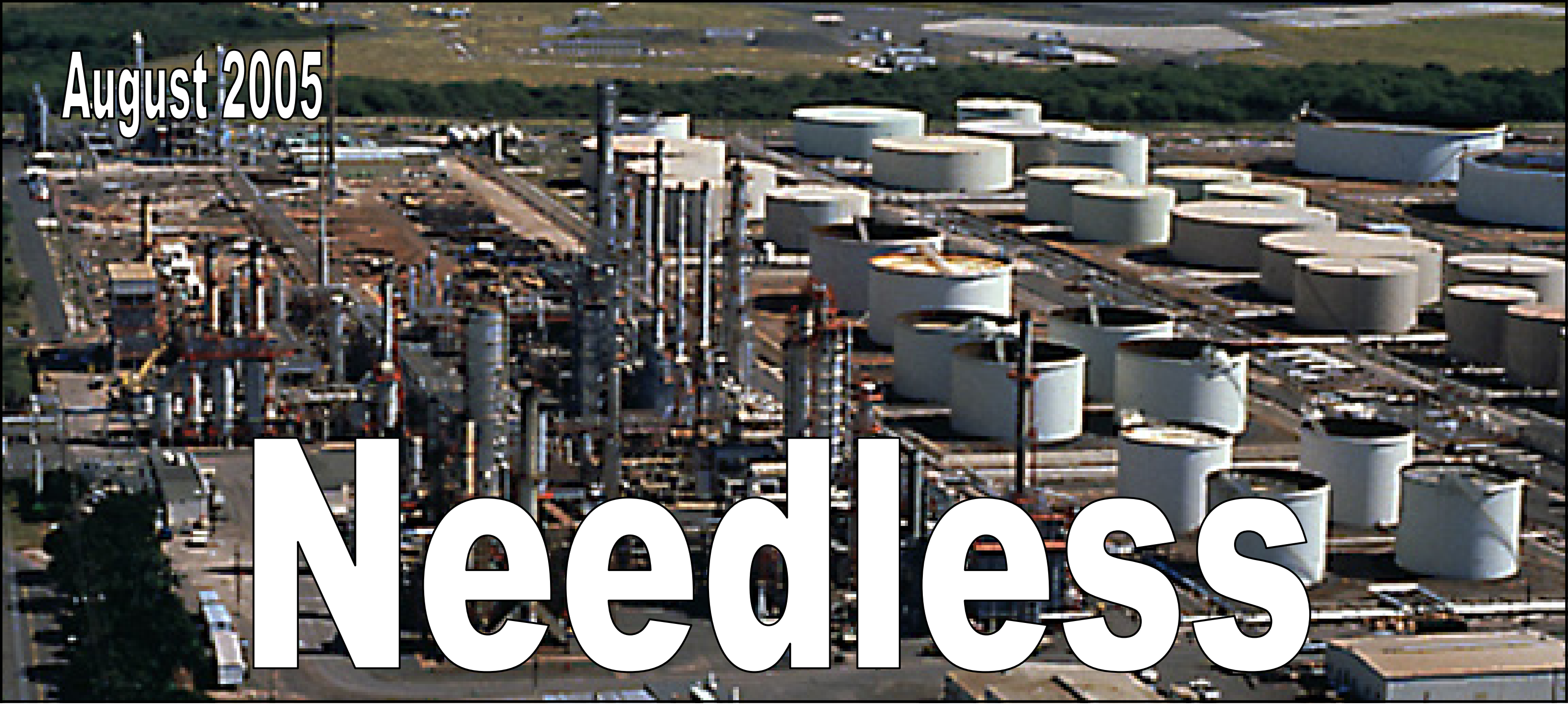
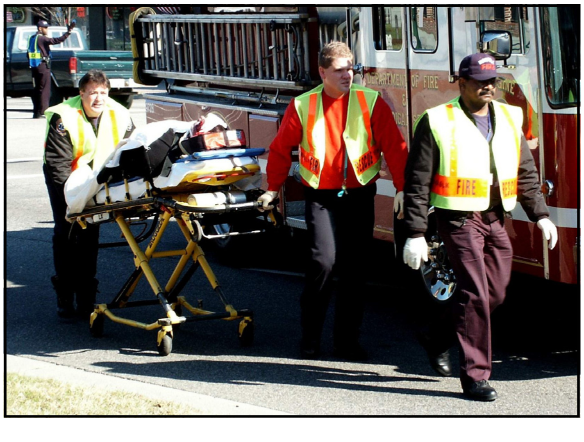


August 2005

Needless Risk



Oil Refineries and Hazard Reduction

U.S. PIRG Education Fund

NEEDLESS RISK:

OIL REFINERIES AND HAZARD REDUCTION

MEGHAN PURVIS
MARGARET HERMAN

U.S. PIRG EDUCATION FUND

AUGUST 2005

ACKNOWLEDGMENTS

Cover photo of oil refinery obtained from the Hawaii State Department of Business, Economic Development & Tourism, at http://www.hawaii.gov/dbedt/ert/refinery.html. Note that this photo is for illustrative use only; this refinery does not use hydrofluoric acid. Photo of children playing courtesy of Denny Larson of the National Refinery Reform Campaign, www.refineryreform.org. This photo shows children from the Carver Terrace federal housing project playing in the shadow of the Premcor refinery in West Port Arthur, Texas. Photo of homes near an oil refinery obtained from EcoIQ.com Online Images. Photo of emergency medical technicians obtained from the City of Norfolk at www.norfolk.gov/NFR/images/emspic.JPG.

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EXECUTIVE SUMMARY

Across the country, petroleum refineries, chemical plants and other industrial facilities use and store large amounts of hazardous chemicals that could be released in the event of an accident or terrorist attack. Such releases could endanger thousands or even millions of people who live in communities in close proximity to these facilities. According to the Environmental Protection Agency (EPA), 106 facilities would each endanger at least one million people in the event of a worst-case chemical release. Another 3,000 facilities would endanger at least 10,000 people. Nearly 5,000 facilities store more than 100,000 pounds of at least one EPA-classified "extremely hazardous substance."

Many of these facilities, however, present an unnecessary risk to their surrounding communities. Industries often have multiple options for carrying out similar processes, and some of these options are inherently safer than others. Facilities that use fewer or smaller quantities of hazardous chemicals, or even make changes to storage pressure or other processes, can eliminate the possibility of on-site chemical accidents and make themselves less appealing terrorist targets.

Petroleum refineries stand as a stark example of the needless risk posed by such facilities in the event of an attack or accident as well as the opportunity to mitigate this risk by using safer alternatives to toxic chemicals.

Many petroleum refineries use hydrofluoric acid in their processing, which poses a great public safety risk both because of its extreme toxicity to humans as well as its propensity to form a toxic aerosol cloud when released. A catastrophic event at one of these facilities could cause a potentially lethal release of hydrofluoric acid, forming a stable aerosol cloud above the facility and surrounding neighborhoods. Exposure to hydrofluoric acid results in devastating burns, and pain associated with the exposure may be delayed for up to 24 hours. If the burn is not addressed, tissue destruction may continue for days. Inhalation of fumes can cause symptoms ranging from severe throat irritation to pulmonary edema.

To estimate the number of Americans at needless risk of exposure to hydrofluoric acid in the event of a catastrophic accident or terrorist attack at a petroleum refinery, we examined the Risk Management Plans submitted by oil refineries to EPA. These plans estimate how far a chemical could travel off-site in the event of a release and report the number of people living within the "vulnerability zone," the area potentially affected by the release. Based on this data, we found that petroleum refineries using hydrofluoric acid endanger millions of people.

