CHAPTER IV

INTERAGENCY COORDINATION

OSHA and EPA are the two Federal agencies with primary responsibility for investigating catastrophic chemical accidents. A third agency, the U.S. Coast Guard, which is entrusted with saving life and property on and over the nation's navigable waters and with providing for the safe movement of vessels, particularly during hazardous conditions, also may have significant responsibilities in the event of certain catastrophic chemical releases, such as the one at the Phillips Complex.

These three Federal agencies--OSHA, EPA and its designated State-program agencies, and the U.S. Coast Guard--responded almost immediately to the Phillips accident. The U.S. Coast Guard was on hand to assure the safety of the Houston Ship Channel. It also was concerned about vessels moored in the area and their crews; it contacted these vessels directly by radio and warned the crew members to go below deck and to close all ventilation ducts. Also of concern to the U.S. Coast Guard was the potential pollution of the ship channel from chemicals and firefighting water run-off from the facility.

OSHA compliance personnel from the agency's area office in Houston were at the scene of the accident within an hour after the first explosion occurred. Additional OSHA personnel arrived that evening, and the next day they conducted a formal opening conference with the company and union officials. EPA also had staff on the scene almost immediately. There was concern that undetermined, but potentially harmful, amounts of asbestos and other chemical pollutants may have been released into the atmosphere, thereby posing a threat to the surrounding community.

The Harris County Fire Marshal, Sheriff, and Coroner participated in the response activity throughout the firefighting and hosing-down effort that continued until early morning, on Tuesday, October 24, the day following the accident.

Every effort was made during the search and rescue effort to ensure that no evidence essential to the investigation would be unduly disturbed. Later on the 24th, the OCAW local obtained a temporary restraining order from the Harris County Court to preserve the site and to prevent any unnecessary disturbance of the equipment involved in the explosion.

At the start of the investigation, OSHA met with officials from Phillips and OCAW to discuss the preservation of evidence in the areas affected by the accident. As a result of these discussions, OSHA and Phillips entered into an oral agreement on October 24, which was followed by a written agreement on November 2, affirming that all evidence and equipment identified by OSHA in Plants IV and V would be preserved intact. The investigation team began touring the accident area and evaluating the equipment located there, identifying what needed to be evaluated or tested. The agreement was extended several times and finally expired on January 8, 1990. After that date the equipment requiring further testing and evaluation was removed and warehoused so that the company could start demolition.

For several days immediately following the accident, there was concern about the consequences of the explosion to the community. The accident caused releases of chlorine gas, asbestos, and large quantities of the four highly flammable process components (isobutane, ethylene, hexene and hydrogen) from the Phillips Complex.

The Texas Air Control Board had a mobile trailer at the site to measure emissions during the fire. In the days immediately following, the Board took air samples for various substances, particularly toluene, xylene, and asbestos. The preliminary results for toluene and xylene showed no significant increase above background levels, and airborne levels of asbestos did not exceed the OSHA permissible exposure limit.

The Texas Water Commission and the Harris County Pollution Control Department toured the plant and took water samples for analysis. Most of the water used to fight the fire was recycled into the plant storm water impoundment pond, which also contained chromium-contaminated water from the cooling tower. The initial loss of water through the ruptured cooling tower caused chromium levels to rise above the permit limit established under the National Pollutant Discharge Elimination System (NPDES). By the morning of October 29, analysis of daily water samples showed conformity with the NPDES permit requirements.

The Texas State Bureau of Radiation Control, which operates the State's Nuclear Regulatory Commission program, visited the site following the accident to inspect for any radiation from 24 density instruments (sealed radioactive sources) that were used in the Phillips polyethylene-processing plant. The Radiation Control Bureau had inspected the site a year earlier. After the accident, they monitored with a radiation survey meter and issued individual radiation dosimeters to appropriate personnel. Logs were kept of individual exposures. The radiation sources were removed by the service company that regularly serviced the plant's sealed sources. The Bureau found no risk to the public or to employees.

Local response activities were aided by information provided to the Local Emergency Planning Committee (LEPC) and by fire services provided by Phillips as a result of the Emergency Planning and Community Right to Know Act of 1986 (Title III of the Superfund Amendments and Reauthorization Act [SARA]). This Act, which established local and State planning structures and required emergency planning, made available to these groups and the public information on chemical hazards, quantities present on site, the manner and location of storage, and accidental and routine emissions of hazardous chemicals. CIMA was able to obtain this information.

It was reasonably clear a week after the explosion that the principal impact of the accident had been on the workers and the plant environment, rather than on the public and the surrounding community. Consequently, the NRT, whose mission it is to coordinate activities in response to emergencies resulting from oil spills and chemical releases, did not become involved in the aftermath of the Phillips explosion. (The NRT is chaired by EPA and the Coast Guard and draws its members from 12 other Federal agencies, including OSHA; regional response teams include regional representatives of the 14 NRT member agencies, as well as representatives of State and local agencies.)

Throughout those first weeks, the OSHA accident inspection team coordinated activities with representatives of the various Federal and State agencies involved in the response to the accident. As discussed below, two weeks after the explosion, EPA conducted a chemical safety audit of the Phillips Complex in which OSHA participated [3]. The OSHA accident investigation team continued its investigation which did not end until 5 months after the explosion occurred. Throughout the investigation, Phillips officials cooperated and provided requested information.

