Appendix A
Hazardous Material Emergency Model

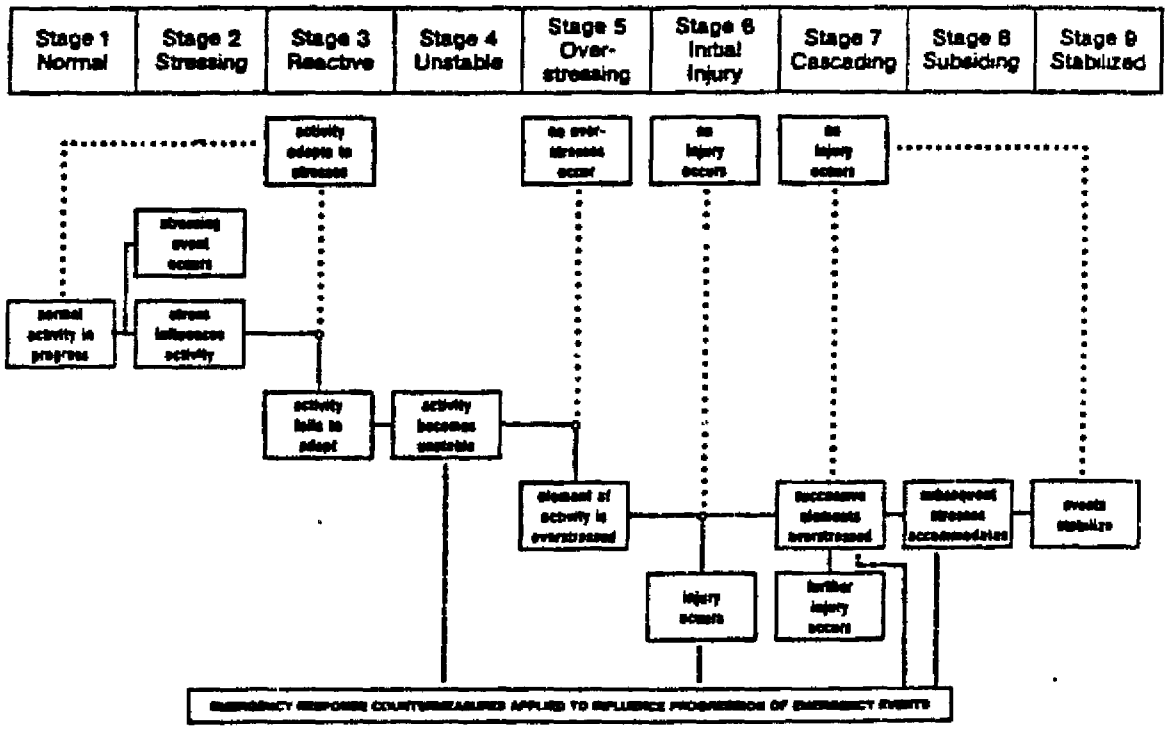
HAZARDOUS MATERIAL EMERGENCY MODEL

An emergency is defined as "a sudden, generally unexpected occurrence demanding immediate action.

A hazardous material emergency may go through several stages before it stabilizes. These stages are depicted in the Hazardous Material Emergency Model.

Rectangles represent events and arrows indicate the flow or sequence of these events.

I. HAZARDOUS MATERIALS EMERGENCY MODEL



SOURCE Benner, Ludwig, 1978. *Hazardous Materials Emergencies*. 2nd Edition Oakton, Va: Events Analysis, Inc.

Hazardous Material Data Sheet

Hazardous Material

Shipping Name _____ DOT Hazard Class _____
Chemical Name _____ ID Number _____ STCC Number _____

Physical Description:

Normal Physical Form: Solid ___ Liquid ___ Gas ___
Color _____ Odor _____
Other _____

Chemical Properties:

Specific Gravity _____ Vapor Density _____
Boiling Point _____ °F Melting Point _____ °F
Vapor Pressure _____ psi or mmHg at _____ °F Expansion Ratio _____
Solubility in water: Yes No Degree of solubility _____
Other _____

Health Hazards:

☐ Yes ☐ No Inhalation Hazard: Yes No TLV/TWA _____ ppm(mg/m3) LC50 _____ ppm/hr
Ingestion Hazard: Yes No LD50 _____ mg/kg
Absorption Hazard Yes No Skin Yes No Eyes Yes No
IDLH Value _____ ppm/air(mg/m3) STEL Value _____ ppm/air(mg/m3)
Chronic Hazard: Carcinogen Yes No Mutagen Yes No Teratogen Yes No
Hazardous to Aquatic Life Yes No
Other _____

Decontamination Procedures: _____

First Aid Procedures _____

Fire Hazards:

☐ Yes ☐ No Flash Point _____ °F Ignition (Autoignition) Temperature _____ °F
Flammable (Explosive) Range: LFL (LEL) _____ % UFL (UEL) _____ %
Toxic Products of Combustion _____
Other _____

Possible Extinguishing Agents: _____

Reactivity Hazards:

☐ Yes ☐ No Reactive with what _____
Other _____

Corrosivity Hazards:

☐ Yes ☐ No pH _____ Corrosive to what: Skin Yes No Steel Yes No Other _____
Other _____

Neutralizing Agents _____

Radioactivity Hazards:

☐ Yes ☐ No Type Radiation Emitted: Alpha Particles _____ Beta Particles _____ Gamma Radiation _____
Other _____

Recommended Protection:

For Public (Evacuation distance _____, for _____ (quantity)) _____

For Response Personnel (Level of protection required _____) _____

For Environment _____

GENERAL HAZARDOUS MATERIALS BEHAVIOR MODEL AND BASIC EVENTS INTERRUPTION PRINCIPLES

Event

Stress	Breach	Release	Engulf	Impinge	Harm

Event Categories

Thermal	Disintegration	Detonation	Cloud	Short term	Thermal
Mechanical	Runaway cracking	Violent rupture	Plume	Medium term	Radiation
Chemical	Attachments open up	Rapid relief	Cone	Long term	Asphyxiation
Irradiation	Punctures	Spill or leak	Stream		Toxic
Etiological	Splits or tears		Irregular deposits		Corrosive
					Etiologic
					Mechanical