Specifically:

- Of the 148 petroleum refineries in the United States, 50 use hydrofluoric acid in their processing or store it on-site. The remainder use safer alternatives, such as sulfuric acid.

- These 50 refineries, using and storing 10.6 million pounds of hydrofluoric acid, endanger more than 17 million people living in surrounding communities in 20 different states.

- With 12 refineries using hydrofluoric acid, Texas has more than any state. Louisiana has five oil refineries that currently use hydrofluoric acid, and Montana has four.

- Refineries using hydrofluoric acid in Pennsylvania endanger more than 4.4 million people residing in their vulnerability zones, according to conservative estimates. Refineries using hydrofluoric acid in both Illinois and New Jersey endanger more than 3.1 million people living within the vulnerability zones.

- Seven petroleum refineries using hydrofluoric acid reported toxic release "worst-case" scenarios in which more than one million people could be affected. Furthermore, 15 refineries could place more than 500,000 people in harm's way, and 28 refineries could endanger more than 100,000 people in the event of a worst-case hydrofluoric acid release.

- The companies operating refineries using hydrofluoric acid with the most people residing in their vulnerability zones include Sunoco, Valero Energy Corporation, Marathon Ashland Petroleum, ConocoPhillips, CITGO, and ExxonMobil, each endangering at least two million people in total.

- Many companies owning refineries using hydrofluoric acid also operate refineries without that technology. ConocoPhillips, ExxonMobil, Valero Energy Corporation, and Marathon Ashland, for example, own refineries using hydrofluoric acid as well as refineries that use other technologies.

Fortunately, hydrofluoric acid is not the only material oil refineries can use in their refining processes. Many other refineries already use sulfuric acid, a safer alternative, in the alkylation process. This cost-effective and widely-used alternative diminishes the appeal of refineries as a terrorist target and mitigates the public health and safety consequences of an accident. In addition, a new technology, solid acid catalysts, will soon be available for widespread commercial use, offering an even safer option than the use of sulfuric acid.

Petroleum refineries are but one example of the facilities that pose an immediate risk to public health in the event of a terrorist attack or chemical accident. Refineries also are not the only example of facilities that could make cost-effective changes to manufacturing processes to reduce or eliminate the use of hazardous chemicals.

Unfortunately, most industrial facilities have not responded to the increased awareness of terrorism by switching to inherently safer technologies. Instead, industry organizations such as the American Chemistry Council, the American Petroleum Institute, and the National Petrochemical and Refiners Association have emphasized increasing physical security at facilities. Hiring more guards, building higher fences, and placing more lights may all be part of a strong security plan, but this does not actually reduce the threat to the community. Switching chemicals and processes to something less volatile not only reduces the chemical hazard to the community, but also reduces the need for costly add-on security measures and the attractiveness of the facility as a target for attack.

Chemical Insecurity: Hazards Leave Communities Exposed

Across the United States, thousands of industrial facilities use and store hazardous chemicals in large quantities that pose major risks to their neighbors. According to the Environmental Protection Agency (EPA), 106 facilities would each endanger at least one million people in the event of a worst-case chemical release. Another 3,000 facilities would endanger at least 10,000 people. Nearly 5,000 facilities store more than 100,000 pounds of at least one EPA-classified "extremely hazardous substance."[1]

Accidents at chemical and industrial facilities are common. Each year tens of thousands of spills and gas leaks occur as a result of the ongoing use of hazardous chemicals.[2] As recently as March 2005, an explosion at a BP oil refinery in Texas City, Texas killed 15 employees. In Gulfport, Mississippi in February 2003, a cloud of toxic ammonia leaked from a chemical plant after an intruder broke into a fenced compound, attempting to steal the chemical to make illegal drugs. The toxic cloud led to the evacuation of seven hotels and the closure of Gulfport-Biloxi International Airport and a 10-mile stretch of Interstate 10 for seven hours.[3]

Since September 11, 2001, it has become increasingly apparent that these facilities pose a more sinister threat, as they may become the target of a terrorist attack. A report by the Army Surgeon General ranked an attack on a chemical plant second only to a widespread biological attack in magnitude of the hazard to the public.[4] On February 12, 2003, the National Infrastructure Protection Center warned, "Al Qa'ida operatives…may attempt to launch conventional attacks against the U.S. nuclear/chemical-industrial infrastructure to cause contamination, disruption, and terror."[5]

Even before September 11, 2001, the Agency for Toxic Substances and Disease Registry (ATSDR) addressed the weak security at chemical facilities. In 1999, ATSDR published a study of chemical site security at two key chemical communities – the Kanawha Valley in West Virginia and Las Vegas, Nevada. The study found the industry poorly prepared for terrorist attacks, noting that industrial chemicals provide terrorists with "effective and readily accessible materials to develop improvised explosives, incendiaries and poisons."[6]

Across the country, select facilities have made major progress by switching to safer chemicals and processes that pose less of a threat to surrounding communities in the event of a major chemical release. Soon after September 11th, for example, the Blue Plains Sewage Treatment Plant in Washington, DC switched from using and storing chlorine and sulfur dioxide on-site to using sodium hypochlorite bleach in its processes. For weeks after September 11th, workers at Blue Plains removed up to 900 tons of liquid chlorine and sulfur dioxide. Whereas chlorine gas from the Blue Plains facility could have enveloped downtown Washington, DC, Anacostia, Reagan National Airport, and Alexandria in a toxic cloud, sodium hypochlorite bleach is far more benign if accidentally released.[7]

Unfortunately, too few other chemical facilities have followed the lead of the Blue Plains facility, changing the processes and chemicals they use to make their facilities inherently safer. Instead, industry groups have emphasized increasing physical security at facilities, such as guards and fences. The American Chemistry Council, the chemical industry's lobbying organization, has issued site security guidelines for its member companies and requires these companies take part in its Responsible Care program in order to continue membership in the organization. This set of guidelines, however, focuses mainly on site security and does not include minimum standards that facilities must follow. For example, it does not require that facilities provide for protection against an armed intruder. In addition, Responsible Care does not require that facilities use inherently safer technology to reduce the threat these facilities pose to surrounding communities. The industry does not even require members to set public goals and timelines to reduce chemical dangers.

Hiring more guards, building higher fences, and placing more lights may all be part of a good security plan, but this does not actually reduce the threat to the community. Switching chemicals and processes to something less volatile not only reduces the chemical hazard to the community, but also reduces the cost of physical security and the attractiveness of the facility as a target for attack.

Furthermore, some in industry and the government have proposed limiting the public's access to information on the potential impact of a major chemical release on public health and safety. Limitations have been placed on the information any individual can obtain to protect themselves and their families from chemical releases at neighboring facilities. Instead of safeguarding these facilities from terrorists, these efforts merely deny public accountability measures that encourage industry reform.

Hydrofluoric Acid and the Petroleum Industry

Petroleum refineries stand as a stark example of the safety hazards posed by using toxic chemicals in the manufacturing process and the opportunities to switch to safer alternatives.