Because of the potentially broad impact of serious chemical accidents, many governmental agencies have a role in the mitigation of the effects of releases that occur. Measures taken to prevent accidental chemical releases may affect worker safety and health and the plant environment. They may also affect the environment in the immediate vicinity of the plant and at some distance from the plant. Coordination among the Federal and State agencies with a legitimate interest in the investigation of serious accidents of this nature is vital. Since the primary impact of the Phillips accident was on the workplace and the employees working there, OSHA was the lead Federal investigatory agency.

EPA's CHEMICAL AUDIT OF PHILLIPS

EPA, as a part of its Chemical Accident Prevention Program, conducted a chemical safety audit of the Phillips Complex on November 6-7, 1989. OSHA staff participated on the EPA audit team. Other agencies contributing to and participating

on the audit team were the Texas Air Control Board, the Texas Department of Health, and the local emergency planning committee.

The purpose of this audit was to assess the facility's chemical emergency preparedness and prevention procedures and to determine the potential for and consequences of releases that have a potential impact off site. Detailed information on the facility was collected from documents provided by Phillips and through discussions with company staff. This information included a description of the physical characteristics of the site, emergency preparedness and planning activities, community emergency response planning, public alert and notification procedures, safety and loss prevention activities, and accidental release investigations. A list was compiled of the hazardous chemicals at the site, and the procedures for handling and processing these chemicals were reviewed. Systems for monitoring the operation of the process and equipment and for mitigating the effects of process upsets were also reviewed. Recommendations were developed for emergency response planning, equipment for monitoring hazardous substance releases, reporting and notification procedures for chemical releases, alarm equipment, and employee evacuation training. The EPA recommendations were transmitted to Phillips in January 1990. The audit report is available from the EPA [3].

EPA's CHEMICAL ACCIDENT PREVENTION PROGRAM

EPA's Chemical Accident Prevention Program is part of an overall effort for dealing with chemical emergencies. The Chemical Preparedness Program was launched in 1985 as part of the agency's Air Toxics Strategy. Much of the program was incorporated into Title III of SARA. Title III established LEPCs, which were tasked with receiving information on chemical hazards for use in dialogue with industry. Much of this information is useful in developing and revising the required emergency plans, as well as in forming a basis for risk reduction discussions. To oversee and assist the effort, the law established State Emergency Response Commissions (SERCs). EPA's role has been to provide guidance and assistance on a wide variety of emergency issues, including prevention of chemical accidents.

In Title III, Congress directed EPA to conduct a review of emergency systems for preventing, detecting, and mitigating accidents and alerting the public. That review has been the keystone of EPA's accident efforts. The resulting report, issued in 1988, stated that prevention of accidental releases requires a holistic approach, integrating technologies, procedures, and management practices at all stages in the life cycle of a facility. It also emphasized that site, process, and chemical-specific hazards dictate the choice of technology and techniques at specific facilities.

In addition to identifying research needs, the report called for attention to small facilities which seemed to be less aware of chemical risk.

The Chemical Accident Prevention Program has concentrated on understanding the causes of accidents and identifying ways to prevent their occurrence and, at the same time, encouraging industry initiatives in this area. Sharing this information with key organizations (e.g. industry, labor, State and local government, other Federal agencies, professional organizations and environmental groups) is an important element of the program. To obtain this information, EPA established two programs, the Accident Release Information Program (ARIP) and the Chemical Safety Audit Program.

ARIP was created in the realization that existing accident data bases provided only preliminary information on cause and no information on steps taken to prevent recurrence. The program examines significant accidental releases, including frequent or large releases, releases of extremely hazardous substances, and those involving a death or injury. Today there are approximately 1,000 entries in the ARIP data base. A technical assistance bulletin based on ARIP has been issued to LEPCs, SERCs, and other interested parties, and additional bulletins are planned.

The Chemical Safety Audit Program is designed to identify problematic and successful practices as well as technologies for preventing and mitigating releases. Audits are conducted at facilities that have had a release or have the potential for a release of a hazardous substance. SERC and LEPC participation in the audit is encouraged. Observations and conclusions from the site visit are presented in a report that also identifies and characterizes the strengths and weaknesses of specific chemical accident prevention program areas, i.e., hazard evaluation and release prevention techniques. To heighten awareness, these reports are shared with interested stakeholders. In addition, EPA will provide an annual report on audit findings.

In fiscal year (FY) 1989, EPA regions conducted 33 audits and will conduct at least 40 audits in FY 1990. These covered a variety of facility types, including three petroleum refineries.

In addition, EPA has undertaken a new effort to assist smaller operations with chemical risks. Initial activities include a series of meetings with small business which will help shape guidance and technical assistance.

Finally, recognizing the need to share information internationally as well as nationally, EPA has worked with several international organizations grappling with the same chemical accident issues. In particular, it is a member of the Ad Hoc Group of Experts on Accidents Involving Hazardous Substances of the Organization for

Economic and Cooperative Development (OECD), which is preparing guidance in this area. OSHA also has been a part of the U.S. delegation in these efforts. EPA is particularly concerned with the effectiveness of prevention models in place in the United States and in Europe and has learned from those experiences. In addition, EPA is working with the World Health Organization, the European Commission, the United Nations Environmental Program, and countries of Central and Eastern Europe.

CHAPTER V

CAUSES OF THE PHILLIPS 66 ACCIDENT

The primary cause of the explosion and fire at the Phillips Complex on October 23, 1989, was the release of flammable process gases which moved rapidly through the facility to an ignition source. The gases--a mixture of four highly flammable substances--were released through an open valve between a reactor and a product settling line located in Plant V, one of two active polyethylene plants in the Phillips Complex.

