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Dirty secrets of the chipmaking industry

A toxic yellow-brown cloud rose from the floor at a Teccor Electronics computer chip plant in Irving, Texas. Acids had leaked from a faulty pump onto silicon wafers littering the floor. The reaction created the dangerous fumes.

Three employees, dizzy and struggling to breathe, wound up in the hospital. For weeks, they suffered respiratory problems. Teccor President Al Lapierre says employees "needlessly stuck their noses" in the fumes.

But federal investigators saw another problem that day in 1995. "Safety was secondary to production" wrote an investigator for the Occupational Safety and Health Administration (OSHA), which governs workplace practices.

Supervisors knew the floor was dirty but did not clean it because they would have had to close the plant for several days, OSHA said.

The Teccor incident is one of many that exposes the dark side of a high-wage, fast-growth industry that is coveted by states and cities across America. A six-month examination of the \$150 billion semiconductor industry, also known as the computer chip industry, reveals that the economic engine powering America's technological renaissance and churning out vast Wall Street fortunes is not nearly as clean as its image.

The USA TODAY investigation, based on dozens of industry interviews and thousands of pages of regulatory documents obtained under the Freedom of Information Act, found that some semiconductor companies:

- Endangered workers, many of them women and minorities, by failing to fully train them about the hazardous, sometimes deadly, chemicals with which they work. About 10% of nearly 200 chip and chip-related plants inspected nationwide since 1992 fell short on training, OSHA records show.
- Failed to make plants meet health and safety standards,

Continued coverage:

- Incidents often unreported
- New plants are safer
- Types of plants
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residents. For example, 10 of 36 plants in California's Silicon Valley were cited for health and safety shortfalls between 1993 and 1997, according to fire department and OSHA records.

- Continued to use chemicals suspected of causing cancer or miscarriages even though the vast majority of companies recognized the danger and switched to safer replacements, Environmental Protection Agency and fire department documents show.
- Expanded in areas of the United States in which environmental and safety regulations — and enforcement of those regulations — are less strict than in Silicon Valley, where the industry was born.

In at least one plant, employees were exposed for years to acids and solvents that workers and doctors say caused mouth sores, headaches, nausea, mood swings and blackouts, according to internal documents from the Zilog chip plant in Nampa, Idaho.

The industry is the target of two sets of lawsuits involving IBM and Motorola. Workers and communities allege that chemicals used to make chips caused cancer, birth defects, and neurological and respiratory disorders.

The industry also has a toxic past. In California's Silicon Valley, at least 18 of 29 federal Superfund sites — the nation's most polluted sites — are tied to the chip industry. Covering miles of aquifers, most of the sites are tainted with trichloroethylene (TCE), a solvent once widely used to clean chips. Regulators now suspect it might cause cancer. TCE is still used at some plants.

More workers and communities are likely to face dangers from the industry as it roars ahead. Thirty major chip plants will open in the United States during the next five years. The giants — Intel, NEC, Motorola and Texas Instruments — are widely known. But scores of other companies supply chipmakers with everything from silicon wafers to equipment.

The industry turns wafers made of silicon, Earth's second most common element after oxygen, into fingernail-size chips powering computers, cars, TVs, high-tech weapons and hundreds of other electronic products.

More than 50 other U.S. industries released more pollutants to the air, land, water and public waste-water treatment facilities than did the semiconductor industry in 1995, the latest year for which EPA data is available, an analysis shows. The industry has largely replaced ozone-depleting compounds with less harmful chemicals, and many toxic solvents, used to clean chips, with water-based

"We are an industry that works very diligently to make sure that our workplace and our neighborhoods are as clean as we can possibly make them given the technical knowledge at the time," says William Seiferth, a Motorola senior vice president.

But the industry poses dangers, some of which are not obvious. The employees work inside low-story buildings in "clean rooms" that are so free of dust that even hospital operating rooms are dirty by comparison. Workers wear head-to-toe suits not to protect themselves but to keep their skin flakes, breath and hair from contaminating the valuable chips.

Surrounding the workers, though, in pipes overhead and waste drains below, flows a perpetual chemical river. More than 60 hazardous acids, solvents, caustics and gases are used to make chips. The chemicals etch microscopic circuits onto the wafers, which go through dozens of steps.

