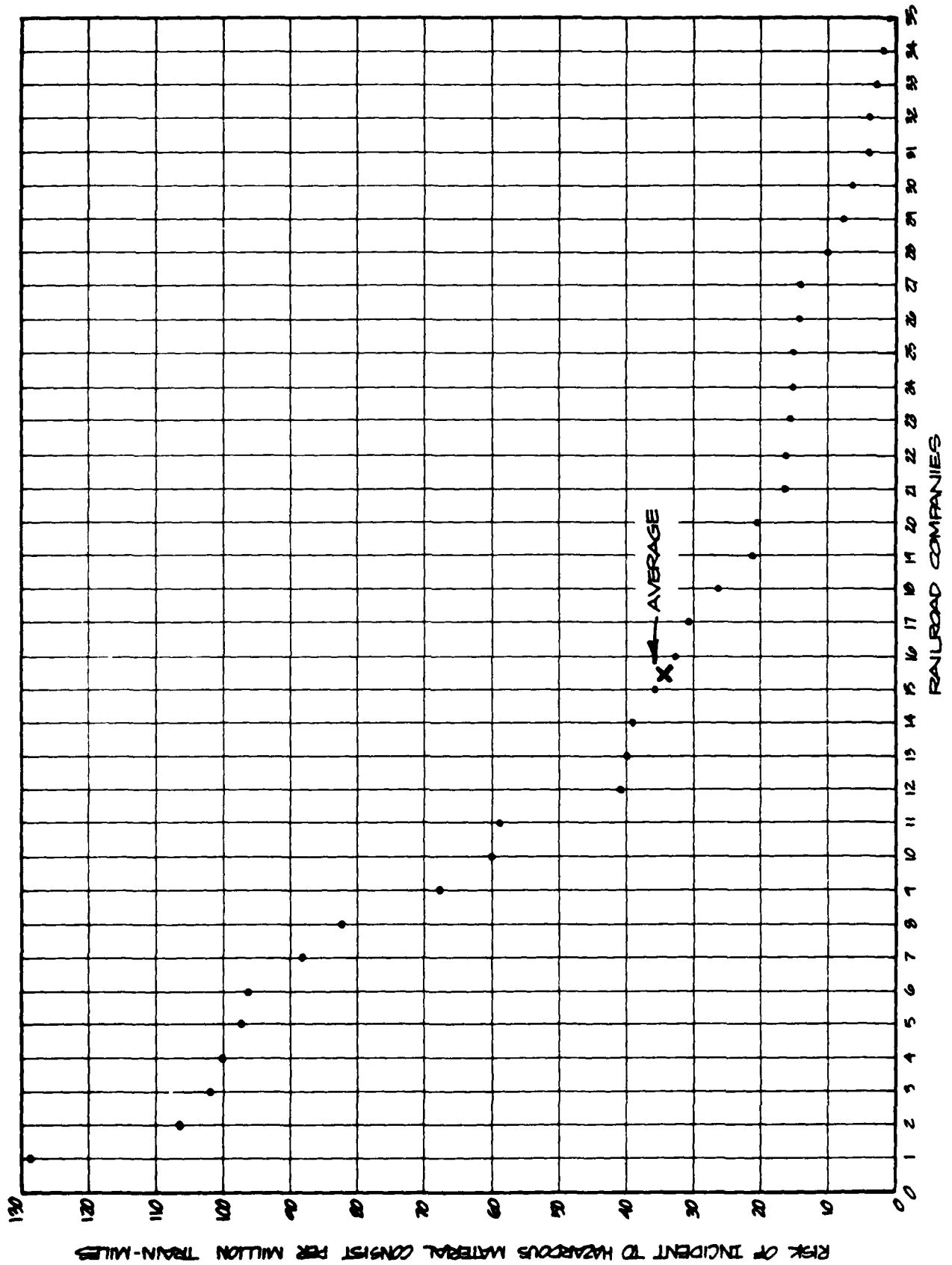


Fig. 7. Risk of Hazardous Materials Incident per Train Mile by Carrier.

6. Coordinate the Acquisition of Logistics Data

In the Figure 7 example, **logistic** information was necessary to the assessment. Pertinent logistic information includes data on materials and quantities, locations, shipping routes, demography, etc., that define how much of what materials may be found where, and how many individuals it can affect at any time. Such data are basic to contingency planning, assessments of worst credible events (for example, by sectors or by transport modes), and analyses of effectiveness or ineffectiveness of hazardous materials handling, management, and control procedures. To explain the latter type of application, logistic data would serve as a normalizing factor; e.g., to show that the 90% of the spill events recorded in the transport sector in the highway mode correspond to only 21.8% of the ton miles of traffic (all materials), whereas the 0.2% of incidents that occur on waterways correspond to 33.3% of the ton miles moved by this mode. If hazardous materials constitute nearly the same portion of all materials transported by each mode, these two sets of data suggest highway transport is 688 times more risky.

Two comments should be made on the apparent disparate risk for the tonnage of material moved. The proper normalizing factor to use (but not available) is **ton miles of hazardous materials**, and it is to be expected that there will be more incidents (but smaller events) associated with feeder modes of transport (involved in the final distribution of materials) than for large volume shippers that move more tonnage a smaller number of miles. In addition, the **magnitude** of incidents associated with volume shippers may be expected to be larger (though on waterways, acute aspects may affect smaller numbers of people).

Perhaps the most pragmatic use of a normalizing function is within a common sector or mode as, for example, all the inter-city (or all the intra-city) trucking firms, to determine incidents per ton mile of hazardous materials shipped. In this application, a given carrier with a poor record for handling, management, and control of these materials will stand out in comparison with other companies for further scrutiny. Frequently, the only management attention required to achieve safer operations among the miscreants is to publish the standings. But, to indicate **application of data** to facilitate management decisions, training and education

programs could be developed based on problem areas identified as a result of seeking reasons for the poorest performance records. In such cases, mitigation programs that are developed could then be geared to specific needs and targeted to specific audiences (e.g., packagers, loading dock foremen, truck drivers, vehicle maintenance personnel). General training and education courses abound that fail to address specific problems, so lack serviceability. To alter this, audiences need to be targeted and information tailored. To rank priorities for targeting, poor performance records need to be identified.

7. Perform Simple Analysis of Catastrophic Incidents

FEMA has also indicated a requirement to consider the problem of mitigating the major disaster that has yet to occur. Establishing worst credible incidents, quantitatively, requires logistic data, among other inputs, to carry out the assessment procedures. Figure 8 is a general model that might be applied to assess the public risk associated with the worst credible hazardous materials incident in each sector, mode, or other applicable subcategory. It was patterned after a model originally proposed to assess worst credible incidents (in the transportation sector) involving radioactive materials. (The model was adapted from Ref. 11, which sought to establish the catastrophic limits.) It is **not** proposed this model be used for that purpose, it is introduced simply to identify factors involved. There is no need to establish probability of occurrence to identify effective mitigation controls — rather, there just won't be a means to assess implementation benefits versus cost.

For hazardous materials, the worst credible (catastrophic) incident is a nationwide nuclear attack on industry (because of widespread damage to containers). Among natural catastrophes, it is likely to be a major earthquake. Earthquake studies (Refs. 12 - 16) indicate that the major damage parameter, in large earthquakes, is fire, principally because response personnel are overtaxed and water mains, alarm systems, communications, and equipment are either damaged or also overtaxed. If the foregoing operational conditions are impressed on earthquake-caused train derailments (Ref. 17) and abandoned, but still operating, in-plant processing equipment, the widespread irregularities in events and routines could