At the time of the event, a settling leg was undergoing a regular maintenance procedure: the removal of a solidified polyethylene blockage. Under Phillips' written procedures for this maintenance function, which was usually performed by a contractor, Phillips' operations personnel were required to prepare the product-settling leg for the maintenance procedure by isolating it from the main reactor loop before turning it over to the maintenance contractor to clear the blockage.

On Sunday, October 22, a Fish Engineering crew began work to unplug three of the six settling legs on Reactor 6. According to witnesses, all three legs were prepared by a Phillips operator and were ready for maintenance, with the DEMCO® valve in the closed position and the air hoses, which are used to rotate the valve, disconnected. Number 1 leg was disassembled and unplugged without incident. At approximately 8:00 on Monday morning, work began on Number 4 leg, the second of the three plugged legs.

The Fish Engineering (contractor) crew partially disassembled the leg and managed to extract a polyethylene "log" from one section of the leg. Part of the plug, however, remained lodged in the pipe 12 to 18 inches below the DEMCO® valve. At noon, the Fish employees went to lunch. Upon their return, they resumed work on Number 4 leg. Witnesses then report that a Fish employee was sent to the reactor control room to ask a Phillips operator for assistance. A short time later, the initial release occurred. Five individuals reported actually observing the vapor release from the disassembled settling leg.

Because of the high operating pressure, the reactor dumped approximately 99 percent of its contents (85,200 pounds of flammable gases) in a matter of seconds. A huge unconfined vapor cloud formed almost instantly and moved rapidly downwind through the plant.

There were several potential ignition sources: a small diesel crane used by a Fish maintenance crew, but not in operation at the time of the blast; an operating forklift; a gas-fired catalyst activator with an open flame; welding and cutting-torch operations; 11 vehicles parked near the polyethylene plant office building; and ordinary electrical gear in the control building and the finishing building. The actual ignition source has not been identified.

Within 2 minutes, and possibly as soon as 90 seconds, the vapor cloud came into contact with an ignition source and was ignited. Two other major explosions occurred subsequently, one about 10 to 15 minutes after the initial explosion when two 20,000-gallon isobutane storage tanks exploded, and another when another polyethylene plant reactor catastrophically failed about 25 to 45 minutes into the event.

After the explosion, a physical examination of the actuator mechanism for the DEMCO® valve showed, and FBI laboratory tests confirmed, that the DEMCO® valve was open at the time of the release. The tests showed that the air hoses that supplied the air pressure (by which the actuator mechanism opened or closed the valve) were improperly connected in a reversed position. The hoses, connected in that way, would open a closed DEMCO® valve even when the actuator switch was in the closed position.

Established Phillips corporate safety procedures and standard industry practice require backup protection in the form of a double valve or blind flange insert whenever a process or chemical line in hydrocarbon service is opened. Phillips, however, at the local plant level, had implemented a special procedure for this maintenance operation which did not incorporate the required backup. Consequently, none was used on October 23.

Additionally, the following unsafe conditions existed: (1) the DEMCO® valve actuator mechanism did not have its "lockout" device in place, (2) the hoses that supplied air to the valve actuator mechanism could be connected at any time even though Phillips' operating procedure stipulated that the hoses should never be connected during maintenance, (3) the air hose connectors for the "open" and "close" sides of the valve were identical, thus allowing the hoses to be cross-connected and permitting the valve to be opened when the operator might have intended to close it, and (4) the air supply valves for the actuator mechanism air hoses were in the open position so that air would flow and cause the actuator to rotate the DEMCO® valve when the hoses were connected.

Field tests have since confirmed that the DEMCO® valve involved in the accidental release was capable of being physically locked in the open as well as in the closed

position. The valve lockout system for this maintenance operation was inadequate to prevent someone from inadvertently or deliberately opening the DEMCO® valve during a maintenance procedure.

Other conditions at the complex, though not causes of the accident, exacerbated its consequences. As noted, the lack of a water system dedicated to firefighting, and deficiencies in the shared system, contributed to the intensity and duration of the fires that followed the explosion. The force of the blasts ruptured water lines and adjacent vessels containing flammable and combustible materials. The ruptured water lines could not be isolated to restore water pressure because the valves to do so were engulfed in flames.

The site layout and the proximity of normally high occupancy structures, such as the control room and the finishing building, to large capacity reactors and hydrocarbon storage vessels also contributed to the severity of the event.

The large number of fatally injured personnel was due in part to the inadequate separation between buildings in the complex. The distances between process equipment were in violation of accepted engineering practices and did not allow personnel to leave the polyethylene plants safely during the initial vapor release; nor was there sufficient separation between the reactors and the control room to carry out emergency shutdown procedures. The control room, in fact, was destroyed by the initial explosion. Of the 22 victims' bodies that were recovered at the scene, all were located within 250 feet of the vapor release point; 15 of them were within 150 feet.

CHAPTER VI

FINDINGS OF OSHA'S INVESTIGATION

Since July 1972, OSHA has conducted 92 inspections in the Dallas region at various Phillips locations; of these, 24 inspections were in response to a fatality or catastrophe; and another 20 were in response to employee complaints of unsafe or unhealthful working conditions. The 92 inspections resulted in citations for 147 violations (including three willful and 44 serious) and $52,595 in penalties. Of these inspections, nine were conducted at the Pasadena facility.

OSHA's investigation of the October 1989 accident determined that Phillips had not acted upon reports issued previously by the company's own safety personnel and outside consultants who pointed out unsafe conditions. Based on a review of these company reports and on the many deficiencies and hazardous conditions found in the investigation of the explosion, a citation has been issued to Phillips for willful violations of the OSH Act's "general duty" clause (which requires an employer to provide each of his employees a workplace free from recognized hazards that can cause death or serious physical harm), with proposed penalties totaling $5.66 million. Willful violations are those committed with an intentional disregard of, or indifference to, the requirements of the OSH Act and the regulations issued under that Act.