Events Interruption Principles

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

SOURCE: Benner, Ludwig, 1978 *Hazardous Materials Emergencies*, 2nd Edition

OUTCOME ESTIMATE WORKSHEET	Without Intervention, Is This A Problem? (YES OR NO)	Will Intervention Help? (YES OR NO)
Fatalities		
Injuries		
Property Damage		
Critical Systems Disruption		
Environmental Damage		

Appendix B
Hazardous Materials Case Histories

HAZARDOUS MATERIALS
CASE HISTORIES

Countless times every day we encounter hazardous materials in our daily life. Whether it is the hydrocarbon fuel in our automobiles or the chlorine used to purify our water, hazardous materials in ever-increasing quantities have become a fact of life for all of us. Normally, these materials contribute positively to our way of life. But in incidents where unintentionally released, they can be a dangerous and treacherous enemy to the firefighter who must deal with them.

To aid your study of hazardous materials incidents, the following incident reports will give you a sense of the kinds of hazardous materials events that are occurring around the country today. The incidents range in size, severity, and complexity from situations easily controlled with simple precautions to incidents requiring multiple alarms. As you read these incidents, think about analyzing an incident like this in your community. Consider both the type and size of the behavior patterns described. Ask yourself whether you and your department are ready to analyze such an incident, should it occur in your jurisdiction.

1. In Oklahoma, during the fall of 1980, a stolen car crashed into a natural gas well, knocked off its cap, and allowed thousands of cubic feet of gas to enter the atmosphere. Firefighters arrived to find the auto, its engine still running, sitting atop the well. A crane was used to gingerly lift the car off the wellhead, and a specialist crew was called in to recap the well. Two lanes of the interstate were closed for a time, and about 100 families were evacuated.
2. Early in 1980, in California, an "empty" tank car of phosphoric acid caused a short-term evacuation of 2,000 people when a train stopped to let off train crew members complaining of respiratory problems and nausea. Firemen called for an evacuation and had the train moved out of town. A loose manway cover was alleged to have allowed phosphoric acid fumes to escape from approximately 200 gallons of product remaining in the "empty" car.
3. Later in 1980, in Massachusetts, a locomotive sideswiped a chemical tank train three miles from downtown Boston releasing clouds of hydrochloric and phosphoric acid. This caused the evacuation of more than 20,000 people and closed I-93, area businesses, and schools. There was an acrid cloud over Boston, but *no* fire or explosion. Approximately 300 were treated for fumes.
4. In October 1980, in Mexico, nine died and 28 were injured when a line burst while liquid ammonia was being pumped from a rail tank car into tank trucks at a loading rack. The resultant vapor cloud killed three passengers on a bus, four motorists, and two pedestrians. An early morning cold wave and lack of wind prevented the gas from covering a larger area.
5. In February, 1981, a California fire department responded to a 2,530-gallon spill of pesticide (Chlordane-72%) spread over a one block area by a pesticide company truck. The area was blocked off, access limited, and a call put in to CHEMTREC. The D.P.W. provided a load of sand for diking, as a command post was initiated. Using information from D.O.T.'s *Emergency Response Guide* and from CHEMTREC, the incident commander directed efforts to absorb the chemical and have it hauled to a waste disposal site. The street was then decontaminated by scrubbing with detergent.
6. Again in California, in December 1981, an engine company responded to a vehicle accident, for an extrication call involving two persons injured and one dead. They were providing first-aid treatment when they noticed containers thrown about from a truck involved in the accident. One of the five-gallon containers was used to make an identification using normal reference sources . . . organic phosphate, pesticide. Later it was found that

paramedics and injured persons were becoming ill from delayed effects of pesticide poisoning. A waste disposal firm was called to the scene, and soil in the area was scraped and removed to a disposal site. The pesticide was said to permeate leather products; therefore, police officers and firefighters were instructed to dispose of all leather products taken into the site on their person.

7. Earlier, in New York, a leaking propane tank truck shut down the George Washington Bridge for eight hours and caused a monumental traffic jam that backed up traffic as far as the Tappan Zee Bridge and the Connecticut state line 15 miles away. Alternate routes through the Lincoln and Holland Tunnels quickly became jammed, bringing traffic between New York City and New Jersey to a near standstill. Approximately 2,000 residents were evacuated from the bridge area on the Manhattan side, as firefighters used a cherrypicker to hose down the leaking tanker. Attempts to offload the cargo were hampered by the malfunctioning pressure relief valve that caused the original leak. Eventually, a police officer in emergency services, who was a former plumber, suggested use of a simple plumber's plug that was obtained from a Bronx hardware store and brought to the bridge by police motorcycle escort, where it was successfully attached to the tanker. The propane was offloaded to another truck and the bridge was reopened in the early evening, eight hours after being closed at 10 a.m. New York City later sued the transportation company for $600,000 to cover city costs in responding to the incident.
8. Late in 1980, a railyards collision in Canada between a yardtrain and two railway tank cars, caused an explosion and spectacular fire fueled by methanol. 17,000 gallons of methanol spilled and ignited at least six boxcars of newsprint just a short distance from stored propane and chlorine. The boxcars looked "like a string of burning Presto Logs" according to one firefighter. Firefighters arrived to find the rail siding on fire, a burning tank car, a railyard loaded with cars of unknown contents, and six flaming telephone poles carrying high-tension wires of 12,000 and 60,000 volts. Nearby tank cars containing propane and chlorine were shunted to safety. Pools of methanol were diked to prevent spread, and product remaining in the extinguished tank car was offloaded into two tank trucks.
9. In California, in 1980, a 10-inch pipeline ruptured and allowed a heavy leak of petroleum. The petroleum ignited, destroying nine homes and injuring four persons. Rivers of flaming fuel oil flowed throughout a residential block, as residents fled for their lives. Firefighters put down a three-foot-deep blanket of foam throughout the area and had the fire under control in two hours.
10. In Massachusetts, in 1981, leaking chemical drums in a 40-foot trailer at a commercial truck terminal gave off toxic vapors forcing the evacuation of up to 100 residents from within a half-mile of the closing of heavily-traveled Route 6. The local fire chief reported the commodity was liquid thionyl chloride, and noted that it could explode on contact with water. Clean-up crews, dressed in protective suits and helmets, were able to neutralize the spill and proceed with the clean-up. Thionyl chloride is corrosive, acidic, and poisonous. It is a colorless fuming liquid with a suffocating, pungent odor. It reacts with water to form sulfur dioxide and hydrochloric acid, and is corrosive to metals and tissues.)
11. In 1981, a Texas grain elevator complex, described by a Federal Grain Inspection Service official as one of the "cleanest" in the nation, was racked by explosions that killed five and injured 33. Damage to the facility on the waterfront was estimated at $30 million. Four silos were blown apart and at 54 of the facilities' 153 silos were heavily damaged. The

