

CHAPTER I

INTRODUCTION

Shortly after 1:00 p.m. on October 23, 1989, an explosion and fire ripped through the Phillips 66 Company, Houston Chemical Complex in Pasadena, Texas. Twenty-three workers were killed and more than 130 injured. Two production plants within the Phillips complex were completely destroyed, causing nearly \$750 million worth of damage. Debris from the explosion was thrown as far as 6 miles into the neighboring community. The accident was one of the worst industrial workplace accidents in the United States in the past 20 years.

Since the disastrous release of methyl isocyanate from a Union Carbide facility in India in December 1984, the Department of Labor's Occupational Safety and Health Administration (OSHA) has been concerned about the possibility of a catastrophe occurring in a petrochemical plant in this country. OSHA's investigations in 1984 and 1985 of all U.S. facilities producing or using methyl isocyanate in significant quantities, and the agency's investigation of an accident at a Union Carbide facility in West Virginia in August 1985, indicated the need to look beyond existing OSHA standards to the best company and industry control measures and systems for managing the hazards of the chemical process.

From October 1985 to December 1986, in a special program of comprehensive inspections at 40 chemical-processing plants, OSHA developed a "system safety" approach to chemical accident investigations. At the same time, the agency began a revision of its standard for the safe handling and storage of hazardous materials to include requirements for management systems to ensure the safety of the chemical process. These efforts were precursors of the agency's current rulemaking for a standard for Process Safety Management of Highly Hazardous Chemicals.

The catastrophe at the Phillips Complex not only emphasized the need for effective implementation of good safety management systems in the petrochemical industry but also raised questions about diffused responsibility for employee safety at work-sites where one or more contractors are engaged in work for a company. OSHA had addressed this issue at construction sites, but not at petrochemical plants like the Phillips Complex, where a contractor was regularly employed to perform key maintenance operations and was directly involved in the October 1989 disaster. The Department of Labor therefore determined that OSHA's investigation of this tragic accident would evaluate whether there had been any violations of the requirements of the Occupational Safety and Health Act (OSH Act); the investigation also would look at the underlying causes of the accident and the factors that

contributed to the severity of its consequences, and report the findings to the President.

The Phillips Complex began producing high-density polyethylene, a plastic material used to make milk bottles and other containers, in 1956. Prior to the accident, production capacity at the two polyethylene plants in the complex was approximately 1.5 billion pounds of high-density polyethylene a year, representing 15 to 20 percent of the entire United States supply. The complex employed 905 company employees and approximately 600 contract employees, who were engaged for the most part in maintenance activities and new plant construction. Of these, approximately 1,150 were employed on the first shift, when the accident occurred.

The accident resulted from the escape of process gas during regular maintenance operations on one polyethylene reactor. Personnel from OSHA's area office in Houston were on site within one hour of the accident. An OSHA team of experts that included chemical and structural engineers and industrial hygienists from the agency's national office was also dispatched to the scene.

The objectives of OSHA's response to the accident were to (1) determine the cause of the accident, (2) investigate possible violations of the OSH Act, and (3) make recommendations as to how such accidents can be prevented in the future. OSHA also made its technical expertise available to the emergency responders as they performed the hazardous duties of firefighting, search, and rescue.

Citations were issued by OSHA in April 1990 for violations of the OSH Act associated with the accident. The complete results of the accident investigation, including the identification of violations and the causes of the accident, are contained in OSHA's case files of the investigation and in an engineering report prepared by the agency [1]. OSHA was careful to protect the confidentiality of company trade secrets and worked closely with Phillips officials in determining the information to be included in the engineering report. Pending the resolution of the Phillips case, this information will be on file and will not be publicly released, except in accordance with applicable legal procedures.

This report presents the results of OSHA findings. Chapters II, III, and V provide a summary of the Phillips accident including a description of the event, the emergency response, the investigation, and the causes of the accident. Chapter IV describes the coordination of activities among the organizations involved, particularly the U.S. Environmental Protection Agency (EPA). Chapter VI summarizes the findings of OSHA's investigation; Chapter VII provides a brief account of recent international activity; Chapter VIII describes OSHA's program to prevent chemical accidents; and Chapter IX summarizes recent industry and labor activities. Chapter X presents an industry profile; Chapter XI provides an analysis of the accident

history of the industry; and Chapter XII provides a brief account of the status of a study on the safety and health implications of the petrochemical industry's practice of contracting out maintenance and other operations. Completion of this study is expected later this year. The Phillips accident, the analysis of the industry, and current accident prevention efforts provide the basis for the conclusions in Chapter XIII and the recommended actions presented in Chapter XIV.

