CHAPTER 10

HAZARD AND RISK REDUCTION STRATEGIES

INTRODUCTION

In both proactive and reactive phases of emergency response planning, hazard and risk reduction are central objectives. Hazard reduction strategies include any attempt to minimize the potential harm or injury associated with any substance, situation, or condition; risk reduction strategies focus not on the source of potential hazards but, rather, on the exposure of persons to those hazards. As coequal efforts to minimize the impact of emergencies, hazard and risk reduction are today most often described as two aspects of the process of *mitigation*.

The concept of mitigation is, in fact, very broad, inclusive of both proactive and reactive actions taken by both response and nonresponse personnel and by governmental as well as private organizations. With specific regard to emergency response personnel and organizations, the practical application of mitigation is directed toward the following objectives:

1. Minimize the Number of Incidents Requiring the Implementation of Emergency Response

While this objective is very much the bottom-line goal of all emergency response planning, emergency responders themselves can actually do little to advance this objective, except by the advice and training they make available to private corporations and the public at large regarding the control of hazards and protection against exposure. Historically, this type of service (i.e., consulting and training) has most often been viewed as essentially ancillary to the main function of a response organization; however, given the paramount importance of a proactive ethos, there is good reason to argue that consulting and training services are at least as important as actual response services.

The primary effort in regard to this mitigation objective (beyond consulting and training) must be made by persons who have primary managerial responsibility for potential sources of hazards (e.g., plant manager). Regulatory authorities also play a vital role, of course, by forcing compliance with standards that are recognized as effective means of hazard and risk management—a role, it should be noted, which gives important support to the consulting and training services of response organizations.

2. Minimize the Magnitude of Incidents

The magnitude of an incident may be described in terms of various considerations, including (but not limited to) (a) geographic extent of hazardous conditions, (b) numbers of persons harmed or killed, (c) loss of property and other resources, (d) duration of the incident , and (e) resources used in response (e.g., personnel, equipment, money).

Certainly these dimensions of an actual incident are influenced by both the proactive and reactive efforts of both response and nonresponse organizations—efforts that, in the midst of an actual incident, become intertwined and hardly distinguishable. For example, the capacity of response personnel to contain a developing emergency in a particular facility is influenced not only by their response preparedness and readiness, but also by the policies of that facility regarding the control of hazardous material inventory and in-plant safeguards, including notification alarms and first-response protocols.

Beyond maintaining their professional response readiness, response organizations are primarily responsible (with regard to this mitigation objective) for minimizing risk to response personnel.

3. Prevent Natural Disasters from Becoming Human-Made Disasters

The historic distinction between natural and human-made disasters is today less distinct. While humans do not cause earthquakes, humans do choose to build upon earthquake-prone faults; while humans do not cause torrential storms and floods, humans do choose to build within floodplains. This is not to say that humans can avoid any and all perils of nature by a mere act of volition, but the fact remains that many ordinary natural phenomena essentially become human disasters simply because of specific

FEMA - Mitigation
Reducing Risk through Mitigation

Protecting Your Property from Earthquakes

Are You at Risk?
If you aren't sure whether your house is at risk from earthquakes, check with your local building official, city engineer, or planning and zoning administrator. They can tell you whether you are in an earthquake hazard area. Also, they usually can tell you how to protect yourself and your house and property from earthquakes.

What You Can Do
Earthquake protection can involve a variety of changes to your house and property -- changes that can vary in complexity and cost. You may be able to make some types of changes yourself. But complicated or large-scale changes and those that affect the structure of your house or its electrical wiring and plumbing should be carried out only by a professional contractor licensed to work in your state, county, or city. Examples of earthquake protection are anchoring and bracing propane tanks and compressed gas cylinders. These are things that skilled homeowners can probably do on their own.

Anchor and Brace Propane Tanks and Gas Cylinders
During earthquakes, propane tanks can break free of their supporting legs. When a tank falls, there is always a danger of a fire or an explosion. Even when a tank remains on its legs, its supply line can be ruptured. Escaping gas can then cause a fire. Similar problems can occur with smaller, compressed gas cylinders, which are often stored inside a house or garage.
One way to prevent damage to propane tanks and compressed gas cylinders is to anchor and brace them securely. The figure shows how the legs of a propane tank can be braced and anchored. Using a flexible connection on the supply line will help reduce the likelihood of a leak. Compressed gas cylinders, because they have to be periodically replaced, cannot be permanently anchored. But you can use chains to attach them to a wall so that they will remain upright.

FIGURE 10.1 Example of FEMA mitigation tip (FEMA Electronic Reference Library).

continues

choices that humans do or do not make—choices that, regrettably, put the lives of emergency responders at risk.

While the basic responsibility for this type of mitigation must lie with political and municipal planning processes, emergency response organizations can and do play an important role with respect to:

- Advising corporations and the general public as to proper location of hazardous facilities and operations
- Providing guidelines for proper design and construction (Fig. 10.1) in areas subject to natural hazards (e.g., storm, flood, wildfire, tornado, earthquake)

Tips

Keep these points in mind when you anchor and brace propane tanks or compressed gas cylinders:

- Before you alter your propane tank in any way, make sure that the tank is your property and not rented from the propane supplier. Before welding new bracing to the tank legs, you must remove the gas from the tank. You should also check with your propane supplier to find out whether additional precautions are necessary.
- Clear the area around the propane tank to ensure that there are no tall or heavy objects that could fall on the tank or rupture the supply line.
- Keep a wrench near the shutoff valve and make sure the members of your family know how to turn off the supply line if they smell a gas leak. On larger tanks, such as farm tanks, consider installing a seismic shutoff valve that will automatically turn off the gas during an earthquake.
- Provide a flexible connection between the propane tank and the supply line and where the supply line enters the house. But keep in mind that adding a flexible connection to a propane tank line should be done by a licensed contractor, who will ensure that the work is done correctly and according to all applicable codes. This is important for your safety.
- To attach a compressed gas cylinder to a wall, use two lengths of chain around the cylinder -- one just below the top of the cylinder and one just above the bottom. The chains should be attached to eye hooks that are screwed into the wall. In wood-frame walls, the eye hooks must be long enough to penetrate not just the wall but the studs behind it as well. In concrete or masonry block walls, the eye hooks should be installed with expansion anchors or molly bolts.