The following is a summary of the major findings of OSHA's investigation of the accident. These findings provide the basis for the Phillips citations:

1. A process hazard analysis or other equivalent method had not been utilized in the Phillips polyethylene plants to identify the process hazards and the potential for malfunction or human error and to reduce or eliminate such hazards.

2. Phillips' existing safe operating procedures for opening lines in hydrocarbon service, which could have prevented the flammable gas release, were not required for maintenance of the polyethylene plant settling legs. The alternate procedure devised for opening settling legs was inadequate; there was no provision for redundancy on DEMCO® valves, no adequate lockout/tagout procedure, and improper design of the valve actuator mechanism and its air hose connections.

3. An effective safety permit system was not enforced with respect to Phillips or contractor employees to ensure that proper safety precautions were observed during maintenance operations, such as unblocking reactor settling legs.

4. There was no permanent combustible gas detection and alarm system in the reactor units or in adjacent strategic locations to monitor hydrocarbon levels and to provide early warning of leaks or releases.

5. Ignition sources were located in proximity to, or downwind (based on prevailing winds) from, large hydrocarbon inventories. Ignition sources also were introduced into high hazard areas without flammable gas testing.

6. Buildings containing personnel or vital control equipment were not separated from process units in accordance with accepted engineering principles or designed with sufficient resistance to fire and explosion.

7. Ventilation system intakes for buildings in close proximity to, or downwind from, hydrocarbon processes or inventories were not designed or configured to prevent the intake of gases in the event of a release.

8. The fire protection system was not maintained in a state of readiness necessary to provide effective firefighting capability. Unknown to the fire chief, one of three emergency standby diesel-powered water pumps had been taken out of service, and another was not fully fueled, with the result that it ran out of fuel during firefighting activities. Further, electric cables supplying power to regular service fire pumps were not located underground, thereby exposing them to blast and fire damage.

Citations were also issued to Phillips for serious violations of other OSHA standards, with additional proposed penalties of $6,200. Among these were failure to provide for emergency evacuation, an inadequate respirator program, and lack of compliance with OSHA's Hazard Communication Standard with respect to company and contractor personnel.

Since July 1972, OSHA has conducted 44 inspections in operations of the Fish Engineering and Construction company at various locations; seven of these inspections were in response to a fatality or catastrophe; and another 17 were in response to employee complaints of unsafe or unhealthful working conditions. The 44 inspections resulted in citations for 62 violations (including 19 serious), and $12,760 in penalties. Of these inspections, two were conducted at the Pasadena facility.

An inspection of Fish operations was conducted as part of the Phillips accident investigation. As a result of that inspection, a citation for willful violations for failing to obtain the necessary vehicle and hot work permits when working in the polyethylene plant has been issued against Fish, with proposed penalties totaling $724,000. Other citations have been issued for serious infractions of OSHA standards, including an inadequate respirator program and deficiencies in the

company's hazard communication program. Additional proposed penalties totaled $5,600 for these and other violations.

The OSHA investigation team had several functions. First, the team investigated the events of the catastrophe to determine the causes of the accident and identify any violations that might have occurred of OSHA's standards, regulations, or the general duty clause of the Act. In this process, the team evaluated safety and health conditions at the worksite, including the safety management systems and procedures that Phillips had in place, and identified deficiencies in the company's overall safety and health program. The compliance team also evaluated the emergency response to the accident to determine the adequacy of Phillips emergency response plans.

Findings were reported to the company for the three areas of the investigation outlined above--the causes of the accident, the system-safety programs in place at the plant, and the emergency response effort during the actual incident. A formal closing conference, which marked the completion of the onsite portion of the compliance inspection, was held with the company and the unions on March 29, 1990, to discuss these findings.

A major part of the emergency response was conducted by CIMA. Employees and equipment were supplied by the petrochemical companies along the Houston Ship Channel. OSHA evaluated CIMA's compliance with OSHA regulations in responding to the emergency, as well as the performance of two of the company members of the organization. Their emergency response activities were performed in accordance with agency safety and health requirements.

CHAPTER VII

INTERNATIONAL ACTIVITY

The occurrence of a number of major catastrophic accidents outside of the United States over the past two decades gave rise to unilateral and multilateral actions to prevent the recurrence and mitigate the consequences of similar accidents. The European Economic Community (EEC) responded to the serious accidents that occurred in Flixborough, England (1974, cyclohexane), and Seveso, Italy (1976, dioxin). In the United States it was the tragedy that occurred in Bhopal, India, in December 1984 (methyl isocyanate), that stimulated actions intended to prevent catastrophic chemical releases and mitigate the impact of any that occurred. The purpose of this chapter is to discuss some of the more significant activities undertaken by the international community with regard to accidents involving highly hazardous chemicals.

The 1974 Flixborough disaster provided the impetus for the United Kingdom (UK) to formulate a national policy addressing catastrophic industrial accidents. The Flixborough incident was caused by the failure of a temporary pipe installation in a series of reactors containing cyclohexane. The resultant release of approximately 50 tons of hot cyclohexane caused an explosion that killed 28 people and injured 36 others [4]. In response to this incident, the UK strengthened regulatory provisions and produced a number of technical evaluations, papers and books [5]. In 1982, the UK put into effect a regulation--the "Notification of Installations Handling Hazardous Substances" (NIHHS)--requiring industry to identify hazardous sites and notify the Health and Safety Executive (HSE) of their existence. The HSE, in turn, was required to notify the Local Planning Authority (LPA) in which the hazardous site is located for the purposes of land-use planning and emergency services.