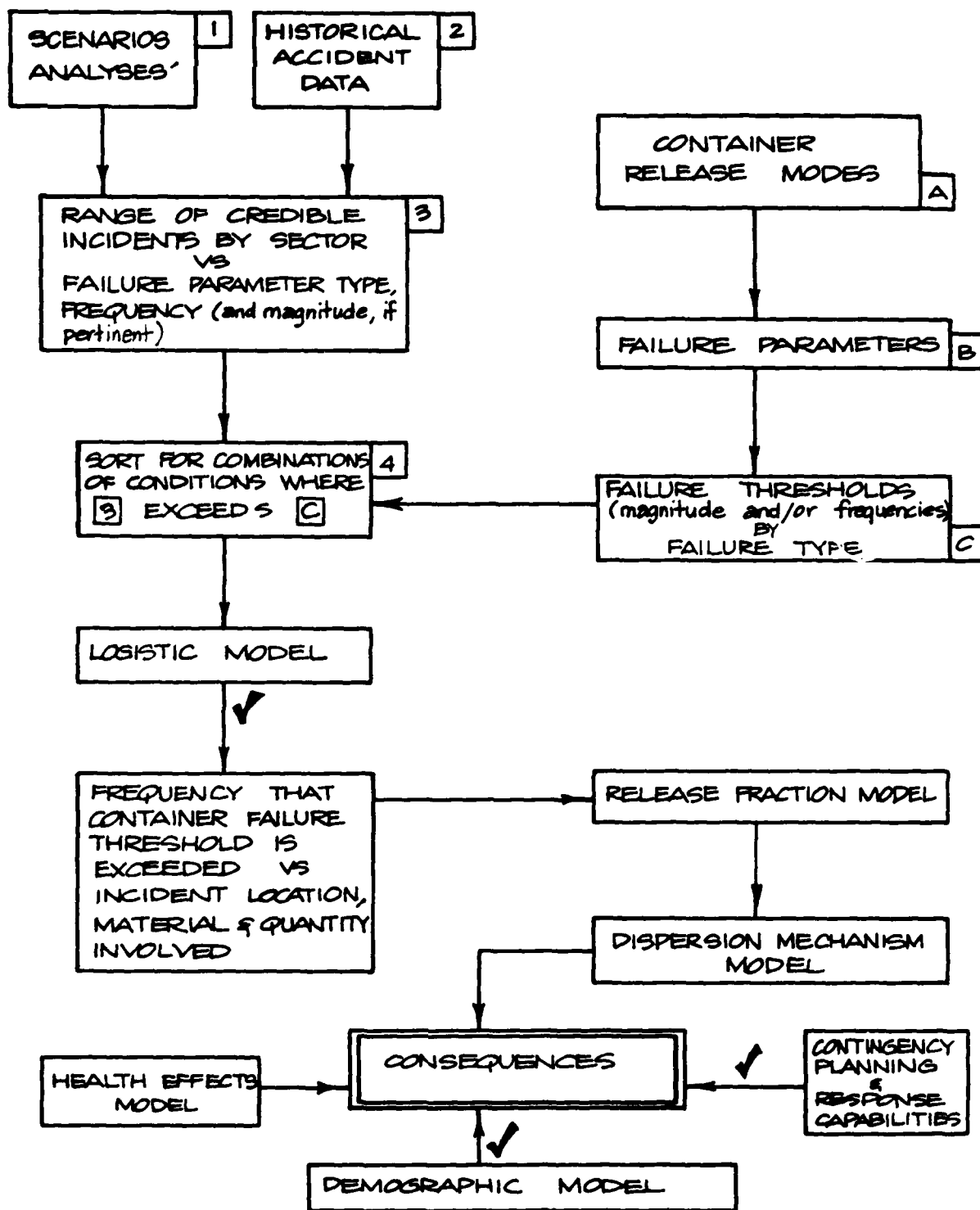


Fig. 8. General Model for Assessment of Public Risk Associated with Worst Credible Hazardous Material Incidents.

cause a multitude of spills in a short time span. In such events, visualize any large fire, or fire-related, container failure disaster, multiplied manyfold.

The value of developing a format such as that of Figure 8 is that it identifies where management action can be taken effectively; i.e., where there is opportunity for management control (see check marks). At present, these control options are limited to: establishing storage limits -- in vulnerable containers; shifting the population, rapidly, to areas where there are no combustibles and no hazardous materials (similar to the approach being taken for protection of the population in the event of nuclear attack); or developing exceptional response capabilities (unlikely to be totally achievable). In an earthquake disaster there would be considerable competition among events for emergency responder attention, and it is doubtful if routine contingency planning would enable communities involved to cope. Therefore, special super-emergency contingency plans would need to be developed that include procedures for selective abandonment (triage). Whatever the emergency, contingency planning and preparation and well-trained response capabilities do play important roles in moderating the final outcome. Recognition of the importance of the planning role has been the basis for a number of studies centered on contingency planning at the community level.

Development of a data base to show accident potential in the transportation sector in the rail and highway modes was fundamental to a State of Virginia study (Ref. 18) conducted for purposes of deploying resources strategically to mitigate hazardous materials incidents. A more comprehensive assessment; i.e., involving more sectors, was developed for purposes of establishing types, location, and volumes of hazardous materials not only transported, but used, and stored within one county (Ref. 19). Thus, major transportation routes used to haul hazardous materials, and potential incidents keyed to them, were just one aspect of the latter study, which was aimed at reducing the number of incidents, mitigating effects of those that occur, and improving both the efficiency of response personnel and general public safety in dealing with all incidents.

Logistic data bases pertinent to the local level that provide information on hazardous materials types, location, and quantities will be necessary in the

development of contingency plans. Compiling such data bases at the community level is currently being encouraged by the Center for Disease Control through development of a methodology for eventual dissemination to communities to help them do it (Ref. 20). It may be expected that increasing numbers of communities will develop logistic data bases as part of their contingency planning. Collecting the summaries of these data bases at the agency level could then provide national averages and other data, which would provide FEMA with priorities for necessary research programs.

As the coordinating agency on emergency management, FEMA has the option of acting as a clearinghouse for information that is developed. In this role, the agency should be able to disseminate useful data wherever developed, so that there is a shorter interval from development to use by those in need. Moreover, on an austere budget, an effective approach that FEMA could apply to provide improved safety, generally, would be to coordinate multi-agency support of contingency planning in a number of communities and supply pertinent information to end-users nationwide through an effective information exchange. The following section discusses information exchange options.

Section 4
INFORMATION EXCHANGE MEDIA

A practical approach to the transfer of usable hazardous materials management and control information is part of the solution to the problem of developing improved safety. Important factors in effective information transfer are to target a particular audience, and to present material tailored to specific needs. Addressing the question of audience, FEMA's long range goal has been stated as: "To be useful to local emergency preparedness organizations; i.e., to support the States in their efforts to serve the local constituency" (Ref. 1). By selecting local emergency response personnel as a direct audience, then, FEMA will best serve the general public.

Emergency response personnel are found in both the public and the private sectors. In the public sector, the fire service, both volunteer and paid, and law enforcement agencies are most frequently called upon as first responders. (State and local departments of emergency services, disaster management, environment, transportation, health, etc., may be involved as backup responders.) In the private sector, in-house emergency brigades often act as first responders to in-house incidents and may assist local fire departments when events require industrial expertise. These groups appear to comprise the principal emergency preparedness organizations at the local level that qualify as the target audience.

As community leaders become aware of the increasing potential hazards from the increasing use and transportation of hazardous materials, there may develop a new move to establish emergency planning groups at a community level. These groups will play an important role in making decisions on allocations for, and deployment of, resources. Establishing a methodology to initiate and maintain liaison between such groups -- to facilitate information exchange -- may provide

FEMA another way to make major contributions to development of better public safety. In all cases information exchange must be geared to audience needs. A primary audience need is to receive pertinent information in a usable form.

AUDIENCE INFORMATION NEEDS

By consensus of participants in the Emmitsburg conference, needs run the gamut of all the items listed in Table 1. Quite separate from funding to provide further progress on any of the field operations support items, current information on status of instrumentation, equipment, and safe disposal techniques would be valuable to compile and pass along together with data on which spill events, materials, sectors, are likely to pose the principal problems. (This information should be among the output obtained from completing the Program and Technical Assessment.) In addition, in recent conversations emergency response personnel have themselves identified four information needs that are currently not being met. They are:

Incident reponse procedures — Which tactics have others used, which were effective, and which should be avoided?

Training course information — Which course(s) are the most appropriate to my needs? Are any available locally? When, and what do they cost? What will I get out of them?

In-house training courses — Simplified courses that emergency response personnel can use individually or in small groups, on their own time.

Information on contingency planning — Specific guidance on the development of local emergency plans.

In summary, the indicated needs can be logically be placed in the following categories:

1. Case studies of incident response procedures vs outcome
2. Training information and course descriptions
3. Abstracts of articles and information on hazards mitigation
4. Research and technical bulletins, and other pertinent announcements
5. In-house training courses
6. Contingency planning information

An analysis was conducted to select appropriate information transfer media (i.e., a simple format to reach a high percentage of the target audience effectively and economically with information in the categories identified). As might be expected, there is no single perfect medium for transfer of all the information noted above. However, some media are better than others, and a combination of two or three might prove most effective.

FORMATS FOR PRESENTING INFORMATION

Several candidate information transfer formats were analyzed, and nine were selected for comparison for potential effectiveness in communicating the categories of information identified. These were: Newsletters/Magazines; Handbooks/Catalogs; Data Banks; three types of Training Courses (live, interactive, and canned); Seminars; Research Reports; and Public Newspapers. Where possible, examples of each were obtained, analyzed, and ranked according to a set of "Usability Criteria", which determine how accessible and acceptable a given information transfer medium will be to the first responder. Usability criteria were prompt dissemination, convenient access, retrievability, cost to user, development cost, implementation time, and acceptability.

Candidate Formats

Several examples of each of the nine candidate information transfer formats were analyzed for potential effectiveness in communicating the categories of information identified. Particular issues that were examined and the assessments

that were made of each are described below:

"Newsletter/Magazine" -- A number of weekly, biweekly, monthly, and bimonthly publications dealing with hazardous materials issues already exist (HWR, HMN, HMMJ, HMIR, ENVRPT, HWN*). These publications vary in content and format, but most seem directed primarily toward management level personnel, as developments in legislation, regulation, policy trends, and research are reported most frequently. Articles dealing with techniques, hardware, and resources -- subjects of particular interest to response personnel -- are only occasionally found. Several magazines directed toward the fire service (FE, FJ, FC, FH*) regularly include useful information on hazardous materials. However, these publications are directed toward all aspects of the fire service, not just hazardous materials.