Some chemicals are suspected carcinogens and reproductive toxins. Others, such as hydrogen fluoride, a colorless liquid or gas, are so strong that they can cause severe burns deep beneath the skin. Arsine gas is the most toxic and attacks red blood cells. A leaking cylinder in a typical living room would be lethal with one whiff. Phosphine gas, also toxic, destroys lung tissue. Silane gas ignites on contact with air and has engulfed workers in flames.

"If we could do it with water, we would do it with water. But we cannot make semiconductors without chemicals," says Lee Neal, head of health and safety for the Semiconductor Industry Association (SIA), a trade group.

Big chemical accidents at the plants, though rare, have killed workers, contaminated streams and forced plant and neighborhood evacuations.

Small accidents, more frequent, have burned fingers, damaged lungs and irritated skin.

"There are risks in anything you do. What we do is try to absolutely minimize the risks," says Intel President Craig Barrett.

Jobs and wonders galore

The economic prowess of the semiconductor industry has eclipsed its toxic side. U.S. companies employ 265,000 people worldwide. In the United States, the industry provides the building blocks for the \$300 billion electronics industry, which employs 2.4 million people. Intel, the largest chipmaker, is one of the world's most

States promise mammoth tax breaks to lure the fast-growth companies. They want the high-wage jobs in what many politicians and business boosters believe to be one of the first clean industries. In New Mexico, the average Intel wage is \$35,000 — three times the state's average. "Everybody in the world wants these companies," says Virginia Gov. George Allen. "They are the jobs of the future."

Such exuberance leaves citizens in growing numbers to fret that health and safety aren't priorities. Says Allen: "The risks here are negligible."

Safety sometimes sacrificed

Yet a probe into the safety and environmental record of the industry reveals that the risks are not always negligible — or mitigated.

OSHA ruled that the Teccor plant was unsafe and endangered workers. OSHA said Teccor needed to clean the floor more often and install a leak-detection system for the pump and a better system to contain leaks.

Teccor disputes that safety was secondary in the 379-employee plant. "It could never be called an unsafe situation," Lapierre says. Since then, Teccor has moved all operations into a new, automated \$60 million building.

At the 500-employee Zilog plant in Idaho, workers had complained of problems for years. In 1993 and 1994, they were repeatedly exposed to acids, solvents and chemical fumes in an old and poorly maintained plant. Thirty workers sued. They said the exposures made them sick and, in some cases, caused miscarriages. The workers settled for \$2.25 million in 1996.

Erin Leishman, 29, a mother of three, chose not to sue. She wanted to forget the three years she worked there and the four miscarriages and one stillbirth she endured during that time. Chemical fumes, she says, drifted over her. "I had mouth sores," she says. "Sometimes, I would go home and vomit."

Zilog denies wrongdoing. But its former safety manager, in a resignation letter, admitted that employees were exposed and that the company should have taken action.

James Cochran, now a safety manager for Philips Semiconductor, wrote: "Corporate management has stated that if they did

of business. . . . A company with \$50 million to \$75 million in cash has a poor defense when stating, 'We can't afford it.'

An LG Epitaxy plant in Santa Clara, Calif., has worried safety officials for years. The 62-employee plant, in a crowded industrial park adjacent to homes, uses toxic gases and chemicals to grow ultrapure layers of silicon on top of wafers. Those wafers then go to other plants, where they are made into chips.

In 1992, city officials ordered workers to evacuate the Epitaxy plant because they believed it was too dangerous. Building officials said the plant was not built to safely house the hazardous chemicals the company used. Fire officials found several problems, including drums of hazardous waste improperly placed next to the property line; inadequate monitors to detect chemical leaks; and incompatible gases stored together, increasing the risk of fires and chemical releases.

Epitaxy, which was struggling financially at the time, made some repairs and promised to do the rest in letters to city officials. But four years later, facilities manager Tom Jacobs, hired by the new owner, Korean-based conglomerate LG, found leaking toxic gas lines and corroded exhaust pipes. "Everything was held together with bailing wire," says Jacobs, who was later laid off. "There were some things that were pretty scary."

In 1996, the plant released a cloud of deadly phosphine and hydrogen chloride, which can cause severe skin burns. The cloud spread over the parking lot. A badly worn electrical plug had come undone, disabling the equipment that was supposed to clean the exhaust, a company report says.

Last year, employee Jeffrey Saurman, 30, died after an accident at the plant. Saurman used powerful acids to clean equipment. He thought he mixed hydrofluoric acid with nitric acid. Instead, he added alcohol, which was in a similar bottle. The mixture exploded, creating a toxic yellow-red plume. The acid splashed. The burned worker ran to an emergency shower. He died two weeks later from chemical burns and inhalation.