company had recently installed a $3 5 million dust collection system.

12 In April, 1981, a Nebraska town was evacuated after a grain elevator operated by Farmers Co-op exploded, killing one and critically injuring two. Officials feared that the damaged structure would collapse on nearby homes and businesses. The Nebraska explosions followed by only a few hours the grain elevator explosion in Texas (see number 11, above).

13. In 1980, California highway workers had a problem when a tank truck transporting molten sulfur from a refinery overturned and burst open in flames. Firefighters had the fire under control in 45 minutes, but once the smoke had cleared tons of hardened sulfur lay across four southbound lanes and one northbound lane of the interstate. High-pressure water hoses proved ineffective in removing the mess, and at last report officials were considering using a huge grinder.
14. In 1981, a Florida man died when the bucket of a backhoe being transported over Seven Mile Bridge on a flatbed trailer suddenly swung up, hit a steel girder of the bridge, and then slammed down into a propane tank next to the bridgetender's shack. The bridgetender died as additional propane tanks exploded in a chain-like sequence.
15. In 1981, a predawn explosion and fire in New York damaged an electrical transformer containing more than 1,000-gallons of pyranol containing polychlorinated biphenyls (PCBs) causing contaminated smoke to seep through the ventilation system of an 18-story state office building. Firefighters at the scene were working on their knees in the chemical, before it was recognized, and they saturated their clothing and skin. After the incident the County Health Commissioner noted· "Every hidden space on all 18 floors is contaminated—every desk, every light fixture, in the air conditioning system and the ducts—just everything." Officials fear the building may be closed for months, even years, during cleanup operations. Government regulations allow up to five parts-per-million of PCBs in edible fish; the soot in the building in Binghamton is reported to contain roughly 100,000 ppm. The PCBs may not be the main danger; the soot also contains dioxin, the chief ingredient in Agent Orange.
16. In California, in 1981, approximately ten gallons of an unknown substance was found on the ground at a construction site. The substance was believed to be oil, from a military-type transformer, spilled when an effort was made to salvage copper inside the transformer. The area was isolated and assistance was called in to make a positive identification by laboratory examination, and to perform clean-up The substance was determined to contain 50 ppm polychlorinated biphenyls (PCBs).
17. In 1981, Pennsylvania officials were called in to inspect an old dump-site that had existed for many years adjacent to a home for the retarded. Officials reported cyanide, chloroform, toluene, and naphthalene . . . some in dangerously high levels. The chemicals were thought to be coal gas products. Cyanide was said to be present at 100 ppm. State drinking water standards set the allowable levels of cyanide at .01 ppm.
18. In 1981, a California fire department responded when a couple of pallets at a department store were tipped over and chlorine and ammonia became mixed. Approximately ten persons had been trying to clean up the spill when they began to show signs of respiratory distress and headaches. Roughly 30 employees were evacuated and six treated.
19. In 1980, a two-to-three-gallon spill of PCB occurred at a South Dakota cement plant, shutting down part of the plant for a week. Workers built a dike around the electrical transformer, which was the leak source, barricaded the building containing the spill, posted a 24-hour

guard, and called in a crew of chemical experts.