Estimated Cost

Bracing and anchoring a propane tank will cost about $250. Having flexible connections installed on the tank and at the house will cost about $75. Attaching one gas cylinder to the wall will cost about $50.

Other Sources of Information

Seismic Retrofit Training for Building Contractors and Building Inspectors: Participant Handbook, FEMA, 1995

Reducing the Risks of Nonstructural Earthquake Damage: A Practical Guide, FEMA-74, 1994

Protecting Your Home and Business from Nonstructural Earthquake Damage, FEMA, 1994

To obtain copies of these and other FEMA documents, call FEMA Publications at 1-800-480-2520. Information is also available on the World Wide Web at http//:www.fema.gov.

FIGURE 10.1—*continued*

- Ensuring that the risks attendant to the various types of natural hazards are appropriately integrated into response procedures, the selection of personal protective clothing and equipment, and personnel training

4. Integrate Lessons Learned from Actual Incidents and Response Actions into both Proactive and Reactive Protocols and Methods

A basic tenant of mitigation is that, however high either the level of sophistication of emergency planning and prevention or the level of response preparedness, every emergency incident is a unique opportunity for learning how to plan and how to respond better (Fig. 10.2). This principle applies directly to response and nonresponse organizations with equal relevance.

MITIGATION MEASURES

Being essentially an interactive, community-wide partnership among all organizations having direct or indirect responsibility for managing human risk, mitigation is inclusive of a wide range of measures that contribute in diverse ways to the (a) prevention, (b) control and containment, and (c) minimization of risk. Many of these measures have long been used in both public and private sectors and are variously encapsulated in such phrases as "good engineering practices," "regulatory standards," "pollution control measures," "quality control measures," and (more recently), "green productivity" and "environmental management." As can be inferred from these phrases, the need to mitigate hazardous incidents has resulted not so much in the invention of whole new technologies as it has the marshaling of both existent and developing technologies toward the achievement of a specific common purpose.

Mitigation of Chemical Hazards

Because of the on-going proliferation of industrial chemicals in densely populated urban areas, renewed attention is being given to specific methods whereby industry can demonstrably reduce both the workplace and community risks associated with hazardous chemicals. It is important to emphasize that whatever an industrial plant does to protect workers and the surrounding community may also provide essential protection to emergency response personnel involved in a facility incident.

> ➢ Personnel working on or around water must wear appropriate personal flotation devices.
>
> ➢ Rotate crews and pace activities to avoid premature exhaustion. Don't let them get burned out in the initial stages of an incident — especially if it is likely to be an extended incident.
>
> ➢ Relieve the initial response personnel and remove them from the immediate operating area as soon as feasible. Critical Incident Stress Management (CISM) is an absolute must! Personnel who were involved in the incident report that their participation in CISM was of significant benefit to them.
>
> ➢ Rehabilitation, although difficult to establish in the tight operational environment of the scene, was an absolute necessity. Given the high temperatures, constant exposure to the sun, and dangerous working conditions, it was critical to ensure that personnel were rehabilitated on a regular, formal basis. Use a large tarp or parachute cloth to set up a shaded area for rehabilitation.
>
> ➢ Personnel should be rotated through various jobs on an extended incident to prevent them from being unduly subjected to too much of any particular sight, sound, smell, etc. Ensure that this rotation occurs even if they are being adequately rehabilitated with rest periods, fluids, and nourishment.
>
> ➢ Personnel must receive ample food and liquids. This will prevent dehydration (which is the most likely source of fatigue) and loss of energy. Care must be taken to ensure that responders do eat and drink as they may have a tendency to ignore sustenance in favor of continuing to work. Personnel must not eat on scene or prior to thoroughly washing their hands.
>
> ➢ In swampy areas, have ample supplies of mosquito repellent on hand. When working in the sun, make sure that sunblock is available to all personnel.

FIGURE 10.2 Lessons learned from train derailment (adapted from FEMA. Technical Rescue Incident Report: The Derailment of the Sunset Limited; September 11, 1993; Big Bayou Canot, Alabama).

Of particular importance are the following techniques, which presume both the redirected use of a current base of knowledge and developing technologies:

- Product reformulation
- Chemical substitution
- Alternative process engineering

In many instances, it is possible to reduce or effectively remove a hazard associated with a particular material or process. One of the hazards of a coolant oil, for example, may be toxicity due to a heavy metal constituent (e.g., cadmium). Such an oil may be reformulated to remove the heavy metal constituent and thus remove the hazard of heavy metal toxicity without impairing the usefulness of the coolant. This is an example of *product reformulation,* which is an increasingly important growth industry today precisely because of the concern for human health and safety and the integration of that concern into global marketing strategies.

Another hazard reduction strategy is *chemical substitution* which, though possibly involving a chemical reformulation of an existing product, primarily focuses on the substitution of a less hazardous chemical for a more hazardous substance. Examples include water-based paint substitutes for oil-based paints, non-chlorine bleaching agents for chlorine-containing bleaching agents, and certain botanical pesticides for synthetic pesticides.

In many situations, neither chemical reformulation nor a simple chemical substitution can be effectively employed. It may therefore become reasonable to consider *alternative process engineering,* as in reengineering a water treatment plant to accomplish disinfection by an ozonation process rather than a chlorination process—an engineering alternative that could significantly reduce both facility and community risk due to catastrophic releases of chlorine caused either by natural phenomena (e.g., earthquake, flood) or by human error. Such an alternative would also, of course, significantly reduce the probability of an incident requiring emergency response services as well as the risk presented to emergency response personnel should they be needed.

In order to minimize the risk associated with a chemical hazard that cannot itself be reduced, it is necessary to minimize exposure. This is accomplished by implementing exposure-control approaches in the following order:

- Management (or executive, or administrative) control, which includes the management of schedules, assignments, and procedures to minimize the frequency and duration of exposure to specific hazards
- Engineering control, which involves the use of space, barriers, and ventilation to limit and isolate exposure
- Personal protective clothing and equipment

Both management control and engineering control approaches are of particular importance to reducing risk not only at the workplace, but also off-site in the surrounding community.