CHAPTER II

THE ACCIDENT

BACKGROUND

The fire and explosion on October 23, 1989, at the Phillips 66 Company's Houston Chemical Complex resulted from a massive release of process gas, a mixture of four flammable chemicals--isobutane, ethylene, hexene and hydrogen--which traveled to an unidentified ignition source and exploded with the force of 2.4 tons of TNT. The release occurred during maintenance operations on a polyethylene reactor in Plant V of the complex. (See Figures 1 and 2.) Two of the six workers on the maintenance crews in the immediate vicinity of the reactor leg where the release occurred were killed, together with 21 other employees of the facility. Debris from the plant was found 6 miles from the explosion site. Structural steel beams were twisted like pretzels by the extreme heat generated during the fire. Two polyethylene production plants at the Phillips site, covering an area of approximately 16 acres, were completely destroyed.

In the months preceding the explosion, according to the sworn testimony of an employee [2], there had been several small fires, and the alarm had sounded as many as four or five times in one day. A siren was used to warn company and maintenance contract workers to vacate the plant. Some of the workers in the finishing building may not have heard the siren because of the ambient noise level inside the building. Consequently, those employees may not have been aware of the impending disaster. The employees in the immediate area of the release began running as soon as they realized the gas was escaping.

High-density polyethylene is manufactured in Plants IV and V of the Phillips Complex from ethylene gas dissolved in isobutane, which is reacted in long pipes under elevated pressure and temperature. Various chemicals are added to the process to modify the polyethylene to meet the desired product characteristics. This combination of process gases at elevated pressure and temperature is extremely flammable. The dissolved ethylene reacts with itself to form polyethylene particles that gradually come to rest in settling legs (see Figure 3), where they are eventually removed through valves at the bottom. At the top of each of these legs, there is a single ball valve (DEMCO® brand) where the legs join with the reactor pipes. The DEMCO® valve (see Figure 4) is kept open during production so that the polyethylene particles can settle into the leg.