20. In August, in 1980, a Pennsylvania garbage truck operator found that his load was on fire and dumped part of it on a residential driveway. Mixed chemicals discarded by a high school science department released cyanide fumes that sent nearly 100 persons to a local hospital. Chemicals involved included quart bottles of asbestos, arsenic, sodium cyanide, potassium cyanide, hydrofluoric acid, mercury, phosphorus, and a quarter-pound bottle of uranyl acetate that did not break. The probable cause of the fire was thought to be either spontaneous combustion or the action of the truck's compactor.
21. In May 1981, 900 people in Alabama were evacuated from within a ten-mile radius of a pesticide plant after it was leveled by an explosion that released toxic fumes. Continuing explosions over a period of hours kept firemen at bay. Attention was directed toward protecting exposures until hours later when firefighters were eventually able to approach the ruins and use light water to mop up burning residues.
22. A bus struck a gasoline tanker in a California highway tunnel. The tanker was torn open; gasoline escaped, ignited and began filling the tunnel with combustion products. Two persons escaped, but seven motorists died in the tunnel downwind of the fire, some as far away as 1300 feet from the tanker. The victims died before firefighters could start rescue operations.
23. In September, in 1980, one Pennsylvania person was killed and 10 injured by a flash explosion as crude oil was being pumped out of a tank car at the site of a freight train derailment. The explosion occurred shortly after firemen used ropes to rescue two persons overcome by fumes inside the car.
24. In May 1980, in Pennsylvania, 11 one-pint glass jars of pesticide were broken in a fall from a department store shelf and caused toxic fumes that sent 60 people to local hospitals. Firemen were called in after a call to the manufacturer showed that the solution contained malathion.
25. In 1981, a fire at a Colorado chemical plant burned for five hours, forced the evacuation of an estimated 250 persons, and allowed leaking flammable styrene to enter the town's sewer system. Frequent explosions were heard throughout the afternoon. Chemicals in the plant included toluene, heptane, styrene, butradiene, sodium disposium, lycon and zilon. All nearby manhole covers were raised to aerate the sewer system, but preliminary tests indicated the styrene was present only in smaller amounts not likely to cause further explosion or fire. (Styrene has a flashpoint of 90 degrees F. Vapors are irritating to eyes and mucous membranes. When contaminated or subjected to heat, it may polymerize. Polymerization inside a container may subject the container to violent rupture.)
26. In June, in 1980, six rail cars derailed in a downtown Louisiana urban area, causing a leak in one derailed car of 23,500 gallons of styrene monomer. Response crews were able to tighten a vent connection to stem the leak. Approximately 2,600 people were evacuated. Fire department crews built an earthen dike to contain spillage which was recovered by a Spill Control Services unit using absorbent materials. There were no injuries.
27. In Texas, in June 1980, nine cars of a train derailed at 2:15 A.M. spilling 5,000 gallons of styrene monomer. Approximately 6,500 persons were evacuated, and five persons were injured slightly. Firefighters used water to dissipate toxic vapors, and AFFF foam to lessen the potential for combustion. Two siphon dams were constructed on a nearby creek by local Civil Defense personnel, and entrapped water and styrene monomer were pumped into tank trucks for disposal at a sanitary landfill. One car of propane was reported leaking as well. There were no injuries.

28 Again in Texas, in August 1980, a jack-up drilling rig 18 miles off the Texas coast burst into flames after a pressure surge released natural gas and left the well burning out of control. Two were known dead, six injured, and three missing. The well was located in 100 feet of water. No attempt was made to fight the out-of-control fire, but 24 hours later material collapsing from the side of the drill hole extinguished the flames and plugged the well.

29. In June, in 1980, a Wyoming fireworks stand exploded killing one adult and three juveniles who were loading fireworks into trucks for transfer to retail outlets. The Assistant Fire Chief hooked a tractor to one burning trailer and pulled it to where firefighters could put water on it. County tanker trucks had to be called in to supply enough water to battle the hot fire.

30. In December, in 1980, toxic fumes (apparently caused when an employee mixed chlorine and another chemical) forced evacuation of a downtown New Hampshire Y.M.C.A. Firefighters in air masks led inhabitants to safety. Thirty-eight adults and children were treated at the local hospital. The nearby fire station was used as an evacuation depot to assemble evacuees in the frigid weather.

31. On July 26, in 1980, a train derailed in a Kentucky community and six of ten derailed tank cars burned. The fire caused a 3,000 foot column of toxic smoke visible over a ten mile area that forced the evacuation of approximately 7,500 area residents. Burning and/or derailed tank cars included six of vinyl chloride; other derailed cars contained chlorine, acrylonitrile, and toluene. Police wearing protective gear patrolled the streets of the community to prevent looting. Evacuees included personnel from nearby Fort Knox where the nation's gold reserves are stored. The cause of the derailment was not immediately known. The derailment occurred 100 yards from the main street of town. Response personnel used plastic explosives to blast the still-burning cars of vinyl chloride.

32. On July 22, 1980, in Louisiana, up to 41,000 pounds of hydrobromic acid fouled part of the Mississippi waterway after a German vessel collided with a Panamanian-flag bulk carrier. When it comes in contact with water, hydrobromic acid causes a volatile reaction and can cause a chemical burn like frostbite. Three thousand persons were evacuated from the adjacent shore area. More serious was the lingering pollution by crystalline pentachlorophenol. (PCP, a wood preservative not to be confused with PCP known as "Angel Dust.") Response personnel used sonar gear in an effort to locate the container carrying the PCP that had dropped into the water. Six days later, it was announced that the 32 crewmen of the second vessel had been exposed to 300 pounds of PCP piled on the main deck and tracked about the ship. Divers in hard hats continued to search the muddy waters trying to locate 12.5 tons of PCP. Blood and urine samples from clean-up workers were checked repeatedly. The PCP spread into Lake Borgne, and a close watch was kept on Lake Pontchartrain. The ship was quarantined, and the rich shrimping and fishing area 25 miles east of New Orleans was closed to all boats for weeks. On July 27, a Navy Minesweeper was brought in to aid in the search for the PCP. On Aug. 2, the lost container was raised but found to be empty of PCP. This incident was one of the biggest polluting chemical spills to date.

33. In Nevada, on December 11, 1980, a propane tank explosion at a water heater manufacturing plant injured 10 persons, one critically. A forklift ruptured a propane tank. As employees attempted to remove the leaking tank from the forklift, an explosion sent a ground-hugging fireball 45 feet.

34. In Florida, in February 1981, 45 persons went to the hospital when two 500 gallon tanks of chlorine and one 300

gallon tank of muriatic acid began leaking at a swimming pool company Toxic by themselves, chlorine and muriatic acid combine to form hydrochloric acid. Firefighters wearing SCBA were able to plug the leaks after the area was evacuated. Since the valves on all three tanks were broken between the tank and the control valve, authorities cited vandalism as the cause. Victims were treated, then released.