Specific examples of management and/or engineering control approaches include:

1. *efficiency improvement,* which is the redesign of production processes to improve the efficiency by which hazardous materials are processed; increased efficiency can result in decreased amounts of on-hand hazardous chemicals as well as hazardous waste

2. *in-process recycling,* which involves the re-routing of hazardous materials directly back into a production process, and which can therefore result in reduced inventories of feedstock and hazardous waste

3. *fugitive release control,* which includes the prevention, entrapment, and/or containment of spills, leaks, and air emissions of hazardous substances

4. *chemical inventory control,* which includes any policy or procedure affecting the purchase and storage of hazardous feedstock chemicals

The reduction in feedstock chemicals and hazardous waste through efficiency improvement and in-process recycling are particularly relevant to emergency response planning not only because they can reduce the probability of large releases of hazardous chemicals (and, therefore, of incidents requiring response) but also, should an incident occur, the risk of exposure presented to the public and to emergency response personnel.

Fugitive release control, especially those measures taken by industry to implement immediate containment of leaks and spills, can mean the difference between a minor incident that can be easily handled by in-plant operational personnel or first responders and a major incident that requires extensive community response services. With respect to incident response services themselves, fugitive release control must be given special attention in the progress of several operationally related activities, including:

a. The control of runoff of water and foams used for fighting fires, which may be contaminated with on-site hazardous chemicals and which could contaminate both subsurface and downstream surface water supplies,
b. The control of wind-borne hazardous particles and other contaminated materials released on-site during and after the incident,
c. The control and containment of incident-related releases (e.g., through tank rupture and other structural failures) of on-site feedstock chemicals, fuels, and hazardous wastes), and
d. The control, containment, and subsequent disposal of waste water and other contaminated materials generated during the decontamination of equipment and clothing used during response operations.

Of all the types of management control approaches to the mitigation of risks associated with industrial chemicals, inventory control is probably the most crucial. However, it is also the approach that most often conflicts with standard operating procedures within industrial bureaucracies. This is because the purchasing function in companies, which is intimately connected to finance and production functions, is typically independent of any corporate authority regarding health and safety.

The objective of the purchasing department is to obtain process-feedstock, analytical, special purpose, and/or general-housekeeping chemicals on schedule with regard to plant operations and at or under cost guidelines. It is typically not the objective of purchasing to assess the potential for substitute chemicals having less severe hazards than ordered chemicals, nor to minimize the day-to-day on-site volume of hazardous chemicals. In fact, because the costs of chemicals can be reduced by bulk buying, usual purchasing guidelines generally result in the purchase of volumes in excess of specific operational needs.

The bulk buying of hazardous chemicals results, of course, in the on-site storage of larger volumes of hazardous chemicals than are necessary, with consequent increase in the potential for:

- Major spills, leaks that can result in explosion, fire, uncontrolled reactions, and toxic releases
- The development of an actual emergency due to unstable or reactive chemicals being stored beyond their safe shelf-life (e.g., chemicals that produce organic peroxides)
- The development of a hazardous chemical emergency due to environmental factors (e.g., heat) and/or natural disasters (e.g., flood, earthquake)
- Increased exposure of response and other personnel as well as the general public to hazardous chemicals

The only practical approach toward ensuring that the purchasing function does not lead or contribute to hazardous chemical incidents is to integrate that function into a facility-wide health and safety program. This is most effectively accomplished by inserting the health and safety officer into the chemical procurement decision-making loop, which extends from the determination of operational needs and specifications to the actual purchase of chemicals.

The impact of inventory control on emergency planning and response extends, of course, well beyond the purchase of chemicals. Inventory control also includes protocols that govern the manner in which chemicals are actually stored and handled. Too often, the storage and handling of chemicals is based solely on grounds of production needs and convenience rather than on an understanding of those physical and chemical characteristics of chemical feedstocks that determine their potential for initiating or exacerbating an emergency.

For example, the vapor density of many commonly used flammable industrial solvents (e.g., ethanol, acetone, benzene) is greater than the density of air (Table 10.1). The direct consequence of this physical characteristic is that such vapors fall to the bottom of the air column (rather than rising to the top), with potential subsequent risk of an incident due to:

TABLE 10.1 Vapor Density (vd) Relative to Air for Common Industrial Solvents (vd_{Air} = 1.0)

Vapor Density for Common Solvents
(relative to air)

Methanol	1.1
Ethanol	1.6
Acetone	2.0
Isopropanol	2.1
Butanol	2.5
Tetrahydrofuran	2.5
Petroleum ether	2.5
Benzene	2.8
Furfural	3.3
Isopropyl ether	3.5
Heptane	3.5
n-Butyl ether	4.5

- *Collection of explosive fumes in subfloor conduits used for electrical wiring and junctions:* explosion could occur in these room conduits; also, because subfloor conduits often extend beneath walls, an explosion could occur at fume collection points far removed from the source of fumes and/or extend (through flashback) throughout plant conduit system
- *Collection at lower floor levels of explosive fumes released on upper floor levels:* this is a particularly dangerous situation because fumes could flow from upper level production areas to lower level areas where cafeterias, smoking-break areas, or other locations where open sparks or flame could ignite the fumes and cause flashback to source areas
- *Misplacement of intake to exhaust ventilation:* in storage areas having exhaust ventilation, the intake to the ventilation system must be at floor level in order to exhaust high-density fumes; misplacement of intake at higher levels, which does not guarantee exhaust of high-density fumes, will lead to a sense of false security. Also, external exhaust of such fumes should be high enough to ensure that there is no contact with sparks or flames (e.g., an outside smoking area or location where there is open-arc machinery).

Regulation-Based Mitigation Methods

While regulations are typically viewed by industry simply as constraints imposed by government on business operations, they are also key sources of information regarding the mitigation of hazards that, if not appropriately addressed, may result in incidents requiring emergency response or otherwise result in conditions that present unnecessary risk to emergency response personnel.

Regardless of the type of hazard or risk addressed by any particular regulation, regulations generally define a wide range of alternative mitigation strategies that may be used to minimize the probability of occurrence and the magnitude of potential incidents, including (a) general policies, (b) analytical and assessment methods for determining the need for mitigation, (c) criteria for selecting appropriate measures from among alternative administrative and engineering mitigation techniques, (d) criteria for selecting, testing, and maintaining personal protective clothing and equipment, (e) ambient monitoring and medical surveillance techniques, and (f) personnel training objectives and methods.