Petroleum refineries are responsible for nearly 11% of all of the high-risk processes in EPA's Risk Management Program, the agency's primary chemical accident prevention program established under the 1990 Clean Air Act Amendments.[8] Most notably, many of these refineries use hydrofluoric acid, also known as hydrogen fluoride, as a catalyst to produce an additive to gasoline. This additive is then used to increase the octane levels in gasoline, which addresses the problem of engine "knocking." Currently, 148 petroleum refineries operate in the United States, 50 of which use hydrofluoric acid as a catalyst to produce alkylate.[9]

Hydrofluoric Acid: A Threat to Health and Safety

Highly toxic, hydrofluoric acid has many acute consequences for human health, as well as the ability "to kill people on the spot," according to Jonathan Ward, director of toxicology at the University of Texas.[10] Even slight contact with hydrofluoric acid may cause a variety of acute symptoms, including skin burns and deep tissue burns, which may not be felt for up to 24 hours after exposure. In addition, hydrofluoric acid exposure commonly causes eye irritation and can lead to permanent damage. If inhaled, the acid can cause irritation of the nose, throat, and lungs, causing coughing and dyspnea, or shortness of breath. Severe exposure can cause cyanosis, an indicator of hypoxemia, lung injury and a build up of fluid in the lungs, known as pulmonary edema.[11]

Once hydrofluoric acid penetrates body tissue, it can react with the calcium and magnesium in the blood stream, causing abnormally low calcium concentrations and a condition known as hypocalcaemia.[12]

Case studies have shown hydrofluoric acid to be fast acting, reporting instances of respiratory irritation in less than one minute after acute inhalation of 122 parts per million (ppm).[13] The Occupational Safety and Health Administration estimates that the lowest lethal concentrations range from 50-250 ppm for a five-minute exposure.[14]

Use of Hydrofluoric Acid in the Petroleum Industry

Petroleum refiners use hydrofluoric acid as a catalyst in the alkylation process. With tighter standards on fuel emissions, alkylate has become a key additive in gasoline because it offers a high octane with very low sulfur and nitrogen content.

Alkylation is the chemical process by which high-octane gasoline is made. Light, gaseous hydrocarbons, made up of compounds like propylene and butylenes, feed into a reactor, where contact with the acid catalyst results in a reaction that produces a heavy mixture of hydrocarbons, along with excess heat, which must be removed. It is the liquid portion of this mixture that is known as alkylate, and it is responsible for the anti-knocking property of unleaded gasoline.[15] Lastly, because some of the acid catalyst leaves the reaction chamber along with the alkylate, further treatment to neutralize the acid is required as well in order to prevent corrosion further down the production line.

CHEMICAL ACCIDENTS INVOLVING HYDROFLUORIC ACID

Hydrofluoric acid has a boiling point of 67º F (19.4º C) at atmospheric pressure, and most reactions take place at about 100º F (37.8º C) in petroleum refineries. Therefore, the acid will vaporize whenever the container is penetrated.[16] Furthermore, when the outside temperature is 67º F or greater, the containment unit housing hydrofluoric acid becomes pressurized because of the acid's high volatility. Therefore, if hydrofluoric acid is released from containment, under certain atmospheric conditions it will form a stable aerosol cloud.

Amoco, Mobil, Allied Chemical and DuPont tested the possibility of a release of hydrofluoric acid from one of their refineries then under construction in a Nevada desert in 1986. Under conditions similar to those in an alkylation unit, lethal concentrations of hydrofluoric acid aerosol were present up to five miles (8 km) from the release points, at levels much higher than anticipated.[17] The amount of hydrofluoric acid released in the test was relatively small—1,000 gallons in two minutes.[18]

Hydrofluoric acid refineries have long had a history of accidental releases that prove the potentially devastating effects of a release caused by simple human error. The National Response Center recorded more than 400 incidents at refineries and other facilities involving hydrofluoric acid or hydrogen fluoride from 1990 to 2005.[19] Simple malfunctions, ruptured valves or pipes, or valves accidentally opened often cause significant leaks that can harm both the people and the environment surrounding the refinery.

- On October 30, 1987, a crane at Marathon Oil's Texas City refinery dropped its load on a storage tank, rupturing a pipe and releasing 30,000 pounds of hydrofluoric acid, the largest known release. The resulting vapor cloud sent 1,037 people to the hospital suffering from respiratory problems and skin rashes and forced 3,000 residents out of their homes for three days. "There were houses right up against the fence," said Ronald Koopman of Lawrence Livermore. "The only thing that saved people was that the [hydrofluoric acid] plume shot 200 feet up in the air, and it went about 900 meters downwind before it actually came down into the neighborhood. If it had squirted out sideways, it would have killed hundreds, if not thousands."[20]

- On March 2, 2003, 13 electricians working at the Marathon Ashland oil refinery in St. Paul Park, Minnesota were hospitalized after being exposed to hydrofluoric acid. They had been hired to repair damage to the facility caused by a fire a few days earlier. While working, a pump leaked one cup of hydrocarbons with trace amounts of hydrofluoric acid, which immediately vaporized and entered their lungs.[21]

- An accidental hydrofluoric acid release in 1991 killed two workers and injured five others at Southwestern Refining Co. in Texas.[22]

- Between 1995 and 1997, four separate one-pound releases of hydrofluoric acid at the Sunoco refinery in Philadelphia injured one worker in each accident.[23]

- On October 2, 2001, 150 pounds of hydrofluoric acid in low concentration leaked within the Valero refinery in Paulsboro, New Jersey. Because the wind was blowing toward neighboring Greenwich Township, a nearby elementary school was forced to secure all the children and staff in the gym by sealing the doors and windows with duct tape and plastic.[24]

- On March 19, 1988, at the Sun Co. refinery in Tulsa, Oklahoma, an accidental release of 210 pounds of hydrofluoric acid sent a cloud of hydrofluoric acid drifting five miles through downtown. Had the accident occurred on a weekday, more people would have been injured. One resident, living in the downtown area, said, "I didn't realize it was hazardous until I could see it leave orange particles everywhere…And then my eyes burned, my throat burned and my head ached."[25]

- On March 23, 2005, an explosion at a BP oil refinery in Texas killed 15 employees and injured more than 100. This was the third major accident in a year at this facility. Although it did not involve a release of hydrofluoric acid, the presence of this chemical on-site was a major cause for concern.[26]

Hydrofluoric Acid: A Terrorist Target

According to Neil Livingstone, board chairman of Global Options, a security firm in Washington, DC, hydrofluoric acid is a "known quantity to some terrorists," particularly those from oil-producing countries where hydrofluoric acid is commonly used.[27] Terrorist attacks over the past 10 years have consistently targeted petroleum facilities throughout the world because of their vulnerability, value to economies, and high volumes of toxic chemicals stored onsite. A few examples of coordinated attacks on petroleum facilities over the past 10 years include:

- During the Croatian war, Serbian armies attacked a natural gas refinery in eastern Slovenia that stored ethane, propane, and butane with rockets and cluster bombs.[28]

- Serbian forces attacked large fuel storage tanks along the highway from Belgrade to the outskirts of Zagreb and started large fires at Osijek, Sisak, and Karlovak.[29]

- A refinery in Sisak, which produced liquefied petroleum gas, fuel, petroleum coke, and solvents, was attacked with thousands of Serbian artillery rounds, which hit 38 petroleum storage tanks. If these attacks had destroyed existing stored chemical containers, lethal concentrations of chemicals would have covered a wide area.[30]

- In October 2001, a group of Tamil Sea Tigers attacked and set ablaze the oil tanker MV Silk Pride. It was carrying 225 tons of low-sulfur diesel, 160 tons of kerosene oil, and 275 tons of auto diesel.[31]

An organized attack on a U.S. oil refinery, similar to the attack on the Sisak refinery by Serbian forces, would be nearly impossible for security guards to prevent.