35. On Jan. 23, 1981, two New Jersey workers were killed and five injured by fumes they inhaled while cleaning inside an 8-foot-by-20-foot chemical mixing vat at a local chemical company. Chemical solutions used in the cleaning process gave off phenol and unital fumes, causing the two men to die.
36. In April, in 1980, fire at an Idaho chemical plant caused the evacuation of 700 residents during Earth Day environmental celebrations. Airborne toxic fumes from pesticides and herbicides were kept from two adjacent towns by the coincidence of a light breeze. Thirty firefighters were treated for fumes.
37. On July 24, 1980, sparks from a welder's torch in New York apparently set off volatile lacquer fumes at a metal fabrication plant causing a flash explosion that killed nine and injured 30. Sixteen firefighters and four paramedics were treated for smoke and toxic fume inhalation.
38. In New Jersey, on December 20, 1980, a 180-foot chemical barge was damaged by two explosions. The first, believed caused by naphtha gas leaking from a valve, critically injured a crew member. The second, believed caused by a build-up of gas in the engine room, injured three firefighters, knocking one into the waterway encumbered by SCBA. Two firefighters who went to the rescue of the first were slightly injured.
39. On March 26, 1981, 11 Arizona citizens became ill after being exposed to nitrogen tetroxide, an oxidizing agent used as a component in Titan II rocket fuel. A state hazardous materials inspector was apparently unaware that his clothing had become contaminated while inspecting a truck, and he exposed the ten other persons over a five-hour period while going about routine duties. His condition became known only after he became violently ill five hours after exposure. He was later reported in good condition at an area hospital.
40. In Kentucky, on February 13, 1981, a predawn series of explosions in a two-mile stretch of a major metropolitan sewer system caused an estimated $42 million in damage to pavements and sewers within a 15- by 14-block area. It caused the evacuation of 100 families. The blasts, which engineers estimated to carry the force of 100 tons of TNT, left 23 craters in the streets and blew manhole covers along 13.5 miles of streets. The blasts were apparently caused by an estimated 150–200 gallons of hexane, an industrial solvent, that reportedly spilled into the sewer system from a local grain and soybean mill. Amazingly, only four persons were injured, none seriously.
41. On a California highway, in May of 1981, a 90-pound container fell off the rear of a chemical company truck. A motorist who stopped and rolled the container off the road received second-degree burns and had to be transported to the hospital by paramedics. A clean-up unit responded, picked-up the container, and did minor residue mop-up on the roadway.
42. On April 2, 1981, two were killed and 25 injured in what police described as the explosion of a bootleg fireworks manufacturing plant in Kentucky. The explosion shattered windows in about 100 buildings within a four-block area, and leveled the concrete block garage where a Newport man was believed engaged in the illegal manufacture of fireworks. An estimated 100 persons were displaced temporarily from their homes pending fire inspections.

43. An employee of an electronics manufacturing concern discovered a fire in a container of scrap aluminum in a 40' × 10' room, and notified guards. Before they could train hoses on the flames, there was one large explosion, then there were either two or three rapid, close-together explosions that sent a plume of black smoke into the air and rattled nearby homes. Fourteen people were treated for minor injuries or smoke inhalation and released. Damage was estimated at $3 million.
44. On May 29, 1980, 800 Washington State employees at an aircraft plant were evacuated for five hours when nitric acid vapor was released during a transfer of 800 gallons from a holding tank to a tank truck. It had entered the plant through the ventilation system. Plant personnel used water mist to control the vapor cloud. Cause of the accident was felt to be either improper lining within the truck tank or a reactive residue remaining within the tank.
45. In October of 1980, eight Washington state workers at a federal chemical processing site were contaminated when plutonium scrap caught fire. Two workers ingested a small amount of plutonium oxide powder. Unlike metallic plutonium, plutonium oxide does not normally flash to flame, and officials are at a loss to explain the cause of this incident.
46. On April 9, 1981, employees of a Michigan chemical plant were attempting to cool a vat of phenol formaldehyde/carbolic acid when a safety valve ruptured emitting a plume of steam that carried a corrosive mist into the air. An acid cloud dripping "white rain" covered a square mile of Detroit's east side, sending 19 persons to local hospitals for treatment of burns, and eye and respiratory problems. The total amount of chemical involved was estimated at 2,000 pounds, There were reports of dead animals and paint stripped from buildings and vehicles. No evacuation was ordered.
47 On Sept. 18, 1980, in Arkansas, nearly 1,400 people were evacuated from three small nearby towns when a fuel leak occurred in an underground Titan II missile silo. The leak was reportedly caused by a three-pound socket dropped from a height of 70 feet. An explosion eight hours later killed one, injured approximately 20, and wrecked the silo, blowing debris (including a nuclear warhead) a couple of hundred feet over the nearby area. A 1978 leak from an aboveground fuel tank had previously required evacuation of the same complex. In that incident, several people were hospitalized for inhalation of toxic fumes. Officials stated there was no leakage of radiation during either incident.
48. In January, in 1981, a California highway incident involving a truck-load of smoldering sulfur raised an interesting issue for response personnel. CHEMTREC, the shipper, and the manufacturer reportedly each gave the dispatcher somewhat different recommendations for extinguishing the sulfur. CHEMTREC recommended using a CO-2 fire extinguisher or a flammable metal type of extinguishing agent; the shipper recommended covering the sulfur with additional sulfur in order to exclude oxygen; the manufacturer recommended using water, saying that a garden hose would do.
49. In February, in 1980, a drain hose from a Vermont electronics plant chemical tank detached from its fitting, and leaked a mixture of methanol, hydrochloric acid, and alcohol on an electric pump motor. It caused a fire that destroyed 50% of the electronics plant. Three firefighters were treated for inhalation of toxic fumes or minor acid burns.
50. In New York, in late 1980, a fire and explosions in two 1.5-million-gallon capacity storage tanks (one containing 30,000 and the other 6,000 gallons) threatened to spread to other full tanks at a storage facility in the Port of Albany. Two explosions 30 minutes

apart occurred three hours after the fire started. The fire began about 10 A.M., reportedly in a separate tank where a vacuum truck was siphoning a foot or so of residue from unleaded gasoline previously stored in the tank. A fire of unknown origin started under the truck and spread to the nearby tanks. Eight persons, mostly firefighters, were injured as nearby residents were evacuated.