Of particular importance as sources of information regarding effective mitigation measures for American industry are the following OSHA regulations:

- 29 CFR 1910.95 *(Hearing Conservation)*—Requires the development of a written program that is inclusive of the ambient monitoring of workplace noise, noise reduction strategies, the selection and proper use of appropriate hearing protectors, and the medical surveillance of personnel
- 29 CFR 1910.109 *(Process Safety Management of Explosive and Blasting Agents)*—Requires the development of written SOPs regarding all aspects of the use of explosive and blasting agents, including marking and labeling, personnel training, and personal protective equipment and clothing
- 29 CFR 1910.119 *(Process Safety Management of Highly Hazardous Chemicals)*—For companies that handle any of more than 135 listed chemicals at or above threshold quantities, requires the development of written SOPs regarding the analysis of potential hazards and appropriate use of alarms and other fail-safe systems for preventing and containing chemical releases; includes requirements for a written management-of-change program
- 29 CFR 1910.120 *(Hazardous Waste Operations and Emergency Response)*—Requires the development of a written emergency response plan that will minimize risks to employees engaged in cleanups at uncontrolled hazardous waste sites, in routine operations and corrective actions at RCRA regulated facilities, and in other emergency response activities without regard to location
- 29 CFR 1910.134 *(Respiratory Protection)*—Requires the development of a written respiratory protection program that is inclusive of the selection, use, and maintenance of respirators as well as personnel training, fit testing, and medical surveillance

- 29 CFR 1910.146 *(Confined Space Entry)*—Requires the development of written SOPs and facility permits for working within areas having limited openings for human entry and egress and which may present physical and/or chemical hazards; includes specific requirements for response personnel who enter confined spaces for the purpose of rescue
- 29 CFR 1910.147 *(Energy Control; Lockout/Tagout)*—Requires the development of written SOPs that direct the servicing of machines and equipment in which unexpected energization or the release of stored energy could cause physical injury to employees performing maintenance tasks
- 29 CFR 1910.252 *(Hotwork)*—Requires the development of written SOPs and facility permits for performing work that results in the generation of an open flame, spark, or (by any other means) sufficient heat to cause fire or explosion, including such commonly performed work as welding, grinding, drilling, and cutting
- 29 CFR 1910.331-.335 *(Electrical Safety-Related Work Practices)*—Requires the development of written procedures and training for personnel who, by the nature of their work, can be expected to work with or near an electrical hazard, as well as personnel who may accidentally become exposed to an electrical hazard
- 29 CFR 1910.1030 *(Bloodborne Pathogens)*—Requires the development of a written exposure control plan to prevent the exposure of personnel to bloodborne pathogens; includes specific requirements regarding the development of SOPs, the use of personal protective clothing and equipment, and personnel training
- 29 CFR 1910.1200 *(Hazard Communication Standard; Right-to-Know)*—Requires the development of a written program that provides employees specific information about workplace chemical hazards and the various means used to protect employees from those hazards
- 29 CFR 1910.1450 *(Laboratory Standard)*—Requires the development of written SOPs regarding the determination of chemical hazards, the use of MSDSs, and personnel training designed to protect laboratory personnel from chemical exposure; essentially a more stringent application of the Hazard Communication Standard to laboratories

The above list of regulations does not exhaust the OSHA regulations that are relevant to emergency response services and operations, but does give a good representation of more recent OSHA regulations that underscore the comprehensive scope of contemporary hazard management in industry. As well, other regulations promulgated by other agencies (e.g., EPA hazardous waste regulations; DOT hazardous materials regulations; NIOSH respiratory standards; EPA SARA Title III regulations) are equally relevant and should be carefully reviewed by response services not only with respect to potential compliance requirements but, even more importantly, with respect to types of mitigation strategies and methods. It should be noted that many regulations include nonmandatory (as well as mandatory) appendices that typically contain very useful information and guidelines for designing and managing mitigation programs.

Another vitally important reason that community response services should become thoroughly familiar with industrial regulations related to hazard and risk mitigation is that they are thereby better prepared to advise local industrial facilities of minimal acceptable standards and, as appropriate, to work with individual corporations to ensure the implementation of adequate policies and programs that can reduce the probability of in-plant incidents and/or of unnecessary risks to emergency response personnel and to the public at-large during any incident that may nonetheless occur.

Mitigation Methods Employed by Professional Response Services

As important as it is for any response service to keep abreast of technological developments (e.g., chemical substitution, alternative process engineering) and regulatory standards, perhaps the most practical information on effective in-service mitigation methods is available through peer professional organizations, including other response service organizations (community fire services, local search and rescue services), professional associations (e.g., NFPA), and governmental emergency service agencies (e.g., FEMA, state emergency response agencies). With the advent of Internet and ready accessibility to personal computers, instantaneous linkage with such organizations gives good assurance that in-service mitigation protocols, procedures, and equipment are continually improved by actual field experience as well as by new developments in technology.

Information readily available includes criteria, procedures, methods, equipment, and technical assessments having both broad and specialized relevance to any comprehensive in-service mitigation program.

For example, ergonomic criteria developed for the selection of tools by one type of response service (Fig. 10.3) can be readily adapted to the needs of other services, regardless of any dissimilarity of incident-related roles and responsibilities. In the same manner, protocols found to be effective by fire services for selecting personal protective clothing and equipment (Fig. 10.4) can be readily adapted to meet comparable needs in swift-water search and rescue and many other specialized services.