Fire department investigators attributed Saurman's death mostly to the mistake he made. They also said he didn't wear an acid-resistant apron to protect him from burns.

Still, Deputy Fire Marshal Martin Von Raesfeld wrote in his investigative report: "I feel the chance of this incident happening was increased by a general lackadaisical approach to training and safety that LG Epitaxy has recently demonstrated."

In the two years before the accident, the fire department had responded to the plant 32 times — an unusually high number for

incidents involving hazardous chemicals at the plant — also a high number.

LG Epitaxy General Manager Rudy Acojedo refused to comment on the plant's history. Reading a prepared statement, he said: "We've done everything as a company to assure that other accidents do not happen again."

OSHA investigators said Saurman had been properly trained. But it did cite LG Epitaxy for, among other things, failing to give all new employees adequate training about hazards. LG has appealed the citations.

At Teccor, workers inhaled the dangerous fumes for a few minutes, evacuating only after another worker entered the room and began to choke. OSHA cited Teccor for training deficiencies regarding chemical hazards.

Ten percent of the industry's plants failed to properly train and inform workers of chemical hazards. That's about twice as good as all manufacturing plants, OSHA says. But few industries use as many different kinds of toxic chemicals as does the semiconductor industry. "We live to very high standards. Ten percent is too high," says Motorola's Seiferth. More than 85% of the semiconductor companies cited for training shortfalls were smaller plants.

Long-term illness concerns

One gets no sense of the dangers encountered by semiconductor workers when looking at national labor injury statistics. Indeed, the Bureau of Labor Statistics data paints the semiconductor industry as one of the safest. Its worker injury and illness rate is about a third as high as the average for all manufacturers.

"This industry is the epitome of where you would want American industry to be," says Donald Lassiter, a health consultant to the industry.

"We take safety incredibly seriously," Intel's Barrett says.

Semiconductor workers did, however, have a 29% higher rate of exposure to chemicals that resulted in lost work days than did all manufacturing workers in 1995, according to the latest data available.

Little is known about the long-term health consequences of those exposures. Several studies have shown that chip workers had more respiratory problems and dermatitis than other manufacturing workers. Three studies between 1986 and 1992 also revealed a

widely used to make chips, and miscarriages among workers. Most plants since have eliminated them.

Now the industry faces the question: Does its use of chemicals cause cancer? The Environmental Protection Agency is considering a cancer and birth-defect study of 100,000 electronics industry workers, including chip workers. It would be the biggest cancer study performed on the industry and would require its cooperation. "There is some reluctance" on the industry's part, says John Bowser, an EPA official overseeing a committee that will weigh the proposal this week.

No specific link between chipmaking and an individual cancer case has been made. But that doesn't mean that one doesn't exist, says Dr. Linda Rosenstock, director of the National Institute for Occupational Safety and Health. The chip industry has long used suspected carcinogens. The industry is young, she notes, and cancer can take 20 to 25 years to show up in large populations of workers. "There is cause for concern," she says.

Industry officials say cancer has not surfaced as a problem and that other industries have used many of the same chemicals in greater volume. "If there is an issue out there, we will address it," the SIA's Neal says.

Courts push issue

For Keith Barrack, 33, of Beacon, N.Y., the concern is immediate. Every time he gets an ache, he thinks his cancer is back. Barrack worked at IBM's East Fishkill plant in New York between 1986 and 1989. He was 30 when he was diagnosed with testicular cancer — cancer that he believes came from exposure at work to chemicals known to cause cancer in rats. Two people who worked near him got cancer, too. One died.

Zachary Ruffing, 12, was born with extreme skeletal deformities. His mother and father worked at the same IBM plant in the 1980s. While pregnant, his mother was barred from handling chemicals suspected of causing birth defects and miscarriages. But "I was breathing everything," says Faye Calton, 35, now of Lexington, Ky. "You could taste the chemicals." She says IBM officials told her she was safe because the plant was properly ventilated. "I trusted them," she says.

Barrack and Ruffing are among 128 former IBM workers and their families who have filed a lawsuit, saying the chemicals gave them cancer or caused birth defects. The case is the biggest to attempt to tie chipmaking to cancer. It is in the discovery phase. Filed in 1996, the lawsuit is against chemical makers, including Union Carbide

But some children born with defects sued IBM. So did Union Carbide, which says there is no valid scientific evidence to support allegations that its products, when properly used, were harmful. "If the chemicals caused problems," it was because IBM or workers used them improperly," says Union Carbide's Robert Berzok.