Appendix C
Glossary of Terms

GLOSSARY OF TERMS

ACTOR:	Who or what does something
ACTION.	What the actor does or did.
ANHYDROUS:	Without water, dry.
BREACH:	An opening in a hazardous material container through which hazardous material matter or energy can or does escape. Opening may be unintentional or made by emergency response personnel.
COMBUSTION:	A chemical reaction characterized by visible flame and heat evolution.
CONDITION:	A particular, steady state of being of a person or thing or set of persons or things.
CONTAINMENT SYSTEM: (CONTAINER)	A system of components which has the capability to receive, enclose, hold and discharge gas, liquid or solid substances in either a static (bottle) or dynamic (pipeline) condition.
DISPERSION:	The scattering, migration, or spreading of energy or matter away from the point where it was contained.
DOT:	The Department of Transportation; the Federal Agency which regulates the transportation of hazardous materials; also publishes aids for emergency response.
EMERGENCY RESPONSE PERSONNEL	Used to describe any persons engaged in the control of hazardous materials emergencies, firefighters, police, civil defense/emergency management officials, sheriffs, military, manufacturing and transportation industry personnel.
ENERGY:	Work (change of state) a system is capable of doing to something else.
ENERGY TRANSFER.	The doing of the work that is done to something else.
ENGULF:	Surround completely by flowing over or around.
EVENT:	As used in this course, one action by one actor. An action by someone or something; includes mental actions such as decisions, conclusions and observations, as well as physical actions such as explosions, stressing, ignition, inhalation, rupture, bending, release, fall, etc. Note that an event is ONE action by ONE person or thing.
EVENT SEQUENCE:	A series of related events in a logical proceed/follow order in time.
HARM:	Injury or damage to an actor.

HAZARDOUS MATERIAL:	Formal: Any substance or material in a quantity and form which may pose an unreasonable risk to safety and health or property. Informal: A substance that jumps out at you when something goes wrong, and harms or hurts the things it touches when released.
HAZARDOUS WASTE:	Materials declared by the U.S. Environmental Protection Agency to be hazardous to the environment; now regulated by DOT and USEPA.
IMPINGE:	Means "strike or collide with"; here it is used to differentiate between being touched by and being hurt by the matter or energy released by a hazardous material or shipment. Exposures impinged are not always hurt—injury depends on the lethality, duration and intensity of the hazardous material impingement experienced.
KINETIC ENERGY:	Energy derived from motion, (i.e., a car moving down the highway).
LETHALITY:	A shipment's relative ability to cause death or serious injury.
MARKING:	A sign, inscription, symbol, or visible impression on an article like a container or containment system.
MONOMER:	A molecule that can be chemically bound as a unit of a polymer
OUTCOME:	A condition produced by a course of events; the state at the end of a hazardous materials emergency, including losses such as fatalities, injuries, property or environmental damages, lost production, damaged reputations, residual fear of hazardous material, and any harm that would not exist if the emergency had not happened. Outcome is the state at the end of a given course of events as defined at a single point in time.
OVERSTRESS:	To stress an actor beyond the actor's recoverable limits, disrupting the functioning of that actor in its expected way.
PATTERNS:	The shapes and configurations formed by dispersing matter or energy released from a containment system holding a hazardous material; these shapes have boundaries, and concentration gradients of matter or energy within the boundaries.
POLYMER:	Any of numerous natural and synthetic compounds of usually high molecular weight consisting of up to millions of repeated linked units, each a relatively.light and simple molecule.
POTENTIAL ENERGY:	Energy derived from position. (I.E., height it can fall).
PRINCIPLE:	A rule, law, or standard concerning how a process or something functions; useful for predicting characteristic behavior.

PROGRAMED:	The expected behavior instilled in people or things through design, training, supervision, etc.
RADIANT ENERGY:	A form of kinetic energy but not visible, i.e., gamma rays from radioactive materials.
REACTION:	Chemical: The combining of two or more materials into another or the chemical breakdown of a chemical material, or the combining of a chemical into a polymer or chain. Physical: The response to a stressing force.
RUPTURE:	The violent, rapid bursting open of a container.
SHIPMENT:	The freight being transported, which includes the hazardous material contents and the containment system (box, truck tank, fittings, valves, lids, labels, etc.) described in the shipping documents. Transportation emergencies involve hazardous materials SHIPMENTS, not just hazardous materials.
STATE:	1. A condition made up of the way real things or people are at a given point in time and place when used in connection with outcomes; 2. Also used to describe the physical condition of matter—solid, liquid, and gaseous.
STCC:	The Standard Transportation Commodity Code
STRESS:	Noun: The condition of being strained or subjected to a force that tends to strain or deform or otherwise change a body or mass; a potentially disturbing or disruptive influence. Verb: to apply a form of force or energy or system of forces that tends to strain or deform or otherwise change a body or mass; disruptive influence. NOTE: Stress conveys application of a force or exertion of some kind of "pressure" on someone or something involved in an emergency. Stress is used in this course primarily to convey a threatening force on containers or people, with harm the potential end result in both instances.

STRESSEE:	The actor whose state is being changed by stress.
STRESSOR:	The actor applying the force or the energy being transferred.
UNSTABLE:	A state immediately preceding erratic or unwanted behavior.

D.E.C.I.D.E. ACRONYMS

The D.E.C.I.D.E. system of instruction also uses several acronyms as a device to help remember the elements of the emergency response decisionmaking process. These acronyms include the following:

D.E.C.I.D.E.:	The first letters of the six essential decisionmaking steps required during a hazardous material emergency.
G.E.B.M.O.:	Stands for the Hazardous Material General Behavior Model.
H.M.:	Stands for Hazardous Materials.
T.R.A.C.E.M.:	Stands for the six principal injury mechanisms that occur during hazardous materials incidents.