Furthermore, it is relatively simple for individuals to gain access to plants with the level of security common at refineries. As recently as January 2002, a robber carrying a shotgun made his way into a CITGO facility in Texas. CITGO was one of the companies that claimed to have dramatically increased security measures after September 11, 2001.[32] In addition, activists and reporters have breached security at refineries and chemical facilities across the country. Greenpeace activists entered Dow Chemical's Plaquemine, Louisiana facility in February 2001 through an unlocked gate and gained access to the control panel that regulates wastewater discharges into the Mississippi River.[33] A reporter in Pennsylvania skirted inadequate security at more than 30 chemical facilities and found that he "could walk or drive right up to tanks, pipes and control rooms considered key targets for terrorists."[34]

Assuming that on-site security was able to prevent all unauthorized access to a refinery and water mitigation systems[a] were installed throughout the refinery, it would still not be difficult to release hydrofluoric acid into surrounding communities. According to Carol Coy, a California regulator whose agency pushed for an end to hydrofluoric acid use in southern California, saboteurs could deactivate the mitigation systems simply by shutting off the electricity.[35] Furthermore, munitions fired from an offsite location could puncture the storage tanks holding hydrofluoric acid.

National security experts recognize that a terrorist attack on chemical facilities and refineries is more likely than an attack with a conventional chemical weapon. Creating chemical weapons is a complex and expensive process, whereas industrial facilities provide relatively easy access to large amounts of chemicals from which a significant chemical release could harm considerable numbers of people. In a Senate committee hearing on June 15, 2005, even the Department of Homeland Security (DHS) expressed concern about the consequences of a terrorist attack on a chemical facility.[36] Robert Stephan, an undersecretary in the DHS, noted that, as an aspect of America's "critical infrastructure," chemical facilities indeed represent a dangerous terrorist target. In addition, chemical facilities have many easy access points, making facility security more difficult. According to Stephan's testimony:

> "DHS has identified five areas as the focus of our primary preparedness work with the industry: access and access control, operational security, process control, facility systems operations, and local first responder and external response and recovery coordination. These preparedness planning variables must be refined with reference to potential methods of attack. These include perhaps most importantly: insider threats or sabotage; cyber attack; and attacks using explosives or other weaponry."[37]

Amy Smithson, director of the Chemical and Biological Weapons Non-Proliferation Project at the Henry L. Stimson Center, testified to this in a House of Representatives committee hearing:

> "Although assembling from scratch an unconventional weapons capability that could cause mass casualties is not that elementary, there are tangible routes whereby terrorists could inflict considerable harm with chemical and biological substances. One shortcut involves foul play with industrial chemicals…Logic dictates that if the same result [mass casualties from a chemical release] can be achieved through a less arduous route, terrorists intent on causing mass casualties with chemicals would probably engineer the intentional release of industrial chemicals rather than wrestle with the complexities of making large quantities of the classic chemical warfare agents."[38]

[a] Water mitigation systems are designed to cool nearby liquid petroleum gas containing vessels and columns to insure their structural integrity and to reduce hydrogen fluoride vapors if a leak were to occur. For water mitigation systems to effectively reduce hydrogen fluoride vapors in the event of a leak, sensors to detect the leak must be installed.

REPORT FINDINGS: COMMUNITIES AT RISK

Under the Clean Air Act's chemical accident prevention requirements, industrial plants that use large volumes of certain toxic materials must file accident prevention plans (Risk Management Plans) with EPA that include worst-case accident scenarios. These estimate how far a chemical could travel off-site and still maintain toxic concentrations in certain weather conditions and report the number of people living within that distance, named the "vulnerability zone."[b] We examined the most recent Risk Management Plans for the 50 petroleum refineries in the United States using hydrofluoric acid in their processing or storing it on-site. These 50 refineries comprise one-third of the 148 refineries operating in the U.S.; meaning, two-thirds of all refineries use technology other than hydrofluoric acid.

These 50 refineries, using and storing 10.6 million pounds of hydrofluoric acid, endanger more than 17 million people living in surrounding communities in 20 states (Table 1). See the Appendix for a list of all 50 refineries using hydrofluoric acid in the U.S.

Texas is home to the most hydrofluoric acid refineries, with 12; Louisiana is second with five facilities; and Montana is third with four facilities. These states are not home to the refineries that collectively endanger the most people, however; often a single refinery can endanger millions. Just two refineries using hydrofluoric acid in Pennsylvania endanger more than 4.4 million people residing in their vulnerability zones, according to conservative estimates. In New Jersey, a single refinery using hydrofluoric acid endangers more than 3.1 million people living within the vulnerability zone. Three Illinois-based refineries also endanger 3.1 million people living within the vulnerability zones.

Table 1. Oil Refineries by State and Population at Risk in Each State in Event of Worst-Case Release of Hydrofluoric (HF) Acid

State	# of Oil Refineries	# of Refineries Using HF Acid	Population Endangered By HF Release
AL	3	0	-
AK	6	0	-
AR	2	0	-
CA	21	2	360,000
CO	2	0	-
DE	1	0	-
GA	1	0	-
HI	2	0	-
IL	4	3	3,183,000
IN	2	1	8,000
KS	3	3	63,800
KY	2	1	300,000
LA	17	5	1,436,411
MI	1	0	-
MN	2	1	2,200,000
MS	4	0	-
MT	4	4	183,704
NV	1	0	-
NJ	6	1	3,170,000
NM	3	2	18,829
ND	1	1	68,013
OH	4	1	940,000
OK	5	3	113,388
OR	1	0	-
PA	5	2	4,400,000
TN	1	1	791,888
TX	26	12	1,930,805
UT	5	3	680,000
VA	1	0	-
WA	5	1	120,000
WV	1	0	-
WI	1	1	180,000
WY	5	2	63,067
Total	**148**	**50**	**17,040,905**[c]

Data on number of oil refineries by state obtained from Energy Information Administration.[39] Data on oil refineries using hydrofluoric acid and the population at risk obtained from company Risk Management Plans (see methodology for more details).

[b] It is important to note that not *all* people living within a vulnerability zone would be affected by a single chemical release; those living downwind during a chemical release are most likely to be affected.

[c] This is not the aggregate total of the state totals, as it takes into account overlapping vulnerability zones between states. As such, this is a conservative estimate.

Table 2. Ten Refineries Endangering the Most People in Event of Worst-Case Release of Hydrofluoric Acid	
Facility Name	**Location**
Sunoco Philadelphia Refinery	Philadelphia, PA
Valero Refining Co.	Paulsboro, NJ
PDV Midwest Refining (CITGO)	Lemont, IL
ConocoPhillips Trainer Refinery	Trainer, PA
Marathon Ashland Petroleum, MN Refining Div.	St. Paul Park, MN
Chalmette Refining	Chalmette, LA
Murphy Oil USA, Inc. Meraux Refinery	Meraux, LA
ExxonMobil Oil Corporation Joliet Refinery	Channahon, IL
Marathon Ashland Petroleum, Ohio Refining Div.	Canton, OH
ConocoPhillips Alliance Refinery	Belle Chasse, LA

Data on oil refineries using hydrofluoric acid obtained from company Risk Management Plans (see methodology for more details).