Specialization and compartmentalization are thoroughly pervasive attributes in any type of human endeavor and, unfortunately, typically result in the proliferation of distinct jargon, informational sources, and, perhaps more importantly, attitudes that isolate groups that otherwise have a common purpose. With respect to community response services (which certainly

It is important to find out how the equipment feels when being used before instructing a fire fighter or EMT to use new equipment. Tools should be tried out and the potential users should understand how they are used and how they feel before being specified.
Hand tools should be selected which are designed so that the wrist can maintain a straight and neutral position. Whenever possible, tools should be chosen that have been designed to reduce vibration and which do not transmit torque to the hand and arm. Power tools are preferred because they reduce the force and exertion required to perform the task. All devices must be designed for safe operation.
Tool balancers should be used where possible. The center of gravity must be aligned with the center of the grasping hand; this provides the leverage necessary to keep the tool in alignment. Tools that are continuously held should weigh approximately one to two pounds. Any heavier tools should be counterbalanced.
Handles should contact as much of the hand and fingers as possible. Handles should be approximately 1.25 – 1.75 inches in diameter. The minimum handle length should be 5 inches. Tools requiring both hands should provide two handles. Handles should be positioned to reduce awkward positions, and have a maximum distance of 2.7 inches. Tools should be equipped with a comfortable grip span between the thumb and forefinger. Vibration dampening materials should be incorporated in or on tool handles. These materials can also be incorporated into gloves. Where possible, use slip-resistance material for tool handles.
Narrow tool handles which concentrate large forces onto small areas of the hand or grips with finger grooves, ridges, or recesses should be avoided. Short tool handles that press into the palm of the hand and tools that exert force onto the sides or back of the hand should be avoided. Power tools that must be grasped by the motor housing should be avoided. Evaluate pinch points, sharp edges, vibration transmitted to the user, tool exhaust air directed toward the wrist or other parts of the body, and excessive noise.
Safety features should be maintained as originally designed. Knives and other tools with a cutting edge must be kept sharp. A regularly scheduled tool maintenance program should be established.

FIGURE 10.3 Ergonomic criteria for selecting tools (adapted from U.S. Fire Administration, 1996: Fire and Medical Services Ergonomics).

do have a common purpose) and, more specifically, to mitigation (which must become a community-wide objective), it is therefore of paramount importance to recognize that all response services, regardless of the special risks engendered by their specific roles, must deal with certain categories of risk that are common to all, including those risks related to the performance levels of personnel, inappropriate protective clothing and equipment, administrative failures, and problems with communication equipment and procedures (Table 10.2). Risk management techniques designed by one type of service to minimize such risks should therefore be carefully reviewed by other services and, as appropriate, adapted to meet needs that, though similar, may differ to some degree in the operational context of an actual incident.

1. **Identify the specific needs of your department**
• Examine current problems or injuries in using protective clothing and equipment. Determine what performance is needed to overcome these limitations.
• Consider current protective clothing and equipment and its compatibility with the items to be purchased.
• Determine if there are specific areas of protection that are required but are not covered in available specifications.
• Decide on clothing sizing and design issues. For example, your department may have a preference for clothing color and trim style. Also, special pockets maybe required to hold radios or other equipment.

2. **Write specification that will meet these needs**
• Solicit help from other organizations (such as NAFER or SAFER) or departments who may have already developed specifications that you can use or modify.
• Use NFPA standards as the basis for purchase specifications. If deviations from a NFPA standard are made, thoroughly document the reasons for the deviations. This limits department liability.
• If trying to purchase specific manufacturer products, determine those product characteristics that are unique which can be specified.
• Establish rating criteria ahead of time that will allow you to evaluate products to your specification.
• Include provision for returning unsatisfactory products and assessing penalties if bid specifications are not met.

FIGURE 10.4 Guidelines for selecting and procuring fire-fighting protective clothing and equipment (adapted from U.S. Fire Administration, 1993: Minimum Standards on Structural Fire Fighting Protective Clothing and Equipment: A Guide for Fire Service Education and Procurement [FA-137]). *continues*

There are, of course, certain mitigative techniques that must be assiduously employed in precisely the same manner by any response service that may have jurisdictional control of incident response. For example, in a prolonged response effort in an isolated area where potable water for responding personnel is problematic, disinfection of drinking water must be implemented in standard fashion, regardless of type of incident or jurisdictional control. The fact that recommended procedures for disinfecting water may vary from state to state (Fig. 10.5) may therefore require that preincident interagency planning and coordination efforts produce a consensual disinfection procedure. Similarly, other mitigative actions must be addressed and resolved by preincident consensus, including (a) proper health maintenance of responders regarding the control of insects and other potential disease-vectors and operational nuisances, (b) location and design of temporary morgues, sanitary facilities, and personnel shelter and rehabilitation areas, and (c) local disposal of incident-related debris and other potentially contaminated materials.

Internet linkages to governmental and professional organizations having specific response expertise are invaluable resources not only for re-

3. Solicit bids for the clothing or equipment needed

- Increase purchasing power by forming collective buys with other departments to obtain larger quantities at volume discounts.
- Require manufacturers to provide one or more samples that can be evaluated. Develop a test plan to evaluate the sample and compare its performance to competing products.
- Specify that manufacturers show evidence of compliance with the appropriate NFPA standard. Have manufacturers supply all data showing compliance of their product in a format that will allow your department to compare all competing products easily.
- Require manufacturers provide complete user instructions and copies of warranties and technical data for examination.

4. Thoroughly evaluate bids

- Carefully check sample clothing against the developed specification.
- Examine information supplied with the products such as instructions, warranties, and technical data. Look for completion of the information and ease of its use.
- Employ an evaluation system to rate products.
- Physically wear or use equipment to ensure that it meets original specifications.

5. Evaluate the performance of clothing or equipment to determine if it does meet the original needs

- Once clothing or equipment has been received, establish SOPs for its use, care, and maintenance.
- Periodically review how clothing or equipment meets fire department needs.
- Revise specifications as needed for new or replacement clothing and equipment. Use the standard as the basis for your specifications.

FIGURE 10.4—*continued*

sponse services, but also for industry as well as the general public. Some of these links (Fig. 10.6) provide immediate access to chemical hazard databases, hazmat-related information, and specific alerts regarding both sources and potential mitigation of various types of hazards. Most links also provide access to international (Fig. 10.7) as well as national sources of information regarding mitigation.