"Handbook/Catalog" -- A number of handbooks of moderate size (50 to 200 pages) are published at intervals of one year or longer (DOT, BOE, HAZCHEM, CHRIS*). These are designed to give pertinent, easily accessed information on basic health, fire, and explosion hazards for hundreds of chemicals (listed alphabetically), plus evacuation guidelines for some of them. Some handbooks (BOE, CHRIS) provide information for individual materials, while others (DOT, HAZCHEM) group materials and provide generic responses. These handbooks are valuable references, but they assume the user has some knowledge or practical experience with chemicals and spill events, and they do not deal directly with other aspects of emergencies that must be considered in a first response protocol.

"Data Bank" -- Several organizations maintain data banks (computerized or non-computerized) that can provide quick access to emergency information on individual chemicals. Two of these systems are computerized versions of the sponsoring organization's response manuals (CHRIS/HACS, BOE*). Another of these systems, which is not computerized, can provide basic, immediate response procedures and will contact the shipper or producer of the materials for assistance (CHEMTREC*). A major drawback is that these three data banks are accessed through a third party, as backup aids in an emergency, after the real first response

* See Glossary, pages 57 and 58.

has already been made. In operation, first responders to hazardous materials incidents contact the organization by telephone; organization staff then obtain the information requested from the data banks and relay it back to the field.

The fourth system examined (OHM-TADS*) is directly accessible by members of the public who are familiar with the computer language, have access to a computer terminal, and pay a fee. Physical, chemical, biological, toxicological, and commercial information, health hazards, safety recommendations, action recommendations, plus the identification of an unknown chemical when its properties are known, are all obtainable from it in emergencies and non-emergencies. To a first responder, this is usually even less accessible than the previously described data banks. A fifth system (CSIN*) under development by the Environmental Protection Agency is also a chemical information system. Initially service will be available only to about 25 selected users. Even in its final version it is not expected to be of much use to the first responder audience.

"Training Course - Live" -- Refers to any hazardous material training course where instructors interact with the students in person. These training courses may provide a broad range of information, detailed information on narrower topic areas, or even hands-on experience. Classes are offered by industry (JTB, SPT, ATA*), government (CSTI, USFA, CTI*), academic institutions (TAM, V.U.*), and private organizations (ERG, NFPA*) on planning and prevention, spill response, mitigation and cleanup procedures, etc. Courses typically last one to two weeks, frequently require travel, and are probably accessible to only a tiny fraction of first responders.

"Training Course - Interactive" -- This is a new concept, which developed from work in the nuclear power plant accident and civil defense areas and from discussions with local and state emergency response personnel. There have been so-called interactive programs before, but with the advent and rapidly expanding use of the micro-computer, the opportunities for this type of training have multiplied. Local fire and police department personnel have indicated through discussions that

* See Glossary, pages 57 and 58.

they would be very receptive to training programs involving micro-computer programs that (1) could be used when time was available, (2) were interactive (i.e., made the user think by leading them through a spill scenario, material identification exercise, etc.), (3) were interesting so that they would be used, (4) did not require large amounts of reading, and (5) provided a scorekeeping mechanism to check if the material was understood.

"Training Course - Canned" -- This refers to a self-contained tape/slide package, videotape, or other audio-visual training program that does not require the presence of an instructor. These have been very popular in the sales and promotion fields for many years and have recently been used in the hazardous material training area (Ref. 21). If done well, they are well received and are a good way to train large numbers of people quickly. They are expensive to produce and, because of audience attention spans, can only convey a limited amount of information at a given time. Also, since there is no interactive process, it is difficult to measure how much material is retained.

"Seminar" -- Seminars and conferences are primarily designed as forums for exchange of information on current issues and research. Speakers discuss a wide range of topics including compliance with regulations, research needs and developments, the relative cost of different storage and disposal techniques, spill cleanup technology, etc. While useful for management purposes and the exchange of ideas, they are not normally useful to the average first responder because the bulk of the subject matter is of little interest to him, and attendance requires travel and a considerable outlay of funds.

"Research Report" -- Research reports, of which this is an example, are typically not written for use by field operations personnel. They do contain specific information on topics of interest to the emergency response community but usually cover a limited topic in great detail, and not in a format that can be understood and easily used. Because these reports are usually written for other researchers or for management, rather than first responders or the general public, they are frequently incomprehensible to those in applied fields.

"Newspaper" — Refers to any general-topic, public daily newspaper. Because most hazardous material incidents tend to be covered in at least the local newspapers it was decided to include this medium in the survey of to assess its value to the first responder.

Usability Criteria

Prompt Dissemination - Means the capability of introducing information quickly as it becomes available. Formats that are issued or updated frequently will be most conducive to prompt dissemination. Handbooks (unless a compilation of data sheets and newsletters), canned training programs, and research reports are not suited; seminars generally are not, depending both on when they are offered relative to when information becomes available, and on the quality of the communication link between the seminar sponsor and FEMA. The best format for this purpose would probably be newsletters or newspapers/magazines.

Convenient Access - Refers to the ease with which potential users can avail themselves of the information once it has been made available. "Live" training courses and seminars usually require some travel on the part of the participant, so access is inconvenient. "Canned" training programs, computer data banks, files of newsletters and data sheets, etc., tend to be more accessible.

Retrievable - Means that a particular piece of information presented can be retrieved systematically; i.e., with an index or an appropriate command. Most newspapers do not publish indexes, and articles are retrievable only through comprehensive review of back issues. Computer banks, canned or interactive training courses, and research reports are generally easily retrievable.

Relatively Low Cost to User - Includes the costs of purchasing or renting items required to access the information, and the costs of any travel and per diem required to gain access. Live training courses and seminars are likely to require the largest expenditures by users (unless the institution bears part of the cost, as does the National Fire Academy). Computer data banks may or

may not be expensive, depending on whether the user already has the appropriate equipment.

Low Development Cost - Takes into account the estimated relative costs of developing the material for use in the field. An attempt was made to include estimated costs for research (if necessary), reproduction, and distribution costs.

Implementation time - Estimates were made of the relative calendar time it would take, under normal circumstances, to develop and introduce the first issue (in effect, to get into production).

Acceptability - This tends to be a somewhat subjective ranking and takes into account such things as: personal habits (i.e., amount of time available); skills (i.e., level of education, including reading ability); audience perception of the need to use the material; and a number of other factors. Assistance in ranking for this criterion was obtained from the comments and criticisms of members of the State and local emergency response community.

Analysis of Formats

Based on examination of available examples of the information transfer media, interviews with emergency responders, information retention studies, cost-benefit estimates, etc., the nine candidate information transfer mediums were analyzed and ranked two ways. The first was based on the type of data presented; i.e., how well suited a given information transfer medium is to the identified data needs (case studies, training course information, abstracts, technical bulletins, in-house training, and contingency planning information). The second was based on usability.

The results of the "type of data" analysis are presented in Figure 9. The ranking procedure used for this analysis was as follows: "Yes" (Y) was used if the given information medium definitely was appropriate for the required item of information; "no" (N), if the data was not normally appropriate in that type of information transfer medium; and "sometimes" (S), for those cases where the required data are intermittently appropriately included in the medium or where

	News-letter	Hand-book	Computer Data Bank	Training Course			Seminar	Research Report	News-paper
				Live	Inter-Active	Canned			
Case Studies	Y Y Y	N N S	N S S	S Y S	S Y Y	S Y S	S S S	S N S	Y Y S
Training Information	Y Y S	N Y S	N S N	S N Y	N Y N	N N Y	S N S	S S S	S S N
Abstracts	Y Y Y	N N N	N Y S	S N S	S S N	S N N	S N S	S N S	N S N
Technical Information	S Y Y	S Y S	S Y S	S Y Y	S Y Y	S Y Y	S Y Y	Y Y Y	N S N
In-house Training	S Y Y	S N Y	N Y S	S S N	Y Y Y	Y Y Y	S N N	N N N	N N N
Contingency Planning	S Y S	N S S	N Y N	S Y Y	Y Y Y	S Y Y	S Y Y	S Y S	N N N

Y = Yes N = No S = Sometimes

Fig. 9. Results of "Type of Data" Analysis of Information Transfer Media.

normally included, are sometimes incomplete or in a format that cannot be easily used. Three independent analyses were obtained, as represented by the three values shown for each item.

Results of the second analysis, "Usability", are presented in Figure 10. The ranking procedure used here was to score each medium with regard to the usability criteria listed above. Ranking was on a scale of 1 to 10, with 1 being the most usable and 10 the least. For example, the medium most expensive to the user would be ranked a 10, and the one that was free would be ranked a 1. Again, three independent analyses were performed.

A summary of these two rankings plus an overall ranking is shown in Figure 11. The newsletter was a leader in all three rankings, followed by the three types of training course. Among the training courses, the interactive type of course was the leader, followed by the canned and live courses. It was interesting to note that the live course was much lower than the other two categories, possibly because of the traveling requirement and, in most cases, the cost. The newspaper ranking was interesting. The good usability rating and the worst information content rating seem to indicate that everybody reads it but nobody gets anything useful out of it. Handbooks, because of their typically limited content, ranked fairly low on the content index, but apparently are reasonably well liked by the response community. Seminars, data banks, and research reports ranked very low under all three rankings.