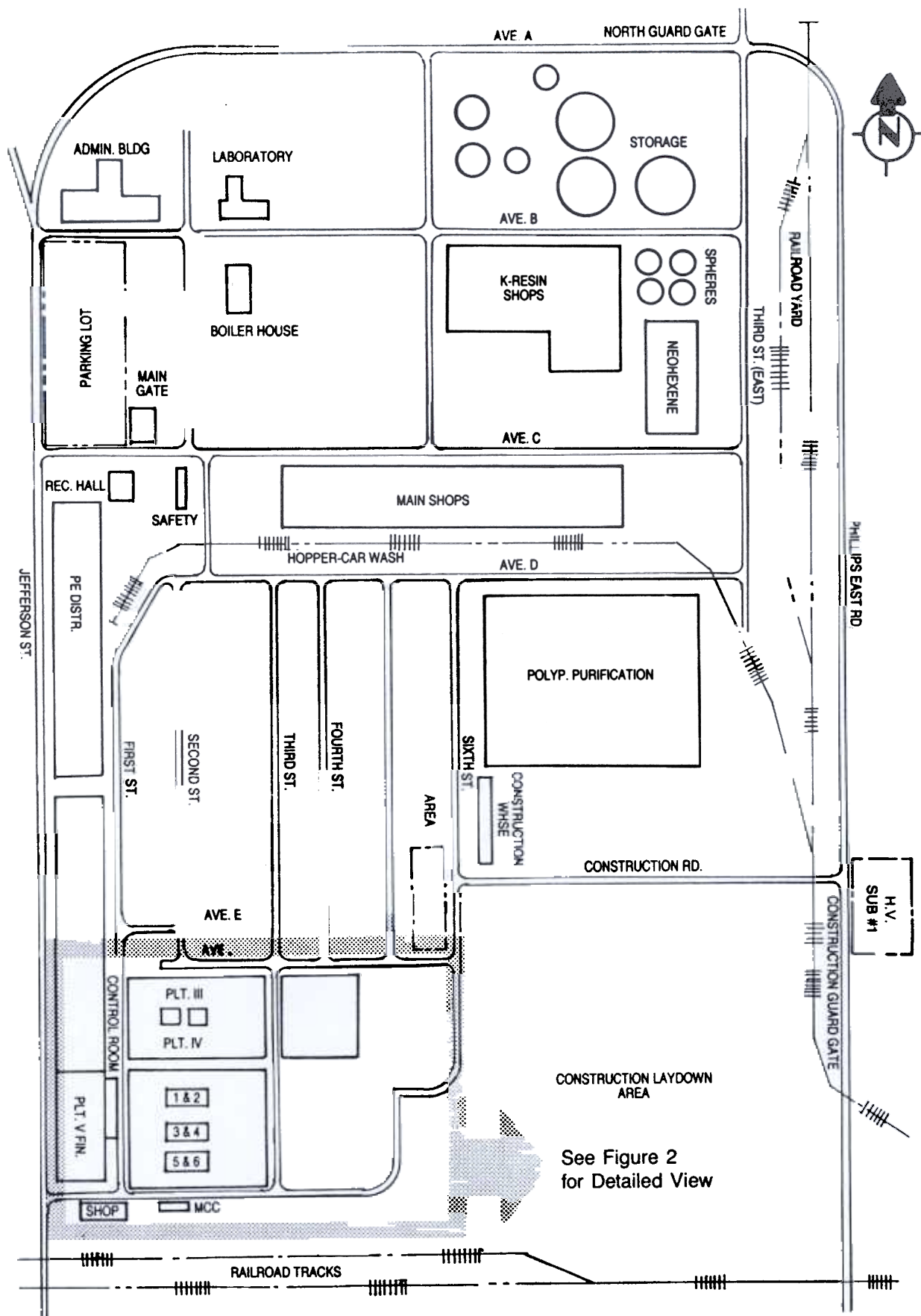


Figure 1. Phillips 66 Company Houston Chemical Complex, Pasadena, TX

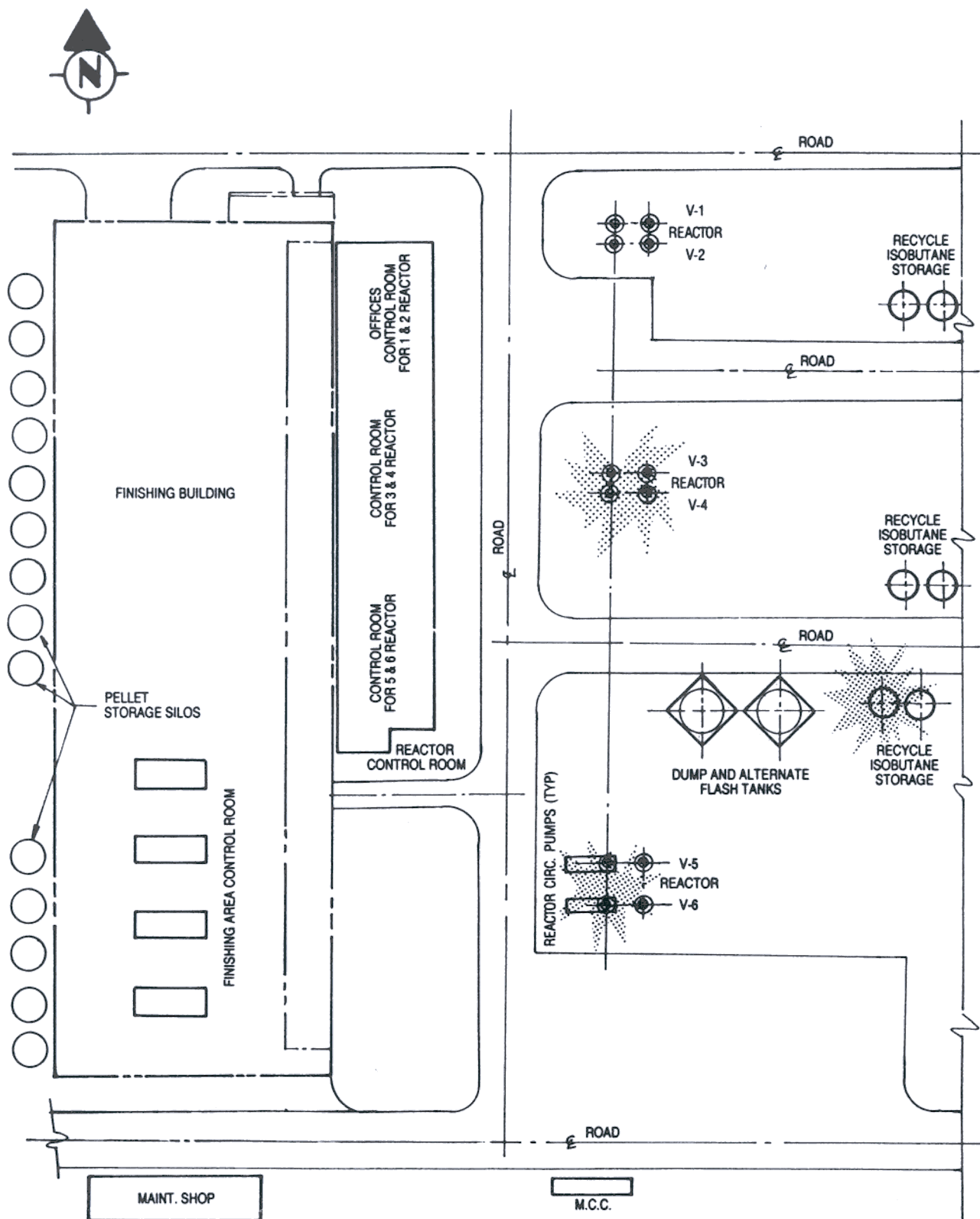


Figure 2. Partial Equipment Location Plan/Reactor Area--Plant V

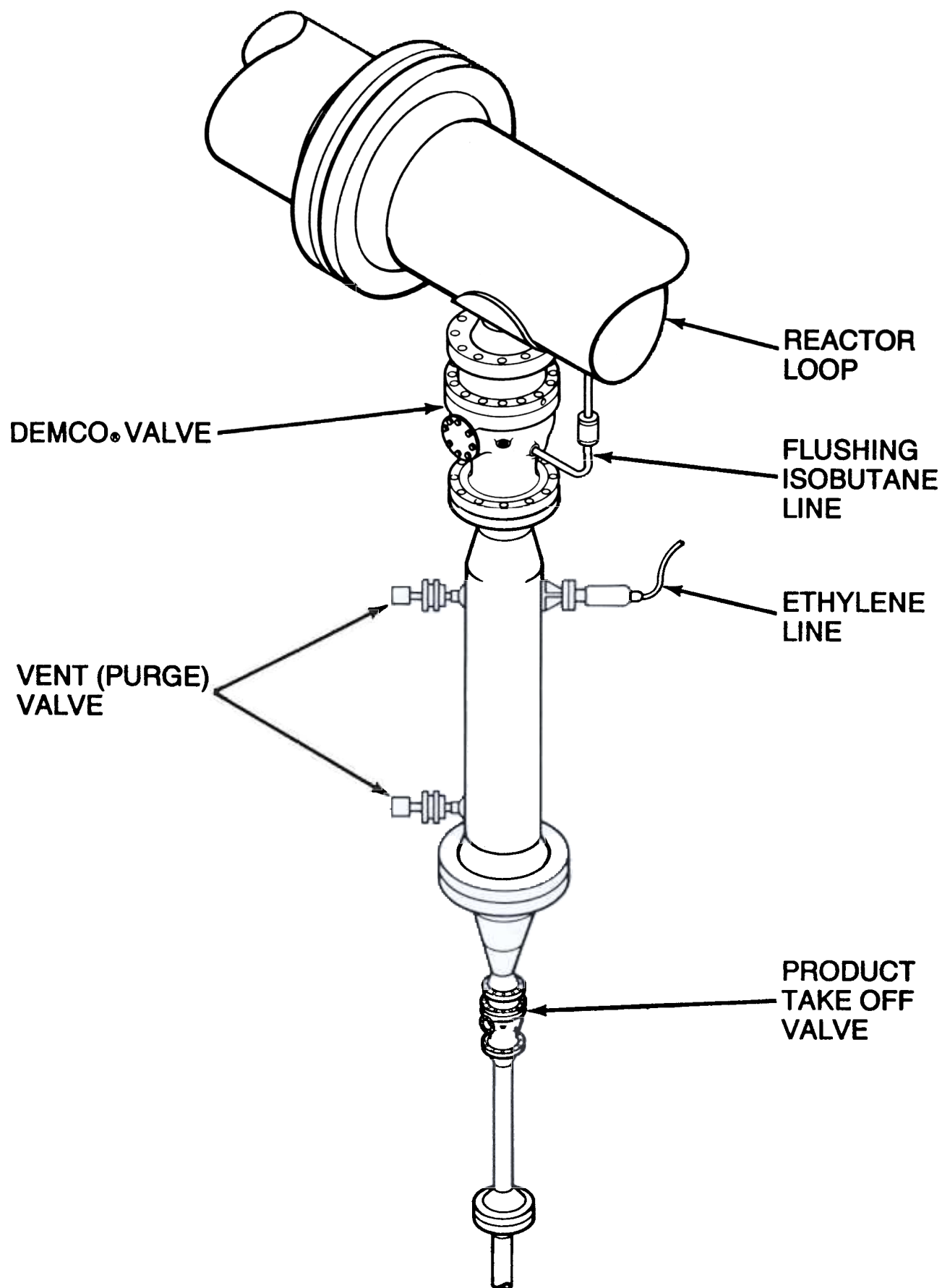


Figure 3. Typical Piping Settling Leg Arrangement

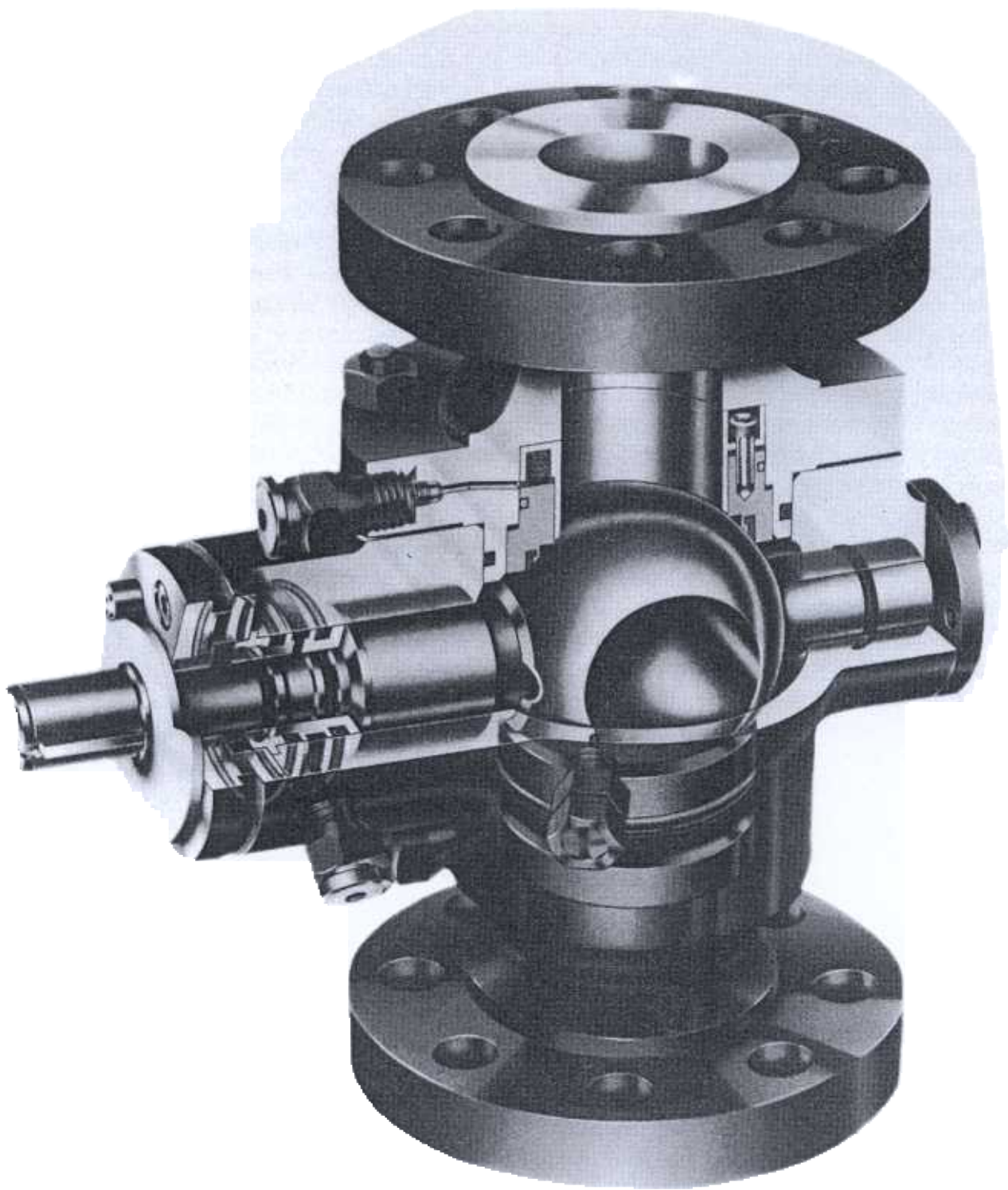


Figure 4. DEMCO® Valve

In the Phillips reactor, the plastic material frequently clogged the settling legs. When this happened, the DEMCO® valve for the blocked leg was closed, the leg disassembled, and the block removed. During this maintenance process, the reaction continued and the product settled out in the legs that remained in place. If the DEMCO® valve were to open during a cleaning-out operation, there would be nothing to prevent the escape of the gas to the atmosphere.