ALL-HAZARD MITIGATION

Environmental and workplace health and safety regulations in the United States have emphasized the importance of (a) assessing the potential impacts of various types of industrial hazardous incidents (e.g., fire, chemical release) and natural disasters (e.g., flood, earthquake) on workplace and community health and safety, and (b) taking effective actions to mitigate the probability and magnitude of such impacts. While governmental agencies

TABLE 10.2 Source of Risk and Corrective Actions (Adapted from U.S. Fire Administration, 1996: Risk Management Practices in the Fire Service [FA-166])

Potential Source of Risk	Risk Management Technique
Personnel	
• Failure to meet minimum performance requirements	➢ Establish minimum performance
• Failure to properly train	➢ Establish and conduct performance-based training for all personnel
....	➢ Training should conform to relevant OSHA, NFPA, and other standards
• Failure to adequately equip personnel	➢ Provide protective equipment that meets NFPA standards
Fire Inspection Practices	
• Failure to notify owners of hazards	➢ Require complete records of every inspection
• Failure to pursue compliance	➢ Consistently issue citations and seek judicial intervention when hazards are imminent
Administration	
• Level of service not defined	➢ Define level of service for all service deliverables
• Incomplete records	➢ Document and address all complaints promptly
Communication	
• Failure to dispatch promptly	➢ Ensure that specific dispatch policies are in place and that performance is monitored
• Failure to properly advise callers of potential delay	➢ Establish policy and procedure to address these issues

have demonstrably moved to integrate response to human-caused and natural disasters into an all-hazard approach to hazard and risk mitigation, much of American industry has failed to do so, persisting in looking at disaster through a regulatory-induced myopia.

The all-hazard approach is based on the recognition that any distinction between human-made and nature-made disaster is essentially irrelevant to the risk to human life and health presented by an actual emergency. Just as the risks imposed by a natural disaster such as flood or earthquake can be

Disinfection of Drilled Wells

1. Determine the amount of water in the well by multiplying the gallons per foot (***Table 1***) by the depth of the well in feet. For example, a well with a 6-inch diameter contains 1.5 gallons of water per foot. If the well is 120 feet deep, multiply 1.5 by 120 (1.5 gal/ft x 120 ft = 180 gallons).
2. For each 100 gallons of water in the well, use the amount of chlorine (liquid or granules) indicated in ***Table 2***. Mix the total amount of liquid or granules with about 10 gallons of water.
3. Pour the solution into the top of the well before the seal is installed.
4. Connect a hose from a faucet on the discharge side of the pressure tank to the well casing top. Start the pump. Spray the water back into the well and wash the side of the casing for at least 15 minutes.
5. Open every faucet in the system and let the water run until the smell of chlorine can be detected. Then close all the faucets and seal the top of the well.
6. Let stand for several hours, preferably overnight.
7. After you have let the water stand, operate the pump by turning on all faucets, continuing until all odor of chlorine disappears. Adjust the flow of water from faucets or fixtures that discharge into septic tank systems to a low flow to avoid overloading the disposal system.

Table 1

Diameter of Well (in inches)	Gallons per Foot of Water
3	0.37
4	0.65
5	1.0
6	1.5
8	2.6
10	4.1
12	6.0

Table 2

Laundry Bleach (5.25 % Chlorine) ——▶ 3 cups*

Hypochlorite Granules (70% Chlorine) —▶ 2 ounces**

* 1 Cup = 8-ounce measuring cup
** 1 Ounce = 2 heaping tablespoons of granules

Source: Illinois Department of Public Health
Note: Recommendations may vary from state to state

FIGURE 10.5 Directions for disinfecting drilled wells (adapted from Centers for Disease Control and Prevention, National Center for Environmental Health. Flood: A Prevention Guide to Promote Your Personal Health and Safety, NCEH Electronic Reference Library).

magnified by subsequent releases of hazardous chemicals or uncontrolled chemical reactions, so the risks imposed by chemical or biological contamination can be magnified by a natural disaster. This recognition of the actual concomitancy of human-made and nature-made risks reflects, perhaps, our growing appreciation of some of the more dire consequences of the simultaneous urbanization of world society and the rapidly expanding dependency of that society on industrial technology.

There can be no question that industry must continue to improve its mitigation measures with respect to specific types of hazards, such as fire and the release of hazardous materials and wastes (Table 10.3). However, industry must also significantly increase its effort to evaluate the consequences of facility-related operations and chemical inventories in light of disasters

Preparedness and Response Links to the Internet

Responders' Toolbox: Chemical, Safety, Health, and Risks

+ **Agency for Toxic Substances and Disease Register (ATSDR) – HazDat Databases** This Hazardous Substance Release/Health Effects Database provides access to information on the release of hazardous substances from Superfund sites or from emergency events and on the effects of hazardous substances on the health of human populations. (Source: ATSDR/HHS)

+ **Agency for Toxic Substances and Disease Registry ToxFAQs Menu** - Searches on information of toxic hazardous substances. (Source: ATSDR/HHS)

+ **Center for Disease Control Sites Query** - Specific facility information for particular sites, such as counties, facility type, etc. (Source: ASTDR)

+ **Emergency Response & Research Institute - EmergencyNet News Service** - Provides direct links to hazmat-related information such as Hazardous Materials Operations Page, Disaster/Rescue Operations Page, etc. (Source: EmergencyNet)

+ **Chemical Safety Alert - "Rupture Hazard of Pressure Vessels" (May 1997)** - An EPA/CEPPO Alert document containing information to protect human health and the environment by preventing chemical accidents. This document provides information on the hazards of improperly operated or maintained pressure vessels that could rupture. Currently only available in **Adobe PDF** format. (Source: CEPPO)

+ **Chemical Safety Alert - "Fire Hazard from Carbon Absorption Deodorizing Systems" (May 1997)** - An EPA/CEPPO Alert document containing information to protect human health and the environment by preventing chemical accidents. This document provides information on activated carbon systems used to adsorb vapors for control of offensive odors. Currently only available in **Adobe PDF** format. (Source: CEPPO)

+ **Chemical Safety Alert - "Catastrophic Failure of Storage Tanks" (May 1997)** - An EPA/CEPPO Alert document containing information to protect human health and the environment by preventing chemical accidents. This document provides information on the catastrophic failure of aboveground, atmospheric storage tanks. Currently only available in **Adobe PDF** format. (Source: CEPPO)

+ **Chemical Safety Alert - "Lightning Hazard to Facilities Handling Flammable Substances" (May 1997)** - An EPA/CEPPO Alert document containing information to protect human health and the environment by preventing chemical accidents. This document provides precaution information for industry in case lightning strikes hit equipment and storage or process vessels containing flammable materials. Currently only available in **Adobe PDF** format. (Source: CEPPO)

FIGURE 10.6 Key internet links and information available through U.S. National Response Team homepage (NRT Electronic Library).

beyond its control, such as hurricane, tornado, flood, winter storm, earthquake, and power outage (Table 10.4). Of course, another increasingly important source of risk that is typically beyond the operational control of industrial facilities is terrorism. Specifically, industry must consider:

1. how such natural disasters as well as terrorism can cause facility-related operations, chemical feedstock, and hazardous wastes to become additional sources of risk to community health and safety,

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FIGURE 10.7 Example of U.S. International Trade Administration alert on handbook relevant to hazard and risk mitigation (International Trade Administration, Electronic Reference Library).