The purpose of this ranking procedure was to find the information transfer medium(s) that would most efficiently and effectively transmit information to the emergency response community with particular emphasis on pertinence and acceptability to first responders. Based on these considerations, a newsletter is definitely the leader, closely followed by training courses that can be used in the field and preferably are interactive. Following are brief descriptions of what might be contained in a newsletter and a concept description of an interactive training course.

	News-Letter	Hand-book	Computer Data Bank	Training Course			Seminar	Research Report	News-paper
				Live	Inter-Active	Canned			
Prompt Dissemination	1 1 3	7 10 7	1 1 2	5 1 2	5 4 7	5 4 7	5 2 2	7 7 8	3 1 1
Convenient Access	2 1 2	2 1 3	2 5 8	8 5 10	3 1 7	4 3 5	5 5 10	4 1 8	5 1 1
Retrievable	3 3 5	2 1 2	2 1 5	9 3 5	3 1 4	4 4 4	9 1 5	6 1 7	7 5 10
Cost to User	1 1 1	1 2 3	3 5 9	5 5 8	3 3 1	2 2 1	5 8 8	3 3 3	1 4 2
Development Cost	4 1 3	6 2 4	9 8 9	5 5 5	8 3 8	5 1 6	5 5 5	9 2 6	1 2 2
Implementation Time	3 2 3	8 7 5	8 1 9	5 6 5	9 4 6	7 7 6	5 6 5	9 5 6	1 1 1
Acceptability	3 3 4	3 3 3	4 2 7	5 2 4	2 1 3	7 2 3	5 4 4	7 6 9	8 8 8

Rank: 1 - 10. 1 = Good 10 = Bad

Fig. 10. Results of "Usability" Analysis of Information Transfer Media.

Information Transfer Medium	Overall Rating	Type of Data Rating	Usability Rating
Newsletter	1	1	1
Interactive Training Course	2	2	4
Canned Course	3	3	5
Live Course	4	4	7
Newspaper	5	9	2
Handbook	6	8	3
Seminar	7	5	8
Computer Data Bank	8	7	6
Research Report	9	6	9

Fig. 11. Summary of Rankings of Information Transfer Media.

RECOMMENDED APPROACHES

Newsletter

It is suggested that there is a need for a relatively small (4 to 12 pages) newsletter distributed periodically by FEMA that would be specifically directed to the emergency response community and would contain the following elements:

Case studies of incident response procedures vs outcome

Training information and course descriptions

Abstracts of articles and information on hazards mitigation

Research and technical bulletins, and technical and other pertinent announcements

Contingency planning information

Incident Response vs Outcome Case Studies: Case study articles describing the sequence of events following a hazardous materials release, actions taken by responders and others, and the consequences of those actions would be valuable to publish in each issue of the newsletter. Each case study should describe:

Events immediately before release

Cause of release

Source of ignition (if applicable)

Notification of response personnel

Response time

Local weather conditions

Local topography

Response actions taken

Consequences of response actions

The major point would be to include an "Analysis" section to evaluate the response actions taken and to discuss possible alternative actions. By encouraging readers to send in their experiences and thoughts, real information exchange among the first responder community could be fostered. Recommendations could be made for preparation and response to similar incidents in the future.

FEMA can collect this information by conducting or coordinating investigations of major hazardous materials incidents, similar to NTSB's transportation accident investigations, but focusing on response rather than cause, and including incidents from all sectors. Major incidents in both stationary and transportation facilities are identifiable through news accounts. Identified incidents can be selected for investigation on the basis of severity, as measured by quantity of hazardous materials released, dollar damage, or number of injuries.

Training Course Descriptions: FEMA can provide decisionmaking information to hazardous materials emergency responders who are uncertain as to which training courses to attend, by publishing descriptions of current courses. Each course description should include:

Course name

Sponsor's name, address, and phone number

Course location(s) and date(s) offered

Price of attendance

Prerequisites

Objectives

Contents

Format

What each student should know or be able to do upon completion of the course

What job titles or descriptions the course is useful for (where possible)

Instructors' names and qualifications

This would provide potential attendees with enough information to compare courses and make rational choices.

Abstracts: Information and articles of interest to hazardous materials responders appear occasionally in each of many different publications examined.

There are so many altogether that it is impossible for most responders to keep track of them. FEMA can provide a needed service by reviewing pertinent articles and publishing brief abstracts of the contents in the FEMA newsletter. Abstracts should be one to two paragraphs long and include:

Title, date, and author(s) of article

Source of the article

Summary of article contents

Topics to be addressed include hazardous material incident prevention; incident response, detection, response and cleanup equipment; sources of information and assistance; and methods of funding hazardous materials operations. Articles for review can be found by scanning periodicals such as Fire Engineering, Fire Command, Firehouse, Hazardous Materials Newsletter, Hazardous Materials Intelligence Report, Hazardous Waste News, and Toxic Materials Transport. The abstracts can be listed alphabetically by title within topics and published as a section of the newsletter.

Research Bulletins and Announcements: FEMA needs a channel through which to quickly notify response personnel of critical research results or other findings. Currently, no such avenue exists, and information dissemination is haphazard. For example, the DOT published and made available free of charge the Hazardous Material Emergency Response Guidebook in July 1980 for use by first responders. Yet, in May 1981 there were still professional fire departments in a major metropolitan area that had heard only vague rumors of the existence of the book. Through a direct channel such as a FEMA hazardous materials newsletter distributed to all first responders free of charge, such announcements could be made effectively.

A prototype example of a newsletter is presented in Appendix B.

Interactive Training Courses

The second most effective information transfer medium identified was the interactive training course. There have been a number of attempts to use this medium in the past using complex hardware -- specifically designed classrooms with buttons on the desks to transmit "yes" or "no" answers to the instructors; slide shows with written tests, which were corrected and handed back at a later date; and

so forth. With the advent and rapidly expanding use of micro-computers, the opportunities for this type of training have multiplied.

Preliminary surveys of State and local fire and police personnel have indicated that they would be receptive to training programs involving micro-computers that: (1) could be used on a time-available basis; (2) were interactive (i.e., make the users make decisions by leading them through a spill scenario and material identification exercise; (3) were interesting so that they would be used; (4) did not require large amounts of reading; and (5) provided a scorekeeping procedure to check if the material was understood. Many of the people interviewed also indicated that they either owned or were planning on acquiring adequate hardware (which could be used for this purpose) for their own use.

Various types of programs could be developed and rapidly and economically distributed by FEMA on floppy discs or cassette tapes for use in either home or local organization computers. Typical examples are:

- o Hazardous material identification review courses
- o Spill response training using either actual incidents or artificial data. Spill scenarios could be developed that would be used as tests of the trainee's response knowledge. (Given the accident, the trainee would be offered a list of choices as to response; as each response was picked the results would be displayed and a new response required.) Various kinds of training courses could be developed with automated scoring procedures incorporated.
- o Other types of courses could include use of equipment, instrumentation, materials for decontamination, etc.

An example of the acceptability of this method is that the State of California and one of the major utilities in the state are cooperating in the development of training courses for nuclear power plant operators on micro-computers.

GLOSSARY

1. Response Handbooks

- BOE — "Emergency Handling of Hazardous Materials in Surface Transportation." Bureau of Explosives, Association of American Railroads, September 1977.
- CHRIS — Chemical Hazard Response Information System, U.S. Coast Guard, Manuals 1-4.
- DOT — Hazardous Material Emergency Response Guidebook, U.S. Department of Transportation, 1980.
- HAZCHEM — "Emergency Response Guide for Dangerous Goods," Copp Clark Pitman in cooperation with Transport Canada, Transport of Dangerous Goods Branch, 1979.

2. Response Information Data Banks

- BOE — Bureau of Explosives, Association of American Railroads, compiled by BOE and operated by individual railroads.
- CHEMTREC — Chemical Transportation Emergency Center, compiled and operated by Chemical Manufacturers' Association.
- CHRIS/HACS — Chemical Hazard Response Information System/Hazard Assessment Computer, compiled and operated by the U.S. Coast Guard.
- OHM-TADS — Oil and Hazardous Materials Technical Assistance Data System, compiled by Environmental Protection Agency and operated by two contractors.

3. Newsletters/Magazines

- ENVRPT — "Environment Reporter," Bureau of National Affairs, Washington, D.C.
- FC — "Fire Command," National Fire Protection Association.
- FE — "Fire Engineering," Technical Publishing.
- FH — "Firehouse," Firehouse Magazine Associates.

FJ — "Fire Journal," National Fire Protection Association.

HMIR — "Hazardous Material Intelligence Report,"
World Information Systems, Cambridge, MA.

HMMJ — "Hazardous Material Management Journal,"
Aspen Systems Corporation, Rockville, MD.

HMN — "Hazardous Materials Newsletter,"
J.R. Cashman, Barre, VT.

HWR — "Hazardous Waste Report,"
Aspen Systems, Corporation, Rockville, MD.

4. Training Course — Live

ATA — American Trucking Association, Inc., Operations Council:
"Handling Hazardous Materials and Wastes."

CSTI — California Specialized Training Institute:
"Contingency Planning for Hazardous Materials."

CTI — Colorado Training Institute

ERG — Environmental Resources Group, IMS America, Ltd:
"Hazardous Materials Training."