OSHA's investigation concludes that on October 23 more than 85,000 pounds of highly flammable gas were suddenly released through an open DEMCO® valve. In less than 2 minutes, the gas rapidly found its way to an ignition source and exploded. The explosion and ensuing fire occurred at approximately 1:00 p.m. Estimates of the time that elapsed from the release of the gas to the initial explosion ranged from 90 seconds to 2 minutes. A second explosion occurred 10 to 15 minutes later when two isobutane storage tanks exploded. Each explosion damaged other units, creating a chain-reaction of explosions. One witness reported hearing ten separate explosions over a 2-hour period.

The accident resulted in significant loss of life and numerous injuries and caused property damage of nearly \$750 million. The most significant and tragic loss occurred in the workplace. Twenty-two bodies were recovered at the accident site; a 23rd victim died off site at a local hospital. The mixture of flammable gases ignited, dissipated, and thus did not pose a threat to the public or the environment. The injuries that occurred outside the complex were related, for the most part, to the debris of the explosion. All of those who died at the scene were within 250 feet of the point of initial release.

RESPONSE TO THE ACCIDENT

The Immediate Response

The Phillips fire brigade provided the initial emergency response, which included administering first aid to injured employees and fighting the fire with onsite equipment. The effort was augmented by local emergency response units including fire, police, and ambulance and by the Channel Industries Mutual Aid organization (CIMA). CIMA, a cooperative of approximately 106 members in the Houston area, which included industrial facilities, municipal fire departments, the U.S. Coast Guard, the County Sheriff's Department, and the County Fire Marshal's Office, was established to provide assistance to its members in emergency situations. This assistance included trained firefighting, rescue, and first-aid personnel and equipment. Command of the site and coordination of the response were under the control of the Phillips Complex fire chief.

EPA Region 6, headquartered in Dallas, was notified of the incident by the National Response Center at 3:27 p.m. after a concerned citizen made the initial report of the accident at 3:14 p.m. EPA Technical Assistance Team representatives were on scene within the hour and performed air monitoring at several locations downwind from the facility. No hydrocarbon concentrations above background levels were found. An EPA on-scene coordinator arrived at 4:30 p.m. to provide technical assistance to Phillips in emergency response procedures, and in accordance with the National Contingency Plan--the national emergency response plan developed by the 14-member interagency (NRT)--to ensure that the response measures were adequately protective of public health and the environment.