Also in response to the Flixborough disaster, the International Process Safety Group was formed [6]. This is an industry group led by the UK's Institution of Chemical Engineers. Information discussed at their meetings is kept confidential unless released for publication by the contributing company.

The UK's efforts to stimulate similar efforts in other countries met with varying degrees of success. Overall, the U.S. reaction to the Flixborough event was minimal; nonetheless, a number of technical publications associated with a study of this incident were well received in this country.

The Seveso, Italy, incident in 1976, which involved a runaway chemical reaction resulting in the release of large quantities of dioxin into the surrounding area,

brought a major reaction from the EEC. In response to the Seveso incident, the EEC, in 1982, developed a directive to control major accident hazards in certain industrial activities. Compliance with this directive was mandatory for member nations as of January 8, 1984 [7]; however, it has not yet been uniformly implemented throughout Europe. The directive was implemented in the UK in 1984, where it was referred to as the Control of Industrial Major Accident Hazards Regulations (CIMAH).

The major elements of these regulations apply to approximately 300 sites known as "large inventory top-tier" sites because of the large quantities of toxic or explosive materials used or stored there, and to an additional 300 sites known as "small inventory top-tier" sites because of their use and storage of smaller amounts of similar materials. The EEC directive, and the UK version, require that these sites and operations be conducted safely. Plant design, construction, inspection, maintenance and operation are governed by these regulations. Management controls are specified for training, supervision, and emergency planning. It should be noted, however, that implementation of the EEC and Seveso directives in Europe has not been uniform, and there is little evidence to date on the effectiveness of these measures.

In 1985, primarily as a consequence of the Bhopal (methyl isocyanate release) and the Mexico City (refinery explosion) disasters, both of which involved developing nations, the World Bank issued guidelines for identifying, analyzing and controlling major hazard installations in developing countries [8]. These were prepared principally for international industrial developers making application for World Bank and International Finance Corporation projects. The guidelines, which are based largely on the EEC directive of 1982, provide criteria for identifying acutely toxic, flammable, and explosive and reactive hazards, as well as a list of these hazardous chemicals. Threshold quantities are specified that require the developer to undertake a major hazard assessment and to implement measures to control the major hazards identified in such an assessment. These guidelines were designed primarily for proper site selection; however, they can be applied to existing plant operations and to rehabilitation or expansion projects.

In 1985 the International Labour Organization (ILO) produced a document [9], which addressed the issue of industries with potential for catastrophic accidents. Much of the information presented in this paper was derived from the 1982 UK regulations on Notification of Installations Handling Hazardous Substances and its CIMAH Regulations of 1984. Recently, the ILO produced a practical manual setting forth comprehensive guidelines for the prevention and management of industrial disasters [10].

The United States is involved in ongoing multilateral discussions with the European Community, Canada, and Australia about possible international harmonization of standards for the communication of information on chemical hazards. OSHA's Hazard Communication Standard--a generic rule covering the more than half million chemical products in use in U.S. workplaces today--is directly concerned in these discussions.

EPA and OSHA are also participating in a series of conferences held by the OECD to consider the catastrophic potential of petrochemical accidents and the means to prevent their occurrence and mitigate their impact. (See Chapter IV.) Discussions, which are ongoing, have addressed the all-important need for good process safety management.

CHAPTER VIII

OSHA'S PROGRAM TO PREVENT PETROCHEMICAL ACCIDENTS

Under its enabling statute, the OSH Act of 1970, OSHA has the responsibility for assuring "to the extent possible...a safe and healthful place of employment for every working man and woman" in virtually all establishments in this country, including those in the petrochemical industry. OSHA thus oversees job-related safety and health in more than 6 million workplaces and for more than 85 million workers.

The OSH Act encourages the States to operate their own job safety and health programs, or "plans," and 21 States and two jurisdictions have elected to do so. Two additional States operate Federally approved programs solely for State and local government employees. Federal OSHA monitors these State plans to assure that they are at least as effective as the Federal program.

The most critical responsibilities for chemical process safety rest not with government agencies but with industry, and specifically with each chemical producer, at each location or workplace. Section 5(a)(1) of the OSH Act--the "general duty clause"--assigns primary responsibility to the employer to "furnish to each of his employees employment and a place of employment which are free from recognized hazards that are causing or are likely to cause death or serious physical harm...." OSHA's role is not that of a supervisory body for the industry or for the individual plant; as specified in the OSH Act, the responsibility for safe operation of any workplace always remains with the employer.

Through regulation, enforcement, technical assistance, training, voluntary protection programs, and other means, OSHA acts to ensure that employers fulfill their responsibility with regard to chemical process safety as well as other types of hazards.

STANDARDS

OSHA has a variety of standards that are applicable to the chemical processing industry. The latest of these is a standard for the control of hazardous energy sources, also known as lockout/tagout, which became effective on January 2, 1990. The standard requires the energy source equipment to be turned off or disconnected and the switch to be locked, or if not capable of being locked, to be labeled with a warning tag. The lockout/tagout standard helps to prevent chemical releases. Specifically, the standard requires employers to block off pipes during maintenance work and to fully train employees in proper procedures for restoring

the system. (This standard was not in effect at the time of the Phillips explosion, but the requirement for proper lockout/tagout procedures was accepted industry practice and established operating procedure for Phillips.)