Appendix D
References

SUGGESTED READING LIST

D.E.C.I.D.E. BIBLIOGRAPHY:

The following references are suggested for further reading about the analytical concepts, principles and methodologies used in this program:

1. Benner, L., "D.E.C.I.D.E. In Hazardous Materials Emergencies", *Fire Journal*, July 1975 (The initial D.E.C.I.D.E. research paper.)
2. Benner, L., "Accident Investigation: Multilinear Events Sequencing Methods", *Journal of Safety Research*, 1975 (A research paper describing events matrixing methods for analyzing accidents).
3. Benner, L. "Predicting Hazardous Material Emergency Outcomes", *Proceedings of System Safety Society, 1975 International Symposium*, Newport Beach, CA. (The paper advancing the idea that outcomes can be predicted).
4. Benner, L., *Hazardous Materials Emergencies: Programmable!* National Fire Protection Association, 81st Annual Meeting, May 1977, Washington, D.C. Available from Lufred Industries, Inc., Oakton, VA. (Discusses behaviors and dangers programmed into hazardous materials shipments.
5. Benner, L., "D.E.C.I.D.E. For Hazardous Materials Emergencies", *Presented Papers, Vol. II, Fifth International Symposium on the Transport of Dangerous Goods by Sea and Inland Waterways*, Hamburg, FRG, 1978 (Follow-up research paper expanding on the analysis methods used to develop the D.E.C.I.D.E. system and updated explanations of system elements.
6. Benner, L., *D.E.C.I.D.E. Process: A Textbook For The Study Of Hazardous Materials Emergencies*, I.S.F.S.I., Quincy, MA 1978. (Detailed study of the D.E.C.I.D.E. system for emergency responses in a 15-week junior-college-level course).
7. Benner, L., *Hazardous Materials Emergencies, Instructor's Manual*, I.S.F.S.I., Quincy, MA 1982 (Instructor's manual for the 15-week course).
8. Benner, L , *Hazardous Materials Emergencies, Student Workbook I.S.F.S.I., Hopkinton, MA 1978 (Student workbook for the 15-week course).*
9. Benner, L. and Hildebrand, M., *Hazardous Materials Emergencies: Specimen Student Workbook*, I.S.F.S.I., Ashland, MA 1980. (Instructor's guide for completing workbook for the 15-week course).
10. Ferry, Ted S., *Advanced Accident Investigation, Chapter 12* John Wiley and Sons, New York, 1981. (Discusses multilinear events sequencing methods for analysis of accidents).
11. Hildebrand, M. and Benner, L., *M.A.P.S.: Mapping Accidents For Planning and Simulations*, The Robert J. Brady Co., Bowie, MD, 1981. (A program to simulate D.E.C.I.D.E. for planning and response simulation.
12. *Recognizing And Identifying Hazardous Materials*, An industry public service audio-visual training program using D.E. in D.E.C.I.D.E. for firefighters. Write to:
    The Association of American Railroads
    1920 L Street, N.W.
    Washington, D.C. 20036

    or

    Chemical Manufacturers Association
    2501 M Street, N.W.
    Washington, D.C. 20037
13. Courses and publications from the Union Pacific Railroad.

GENERAL REFERENCE LIST

This hazardous material incident analysis course should prepare you to learn more effectively from other incidents. Descriptive reports of other incidents are available from numerous sources. These sources include periodicals, government agency reports, newsletters, and your local newspapers.

PERIODICALS:

Periodicals that publish hazardous materials incident reports and related articles are often available in local fire departments, local libraries, or from individuals who may be members of the publishing organizations who subscribe to the periodicals, or from governmental agency libraries.

Some of the periodicals listed publish an annual index of articles they have printed. Try to locate and use that index whenever you are engaged in an inquiry into a specific problem:

Fire Journal
Fire Engineering
Firehouse Magazine
Fire Service Today
The Hazardous Materials Newsletter
Chemical Week
Chemical and Engineering News Gefahrliche Gute (Marine Incidents, in German)

GOVERNMENTAL AGENCIES:

In addition to usual state fire service incident information sources, accident reports are published from time to time by the following governmental agencies. Reports can be requested by writing and asking for incident reports released during a recent (quarterly) period, or writing about a specific incident report when you know the agency has investigated the incident:

NATIONAL TRANSPORTATION SAFETY BOARD
Chairman
National Transportation Safety Board
Washington, D.C. 20594

FEDERAL RAILROAD ADMINISTRATION
Associate Administrator for Safety
Federal Railroad Administration
Department of Transportation
Washington, D.C. 20590
(or contact local field office)

FEDERAL HIGHWAY ADMINISTRATION
Director, Bureau of Motor Carrier Safety
Federal Highway Administration
Department of Transportation
Washington, D.C. 20590
(or contact local field office)

U.S. COAST GUARD
Commandant
U.S. Coast Guard
Washington, D.C. 20593
(or contact local Captain of the Port)

U.S. NUCLEAR REGULATORY COMMISSION
Office of Public Affairs
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

U.S. DEPARTMENT OF ENERGY
Secretary
U.S. Department of Energy
Washington, D.C. 20545

U.S. ENVIRONMENTAL PROTECTION AGENCY
Administrator
U.S. Environmental Protection Agency
401 M Street, S.W.
Washington, D.C. 20460
(or contact a Regional Office or your State EPA official for help)

NEWSLETTERS:

The Hazardous Materials Newsletter, Barre, Vermont 05641. (Reports more incidents than other newsletters).

OTHER SOURCES OF INCIDENT INFORMATION:

Personal sources can provide valuable information about hazardous materials incidents that may be of interest to you. These include (in addition to your normal fire service contacts) safety personnel from industries in your

community and carrier safety personnel, among others. If you plan to put this information to work for you, get it where you can. However, if you are just getting the incident information because it would be nice to know, remember that getting, handling and storing information takes time, effort and money.