Phillips officials notified the Texas Air Control Board, the Harris County Pollution Control Board and the Community Awareness Emergency Response Program immediately following the explosion. The Federal Aviation Administration took steps to limit air traffic in the vicinity of the site, and the U.S. Coast Guard temporarily closed the Houston Ship Channel.

Firefighting

The Phillips Complex did not have a dedicated water system for fighting fires. Water for that purpose came from the same water system that was used for the chemical process. Consequently, when the process water system was extensively compromised by the explosion, the plant's water supply for fighting fires was also disrupted. Fire hydrants were sheared off in the blast, and because of ruptures in the system, water pressure was inadequate for firefighting needs. It was necessary to lay hose to remote water sources--settling ponds, a cooling tower, a water treatment plant, and a water main at a neighboring plant. Of the three backup diesel pumps that could have been used to provide water pressure to fight the fire, one had been taken out of service and was therefore unavailable, and another soon ran out of fuel and it, too, went out of service. Electric cables supplying power to regular service fire pumps were damaged by the fire, and those pumps were rendered inoperable. Nonetheless, the fire was brought under control within approximately 10 hours, with the help of several Phillips Complex fire trucks, which were able to pump foam on the fire, and with the assistance of firefighting equipment brought to the site by CIMA members and local fire departments.

Search and Rescue

Search and rescue efforts could not begin until daylight when the fire and the tremendous heat generated during the fire had subsided. These efforts were difficult because of the danger of structural collapse from the damage caused by the explosion. The U.S. Coast Guard and Houston fireboats evacuated more than 100 people from the facility and transported them across the Houston Ship Channel. These people had been in the Administration Building and would have had to cross the area of the explosion to reach safety had not the U.S. Coast Guard and fire department vessels been on the scene. The search was coordinated by the Harris County Medical Examiner and County Coroner. Any evidence that OSHA investigation personnel deemed useful in determining the cause of the accident was preserved during the search.

CHAPTER III

OSHA'S INVESTIGATION

OSHA's investigation was conducted by a team selected by the Regional Administrator from experienced field staff, including supervisors, industrial hygienists, and safety engineers, who were assisted by engineers from OSHA's national office and outside consultants. The team held an opening conference with officials of Phillips and of the Oil, Chemical, and Atomic Workers Union (OCAW) and the International Brotherhood of Electrical Workers (IBEW) prior to commencing a detailed inspection of the worksite.

The investigation into the causes of the accident was conducted concurrently with the investigation of possible violations of the OSH Act and involved the following activities: (1) obtaining scores of witness statements; (2) identifying and testing critical pieces of evidence from the debris; (3) reviewing thousands of pages of documentation; and (4) mapping the accident scene and documenting the condition of damaged or destroyed plant equipment.

Forty-six witnesses, who were identified as potential sources of valuable information about conditions at the plant immediately prior to the explosion, were interviewed by OSHA staff and the Harris County Fire Marshal's staff. Among those interviewed were four surviving eyewitnesses who were present at the point of the gas escape at the time of the event, but who managed to escape death. The other witnesses included Phillips plant supervisors, operators, maintenance and security personnel, and supervisory and maintenance personnel from the onsite contractor (Fish Engineering and Construction, Inc.), which was responsible for maintenance activities at the complex.

The investigating team began photographing and videotaping the site while rescue operations were being conducted. OSHA personnel assisted in the search and rescue effort by providing information relating to critical safety issues. Immediately following the rescue operations, when OSHA investigators were first able to enter the accident site, they identified specific areas in the plant and equipment relevant to the investigation. These were isolated, and an extensive tagging and documentation operation was initiated to establish a chain of custody for evidence. Certain materials were removed by OSHA for laboratory tests.

In the course of the investigation, thousands of pages of documents relating to the facilities, equipment, and work practices at the complex were reviewed by OSHA compliance officers and engineers. Among these documents were process flow diagrams, instrumentation diagrams, maintenance records, standard operating procedures manuals, training manuals, and plant and corporate safety manuals.