In some cases, however, the vulnerability zones of two or more refineries overlap, posing an even greater danger to people who live and work within the overlapping areas. In Philadelphia, for example, the vulnerability zones of two refineries overlap across the Delaware River, encompassing the airport, sports stadiums, and many neighborhoods.[40] In Corpus Christi, Texas, four refineries using hydrofluoric acid are located near each other; similarly, three refineries using hydrofluoric acid are situated close together near New Orleans, Louisiana.

Single refineries can endanger thousands or millions of people. Seven petroleum refineries with hydrofluoric acid alkylation facilities reported toxic release "worst-case" scenarios in which more than one million people could be affected. Furthermore, 15 refineries could place more than 500,000 people in harm's way, and 28 refineries could endanger more than 100,000 people in the event of a worst-case hydrofluoric acid release.

The 10 facilities putting the most people at risk in the event of a worst-case release of hydrofluoric acid are found in Illinois, Louisiana, Minnesota, New Jersey, Ohio, and Pennsylvania (Table 2).

Many parent companies put millions of people at risk from the hydrofluoric acid they use and store at their refineries. The companies with the most people residing in the vulnerability zones of refineries using hydrofluoric acid include Sunoco, Valero Energy Corporation, Marathon Ashland Petroleum, ConocoPhillips, CITGO, and ExxonMobil (Table 3). These companies each put at least two million people at risk.

Table 3. Parent Companies With at Least One Million People Living in Vulnerability Zones of Their Refineries Using Hydrofluoric Acid	
Parent Company	**Population at Risk**
Sunoco, Inc.	4,400,000
Valero Energy Corporation	4,366,193
Marathon Ashland Petroleum	4,132,993
ConocoPhillips	3,532,763
CITGO	3,415,420
ExxonMobil	2,393,847
Murphy Oil Corporation	1,236,000
Premcor Inc.	1,121,888

Data on oil refineries using hydrofluoric acid and the population at risk obtained from company Risk Management Plans (see methodology for more details).

Many companies that utilize the dangerous hydrofluoric acid technology also use refineries without that technology.

ConocoPhillips, ExxonMobil, Valero Energy Corporaton, and Marathon Ashland, for example, own refineries that use hydrofluoric acid as well as refineries that use other technologies.

- ConocoPhillips owns six refineries that report to EPA's Risk Management Program for their use of hydrofluoric acid, but runs 12 refineries in the United States. The other six facilities presumably use a safer technology than hydrofluoric acid.

- Valero Energy Corporation owns seven refineries in the United States that use hydrofluoric acid and five others that do not use that technology. One Valero refinery in Wilmington, California has responded to concerned residents and is switching from hydrofluoric acid to a safer technology.[41]

- ExxonMobil owns or co-owns four refineries that use hydrofluoric acid and three other refineries in the United States that do not.

- Marathon Ashland owns six hydrofluoric acid refineries in the U.S. and one refinery that does not use that technology.

Companies owning facilities that use different types of chemicals in their alkylation processes illustrate not only that alternative processes are possible to implement, but that some companies have knowledge of safer alternatives and choose not to implement them.

How Policymakers and Industry Should Protect Communities

A Preventive Approach

The actions of American industry—and American regulatory policy—have historically focused on preparing for or managing chemical accidents and releases rather than preventing them. The continuing legacy of chemical accidents and un-addressed vulnerabilities in the United States is evidence that this strategy has failed to protect public safety. Furthermore, the events of September 11th make plain the need for preventive action. Safety valves may mitigate the effects of an accidental release, and employee training may reduce the chances of an accident, but neither can protect public safety if a terrorist parks a truck bomb at a chemical plant or refinery. Designed to protect only against accidental releases, many accident mitigation technologies could be foiled by a deliberate saboteur.

Reducing or eliminating chemical hazards offers the best strategy to fully protect American communities from both accidents and terrorist attacks involving industrial chemicals. Hazard reduction means making a chemical process *inherently* safer by eliminating the use of highly toxic, volatile, or flammable chemicals or using chemicals in safer quantities or conditions. The concept of inherent safety leads to a hierarchy to guide decisions on the use and management of chemicals:

First, reduce or eliminate the *possibility* of a chemical release by choosing inherently safer materials and technologies.

Second, reduce the *probability* of a chemical release through secondary prevention measures such as safety valves and double-walled vessels. In preventing terrorism, increasing site security is an additional secondary prevention measure (although inadequate in the context of modern terrorists' tactics).

Third, reduce the *potential severity* of the impacts of a chemical release through mitigation measures (containment dikes, sprinkler systems) or emergency response plans.[42]

Again, the first option—inherent safety—provides the best response to the threat of chemical releases caused by acts of terrorism because it eliminates the potential hazard. Add-on security and mitigation measures could make minor contributions toward preventing an act of terrorism, but traditional tools of terrorists—truck bombs, suicide bombers, and now airplanes—would likely render such measures useless. Site security measures could prevent a terrorist from entering the grounds of a facility, but in the embassy bombings in Africa, the trucks containing bombs were parked near, not inside, facility grounds. Increasing physical security would have been of little help.

Inherent Safety at Refineries: Alternatives to Hydrofluoric Acid

Three options are available to petroleum refineries using hydrofluoric acid as a catalyst for alkylates in order to make this process inherently safer.

- Change the alkylation process to use a solid acid catalyst;
- Convert the hydrofluoric acid alkylation unit into a sulfuric acid unit; or
- Add modifiers to the hydrofluoric acid that decrease the gaseous nature of hydrofluoric acid and install mitigation systems.

Prevent the Possibility: Solid Acid Catalyst

The best option available to oil refineries is switching from using hydrofluoric acid to a solid acid catalyst, which completely eliminates the need to use either hydrofluoric acid or sulfuric acid to produce alkylate. Industry experts report that a variety of solid acid catalysts will be available for use in alkylation facilities within the next four years. Critics, however, insist this technology has been available since the late 1990s, and simple industry inertia has kept solid acid catalysts from becoming the popular choice for refinery alkylation processes.[43]

Solid acid catalysts have tremendous environmental and safety advantages over both hydrofluoric acid and sulfuric acid because they are neither corrosive nor particularly hazardous to people or the environment. Furthermore, in the event that the container housing the catalyst is breached, no further damage would result. Using a solid acid catalyst provides many benefits, including reduced waste disposal costs and hazards, possibility to expand capacity at a lowered capital cost, and less corrosion of the equipment, resulting in lower maintenance costs.[44]

Considerable research is being conducted on solid acid catalysts, and three main options currently exist: Albemarle Corp./ABB Lummus Global/Fortum Oil's AlkyClean™, UOP's Alkylene™, and Exelus Inc.'s ExSact™.