Other applicable regulations include standards for (1) the handling and storing of liquids that are flammable and combustible and of certain chemicals that are reactive and unstable; (2) the design, installation and use of storage tanks; (3) fire protection within a facility; (4) firefighting operations, including training and equipment; (5) emergency preparedness and evacuation plans; (6) permissible exposure limits for more than 600 air contaminants; (7) employee access to medical records of their workplace exposure to toxic substances or harmful physical agents; (8) medical services and first aid; (9) protection of workers engaged in hazardous waste operations; (10) respiratory protection; (11) use of personal protective equipment; (12) and communication of information about hazardous chemicals, including the important requirement that employers train workers in the precautions needed to minimize the risk of potentially dangerous exposures. For hazards not addressed by a particular standard, OSHA enforces the general duty clause of the OSH Act which, as noted, requires employers to provide employment and a place of employment free from recognized hazards that are causing or are likely to cause death or serious physical harm to employees.

In addition to these regulations, OSHA is developing a Notice of Proposed Rulemaking for Process Safety Management of Highly Hazardous Chemicals, and expects to publish it for public comment by this summer. This high priority rulemaking will consider a number of possible risk reduction steps, including measures requiring employers to (1) set up a management system to identify (in writing), understand, and correct the hazards involved in the use, storage, manufacturing, handling, and movement of highly hazardous materials; (2) communicate that information to employees; (3) conduct hazard analyses; (4) establish and implement procedures to accommodate changes in plant equipment and technology; (5) develop and implement operating procedures including emergency and shutdown procedures; (6) train employees in those procedures; (7) implement a preventive maintenance program that includes the testing and inspection of critical equipment; (8) implement a hot-work permit system; (9) establish a workplace facility emergency action plan; and (10) ensure that contractors working at the facility are aware of the hazards associated with their work at the site and of the applicable safety rules and actions to be taken during an emergency.

ENFORCEMENT

To the limit of its regulations and resources, OSHA monitors the performance of employers and takes enforcement action when their performance is below

acceptable levels and is in violation of safety and health standards and OSH Act requirements. Generally, enforcement activity includes targeting industries and workplaces for inspection, onsite investigations of the physical plant and its safety and health programs, issuance of citations for alleged violations of standards when hazards are found, proposal of penalties, and assurance of abatement through appropriate followup.

OSHA initiates comprehensive inspections based on serious health hazards historically found in the industry (health inspections) and on the injury rates that prevail in the industry (safety inspections). In addition to these inspections, OSHA also conducts onsite inspections in response to information about specific hazards at workplaces provided through various sources, such as employee complaints, referrals from other safety and health professionals, and catastrophes (which OSHA defines as incidents involving a fatality or the hospitalization of five or more employees).

INSPECTION PROGRAM

OSHA investigates all serious workplace accidents involving chemical releases--that is, all fatalities and catastrophes which employers are required to report to OSHA, as well as some accidents that come to the agency's attention through other means. The aim of OSHA's investigation is (1) to identify and require abatement of any violations of the OSH Act or any regulations under that Act; (2) to determine the cause of the accident; and (3) to recommend how to prevent the recurrence of similar accidents in the future.

In OSHA's history, anywhere from zero to five major--and potentially catastrophic--accidents have occurred in the petrochemical industry in any year. On an average, from two to three such accidents a year have occurred in the petrochemical industry.

In the most serious catastrophes, OSHA has typically assembled a team of experts not only from the region in which the accident occurred, but also from other regions that have the necessary expertise, and from the agency's Health Response Team based in Salt Lake City. Such a team thus consists of experts in regulatory compliance and the technologies relevant to the operations and processes being investigated.

In the event of major catastrophes in the construction sector, OSHA has, on a number of occasions, contracted with the National Bureau of Standards (now National Institute of Standards and Technology) for an indepth study of the causes of the accident. OSHA can now use its newly constituted Office of Construction and Engineering for this purpose, as it did in the Phillips investigation. Some of

these investigations require coordination with other Federal agencies such as EPA, as well as State and local authorities.

Historically, the petrochemical industry has a lower rate of injury relative to other industries; thus, the petrochemical industry has generally not been accorded high priority status for OSHA's enforcement program. There are exceptions to this generality, however. In 1984 and 1985, two accidents involving the Union Carbide plants, one in Bhopal, India, and one in West Virginia, resulted in OSHA's developing (in FY 1986) a Chemical Special Emphasis Program (ChemSEP) involving indepth safety inspections of chemical manufacturing processes. The origins of that program have a direct bearing on this report.

On December 16, 1984, 3 days after the Bhopal accident, OSHA initiated an inspection at the Union Carbide facility in Institute, West Virginia, which was the sole manufacturer of methyl isocyanate in the United States. Union Carbide had suspended methyl isocyanate production at this plant immediately following the Bhopal disaster, and since the production could not be observed directly, OSHA's expert team of compliance officers focused on the company's overall safety and health program.

The OSHA team examined diagrams of the plant and the methyl isocyanate process and looked at company control measures for storage, backup storage, and transfer of hazardous chemicals. The company's documentation of the systems that were in place to manage the hazards of the chemical process were closely scrutinized. Those systems included, but were not limited to, programs and procedures for redundant safety systems, safe work practices, preventive-maintenance programs, job-safety analyses, employee training, and emergency response.

