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The Washington Post

August 8, 1999, Sunday, Final Edition

## In Harm's Way, And in the Dark; Workers Exposed to Plutonium at U.S. Plant

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**SECTION:** A SECTION; Pg. A01

**LENGTH:** 4790 words

**DATELINE:** **PADUCAH**, Ky.

Thousands of uranium workers were unwittingly exposed to plutonium and other highly radioactive metals here at a federally owned plant where contamination spread through work areas, locker rooms and even cafeterias, a Washington Post investigation has found.

Unsuspecting workers inhaled plutonium-laced dust brought into the plant for 23 years as part of a flawed government experiment to recycle used nuclear reactor fuel at the **Paducah** Gaseous Diffusion Plant, according to a review of court documents, plant records, and interviews with current and former workers. The government and its contractors did not inform workers about the hazards for decades, even as employees in the 1980s began to notice a string of cancers.

Radioactive contaminants from the plant spilled into ditches and eventually seeped into creeks, a state-owned wildlife area and private wells, documents show. Plant workers contend in sealed court documents that radioactive waste also was deliberately dumped into nearby fields, abandoned buildings and a landfill not licensed for hazardous waste.

The sprawling Kentucky plant on the Ohio River represents an unpublished chapter in the still-unfolding story of radioactive contamination and concealment in the chain of factories across the country that produced America's Cold War nuclear arsenal. Opened in 1952 in an impoverished region, the 750-acre plant built a fiercely loyal work force of more than 1,800 men and women who labored in hot, stadium-sized buildings turning trainloads of dusty uranium powder into material for bombs.

Today, the Department of Energy contends that worker exposure was minimal and that contamination is being cleaned up. A lawsuit filed under seal in June by three current plant employees alleges that radiation exposure was a problem at **Paducah** well into the 1990s.

The Post's investigation shows that contractors buried the facts about the plutonium contamination, which occurred from the mid-1950s to the mid-1970s, in reports filed in archives. Plutonium, a core ingredient in nuclear bombs, is a highly radioactive metal that can cause cancer if ingested in quantities as small as a millionth of an ounce. The **Paducah** plant was designed to handle only uranium, a mildly radioactive metal.

"The community to this day has no idea of the kinds of contaminants they were exposed to," said James W. Owens, a **Paducah** lawyer representing residents whose water has been polluted by the plant.

Health consequences remain unclear. No comprehensive study of worker medical histories has been attempted at

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**Paducah.** In neighborhoods where older workers live, stories abound of cancer clusters and unusual illnesses. One 20-year veteran worker who died in 1980 compiled a list of 50 employees he worked with who had died of cancer.

"Everything was so safe, so riskless," the worker, Joe Harding, said in an interview just before his death. "Today we know the truth about those promises. I can feel it in my body."

Even though the plant's procedures and purpose have changed -- **Paducah's** enriched uranium is now used in commercial nuclear power plants -- problems have continued. Workers weave between makeshift fences that cordon off hundreds of radioactive "hot spots" scattered across the complex. In one corner of the plant, mildly radioactive runoff trickles from a nearly half-mile-long mound of rusting barrels that still contain traces of uranium.

"The situation is as close to a complete lack of health physics as I have observed outside of the former Soviet Union," Thomas Cochran, nuclear program director for the Natural Resources Defense Council, said in documents filed in the lawsuit.

The Department of Energy, which owns the plant, said it could not comment on allegations made in the suit because of the court-ordered seal. The agency is investigating the charges and dispatched a team to **Paducah** to determine if conditions posed an immediate threat to workers or the public.

Energy Secretary Bill Richardson said the agency's national security goals had "sent many of our workers into harm's way," but he said the agency must now live up to its responsibility to "right the wrongs of the past." Two weeks ago, Richardson pledged millions of dollars for medical monitoring of nuclear workers who were exposed to beryllium, a highly toxic metal.

"The Department of Energy will continue to take any actions that are necessary to ensure the protection of public health, the workers and the environment," he said.

Still, agency officials, in a written response to questions from The Post, strongly defended past safety practices at **Paducah** and said no workers are at risk today.

"The plant's monitoring data did not indicate an accumulation of [plutonium and other highly radioactive wastes] in the workplace or the environment that would be a health concern to workers or to the public," the DOE said.