JTB — J.T. Baker Chemical Company:
"Hazardous Chemical Safety."

NFPA — National Fire Protection Association:
"Introduction to Industrial Fire Protection," (includes
hazardous materials).

SPT — Southern Pacific Transportation Company.

TAM — Texas A & M University System:
"Hazardous Material Control Course."
"Oil Spill Control Course."

USFA — U.S. Fire Administration, National Fire Academy:
"Hazardous Material Spill and Fire Control."

V.U. — Vanderbilt University
(see ERG course listed above.)

Section 5

CONCLUSIONS AND RECOMMENDATIONS

FEMA's role in the hazardous materials area will have a fundamental bearing on what sort of management information approach is practical, politic, and effective. But, whatever the outcome of the deliberations on scope of FEMA's activities, developing the incident data base is the **ranking** data requirement to establish the what, where, when, who, and why of incidents.

Figure 12 shows a schematic of the hazardous materials life cycle (centered in the figure) in which emergency management may need to be exercised. Throughout the cycle there exist chances for emergency situations to develop with their attendant consequences. These consequences are damage to life, property, and the environment. The objective of hazardous materials management is to minimize these consequences — or to prevent them altogether. To mitigate them in any way (by prevention or by alleviation after the fact) it is mandatory to know a good deal about the incidents; i.e., to know where they occur and how they occur in order to assess why they occur, and the options available to alleviate them when they do occur.

From the standpoint of **emergency** management, it is the **acute** hazards that are the major concern to FEMA; the EPA has responsibility for much of what constitutes long-term hazards in any case. Thus, FEMA will not **generally** have interest in such incidents as industrial discharges that do not meet the Clean Water Act requirements, nor improper incineration leading to some air pollution, nor inadequate disposal of waste. The latter sorts of incidents **will** be of interest to **emergency** management, however, when they require emergency action or contribute to buildup of a threat that could **lead** to a requirement for emergency action.

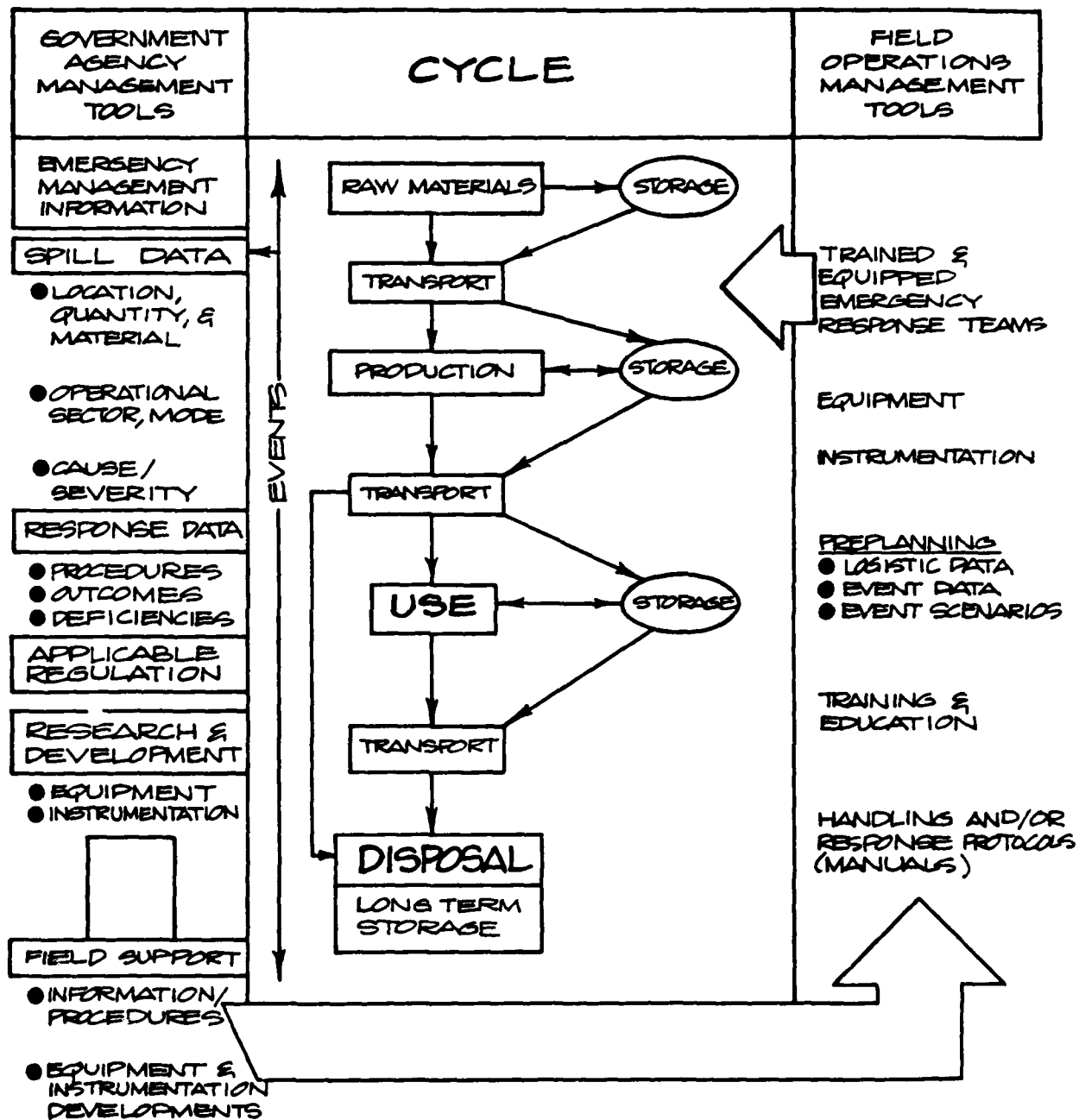


Fig. 12. Hazardous Materials Generalized Life Cycle.

Because the majority of incidents FEMA needs to apply its expertise to control are accidental emergencies that occur in the day-to-day operations of the normal environment, this pretty much identifies the elements, management tools, and information needs that are factors in the hazardous materials management and control problem FEMA must face. These management factors have also been summarized in Figure 12 (to the right and left of the life cycle schematic), and the arrows show the general direction of flow of materials, information, developments, and events. The column on the right in the figure is sufficiently general to include other practitioners than emergency response personnel involved in handling hazardous materials, whether loading dock foreman, truck driver, or whatever. The column on the left is sufficiently general to include any governmental agency charged with responsibility for elements of the hazardous materials management problem, whether FEMA, DOT, OSHA, State, etc.

On the agency side of hazardous materials management, different governmental agencies are essentially concentrating on different aspects of the problem and reaching different practitioners. Helping in these efforts are many independent groups in private industry (Chemical Manufacturers Association, Association of American Railroads, American Industrial Hygiene Association, etc.). Thus, a broad range of incident data are being collected at the local, state, Federal, and private industry level, some of which may be pertinent, but all of which are organized for various purposes and in different fashion so that they have limited accessibility. The major difficulty is that there is no single agency pulling key pieces together to fit into a coherent pattern and to see that important parts of the problem are not "slipping through the cracks." The corollary is also true, there needs to be some authority to make decisions regarding when to redirect emergency management effort that is likely to be unproductive to where it will be more productive.*

* For example, if it is found that hazardous materials transportation incidents that result from vehicular accidents occur at a lower relative frequency for the ton miles of such materials hauled than non-hazardous materials accidents, then control aimed at reducing hazardous material vehicular accidents further below the norm is already well on the way to diminished returns. In that event, further progress toward incident control might better be directed to container improvements, controlled routing, or sanctions against specific carriers with records for incidents that exceed normal statistical expectations.

What appears to be needed, then, is a simple management information methodology or system for organizing the existing data and data bases. It should be deliberately simple so that virtually anyone can understand it, and it should reflect the multi-agency involvement in the hazardous material problem -- which by nature is going to be fragmented, so will require assembly of pieces that have essentially been unrelated heretofore. The multi-dimensional matrix discussed herein provides just such a system because it is specifically contrived to relate a variety of individual factors and can be used to track, and to rank and compare, their impacts on the hazardous materials problem. With the application of some adroit management, this approach to developing decision information has the potential to be comprehensive, yet pragmatic and simple at the same time. It will also enable gaps in management information to be identified. Coupled with a mechanism to build a good incident data base (see Appendix A) the combination constitutes a decision information system (methodology) and data collection protocol for a comprehensive management approach to hazardous materials that also incorporates simplicity and pragmatism.

The major value of developing decision information is for the benefit that can be realized in better prevention and handling of emergency incidents. The latter are best keyed directly to detailed knowledge of what is being spilled, where, how often, why, and with what consequences. Because random events are harder to change (though possible, with blanket regulation) the systematic occurrences are of major or primary interest; consistent problems offer hope for analysis that can pinpoint options for corrective action. The particular level at which the data must be analyzed, if it is to be practical, is where the action is taking place -- the local community. Federal efforts at organizing data are generally for the purpose of deciding where support is more needed in the communities and what will do the most good. In effect, then, the best data would be those data developed (and processed) at the community level, where they are directly pertinent to events and operations. In addition, these can be aggregated for Federal use to identify those specific areas where many communities are generally in need of help. The latter would presumably be supplied at the Federal level, contingent on a sufficiently general demand. A systematic process, however, is unlikely to be initiated at the community level except, perhaps, in a few isolated cases, which would likely remain

unrelated efforts. To be initiated and evaluated effectively, it should be centrally organized, with specific objectives for solving common problems, once, and transferring the technology or procedures. This is where some Federal input is most effective.