IBM says that its controls against chemical exposures exceed government standards. "We do not believe the illnesses of those involved with the lawsuit have anything to do with their jobs," says spokesman Tom Beermann. Kodak refused comment.

Environment at risk, too

While the potential health risks of the industry are disputed, its ability to harm the environment is well documented. The Superfund sites created in the 1970s and 1980s closed dozens of drinking water wells in Santa Clara County, the heart of Silicon Valley.

In Phoenix, Motorola, along with other electronics and aerospace companies, created two Superfund sites that encompass water supplies under Phoenix and into neighboring Scottsdale. Motorola has spent more than \$74 million trying to stop the spread of the contamination, which endangers scarce water resources.

Five lawsuits have been filed against Motorola and other responsible entities. The first lawsuit goes to trial in March. Dozens of plaintiffs claim they got cancer from drinking contaminated water or from exposure to TCE in the air and soil. Hundreds of other plaintiffs say they suffered neurological or respiratory disorders or that their properties lost value.

Motorola disputes all claims. It says nobody drank enough TCE to be harmed. "We do not feel that anybody has been exposed to anything that could have been harmful," says spokesman Lawrence Hurst.

Chipmakers no longer store wastes in single-walled underground tanks, which leaked and created Superfund sites. But they affect the environment in other ways. The industry is a big user of the most potent gases responsible for global warming. One, sulfur hexafluoride, is 23,000 times more potent than carbon dioxide, a global warmer created by the burning of fossil fuels.

Accidents can happen. In October 1996, 50 to 100 gallons of diluted sodium hydroxide streamed into a storm drain at a Mitsubishi Silicon America plant in Salem, Ore. The chemical overflowed the backup tanks and ended up in a nearby creek,

such spill at the plant that year. Mitsubishi blamed poor plant design, which it then changed.

Water is the biggest liquid component in chipmaking. About 2,000 gallons are needed for each 6-inch wafer. Newberg, Ore., turned away a Sumitomo Sitix plant in 1995, in part because it would have doubled the city's water use. A large chip plant can create 3 million gallons of waste water a day. The water is treated by the companies before it is discharged to city treatment facilities or waterways. The industry is the eighth-biggest releaser of toxic pollutants to public sewer facilities, EPA data show. When released to the environment, the waste water should be clean enough to meet standards. But in September 1994, a Matsushita Semiconductor plant in Puyallup, Wash., was fined \$37,500 because it had discharged too many pollutants to the Puyallup River — endangering fish, state records show. Matsushita says it had trouble with its treatment facility.

Laws, enforcement vary

A plant's design and construction can do much to reduce problems. Plants in Silicon Valley generally face the strictest building and fire codes, which govern construction. That makes the \$1 billion-plus plants more expensive — but safer.

In fact, some industry consultants and officials say California's tougher regulations played a part in the industry's expansion beyond the state. "When it got to the point where you could no longer afford to build because the codes made it so hard, companies took initiatives to go elsewhere," says Larry Hutker, senior facilities manager at Harris Semiconductor in Palm Bay, Fla.

Other industry executives disagree, noting that many big companies build plants to the same standard no matter where they are. "We do so because we want to make sure that our employees and our neighbors are safe," Motorola's Seiferth says.

Still, differences in the codes are worth noting. Silicon Valley plants are required to transport toxic and corrosive gases in pipes that are themselves contained in pipes. If a pipe breaks, the chemical is caught before it reaches employees or escapes to the environment. But double pipes are not widely required outside Silicon Valley.

Big companies, such as LSI Logic, say they put them in anyway, but not all companies have — and that worries mechanical contractor William Bianco, CEO of Kinetic Systems. Bianco says some plants are so dangerous that his company won't even work in them. He says double-piping "should be implemented all over despite the cost," which is generally three times that for single

Enforcement of codes that do exist also varies. "In California, the semiconductor industry is well regulated. You can go elsewhere and find no enforcement whatsoever," says Gale Bate of consultant Code Resource.