At the same time, OSHA conducted a series of inspections at the four other facilities in this country where methyl isocyanate was used in significant quantities: Union Carbide, Woodbine, Georgia; FMC, Middleport, New York; Morton Chemical Company, Weeks Island, Louisiana; and E.I. duPont de Nemours, LaPorte, Texas. In addition to company documentation of safety management systems, internal safety audit reports and similar reports by outside consultants were examined on these inspections.

The investigative procedures developed during the methyl isocyanate inspections led to a special emphasis program of comprehensive inspections in 40 chemical processing plants conducted from October 1985 to December 1986 (ChemSEP). On these inspections, OSHA used a "system safety" approach to chemical plant inspections which stressed management systems to ensure the safety of the chemical process. The major objectives of the experimental program were to test OSHA's capacity to inspect chemical manufacturing workplaces using current safety and

health standards, and to assess industry practices with respect to prevention and investigation of disastrous releases of hazardous chemicals. A single processing unit which manufactured one of ten targeted chemicals was inspected at each plant. OSHA issued a report in 1987 at the conclusion of this program, in which both long- and short-term recommendations were made [11]. One long-term recommendation was the development of an OSHA standard for chemical process safety.

Short-term recommendations resulting from OSHA's ChemSEP included integration of some of the inspection techniques developed in the program into OSHA inspections of chemical operations which have catastrophic potential, including petroleum production and refining. (Petrochemical operations with catastrophic potential are, for the most part, those involving significant quantities of highly flammable and explosive materials. Although accidents involving these materials occur relatively infrequently, when they do occur, the injuries and fatalities that result can be catastrophic.)

In July 1987, OSHA issued a notice to its field staff [12] on procedures to follow in conducting system safety inspections and, in September 1988, issued instructions entitled, "System Safety Evaluation of Operations with Catastrophic Potential" [13]. When conducting an OSHA-initiated comprehensive health inspection or investigation of a complaint, referral or fatality/catastrophe related to chemical hazards, system safety inspection guidelines are followed. If the facility uses chemicals with catastrophic potential--those that are the most dangerous and reactive--the inspection should be expanded to include an evaluation of management programs, hazard assessments, process design and control, and emergency response procedures.

These recommendations were only partially implemented. In 1985, OSHA proceeded with preliminary work on a proposed revision of its Standard for Storage and Handling of Hazardous Materials to include requirements for safety management systems for chemical process hazards. A limited system safety inspection program was initiated pursuant to the agency's directives of 1987 and 1988.

Beginning in the summer of 1989, OSHA, under new leadership, made a Notice of Proposed Rulemaking for chemical process safety a high priority. This proposal is expected to be published this summer. Further, as a result of its investigation of the Phillips accident, OSHA is taking actions to implement new and previous recommendations to prevent future chemical accidents. Among these are the need to target the petrochemical industry as a priority for OSHA's regulatory, enforcement, and voluntary compliance programs.

CHAPTER IX

INDUSTRY AND LABOR ACTIVITY

INDUSTRY

In March 1985, 4 months after Bhopal, the Center for Chemical Process Safety (CCPS) was established in the United States [14]. This organization was formed as a separate branch of the American Institute of Chemical Engineers (AIChE) and is funded by a variety of organizations and major corporations. The Center's charter is to develop and disseminate technical information to be used in the prevention of major chemical accidents. It maintains an open dialogue with trade and professional organizations, government agencies, and other interested parties. To date, the Center has published guidelines on such topics as chemical process safety, risk analysis, and hazard evaluation. It also has held international symposia on topics relating to chemical process safety.

The Design Institute for Emergency Relief Systems (DIERS) is another separate branch of AIChE [15]. It was formed in 1976 to develop methods for designing emergency relief systems to handle runaway reactions. A major product of this group has been a computer program, System Analysis for Integral Relief Evaluation (SAFIRE), used in the evaluation and design of relief valve systems for batch reactors or storage vessels.

In 1990, the American Petroleum Institute (API) published guidelines for management of process hazards [16]. These guidelines are intended to assist in preventing the occurrence or minimizing the consequences of catastrophic releases of toxic or flammable materials. The guidelines recommend a management system addressing 11 areas: process safety information, process hazards analysis, management of change, operating procedures, safe work practices, training, critical equipment quality assurance and mechanical integrity, pre-startup safety review, emergency response and control, process-related incident investigation, and audit of process hazards management systems.

The guidelines are intended to apply to all facilities that use, produce, process, or store flammable or explosive substances which are present in such quantity and condition that a sudden, catastrophic release exceeding 5 tons of gas or vapor can occur in a matter of minutes, based upon credible failure scenarios and the properties of the materials involved. A 5-ton limit was selected based on data indicating (1) that a 5-ton release is the lower limit at which there is a 5-percent probability for explosion, and (2) that a 5-ton cloud can cause significantly higher damages than

a 1-ton cloud. The API guidelines also apply to toxic substances that have a substance hazard index greater than 5,000 and are present above a threshold.In 1988, after more than a year of effort by a special task force, the Organization Resources Counselors, Inc., an industry consulting entity, presented OSHA with a report entitled, "Recommendations for Process Hazards Management of Substances with Catastrophic Potential" [17]. This document was prepared to assist in OSHA's development of a standard directed toward eliminating or mitigating catastrophic releases (discussed in Chapter VIII, page 34).

In 1985, the Occupational Safety and Health Committee of the Chemical Manufacturers Association (CMA) formed a task force which produced a report on process safety management [18]. The purpose of the report was to increase knowledge among CMA members about systematic approaches to process safety analysis. The report includes (1) survey data on company policies for hazard identification, assessment, and control; and (2) descriptive information on methods of hazard identification and assessment, hazard control during design and operation, and corporate process hazard management.