AlkyClean™'s demonstration phase at Fortum's facilities in Porvoo, Finland was completed in January 2005 and is currently commercially available. According to the manufacturers, the operating and capital costs of the AlkyClean™ process rival those of the liquid acid catalyst processes and produce an alkylate of similar high quality.[45]

This solid acid catalyst also can replace existing hydrofluoric acid or sulfuric acid alkylation units, reusing the existing feedstock pretreatment and product distillation/recycle facilities. Converting to a solid acid catalyst would save the facility money over a sulfuric acid plant because this technology does not require refrigeration for the reaction to take place. Furthermore, there is no need to remove acid from the finished product, thereby eliminating yet another step in the process.[46]

UOP's Alkylene™ operates similarly, with the primary difference between the two available processes consisting of how the solid acid is regenerated. The biggest difference is that Alkylene™ does not have the energy savings associated with AlkyClean™. Furthermore, the feedstock does have to be treated to remove impurities. Yet, even with these differences, Alkylene™ is still very cost competitive with hydrofluoric and sulfuric acid facilities.[47] Recent industry publications report this technology has "overall economics superior to sulfuric acid technology."[48] Alkylene™ also has recently become commercially available, though there is limited interest so far in the United States and Europe given the need to construct new solid acid units.[49] In February 2005, however, the Baku Heydar Aliyev Refinery of Azerbaijan awarded UOP a contract for the design of a new high-octane gas facility, which included, among other technologies, the world's first Alkylene™ unit. Production is estimated to start by 2008.[50]

Exelus Inc. also has a new solid acid catalyst technology (ExSact™) that is currently in its six to nine month demonstration phase that precedes commercialization. This technology not only includes a stable and active catalyst, but also a fixed-bed reactor that enhances the efficiency of the reaction and reduces the cost.[51] According to a representative of Exelus Inc, U.S. petrochemical companies, not refineries, have shown interest in this technology; oil refineries in Norway and Eastern Europe have demonstrated interest.[52]

All three of these alkylation processes cost significantly less than sulfuric acid alkylation units and virtually the same as hydrofluoric acid units. Manufacturers expect the market for solid acid catalyst technology to increase significantly as oil refinery alkylation units age and have to be replaced. The mounting costs of physical site security also add an incentive for refineries to select alternatives to dangerous hydrofluoric acid.

REDUCE THE SEVERITY: SULFURIC ACID AS AN OPTION

Sulfuric acid is often used in the alkylation process instead of hydrofluoric acid because when released, it will not readily form a toxic aerosol cloud. Instead, sulfuric acid is released as a liquid form, making it much easier to contain and prevent exposure to those offsite. As a result, sulfuric acid does not pose as much as a threat to life outside of the facility.

Converting a hydrofluoric acid alkylation unit into a sulfuric acid alkylation unit requires several equipment changes. First, a sulfuric acid alkylation unit requires a refrigeration process.[d] Second, if the hydrofluoric acid facility contains the metal monel, it must be replaced because it reacts with sulfuric acid. Finally, an acid regeneration facility also should be constructed onsite so as to decrease the need to frequently transport sulfuric acid, which poses the risk of offsite consequences.

The fundamental difference between using hydrofluoric acid and sulfuric acid in the production of alkylate is in how the acid is regenerated, once the acid becomes too contaminated with impurities. Hydrofluoric acid can be distilled to remove impurities. However, sulfuric acid must go through a series of steps that first break down the acid into sulfur dioxide and then mix the sulfur dioxide with water to create regenerated sulfuric acid.[53] Sulfuric acid catalysts inevitably cost about fifty cents per barrel of alkylate more than hydrofluoric acid catalysts because of the elaborate regeneration process that sulfuric acid requires.[54]

Although sulfuric acid is less hazardous than hydrofluoric acid, direct exposure to sulfuric acid can cause many detrimental health effects at concentrated levels, such as burns or severe irritation to the eyes, skin, and respiratory

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[d] The catalytic reaction using hydrofluoric acid takes place around 100º F, which only necessitates the use of water cooling towers to maintain an optimum reaction temperature. The reaction to produce alkylate using sulfuric acid is optimized at 45º-50º F (7º-10º C), requiring refrigeration to maintain the optimum reaction temperature.

tract if concentrated fumes are inhaled. Because sulfuric acid is often regenerated offsite, there is a risk of an accident involving sulfuric acid during transportation. Once onsite, however, it can be regenerated indefinitely if the refinery builds a regeneration facility.

Two options exist to switch the alkylation process from hydrofluoric acid to sulfuric acid: using a conversion system or building a new sulfuric acid alkylation unit. One system for switching from hydrofluoric acid to sulfuric acid is the Alkysafe™ conversion/expansion process, offered by STRATCO®. Alkysafe™ reuses both the reaction and distillation sections of the alkylation facility.[e] Due to the short downtime and the amount of equipment that is reused, STRATCO claims that Alkysafe™ is cost-competitive with mitigation systems being installed on hydrofluoric acid alkylation units. These mitigation systems, on average, will cost a refinery between $20 million and $30 million, with costs reaching at most $50 million.[55]

The cost of building a sulfuric acid alkylation unit varies according to the amount of alkylate the refinery produces each day. As a general rule, a new alkylation unit will cost about $5,000 per barrel of alkylate produced, per day. Therefore, a new alkylation unit capable of producing 10,000 barrels of alkylate per day would cost about $50 million. STRATCO's Alkysafe™ process is estimated to cost one-half to two-thirds the cost of installing a new sulfuric acid alkylation unit.[56]

ExxonMobil also offers a sulfuric acid alkylation process that can replace hydrofluoric acid alkylation systems, although the cost of the process is higher than using the STRATCO designs. However, this process also would be competitive with building a new hydrofluoric acid alkylation unit.[57] It is currently in use in approximately 12 refineries.[58]

REDUCE THE PROBABILITY: HYDROFLUORIC ACID MODIFIERS

The final option available to decrease the threat of a hydrofluoric acid release is to invest in alkylation modifiers and install active mitigation units, such as water spray systems. This option, however, does not remove the possibility of a terrorist threat, and an adversary could thwart mitigation systems.

Modified hydrofluoric acid reduces the ability of the acid to form an aerosol cloud by a certain percentage, thereby mitigating the impact the toxic cloud will have on the surrounding community. UOP and Texaco estimate the cost of modifying a hydrofluoric acid alkylation refinery using Alkad, a passive mitigation system, at $7 million. This estimate, however, does not include the cost of active mitigation systems, which would be necessary in order to truly reduce the potential severity of a release.[59] Mitigation systems cost, on average, between $20 million and $30 million to install.[60]

ConocoPhillips and ExxonMobil have devised their own alkylation modifier under the name ReVAP, which has the ability to reduce hydrofluoric acid aerosol formation when leaked by 60% to 90%. ReVAP is currently licensed at five refineries, including the Woods Cross Refinery in Utah and the Torrance Refinery in California.[61]

In 2003, public pressure succeeded in persuading the Valero Energy Corporation to switch to modified hydrofluoric acid at its Wilmington, California refinery, near Los Angeles. Since an explosion that caused an accidental release of hydrofluoric acid at a neighboring Torrance refinery in 1987, the local community and government have

[e] The distillation section of the alkylation unit neutralizes any acid leaving the reaction chamber with the alkylate.

pushed to shut down two refineries that used hydrofluoric acid and required a third facility to change to modified hydrofluoric acid. The community was able to negotiate an agreement with the South Coast Air Quality Management District with regards to the Valero facility; Valero decided on ConocoPhillips' ReVap technology and will pay a fine up to $1 million if the renovation is not complete by the end of 2005. The change is expected to cost Valero about $30 million.[62,63]

Since both modification systems cannot completely reduce the threat of a hydrofluoric acid release, active mitigation units also must be installed. Active mitigation for hydrofluoric acid requires sensors to detect a hydrofluoric acid release; acid pumps to quickly move the acid to remote locations and decrease the amount of acid that is released; and water spray systems that knock the acid to the ground and prevent it from affecting surrounding communities. If the sensors are working properly and detect a leak immediately, water spray systems can knock up to 90% of the hydrofluoric acid to the ground; however, tests have shown that it requires at least 40 volumes of water for each volume of hydrofluoric acid released. Effective water spray systems often include water spray curtains and remotely operated water cannons.[64]