Albuquerque has eight officials to review building plans and inspect commercial construction sites. Santa Clara, Calif., a city one-fourth the size of Albuquerque, has nine. "In New Mexico, you never see the code people. You just go in there with plans, and they stamp them," says Robert Moats, consultant at Environmental and Occupational Risk Management in Sunnyvale, Calif.

Tony Reynolds, Albuquerque's supervisor of building plan review, admits the city has to rely heavily on voluntary compliance. "But we protect the public safety and get a lot of criticism for being too tough," he says.

Once plants are built, fire departments often have the most oversight. In Santa Clara, plants are inspected once a year, more often if problems persist, says hazardous materials administrator Dave Parker. In Chandler, Ariz., plants are inspected twice a year. In Tempe, Ariz., though, plants are not inspected unless there is an incident; inspectors say they are too busy. Fire officials even moonlight for Motorola, which they also regulate. Senior Fire Inspector Russell Wollam sees no conflict. Motorola often provides fire officials with expertise and training on semiconductor chemicals, he says.

But such close relations between companies and city officials alarm some residents. They fear that citizens will be shut out of the decision-making process and that safety issues might be overlooked as cities and states compete for chip plants.

"People were furious at the city because it gave up its regulatory role and became a cheerleader for Hyundai," says Bern Johnson, environmental lawyer with Citizens for Public Accountability in Eugene, Ore.

Door too open?

He notes that Eugene hired a public relations firm in part to "minimize unwarranted community fears" about a Hyundai Semiconductor plant in 1995. Hyundai hired former Oregon governor Neil Goldschmidt as a lobbyist. And some city council members were shocked when Hyundai announced its intent to build after being wooed for months by economic officials.

"I learned about it from a news program," says former council

Residents demanded hearings. The city resisted before holding a public forum attended by hundreds of people. "The denial of public process was unfortunate," says council member Scott Meisner.

Eugene City Attorney Glenn Klein says the city did not need to call a hearing because the property already was properly zoned for Hyundai.

Across the nation, cities are promising to speed the plants through the time-consuming permit approval process — which is heightening fears that problems will be missed.

In December, New York Gov. George Pataki unveiled a plan to shorten the yearlong permit process by offering 10 ready-to-build sites for plants.

Virginia recently issued an air-pollution permit to a new joint-venture chip plant in 28 days — one-third the time it usually takes, officials say. The state has promised \$113 million in cash grants over 10 years to win three chip plants. In Phoenix, a new Sumitomo Sitix plant went up in 14 months, about eight months faster than normal, city officials say. Sumitomo had even installed chemical tanks before fire inspectors discovered that the tanks were too big for their backup tanks, which are designed to contain leaks. Sumitomo fixed the problem.

Officials say fast construction does not mean poor construction. "We looked at everything," says Phoenix fire engineer Dwight Havens.

Yet even Phoenix Mayor Skip Rimsza, a Sumitomo proponent, admits the speed with which Sumitomo came to build resulted in some residents not being as involved as he now would have liked. But he adds: "We do not live in the 1960s anymore, when it doesn't matter when the factory opens. These companies have choices about where to build."

When Motorola recently recommitted to building a \$3 billion complex near Richmond, Gov. Allen called it "one of the best events in the history of Virginia." But not everybody looks at the semiconductor industry with such awe. Environmentalist Stephen Brittle of Phoenix, an outspoken industry critic, calls the new Sumitomo Sitix plant in his town "a chemical bomb waiting to happen."

For Hemlock, Mich., the truth is probably somewhere in between.

The rural community is home to the 470-employee Hemlock Semiconductor. The plant, the area's biggest industrial employer, makes silicon crystal. It has been a mainstay of the community for more than 30 years.

In 1995, the plant released 1,240 pounds of hydrogen chloride gas in two separate accidents, company documents say. The gas was not detectable off company property, the company says.

In 1996, it released 998 pounds in an incident in which about 10 homes in a 2-square-mile area were evacuated. Again, the company says the gas was not detectable at ground level off the property and that the evacuation was precautionary. Yet several residents complained of sore throats and nasal passages for days.

It could have been much worse, the company says. The plant lost power because of an equipment failure. That caused pressurized gases, which are usually cooled, to expand as they warmed up — threatening to break equipment and raising the prospect of a larger release. The gas was released to ease the pressure. But the event was so alarming that the plant now has warning sirens to alert residents to chemical accidents. It also has a computerized telephone system that can dial 300 numbers in 15 minutes.

"We take every precaution. But the reality is, you can never say never," says Bill Schock, site manager.

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