CMA has also developed a Community Awareness and Emergency Response program to foster cooperation, knowledge, and emergency response activities within communities [19]. As of 1986, there were 170 chemical companies participating in this program, representing 1,400 chemical plants that interact with more than 200 communities in the U.S.

Another CMA initiative is the National Chemical Response and Information Center, which provides information about chemical hazards to the public in routine and emergency situations. The Center operates the Chemical Transportation Emergency Center hotline linking local emergency response groups with shippers, manufacturers, and a number of Federal agencies during transportation emergencies involving chemicals.

The National Association of Manufacturers (NAM) conducts a computerized data-collection effort--SAFESystem--(Standardized Accident Frequency and Evaluation System) [20], which collects and analyzes accident and illness reports from a group of chemical companies with manufacturing plants around the country. A primary objective of the SAFESystem is to allow companies and industries to compare and evaluate safety problems that are more readily apparent in a broader data base than in a single company's experience.

In 1988, 11 companies participated in a coordinated effort to pool basic information about their plant operations to determine the factors that correlate most closely to

accidents or illnesses within the plant--factors such as employee condition or action, equipment or tools, job procedures, management action or systems, and the plant environment.

LABOR

For a number of years, labor unions in the United States have been actively involved in efforts to improve safety and health conditions in the petrochemical industry. Organized labor was a leader in the grass roots coalition that fostered the community-right-to-know movement and enactment of Title III of SARA. That movement was a logical outgrowth of earlier activities, in which labor played a key role, to establish employees' right to know about chemical hazards encountered at work and to encourage issuance of OSHA's Hazard Communication Standard.

The potential for catastrophe on the job has led many labor unions, including OCAW, the United Steelworkers of America, and the International Chemical Workers Union to undertake large-scale efforts to train and educate their members who work in the petrochemical industry. Much of the training and education has come as a result of Federal grant programs such as the OSHA New Directions program and the National Institute for Environmental Health Sciences programs under the Superfund legislation.

Areas of training and education that have been emphasized in programs carried out under these grants include hazard recognition, emergency response, hazard abatement, hazard communication, hazardous material handling and disposal, hazardous material storage, fire brigade requirements, personal protective equipment, chemical accident prevention, emergency preparedness, and cancer control education. All of these areas are critical to the training and education of workers in the petrochemical industry and to the safe operation of facilities in that industry.

An example of training offered under these grants is a 20-hour course developed by OCAW for the union's job safety and health personnel. The course covers the methods of identifying hazards, problem-solving techniques, information on better utilization of OSHA and National Institute for Occupational Safety and Health (NIOSH) resources, and a slide-tape program entitled, "Working Safely in Oil Refineries." The union safety officials who take the course use the information to instruct their local members.

CHAPTER X

INDUSTRY PROFILE

Normal production processes in some sectors of the petrochemical industry have greater potential for fire, explosion, or catastrophic release of highly hazardous materials than in others. Five petrochemical sectors with high potential for fire, explosion, or catastrophic release have been selected for analysis in Chapters XI and XII. These sectors are Natural Gas Liquids - Standard Industrial Classification (SIC) 1321; Plastics Materials, Synthetic Resins, and Nonvulcanizable Elastomers - SIC 2821; Synthetic Rubber (Vulcanizable Elastomers) - SIC 2822; Industrial Organic Chemicals, Not Elsewhere Classified - SIC 2869; and Petroleum Refining - SIC 2911. The Phillips complex is classified in SIC 2821.

The employment size of the establishments in these petrochemical industries, their geographic distribution, the nature of their work force, and the economic climate in which they operate are considered in this profile.

Although nearly 2,300 petrochemical plants are distributed throughout the United States, the 20 percent in Texas and Louisiana account for 30 percent of employment and 50 percent of production. New York, New Jersey, and Pennsylvania share an additional 20 percent of employees, and California another 10 percent. Other States with significant employment in the petrochemical industry include Illinois, Michigan, Ohio, Oklahoma, and Tennessee.

As a whole, the petrochemical industry is projected to grow at an annual rate of 2.5 to 3.0 percent through 1993. Most of the growth should be in the chemical industry, whereas petroleum refining expansion should be slower, about a 1.5 percent growth rate annually, and for natural gas, a growth rate of under 0.5 percent per year.

The petrochemical industry has been operating at an 87 percent capacity utilization rate. This level represents virtually full capacity utilization. During 1989, the refinery capacity utilization rate rose to 90 percent, with some plants running at more than 100 percent of their "official" ratings. This compares to a rate of less than 70 percent in the early 1980s.

Even though 79 percent of petrochemical facilities are small establishments employing fewer than 100 workers, 83 percent of petrochemical employees actually work for larger plants (see Table 1). Above-average pay scales and a relatively high degree of unionization help account for comparatively low labor turnover rates.

Further, the industry is capital-intensive with a below-average proportion of production workers in the total work force. In addition, it is not uncommon to contract out some production-related maintenance operations.

Table 1
Petrochemical Industry Employment

Industry Sector	SIC	Employees		Establishments	
		No.	Percent in large firms (more than 100 workers)	No.	Percent in small firms (under 100 workers)
Natural Gas Liquids	1321	13,000	9	674	98
Petroleum Refineries	2911	87,000	93	441	62
Plastics Materials, Synthetic Resins, and Nonvulcanizable Elastomers	2821	52,000	73	477	75
Synthetic Rubber	2822	10,000	86	87	75
Industrial Organic Chemicals, Not Elsewhere Classified	2869	95,000	86	619	73