2. what managerial and/or engineering means of mitigation can be implemented to reduce those risks, and
3. what quality control measures must be implemented to ensure the effective implementation of selected mitigation measures.

SHIFT IN PARADIGM

Throughout the world, the phrase *shift- in paradigm* is used to denote a significant change in perspective if not methodology in the conduct of any

TABLE 10.3 Basic Steps in Fire and Hazardous Material Incident Mitigation (Adapted from FEMA Emergency Management Guide for Business, FEMA Electronic Library)

Fire Mitigation

- Meet with fire department to talk about community fire response capabilities; discuss your operations; identify processes and materials that could cause or fuel a fire, or contaminate the environment in a fire
- Have facility inspected for fire hazards; ask about fire codes and regulations
- Request insurance carrier to recommend fire prevention and protection measures; carrier may also offer training
- Distribute fire safety information to employees regarding: how to prevent workplace fire; how to contain a fire; how to evacuate the facility; where to report a fire
- Instruct personnel to use the stairs — not elevators — in a fire; instruct them to crawl on their hands and knees when escaping a hot or smoke-filled area
- Conduct evacuation drills; post maps of evacuation routes in prominent places; keep evacuation routes, including stairways and doorways, clear of debris
- Assign fire wardens for each area to monitor shutdown and evacuation procedures
- Establish procedures for the safe handling and storage of flammable liquids and gases
- Establish procedures to prevent the accumulation of combustible materials
- Provide for the safe disposal of smoking materials
- Establish preventive maintenance schedule to keep equipment operating safely
- Place fire extinguishers in appropriate locations
- Train employees in use of fire extinguishers
- Install smoke detectors; check smoke detectors once a month; change batteries at least once a year
- Establish system for warning personnel of a fire; consider installing a fire alarm with automatic notification to the fire department
- Consider installing a sprinkler system, fire hoses and fire-resistant walls and doors
- Ensure that key personnel are familiar with all fire safety systems
- Identify and mark all utility shutoffs so that electrical power, gas or water can be shut off quickly by fire wardens or responding personnel
- Determine the level of response facility will take if a fire occurs, considering the following options: (a) immediate evacuation of all personnel on alarm, (b) all personnel are trained in fire extinguisher use; personnel in immediate are of a fire attempt to control it; if they cannot, the fire alarm is sounded and all personnel evacuate, (c) only designated personnel are trained in fire extinguisher use, (d) a fire team is trained to fight incipient-stage fires that can be controlled without protective equipment or breathing apparatus; beyond this level of fire, the team evacuates, (e) a fire team is trained and equipped to fight structural fires using protective equipment and breathing apparatus

continues

enterprise, whether in science, business, government, or any other sphere of professional or technical endeavor. Such a change in perspective or methodology begins with a clear recognition that the former way of doing things does not work—that current objectives have outstripped long-established techniques and that, if current objectives are not to be abruptly abandoned,

TABLE 10.3—*continued*

Hazardous Material Incident Mitigation

- Identify and label all hazardous materials stored, handled, produced and disposed of by facility; follow government regulations that apply to facility and operations; obtain material safety data sheets for all hazardous materials at facility
- Ask local fire department for assistance in developing appropriate response procedures
- Train employees to recognize and report hazardous material spills and releases; train employees in proper handling and storage
- Establish a hazardous material response place, including:
  1. procedures to notify management and emergency response organizations of an incident,
  2. procedures to warn employees of an incident, and
  3. procedures for evacuating facility
- Depending on operations, organize and train an emergency response team to confine and control hazardous materials spills in accordance with applicable regulations
- Identify other facilities in area that use hazardous materials; determine when an incident could affect your facility
- Identify highways, railroads and waterways near facility used for the transportation of hazardous materials; determine how a transportation accident near your facility could affect your operations

new methodologies, technologies, and/or new approaches must be constructed and implemented.

The all-hazard approach to mitigation constitutes such a shift in paradigm. At both federal and state levels of government, it cuts across long-established boundaries of jurisdictional authority, forcing not only a significant increase in interagency cooperation, but also a growing partnership among federal and state authorities as well as private sector organizations and corporations. But the shift in paradigm required for effective all-hazard mitigation does exact specific costs, whether paid by governmental agencies or corporations.

For governmental agencies, the cost is certainly a blurring of jurisdictional authority that too often results in confusion in the midst of incident response. It can be expected that innovative procedures, such as recent formulations of *unified command* and *unified contingency plans,* will continue to be explored to reduce this confusion.

For industry, the cost is not measured in jurisdictional authority but, rather, in changing social expectations of moral and legal responsibility. For example, in Southeast Asia, various governments have made substantial effort to establish as a working principle the dictum: *those who are responsible*

TABLE 10.4 Basic Steps in Mitigation with Respect to Natural Disasters (Adapted from FEMA Emergency Management Guide for Business, FEMA Electronic Library)

Hurricane & Tornado Mitigation

Hurricane

- Review communication evacuation plans
- Establish facility shutdown procedures; establish warning and evacuation procedures; make plans for assisting employees who may need transportation
- Make plans for communicating with employees' families before and after a hurricane
- Purchase a NOAA Weather Radio with a warning alarm tone and battery backup; listen for hurricane watches and warnings
- Survey facility and take steps to protect outside equipment and structures
- Protect windows; permanent storm shutters offer the best protection; covering windows with 5/8 inch marine plywood is another option
- Consider the need for back-up systems: portable pumps; alternative power sources; battery-powered emergency lighting
- Prepare to relocate records, computers and other items within facility or to another location

Tornado

- Review community tornado warning system
- Purchase a NOAA Weather Radio with a warning alarm tone and battery backup; listen for tornado watches and warnings
- Establish procedures to inform personnel when tornado warnings are posted; consider the need for spotters to be responsible for looking out for approaching storms
- Work with structural engineer or architect to designate shelter areas in facility; ask local emergency management office or National Weather Service office for guidance
- Consider the amount of space needed; adults require about six square feet of space; nursing home and hospital patients require more space
- If an underground protective area is not available, consider: small interior rooms on lowest floor and without windows; hallways on lowest floor away from doors and windows; rooms constructed with reinforced concrete, brick or block with no windows and heavy concrete floor or roof system; protected areas away from doors and windows. *Note: auditoriums, cafeterias and gymnasiums that are covered with a flat, wide-span roof are not considered safe.*
- Make plans for evacuating personnel away from lightweight modular offices or mobile home-size buildings; these structures offer no protection from tornadoes.
- Conduct tornado drills
- Once in a shelter, personnel should protect their heads with their arms and crouch down.

continues

for causing hazards and risks are precisely the persons who have primary responsibility for controlling those hazards and risks.