As a first step, several community programs could be established to serve as demonstrations of how the process might work (and to serve as a mechanism to test the concept and guide its evaluation). The second step would require following through with assessments of costs and benefits associated with such community efforts. The latter will be needed to convince communities that the former is worth the trouble before many of them will undertake the effort. Therefore, an important third step is the general dissemination of the results of the demonstration program as it progresses.

These thoughts, together with the flow chart of Figure 12 -- which relates emergency response needs to the hazardous materials cycle -- have been used to devise a proposed program approach to FEMA's initial involvement in hazardous materials emergency management. This program is outlined below.

RECOMMENDED PROGRAM

Agency-Level Program Elements

Programs and Technical Assessments:

Compile a summary of ongoing programs in hazardous materials emergency management; develop assessments of these programs and identify specific applications pertinent at the community level.

Develop comparative study and assessments of available and affordable items such as:

- Protective clothing
- Materials identification instruments
- Breathing apparatus
- Hazardous materials response vans
- Communications equipment/systems

Develop a forecast of the above items in development expected to be available in the near future (items being field tested)

Develop flow diagram response protocols for well-established response procedures

Develop comparative assessment of community preplanning methods

Develop assessment of costs and benefits of community preplanning; develop emergency incident data to show improvement due to preplanning

Information-Transfer Program Elements:

Develop information transfer methods to provide the above developed information to first responders -- and to emergency planners -- at the local level:

- A. Explore a newsletter approach -- with the above information targeted for first responders and emergency planners.
- B. Explore the use of interactive training options for supplying first responders with effective, realistic incident scenarios:
 - 1. Develop an initial program -- consider use of scenarios developed from existing courses (e.g., Fire Academy) and from incident/response data of record.
 - 2. Test the program in a participating community.

Community-Level Program Elements

Community Programs and Applications Assessments:

Establish several test communities to participate in information exchange programs. (Some or all of the participants should be involved in community preplanning efforts.)

- A. Evaluate the use and application in each participating community of the information developed in the first program element.
- B. Initiate development of a uniform comprehensive data collection format for recording community emergency incidents as a collective effort among participating communities -- with Federal representation and input.
- C. Develop emergency incident data in each community using the format developed.
- D. Develop the data collected over one year for each community to show:
 - 1. Materials spilled -- in order of spill frequency
 - 2. Materials spilled -- in order of severity (to the general public and to first responders)
 - 3. Locations of incidents (using zip codes to identify impacted regions, and combinations of zip codes to identify impacted transportation routes)
 - 4. Spiller
 - 5. Principal cause and causal sequence
 - 6. Response/outcome

E. Compare the data among communities to identify the problems held in common.

F. Develop response protocols for common materials problems.

Section 6

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APPENDIX A
Required Data

Appendix A

REQUIRED DATA

Successful application of decision information hinges on acquiring the relevant data and designing the data bases so that the desired management information can be accessed, and assessed and integrated. Pertinent data are identified as:

1. Spill and release incidents reports disaggregated by transport, processing, storage, and disposal sectors and further disaggregated by mode (whether transport, processing, storage, or disposal) giving detail on material(s), quantities spilled, fraction released, location (zip code), cognizant controllers, etc.
2. Containment failure causes, including human error, keyed to individual spill or release incidents with sequences of causes identified. (For example, tank rupture caused by overpressurization exceeding relief valve capacity, due to heat transfer caused by fire, resulting from fuel spilled and ignited, in train derailment -- ignition source unknown, spark from derailment suspected.)
3. Incident severity data in categories of deaths, injuries, lost time (including evacuation), and in total property damage, disaggregated to show outcome values for operating and response personnel and for the public, separately.
4. Response protocol applied; response time; time from incident until emergency response measures started, and ended; size of team; equipment available vs needed; significant errors of omission or commission, etc.

5. Life hazards data and material properties.

6. Cleanup and ultimate disposal protocol applied; cost of cleanup; magnitude of impact on local environment; release to ground water, ground water contamination levels; air pollution; long-range environmental impact; etc.

7. Logistic data on dump sites giving capacity of site, rate of filling, principal wastes, disposal process(es) used, age since startup, etc.

8. Logistic data by zip code giving material(s) vs quantities: on hand, shipped, and received -- periodically -- by shipping mode, routes, and carrier.

9. Regulatory impact data, including effective dates of regulations, indicating violations observed covering all aspects of hazardous materials handling, labeling, placarding, and response, giving reasons for violation whenever possible.

These data bases cover the major data categories required to put the decisionmaking process for hazardous materials management and control on a firm quantitative basis. The first four items constitute the emergency spill incident data that need to be obtained through consistent, more comprehensive emergency incident reporting. What is needed in this regard is a single format that is used by all agencies to record the information, so that it is consistent, and readily available for processing. Establishing a lead agency with responsibility, authority and funding to arrange this is one effective approach. The following lists the desired information, in brief:

Report No./Date

Material(s) ID / Spiller ID / Spill quantity / Fraction spilled

Sector / Mode / Location

Cause / Severity (to general public and to responders)

Response / Outcome

Report Number could be used to identify both the agency collecting the data and the report.

Date is self-explanatory.

Materials spilled could simply be the U.N. numbers.

Spiller's ID would be the organizations in whose care the hazardous material was at the time of spill (zip code plus name coding).

Spill quantity could be supplied in several ranges so only a box need be checked.

Fraction spilled could also be supplied by checking a box.

Sector -- A separate form could be used for each sector as is done now, but the incident data format would have to be consistent on all forms.

Mode -- This could be supplied by checking a box.

Location -- This could be a zip code number, and it would be quite sufficient to identify particularly hazardous transportation corridors or routes.

Severity -- This could be a box giving ranges for deaths, injuries, damage estimates.

Cause -- All causes are a failure to maintain containment, but the sequence of circumstances is desirable. A coding system such as that used in Ref. 3 might suffice.

Response/Outcome -- This rating would require careful thought to code -- perhaps using a technique something like Benner's event model, Figure A-1 (from Ref. 9), with categories coded numerically. The narrative backup could be reviewed, should the event be called out for further scrutiny.

The form might well be several pages, but the task of filling it out could be very simple. With a common format in use among agencies, it would be an easy matter to integrate data collected. Moreover, a part of the data would already be disaggregated by sector (e.g., DOT's data would summarize transportation incidents). Simple sorting procedures could be used to identify ranking hazards. Sorting could be by sector, by mode (which will be dependent on sector), location (both region and/or route can be determined by zip code), material and quantity, severity, spiller, etc. The first objective of ranking is to identify the major problem materials for

**GENERAL HAZARDOUS MATERIALS BEHAVIOR MODEL
AND
BASIC EVENTS INTERRUPTION PRINCIPLES**

Fig. A-1.

Event		Event Categories		Events Interruption Principles	
Stress	Breach	Release	Engulf	Impingement	Harm

Event Categories

Thermal Mechanical Chemical Irradiation Etiological	Consumed catastrophic disintegration Runaway linear cracking Attachments open up Punctures occur Splits or tears	Puff Steady flow Diminishing flow Pulsating flow	Hemispherical Spherical Conical Plume Circular Stream shaped Irregular	Transient Lingering Permanent	Thermal Radiation Asphyxiation Chemical Etiologic Mechanical

Events Interruption Principles

Influence Applied Stresses	Influence Breach Size	Influence Quantity Size	Influence Size of Danger Zone	Influence Exposures Impinged	Influence Severity of Injury
Redirect impingement Shield stressed system Move stressed system	Chill contents Limit stress level Activate venting devices	Change container position Minimize pressure differential Cap off breach	Initiate controlled ignition Erect dikes or barriers Dilute	Provide shielding Begin evacuation	Rinse off contaminant Increase distance from source Provide shielding

SOURCE: Benner, Ludwig, 1978. *Hazardous Materials Emergencies*. 2nd Edition. Dakton, Va: Lufred Industries, Inc.

each sector and mode, the most probable causes and severity, etc. Response protocols can then be developed for these incidents and supplied to response teams tailored to geographical regions where the events are reported to occur. The second objective should be to identify systematic as opposed to random differences. For example, carriers or procedures with the most frequent accidents may need better training for employees -- or they may simply process more hazardous materials than the others. Additional data would be needed to determine which, but such data could be acquired selectively, whereas the incident data would need to be gathered for all spills -- above whatever severity is the acceptable limit for cutoff. In any case there will be little management information content in the data that wasn't designed to be there at the collection stage. With comprehensive collection of emergency incident data by all agencies, virtually the only limit to organization for management application is the ingenuity of the manager.