TABLE 4. COMPARISON OF INHERENTLY SAFER TECHNOLOGIES FOR PETROLEUM REFINERIES USING HYDROFLUORIC ACID

	Sulfuric Acid	Solid Acid Catalyst	HF modifier
How Catalyst Regenerated	Decomposed into sulfur dioxide, then regenerated by mixing with water vapor	Frequent regeneration with dissolved hydrogen every two to four weeks.	Distilled
Required Facility Modification	Some versions require a new refrigeration facility and design change and modifications of current equipment; other versions cannot be fitted to existing alkylation processes.	Alkylene™ and ExSact™ require entirely new alkylation facilities, while AlkyClean™ only requires a new regeneration system.	Additional separation equipment needed to remove leaching acid from alkylate.
Advantage over HF Alkylation Unit	Will not form an aerosol cloud and will not pose a threat to life outside the facility.	No corrosive acid can leave the reaction chamber. *No threat of a chemical spill to anyone.*	Decrease HF aerosol formation from 60% to 90% in the event of a leak, depending on version used.
Additional Mitigation Systems Needed	None	None	Active mitigation systems needed.
Safety Concerns	Acid spill during transport to the refinery and to the regeneration facility if the regeneration facility is not part of the refinery.	None	Active mitigation systems can fail.
Cost of Conversion	Varies depending on the daily output required. Estimated to cost between $2,500 to $3,333 per barrel of alkylate produced per day for one version, $5,000 per barrel for another.	Cost competitive with installing a new hydrofluoric acid unit, less than installing a sulfuric acid alkylation unit.	Valero is paying an estimated $30 million to convert its Wilmington, CA refinery; most modifiers cost $7 million plus the cost of active mitigation systems.

Reducing Chemical Hazards Through Policy Measures

The possibility that terrorists could turn American industry into weapons that threaten Americans' safety provides policy-makers with a clear imperative to revise existing policy on lethal chemical releases. Furthermore, more action is needed than simply increasing physical security at chemical facilities; more physical security measures do not offset the possibility of terrorists taking extreme measures to orchestrate a chemical release.

Inadequacies of Existing Policies

Industry Cannot Be Left to Voluntary Measures

Since September 11, 2001, our nation has tightened security in a variety of venues. Airports and airlines have numerous new regulations they must follow; airplanes have routinely patrolled our water supply; our government has even established an entire new governmental department, the Department of Homeland Security. Despite the repeated admission by government officials that the chemical industry poses a significant security threat, however, no federal regulations exist that require oil refineries or any chemical facility to reduce their hazards when they are able to do so.

Instead, some facilities subscribe to a voluntary industry program known as Responsible Care. Responsible Care is an initiative developed by the Chemical Manufacturers Association (CMA), now the American Chemistry Council (ACC), in 1988 to respond to the public's lack of confidence in the chemical industry. The CMA needed to act to address the poor public image or "end up in worse shape than the atomic industry," according to John Johnstone, a former chairman of CMA.[65] Fifteen years later, the ACC requires all member companies to comply with this voluntary initiative to improve security. Responsible Care, however, only requires facilities to install physical security and does not address preventing accidents or terrorist attacks by requiring companies to switch to safer technology.

A former member of the Security Committee of the American Chemistry Council, as well as a former Security Manager for Georgia-Pacific Company, has addressed just how inadequate these voluntary guidelines are. In a June 2005 hearing in the House Subcommittee on Economic Security, Infrastructure Protection, and Cybersecurity, Sal DePasquale said, "it may be argued that inner city liquor stores are better protected than are the facilities that manufacture and use highly toxic and lethal chemicals." Despite industry's claims of effective self regulation, he continued, "if the industry will not issue substantive standards, it cannot say that it is self regulating. It is simply a contradiction in terms."[66]

Furthermore, ACC is made up of only around 160 of the largest chemical companies, meaning that, according to Department of Homeland Security statistics, 20% of chemical companies in the United States do not fall under any sort of voluntary chemical security standards.[67]

The Emergency Planning and Community Right-to-Know Act

After the 1984 Union Carbide chemical disaster in Bhopal, India, which killed thousands of people, grassroots pressure convinced Congress to pass the Emergency Planning and Community Right-to-Know Act (EPCRA). This act established a network of

Local Emergency Planning Committees (LEPCs) and required facilities to disclose a baseline of important information on chemical risks, including the amount of hazardous materials stored at particular facilities.

Despite some positive results of EPCRA, including the creation of the Toxics Release Inventory and a general decline in toxic releases, this law did not address the need to prevent chemical releases before they happen. Instead, it only addressed the need to prepare for and respond to them. The LEPCs lack the authority to mandate hazard reduction, and many are inactive.[68]

The Clean Air Act and Risk Management Planning Program

In response to an explosion at a Phillips chemical facility in Texas that killed 23 workers in 1989, Congress took further action by adding amendments to the Clean Air Act in section 112(r). These amendments established the Risk Management Planning (RMP) program that requires industry to develop a hazard assessment that covers various release scenarios, off-site consequences, and a five-year accident history; a prevention program that manages procedural areas such as training and safety audits; and an emergency response program.

Therefore, the Risk Management Planning program addresses the management of chemical risks, but not their prevention. If the RMP program were fully implemented as EPA originally intended, the worst-case scenario estimates of off-site impacts of chemical releases would be available in a national database and could help reduce chemical hazards, much as the Toxics Release Inventory has. Although originally available to the public online, the RMP plans have been removed from public view and are now difficult for individuals to obtain.

The case study of the voluntary changes at the Valero refinery in California shows that when a community is aware of the threat a local refinery poses to its safety, public pressure may successfully persuade the facility to change its chemicals and processes in order to reduce the threat. In order for the RMP program to be successful, risk management plans must be readily available to the public.

EPCRA and RMP Too Specific to Address Threat

In addition to the limitations addressed above, both EPCRA and the RMP program were not designed to address the threat of a terrorist attack at a chemical facility, and consequently pertain only to certain chemicals, industries, and facilities using quantities of chemicals above certain thresholds.

Smaller quantities of chemicals are easier to manage onsite and therefore pose less of a concern for accidental releases. Terrorists, however, could specifically target smaller quantities of chemicals and still cause significant harm. For example, a single one-ton cylinder of chlorine gas can fall below thresholds for the RMP program. The quantity of chlorine gas in this cylinder, however, could result in toxic concentrations nearly two miles off-site.

The Right-To-Know as a Safety Tool

The federal government should not limit the public'd access to information about chemical use and releases in the effort to prevent chemical terrorism.

Ensuring a community's right-to-know about chemicals used, stored and released has long been a useful tool in protecting public safety from toxic hazards. In Massachusetts, for example, companies are required to assess and disclose all chemicals used by their facilities as well as complete toxics use reduction plans. Simply by completing these plans, and not necessarily even implementing them, Massachusetts companies have reduced their overall use of toxic chemicals by 40%, the waste generated by 70%, and their environmental releases by 92% between 1990 and 2003. At the same time, production increased 23% at these facilities.[69]

New Jersey has seen similar success with its Pollution Prevention Act, which requires companies to assess and report chemical use. As a result of these reporting requirements and the Toxic Catastrophe Prevention Act, hundreds of drinking water facilities and sewage treatment facilities have stopped using chlorine gas.

Based on these examples, it is likely that if a petroleum refinery completed an assessment of available inherently safer technologies, and was required to disclose the findings to the public, it would be compelled to switch to a safer technology.