That industry, wherever it might be, now has the primary responsibility for mitigating those hazards and risks posed to the community in which it conducts its operations is, perhaps, an arguable question under locally relevant law—but, that there is a significant world-wide trend toward holding not only corporations but also their owners and officers to such a stan-

TABLE 10.4—*continued*

Flood Mitigation

Planning Measures

- Determine location of facility in relation to flood plain and elevation in relation to streams, rivers and dams
- Review community emergency plan and community evacuation routes; know where to find higher ground in case of flood
- Establish warning and evacuation procedures for facility; make plans for assisting employees who may need transportation
- Inspect areas in facility subject to flooding; identify records and equipment that can be moved to a higher location; make plans to move records and equipment in case of flood
- Purchase a NOAA Weather Radio with a warning alarm tone and battery backup; listen for flood watches and warnings
- Consider feasibility of flood-proofing facility

Permanent Flood-proofing Measures

- Fill windows, doors or other openings with water-resistant materials such as concrete blocks or bricks
- Install check valves to prevent water from entering where utility and sewer lines enter facility
- Reinforce walls to resist water pressure; seal walls to prevent or reduce seepage
- Build watertight walls around equipment or work areas within facility that are susceptible to flood damage
- Construct floodwalls or levees outside facility to keep flood waters away
- Elevate facility on walls, columns or compacted fill

Contingent Flood-proofing Measures

- Install watertight barriers called flood shields to prevent passage of water through doors, windows, ventilation shafts or other openings
- Install permanent watertight doors
- Construct movable floodwalls
- Install permanent pumps to remove flood waters

Emergency Flood-proofing Measures

- Build walls with sandbags
- Construct double row of walls with boards and posts to create a crib and fill crib with soil
- Construct a single wall by stacking small beams or planks on top of each other
- Consider need for back-up systems: portable pumps; alternative power sources; battery-powered emergency lighting
- Participate in community flood control projects

continues

TABLE 10.4—*continued*

Severe Winter Storm & Earthquake Mitigation

Severe Winter Storm

- Listen to NOAA Weather Radio and local radio and television stations for weather information
- Establish procedures for facility shutdown and early release of employees
- Store food, water, blankets, battery-powered radios with extra batteries and other emergency supplies for employees who become stranded at the facility
- Provide a backup power source for critical operations
- Arrange for snow and ice removal from parking lots, walkways, loading docks, etc.

Earthquake

- Assess facility vulnerability to earthquake; ask local governmental agencies for seismic information for area
- Have facility inspected by structural engineer; develop and prioritize strengthening measures, including: adding steel bracing to frames; adding sheer walls to frames; strengthening columns and building foundations; replacing un-reinforced brick filler walls
- Inspect non-structural systems such as air conditioning, communications and pollution control systems; assess potential for damage and prioritize preventive measures
- Inspect facility for any item that could fall, spill, break or move during an earthquake, and take steps to reduce these hazards
- Move large and heavy objects to lower shelves or the floor; hang heavy items away from where people work
- Secure shelves, filing cabinets, tall furniture, desktop equipment, computers, printers, copiers and light fixtures
- Secure fixed equipment and heavy machinery to the floor; larger equipment can be placed on casters and attached to tethers which attach to wall
- Add bracing to suspended ceilings; install safety glass; secure large utility and process piping
- Keep copies of design drawings to be used in assessing facility safety after an earthquake
- Review processes for handling and storing hazardous materials: store incompatible chemicals separately
- Establish post-earthquake evacuation procedures
- Designate areas away from exterior walls and windows where occupants should gather after an earthquake if an evacuation is not necessary
- Conduct earthquake drills; provide personnel with following information: (a) during earthquake, if indoors, stay there; take cover under sturdy furniture or counter; brace against inside wall; protect head and neck, (b) if outdoors, move into the open, away from buildings, street lights and utility wires, (c) after earthquake, stay away from windows, skylights and items that could fall; do not use elevators, (d) use stairways to leave building if it is determined that a building evacuation is necessary

continues

TABLE 10.4—*continued*

Technological Mitigation
(Technological emergency is any interruption or loss of a utility service, power source, life support systems, information system or equipment needed to keep business in operation)
• Identify all critical operations, including: a. utilities, including electric power, gas, water, hydraulics, compressed air, municipal and internal sewer systems, wastewater treatment services b. security and alarm systems, elevators, lighting, life support systems, heating, ventilation and air condition systems, electrical distribution system c. manufacturing equipment, pollution control equipment d. communication systems, both data and voice computer networks e. transportation systems, including air, highway, railroad and waterway
• Determine the impact of service disruption to each system • Ensure that key safety and maintenance personnel are thoroughly familiar with all building systems • Establish procedures for restoring systems • Determine need for backup systems • Establish preventive maintenance schedule for all systems and equipment

dard cannot be questioned. In the United States, this trend is well established (if not boldly enunciated) in the plethora of health and safety regulations implemented over the past 15 years; it is also becoming increasingly documented in the case law used in both civil and criminal proceedings.

What, therefore, does an all-hazard approach to hazard and risk mitigation actually portend if not yet signify to industry? Simply, that whatever the specific circumstance, whatever the sequence of specific causes and specific effects, and whatever the level of compliance to specific regulations, corporate owners, officers, and operators (and, perhaps even corporate boards of directors; even investors) are increasingly at personal financial and criminal risk if they do not take effective measures to mitigate the hazards and risks they present to the community by way of both their on- and off-site operations.