There is an effective pragmatic alternative to multi-agency collection of data. That is, insight into problems specifically affecting first responders in the public domain would be assuredly pertinent if it were collected by exactly these first responders. Using a simple collection format such as that suggested, the emergency incident data could be incorporated into the fire service reporting net for coding either at the state level or at the Fire Data Center. Moreover, it could be done on a sampling basis by instituting a program of collection in communities (such as the Puget Sound and Multnomah County areas) where a community program has been set up to track hazardous materials within the local area. The resulting emergency incident data would have immediate application to development of pertinent response protocols and deployment of resources according to what materials are most involved in spills and where the events are occurring within the community, as well as where the materials are concentrated.

APPENDIX B

Prototype Newsletter

Appendix B
HAZARDOUS MATERIALS EMERGENCY MANAGEMENT PUBLICATION

A format that has a consistent theme in each issue:

- (1) Article on an event or events -- preferably with regular inclusion of current incidents -- with suggestions of alternative responses.
- (2) Article on instrumentation, equipment, methods that could have been applied to the case described in the article under (1). Article backed up with data sheet on manufacturers, typical specs, cost. What to look for.
- (3) Article on aspects of preplanning. Can be on level of fire department, community, what FEMA is doing that will help, etc.
- (4) Article on how preplanning has paid off for a first responder, community. A tracking of benefits of preplanning, in effect.
- (5) Article on what is coming onstream soon. Probably extracted from research reports.



HAZMAT NEWS

WATCH FOR HIDDEN CONSEQUENCES IN FLAMMABLE LIQUID SPILLS

Spills of flammable liquids can produce some acute hazards that aren't always easy to recognize. Flammable liquids such as gasoline, toluene, xylene, and other volatile solvents have flash points at temperatures found in normal environments. Moreover, because of the volatility of these materials, pockets of runoff from a spill can produce a lot of vapor over the exposed pool. If the pocket winds up in an enclosed space, it doesn't take much gasoline to produce a serious explosive potential — which may be even worse than the secondary fire hazard. Here is something you don't want to have happen.

During a gasoline spill from a tank truck that occurred in a small town, a portion of the gasoline that spilled wasn't noticed because of activities involving the main spill. The gasoline entered the crawl space under a house a distance away, and vapor was drawn up into a gas-fired water heater where ignition occurred. There was a flashback to the crawl space, where the vapor was trapped, and a low order explosion took place in the vapor, under the floor, which destroyed the house. One person was killed and two others injured. But it didn't end there. Flame also flashed back along the vapor trail to the source of the spill and caused another explosion — this time in the vapor space in the tanker. The result of the tanker explosion was to ignite additional fires and consume the remaining gasoline.

When the ground surfaces are essentially dry, it is not too difficult to trace the runoff paths and either control the area, dam the runoff, or both. But before you cut off the runoff, you had better check where it goes if you don't have a detector to sniff the vapors. After cutoff, the liquid will volatilize from a porous dry surface on a warm day even after there is no sign of liquid left — and a flame could flash back along that track from a pocket of liquid you didn't know existed, if the volatile vapor is ignited as in the case history.



COMBUSTIBLE GAS DETECTION

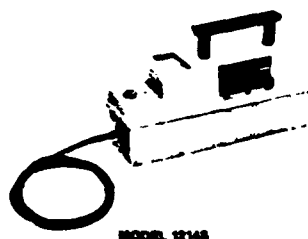
There are a variety of portable instruments for detecting combustible gases (often called sniffers) in widespread use by fire departments that cover a broad range of applications and sensitivities. Some of these instruments simply give an audible or visible alarm when certain threshold limits are exceeded, while others will measure concentrations in percent of the Lower Explosive Limit (LEL). The LEL is the concentration where the vapor has become an explosive mixture.

For the type of use suggested in the spill situation described in the previous article, the less sensitive instruments are not as satisfactory. Prices for instru-

ments range from several hundred to about one thousand dollars. Manufacturers include Grace Industries, Mine Safety Appliances (MSA), Scott/Davis, Bacharach. (Should give list of mfrs, and addresses). Several models produced by one of the manufacturers are described on the data sheet enclosed.

You might want to check your preplanning records to see what specific kinds of materials you have in your community before purchasing or replacing your detector. Then check with several manufacturers on their instrumentation specifications to be sure you have the capabilities you want.

DATA SHEET: COMBUSTIBLE GAS DETECTORS



MODEL 1214S COMBUSTIBLE GAS/OXYGEN DEFICIENCY INDICATOR/ALARM

Application

The Model 1214 continuously and simultaneously tests for both explosive hazards and oxygen deficiency. Characteristically coded audible and visual alarms are actuated whenever either danger (or both) is encountered. Its major application is for use by workers who must enter enclosed spaces, such as manholes, tanks and other underground structures where both hazards might exist.

Description

The Model 1214 combines the Model 1177 combustible gas and Model 1313 oxygen deficiency indicators / alarms and uses the same detectors. Both the combustibles and oxygen sensors can be either plugged into the front of the instrument or extended to a remote point by use of the cable and socket assembly that comes with the instrument.

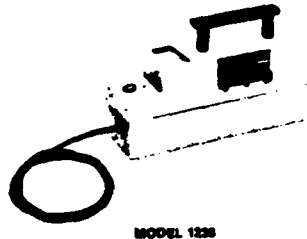
MODEL 1214S COMBUSTIBLE GAS/OXYGEN DEFICIENCY DETECTOR/ALARM

Application

This sample drawing instrument with hose and probe is for use in areas where the sampled atmosphere must be transported to the sensor. The 1/4" diameter probe can be easily inserted through vent holes or other small openings.

Description

The 1214S is a sample-drawing instrument, otherwise having the same ranges and capabilities as the Model 1214. An internal rotary diaphragm pump with a brushless motor draws the sample rapidly enough to give a response within 5 seconds. It comes with a 6' hose and a probe for convenient sampling.



MODEL 1238 HYDROCARBON SURVEYOR PPM/LEL COMBUSTIBLE SURVEY METER

Application

This highly-sensitive portable instrument is a dual-range indicator for testing the toxic and combustible levels of hydrocarbon gases and vapors in industrial work areas.

Designed primarily to meet the special requirements of industrial hygienists, it is also ideal for other uses requiring broad range sensitivity. It provides good readability from 0 to 500 parts per million (PPM) and 0 to 100% lower explosive limit (LEL). Because of its high sensitivity, the Surveyor is also used in arson investigations. It detects small residual traces of hydrocarbon vapors from fuels or solvents used to start a fire, thus leading investigators to the origin of the fire.

Description

The Surveyor is much more than an amplified combustible indicator. It is a true precision field instrument with several unique features:

- Catalytic sensor using two closely-matched elements. Both elements are exposed to the sample stream to minimize temperature and thermal conductivity effects caused by water vapor and non-combustible background gases. Rugged design of the sensor ensures continued satisfactory operation in field use.
- Internal sample pump which provides a precisely controlled sample flow rate to guarantee indicator accuracy. Pump is a rotary diaphragm type with brushless DC motor.
- Dual balance adjustments which allow adequate adjustment on the LEL range without excessive sensitivity in setting PPM range.

Calibration is provided as required for the application (toluene calibration standard when not otherwise specified). The instrument is backed by



factory technical support and calibration gases to insure accurate onsite measurement.

Basic Operation

To operate the Model 1238, the sampling hose is attached to a quick-connect fitting on the front of the instrument. After appropriate settings are made, the sampling hose is inserted into the area to be tested. If reading gases above the alarm setting, a pulsed audible alarm will start. It continues as long as the reading remains above the alarm point. Alarms are independently adjustable.

MODEL 1314 HYDROCARBON SUPER SURVEYOR

Application

The Super Surveyor detects and indicates concentrations of combustible gas or vapor in air, in the explosibility and parts per million ranges. It also measures oxygen and detects oxygen deficiency. In fact, the instrument automatically tests for oxygen deficiency every time it is used. The Model 1314 is intended primarily for industrial use. However, it is adaptable for any measurements where small concentrations of combustible gas are to be detected.

Basic Operation

Operation is very similar to the Model 1238 except for the added oxygen detection capability. Samples of the atmosphere under test are drawn continuously by a built-in pump, and analyzed for combustible gas on a heated catalytic platinum element. A solid-state amplifier amplifies indications of the catalytic element to give adequate meter deflection even in the presence of trace gas concentrations. At the same time, the sample passes over an oxygen detector which gives an output in terms of percent oxygen. If the oxygen content drops below 19% the instrument produces both pulsed audible and amber-light alarms.