CREDITS FOR CONTENTS

The following materials are reproduced by permission:

1. The D.E.C.I.D.E. system of instruction is adapted from HAZARDOUS MATERIALS EMERGENCIES, by Ludwig Benner, Jr., and is used by permission of LUFRED INDUSTRIES, INC., Oakton, VA 22124.
2. HOW TO FACE A HAZARDOUS MATERIALS EMERGENCY, by James B. King, is used by permission of Firehouse Magazine Associates, New York, NY 10022.
3. D.E.C.I.D.E. IN HAZARDOUS MATERIALS EMERGENCIES, by Ludwig Benner, Jr., is used by permission of the author and the National Fire Protection Association, Quincy, MA 02269.
4. Slides from HAZARDOUS MATERIALS MANAGEMENT SYSTEMS: THE M.A.P.S. METHOD, by Michael S. Hildebrand and Ludwig Benner, Jr., are used by permission of the Robert J. Brady Company, Bowie, MD 20715.
5. Excerpts from THE HAZARDOUS MATERIALS NEWSLETTER are used by permission of the author, John Cashman. Box 204, Barre, Vermont 05641.

Appendix E
Examination Answer Sheet

HAZARDOUS MATERIALS INCIDENT ANALYSIS
Course Exam

For each question write your answer *on the answer sheet*, indicating either true or false or your choice that *best completes* the statement.

True or False:

1. The faster the hazardous material escapes from its container, the greater the chance that emergency response forces can influence the outcome.

2. CHEMTREC is a hazardous materials information resource manned by chemists and hazardous materials experts.

3. In general, the dome arrangement fitting will always be enclosed in pressurized railroad tank cars.

4. By predicting dispersion patterns, firefighters can identify their exposure problems.

5. The NFPA 704 marking system will *specifically* identify the material in the marked container.

6. If the container itself is not stressed, there is no danger of the hazardous material inside the container being stressed.

7. More than one material, all having similar properties, can be assigned the same DOT four-digit identification number.

Multiple Choice:

8. If the hazardous material has not yet released when you arrive at the scene, you should look for containers which have been:

   a. stressed.
   b. breached.
   c. released.
   d. dispersed.

9. A railroad LPG tank car has been rolled onto its side as a result of a derailment. This type of stressor is:

   a. mechanical.
   b. chemical.
   c. thermal.
   d. none of the above.

10. The shipping papers found on a train are called the:

   a. waybill or airbill.
   b. bill of lading.
   c. dangerous cargo manifest.
   d. consist and bill of lading.
   e. both a and d.

11. Of the following hazard classes, a red and white placard with the U.N. number 4 indicates:

    a. explosives.
    b. flammable gases.
    c. flammable liquids.
    d. flammable solids.

12. The Standard Transportation Commodity Code is a seven-digit number used by the railroads for commodity identification. The first two digits, indicating the presence of hazardous materials, are:

    a. 48.
    b. 94.
    c. 49.
    d. none of the above.

13. Frostbite injuries are an example of:

    a. thermal harm.
    b. chemical harm.
    c. etiological harm.
    d. mechanical harm.

14. A BLEVE scenario would include a breach mechanism involving:

    a. consumed catastrophic disintegration.
    b. runaway linear cracking.
    c. attachments opening up.
    d. punctures.
    e. splits or tears.

HAZARDOUS MATERIALS INCIDENT ANALYSIS
Course Examination

Instructor Note

A 14-question objective test is provided for the instructor who wishes to use it. It is designed to be administered and scored quickly.

The questionnaire will need to be copied for distribution at the time of the test because it is not in the Student Manual.

Answer Key

True or False:

1. F
2. F
3. T
4. T
5. F
6. F
7. T

Multiple Choice:

8. a
9. a
10. e
11. c
12. c
13. a
14. b

Appendix F
Background Reading For Course Incidents

INCIDENT 2

In Memphis, TN, in 1981, a tractor trailer carrying numerous drums of flammable liquids was forced off Interstate 40 by another driver. The trailer tipped over when its driver, swerving to the right to avoid striking the other car, left the roadway and entered a ditch.

While ignition did not occur, several of the drums broke open and spilled their contents onto the interstate. Upon arrival the responding emergency crew encountered an obstacle: no hydrant was available directly on the interstate. A 2½-inch hose was connected to the engine company off the closest hydrant and then attached to two 1½-inch hose lines. One of these acted as a foam line; the second was used by the engine company on the interstate to keep a booster tank filled and a pre-connected 1½-inch foam line in operation.

When the emergency crew attempted to apply AFFF foam to the spill, they discovered that part of the truck's load consisted of benzine, a polar solvent. The material caused the foam to dissipate as soon as it was applied, and the ensuing clean-up process lasted 4½ hours. A private contractor disposed of the drums and completed the clean-up operation. There were no reported injuries.

INCIDENT 3

In Memphis, TN, 1980, a tanker on a delivery run carrying 8,000 gallons of gasoline flipped over onto its left side when its driver turned a corner too quickly and struck a curb.

Upon impact, the tanker's number one dome assembly disengaged from the tank and landed in the street; an immediate spill of approximately 1,300 gallons of gas occurred. The three remaining compartment domes remained intact, but bad gaskets caused them to leak gasoline at a rate of 50 gallons per minute. The spilled materials entered a storm drain 50 feet from the front of the truck, flowed through the drain and emptied into an open drainage ditch.

Eight minutes after the fire department received the alarm, ignition occurred. The fire spread from the tanker through the storm drain into the open drainage ditch.

The crews used foam to extinguish the fire, which was approximately 30 minutes in duration. The clean-up process took 10 hours; the truck line's owner provided crews. No injuries were reported.