PROTECTING COMMUNITIES THROUGH INHERENTLY SAFER TECHNOLOGY

The most effective means of protecting American communities from the consequence of an act of chemical terrorism is to require facilities to implement inherently safer technologies.

In the case of hydrofluoric acid in alkylation units, inherently safer technology exists and is proven to work. Facilities should change their chemicals and processes to a safer technology as soon as possible, and new facilities should be built using the safest technology available.

Policymakers could require refineries to change their processes or to conduct a technology options analysis.[70] A technology options analysis is a way to address a range of industries and require them to make a concerted effort to identify inherently safer options in their chemical uses and processes. Furthermore, a technology options analysis provides an opportunity for facilities to adopt technologies with acceptable cost and appropriate performance characteristics and to explain why technologically feasible options were not selected. These technology options analyses should be made public, while protecting legitimate confidential business information, in order to inform communities of safety measures at nearby facilities as well as to disseminate information on innovative technologies.

Oil refineries using hydrofluoric acid on site pose an unnecessary risk to surrounding communities. By requiring facilities to switch to inherently safer technologies, as well as requiring them to publicly disclose plans to protect surrounding communities, oil refineries could greatly reduce their risk. As oil refineries are not the only facilities that pose unnecessary risk to surrounding communities, these same policy changes should apply to a variety of industries and facilities. Future policy must focus on significantly reducing or eliminating the potential harm posed by terrorist attacks on industrial facilities, instead of focusing on physical security and the unachievable task of mitigating the consequences of a major chemical release.

METHODOLOGY

The vulnerability zone data in this report were collected from Risk Management Planning reports obtained at public reading rooms operated by the Environmental Protection Agency in Washington DC, in compliance with all rules that currently govern the collection of such data. We collected this data in June and July 2005.

Facilities had to report their latest Risk Management Plans to EPA starting in June 1999 with revised reports due no less often then every five years. The data used in this report are current as of December 2004. Facilities are required to file RMPs if they store hazardous chemicals listed in section 112(r) of the Clean Air Act above a threshold level used in regulated processes. These facilities span a broad spectrum of industries, including chemical manufacturers, petroleum refineries, agricultural wholesalers, drinking water and wastewater treatment systems, electric utilities, and others.

To estimate the total number of people living in the vulnerability zones in each state and nationally, we reviewed the geographic location of each facility, as oil refineries are often grouped together only a few miles apart. In order to avoid double counting, we assumed if the vulnerability zones of two or more facilities overlapped that they overlapped entirely. In these instances, we included the highest at-risk population from the facilities in our calculations.

As a result, the reported totals are a conservative estimate of the total population at risk in each state. In addition, the totals do not reflect the fact that many individuals are at a heightened risk because they live within the vulnerability zone of two or more oil refineries using hydrofluoric acid.

APPENDIX: OIL REFINERIES USING OR STORING HYDROFLUORIC ACID ON-SITE

State	Facility Name	City	Parent Company
CA	ExxonMobil Torrance Refinery	Torrance	ExxonMobil
CA	Ultramar Inc. d/b/a Valero Wilmington Refinery	Wilmington	Valero Energy Corporation
IL	ExxonMobil Oil Corporation Joliet Refinery	Channahon	ExxonMobil
IL	PDV Midwest Refining, LLC	Lemont	CITGO
IL	Marathon Ashland Petroleum LLC IRD	Robinson	Marathon Ashland Petroleum LLC
IN	Countrymark Cooperative, Inc.	Mt. Vernon	Countrymark Cooperative, Inc.
KS	Coffeyville Resources Refining & Marketing	Coffeyville	Coffeyville Resources, LLC
KS	Frontier El Dorado Refining Company	El Dorado	Frontier Oil Corporation
KS	National Cooperative Refinery Association	McPherson	Cenex
KY	Catlettsburg Refining, LLC	Catlettsburg	Marathon Ashland Petroleum LLC
LA	ConocoPhillips Company Alliance Refinery	Belle Chasse	ConocoPhillips
LA	Chalmette Refining, L.L.C.	Chalmette	Chalmette Refining, L.L.C (ExxonMobil and Petroleos de Venezuela S.A.)
LA	Marathon Ashland Petroleum, LA Refining Division	Garyville	Marathon Ashland Petroleum LLC
LA	Murphy Oil USA, Inc. Meraux Refinery	Meraux	Murphy Oil Corporation
LA	Placid Refining Co. L.L.C. -Port Allen Refinery	Port Allen	Placid Refining Co./Petro-Hunt
MN	Marathon Ashland Petroleum, MN Refining Div.	St. Paul Park	Marathon Ashland Petroleum LLC
MT	ConocoPhillips Billings Refinery	Billings	ConocoPhillips
MT	Montana Refining Company	Great Falls	Holly Corporation
MT	CHS Inc. - Laurel Refinery	Laurel	Cenex
MT	ExxonMobil Billings Refinery	near Billings	ExxonMobil
ND	Tesoro Mandan Refinery	Mandan	Tesoro Corporation
NJ	Valero Refining Co. - New Jersey	Paulsboro	Valero Energy Corporation
NM	Navajo Refining Company	Artesia	Holly Corporation
NM	Ciniza Refinery	Jamestown	Giant Industries
OH	Ohio Refining Division	Canton	Marathon Ashland Petroleum LLC
OK	TPI Petroleum Inc.	Ardmore	Valero Energy Corporation
OK	ConocoPhillips Refinery - Ponca City, Oklahoma	Ponca City	ConocoPhillips
OK	Wynnewood Refining Company	Wynnewood	Gary-Williams Energy Corporation
PA	Sunoco Philadelphia Refinery	Philadelphia	Sunoco, Inc.
PA	Trainer Refinery	Trainer	ConocoPhillips
TN	The Premcor Refining Group Inc.	Memphis	Premcor Inc.
TX	Alon USA Big Spring Refinery	Big Spring	Alon USA LP
TX	Borger Refinery and NGL Center	Borger	ConocoPhillips
TX	Flint Hills Resources, L.P. - CC West Refinery	Corpus Christi	Koch Industries
TX	Valero Refining Co. - Texas, L.P. - West Plant	Corpus Christi	Valero Energy Corporation
TX	CITGO Corpus Christi Refinery East Plant	Corpus Christi	CITGO
TX	Valero Refining Co - Texas, L.P. - East Plant	Corpus Christi	Valero Energy Corporation

State	Facility Name	City	Parent Company
TX	Crown Central Petroleum, Houston Refinery	Pasadena	Crown Central LLC
TX	Premcor Port Arthur Refinery	Port Arthur	Premcor Inc.
TX	Marathon Ashland Petroleum Texas Refining	Texas City	Marathon Ashland Petroleum LLC
TX	BP America, BP Texas City Site	Texas City	BP
TX	Valero Refining - Texas, L.P.	Texas City	Valero Energy Corporation
TX	Diamond Shamrock Refinery - Three Rivers	Three Rivers	Valero Energy Corporation
UT	Big West Oil LLC	North Salt Lake	Flying J, Inc.
UT	ChevronTexaco Salt Lake Refinery	Salt Lake City	ChevronTexaco Corporation
UT	Woods Cross Refinery	Woods Cross	Holly Corporation
WA	ConocoPhillips Company	Ferndale	ConocoPhillips
WI	Murphy Oil USA Superior Refinery	Superior	Murphy Oil Corporation
WY	Frontier Refining Inc.	Cheyenne	Frontier Oil Corporation
WY	Wyoming Refining Company	Newcastle	Hermes Consolidated

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