DATA SHEET: COMBUSTIBLE GAS DETECTORS

SPECIFICATIONS

Model No Stock No	1177 72-0140*	1313 72-0150	1214 72-0145*	1214S 72-0146	1238 72-0130	1314 72-0135
Functions						
LEL Detection	X	—	X	X	X	X
Oxygen Deficiency	—	X	X	X	—	X
PPM Range	—	—	—	—	X	X
Range						
LEL	0-100% *(0-5% methane)	—	0-100% *(0-5% methane)	0-100%	0-100%	0-100%
PPM	—	—	—	—	**0-500 PPM organic vapors	**0-500 PPM organic vapors
O ₂	—	0-25%	0-25%	0-25%	—	0-25%
Standard Alarm Setting						
LEL	20%	—	20%	20%	20%	20%
PPM	—	—	—	—	100 PPM	100 PPM
O ₂	—	19% (Falling) 25% (Rising)	19%	19%	—	19%
(All alarms adjustable)						
Alarms						
LEL						
Audible	Pulsating	—	Equal Pulse Length	Equal Pulse Length	Pulsating	Eq Pulse Length
Visual	—	—	Synch Red Pulse	Synch Red Pulse	—	Synch Red Pulse
O ₂						
Audible	—	Equal Pulse Length	Short-Long Pulse	Short-Long Pulse	—	Short-Long Pulse
Visual	—	—	Synch Yellow	Synch Yellow	—	Synch Yellow
Malfunction	Steady	Steady	Steady	Steady	Steady	Steady
External Controls						
On/Off PB Switch	X	X	X	X	X	X
Battery Chk. Switch	X	X	X	X	X	X
Zero Adjust	X	—	X	X	X	X
P/B Comb/O ₂ Switch	—	—	X	X	—	X
P/B LEL/PPM Switch	—	—	—	—	X	X
O ₂ Span Adjust	—	X	X	X	—	X
Internal Controls						
Alarm Point(s)	LEL	Falling & Rising	LEL & O ₂	LEL & O ₂	LEL/PPM	LEL/PPM & O ₂
Adjustable Calibration	LEL	—	LEL	LEL	LEL & PPM	LEL & PPM
Adjustable Zero	—	O ₂	O ₂	O ₂	LEL	LEL, O ₂
Batteries	Rechargeable NiCad Battery Pack, 6 5V, 4.0 AH Encapsulated					
Type	Plug-in 115 AC standard (220V also available)					
Charger	10	40	10	8	8	8
Life Between Charges						
Sampling Method	Diffusion	Diffusion	Diffusion	Sample Draw	Sample Draw	Sample Draw
Combustibles Detector	Catalytic Compensated	—	Catalytic Compensated	Catalytic Compensated	Catalytic Compensated	Catalytic Compensated
Oxygen Detector	—	Plug-in Self- Generating Electrochem	Plug-in Self- Generating Electrochem	Plug-in Self- Generating Electrochem	—	Plug-in Self- Generating Electrochem
Dimensions	12" L x 3 1/4" W x 5 1/4" H					
Size	7	7	8	8	8	8
Weight (lbs)						
Furnished Accessories						
Charger	X	X	X	X	X	X
Battery Pack	X	X	X	X	X	X
Exten. Cable	10'	10'	20'	—	—	—
Teflon-lined Hose	—	—	—	6'	5'	5'
Probe	—	—	—	10"	—	—
Repeater Signal for Remote Signaling	—	X	X	—	—	—

* Also available with MSHA approval label **0-1000 ppm also offered as option

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HAZARDOUS MATERIAL INCIDENT PREPLANNING

Historical records on experiences of firefighters are certain to include incidents such as the following:

- o Nitric acid leaks from a 5,000 gallon storage tank in a plant one night and damages a copper pipeline. The pipeline contains compressed nitrogen, but the line is labeled as compressed air. The pipe damage causes a cloud of acid vapor, which damages equipment and causes minor burns to one firefighter. The last part of this incident occurs because the location of the shutoff switch for the nitrogen line is unknown. Shutoff is delayed until somebody from the plant is finally located who knows the layout. **Preplanning would include identifying who should be called in an emergency, and an alternate.**
- o A large fire in a materials research facility produces unidentified toxic fumes. The fumes injure several firefighters and police officers. **Even if the fire and fumes couldn't have been avoided, preplanning could have prepared the responders to avoid injury because they would have known what was in the plant and what was burning in the area of the fire.**

Incidents like these are common in highly industrialized areas, but can occur anywhere that large quantities of chemicals are present. Because the properties of toxic, flammable, and explosive chemicals such as silane, phosphine, diborane, liquid hydrogen, and ammonia are unfamiliar to most firefighters, extra attention is required to protect firefighters and the public from the hazards posed by these materials.

An innovative approach to improving the response to hazardous material incidents, and thereby increasing the

level of public protection, has been undertaken by the Santa Clara (California) Fire Department. The city (population 100,000) is located in an area with a high and growing concentration of electronics industries. Over the last few years, it became apparent to the fire chief that conventional building inspections were inadequate for keeping up with the growing and changing chemical hazards in industry.

Consequently, in 1980, he proposed a citywide "Chemical Hazard Assistance Program." The first step in the program was to conduct an inventory to determine the types, quantities, and locations of stored hazardous materials in every commercial occupancy in the city. This has now been completed. The inventory was taken by using all 13 fire companies six hours a day, six days a week, for a month. The chief has been using the information gathered in two ways:

1. Locations of quantities of hazardous materials have been and are being incorporated into prefire plans.
2. Occupancies storing more than a specified quantity of certain types of materials are being assessed fees to fund a specially equipped chemical hazards response van and two chemical specialists. One of the specialists has already been hired, and the community capability to respond improved as a result.

Because of the chief's foresight, this preplanning program will provide firefighters in Santa Clara responding to fires or spills in the inventoried plants with a better idea of what hazards to expect. In addition, special equipment and a chemical expert will be readily available to assist with the more difficult problems.

APPENDIX C
Common Chemicals

Appendix C

COMMON CHEMICALS

The attached table identifies over 100 common chemicals that are a serious hazard. The table is divided into 18 subgroups that are compatible enough within a group they can be stored together. But, between groups, chemicals should be separated, because mixtures across groups may explode, combust, boil and vaporize, or otherwise react to cause additional rupture and spreading.

Note, it is particularly important to isolate the toxic materials so that they will not become a problem during recovery after an earthquake.

TABLE C-1: COMMON CHEMICALS

Group I: Hydrocarbons

a) Gases

hydrogen
methane
ethane
natural gas
ethylene
acetylene
propane
propylene
butane
isobutane

b) Liquids

pentane
hexane
cyclohexane
heptane
octane
benzene
toluene
xylene
mesitylene
ethylbenzene
gasoline
kerosene
fuel oils
gasoline (aviation grade)

c) Solid

naphthalene

Group II: Halogenated Compounds

a) Gases

methyl chloride
methyl bromide
ethyl chloride

b) Liquids

methylene chloride
chloroform
carbon tetrachloride
ethylene dichloride
trichloroethane
trichloroethylene
chlorobenzene
dichlorobenzene

Group III: Self-polymerizing Compounds

a) Gases

vinyl chloride
vinyl bromide
butadiene
formaldehyde

b) Liquids

formaldehyde-water solution
acetaldehyde
acrolein
acrylonitrile
vinyl acetate
isoprene
styrene
methyl acrylate
methyl methacrylate
turpentine

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Group IV: Oxides and Peroxide-forming Compounds

- | | |
|----------------|-------------------|
| a) Gases | b) Liquids |
| ethylene oxide | propylene oxide |
| dimethyl ether | diethyl ether |
| | tetrahydrofuran |
| | dioxane |
| | dimethoxy ethane |
| | diisopropyl ether |

Group V: Combustible Compounds

- | | |
|----------------------|------------------|
| a) Non-toxic liquids | b) Toxic liquids |
| methanol | methyl mercaptan |
| ethanol | acetonitrile |
| acetone | dimethyl sulfate |
| methyl ethyl ketone | |
| ethyl acetate | c) Solid |
| dimethyl sulfoxide | phenol |
| propyl alcohol | |
| isopropyl alcohol | |
| butanol | |

Group VI: Bases

- | | |
|---------------------|--------------|
| a) Gases | b) Liquids |
| ammonia anhydrous | ethanolamine |
| methylamine | ethylenimine |
| | aniline |
| | pyridine |
| c) Solids | |
| sodium hydroxide | |
| potassium hydroxide | |

Group VII: Acids A

- acetic acid
phosphoric acid

Group VIII: Acids B - Oxidizers

- | | |
|----------------------------|------------------|
| a) Gas | b) Liquids |
| nitrogen tetroxide | nitric acid |
| | perchloric acid* |
| *store protected from sun. | |

Group IX: Acids C

- chlorosulfonic acid

Group X: Acid D

- sulfuric acid

Group XI: Poison A

a) Gases

hydrogen chloride
hydrogen fluoride
carbon monoxide
hydrogen sulfide
phosgene

b) Liquids

hydrogen cyanide
carbon disulfide
hydrochloric acid
acetone cyanohydrin

Group XII: Poison B - Miscellaneous

a) Gases

sulfur dioxide
chlorine
boron trifluoride

b) Liquids

bromine

Group XIII: Poison C

Liquid

tetraethyl lead

Group XIV: Poison D

Gas

fluorine

Group XV: Poison E

Solid

phosphorus red
phosphorus white or
yellow

Group XVI: Oxidizers

Solid

ammonium nitrate
ammonium perchlorate

Group XVII: Metals and Derivatives

Solid

lithium
sodium
potassium
magnesium
calcium hydride

Group XVIII: Non-Metals Derivatives

a) Liquids

sulfur trioxide, oleum
sulfuryl chloride
thionyl chloride
phosphorus trichloride
phosphorus oxychloride
titanium tetrachloride

b) Solids

phosphorus pentoxide
phosphorus pentasulfide

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Information exchange media are examined and assessed for potential effectiveness in transferring the acquired and developed information to the area where information needs are greatest — the level of first responder. Test communities should be established to participate in information exchange programs.

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