That position is vigorously contested in more than 2,000 pages of documents filed in the lawsuit by two of the plant's health physicists, or radiation safety experts, and a veteran worker who had his esophagus removed after three decades of work inside contaminated buildings. Copies of the documents were obtained by The Post from government sources.

"The management line for years has been there was an insignificant amount" of plutonium at **Paducah**, said Mark Griffon, a health physicist at the University of Massachusetts at Lowell who is participating in a federal study of radiation conditions at nuclear weapons plants, including **Paducah**. Griffon reviewed plant documents provided by The Post.

"If the levels were this significant," he said, "it raises an important question: Why weren't workers ever monitored?"

The two health physicists suing the plant say in court documents they tried to call attention to the radiation problems but were confronted by a culture of unconcern.

"I was told by my superior . . . in so many words that 'this is **Paducah** -- it doesn't matter here,' " said one of the physicists, Ronald Fowler, 50, who came to the plant in 1991.

The suit was brought under a law that allows employees to collect payment for exposing fraud against the government. It was filed under seal to give Justice Department officials an opportunity to decide whether to join the suit or begin a criminal investigation.

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The suit names Lockheed Martin and Martin Marietta, which managed the uranium enrichment plant during the 1980s and 1990s. It does not name the original manager, Union Carbide, which ran the facility for a 32-year period during which the bulk of the contamination occurred. None of the companies had been served with the suit and none would comment on the allegations.

The current plant operator, U.S. Enrichment Corp., a government-chartered private company that assumed management this year, concedes past problems but says safeguards are now in place. USEC, which sold shares to the public last year, says it has fully disclosed the plant's environmental problems to regulators, workers and stockholders.

"It was acknowledged by all sides that contaminated conditions existed, . . . but USEC wasn't responsible for them," said Jim Miller, USEC executive vice president.

**Paducah** is the latest DOE facility to be rocked by lawsuits and revelations of contamination. Cleaning up the complex is expected to cost \$ 240 billion and take at least 75 years.

Measured by the gram, the contamination at **Paducah** isn't nearly as extreme as that in plutonium production plants such as Washington state's Hanford Nuclear Reservation, where vast swaths of land have been sealed off from humans. But unlike the workers at those plants, employees at **Paducah** did not know of the risks in the uranium dust they breathed every day.

Worker exposure to such dust has cost the government in the past. The Energy Department paid a \$ 15 million settlement five years ago to former workers who had breathed uranium dust at the Fernald Feed Materials Production Center near Cincinnati.

The difference between the dust at Fernald and that at **Paducah** comes down to one word: plutonium.

For 2 Decades, Freight Cars

Brought Unknown Danger

The **Paducah** complex was the second of three U.S. government plants designed after World War II to create enriched uranium. The plants were operated for the government by private contractors who over time were paid bonuses for running safe, efficient facilities.

In the beginning, uranium ore was scarce. The Atomic Energy Commission, forerunner of today's Energy Department, tried to fill the gap by "recycling" leftover uranium -- from nuclear reactors that made plutonium for bombs -- through the enrichment process at **Paducah**.

From 1953 to 1976, more than 103,000 metric tons of used uranium was shipped to **Paducah**, records show. It arrived in freight cars as a fine black powder. Unknown to workers, the powder contained dangerous substances left over from the plutonium-making process -- fission byproducts such as technetium-99 and heavy metals known as "transuranics": neptunium and plutonium.

"Plutonium is roughly 100,000 times more radioactive per gram than uranium," said Arjun Makhijani, president of the Institute for Energy and Environmental Research.

Over time, through spills and waste discharges, the contaminants accumulated in the miles of pipes used to gasify and enrich uranium, around loading docks and in ditches, documents show.

Plant officials were aware of the plutonium and other contaminants as early as the mid-1950s -- it made their recycled uranium less efficient. But they believed the amounts were too small to pose a health threat.

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Today, the DOE is able to rely only on a contractor's estimate of the total amount of contaminants introduced in that period: 12 ounces of plutonium, 40 pounds of neptunium and 1,320 pounds of technetium-99.

The government today takes the same position as it did in the 1950s: The amounts were most likely not enough to harm workers. "The general protection provided to workers from the hazardous effects of uranium would have provided adequate protection" from the contaminants, the DOE statement said.

But documents obtained by The Post show that plant officials became increasingly concerned about the contaminants. A 1992 report by Martin Marietta concluded that they caused "significant" environmental problems and "also pose a radiation hazard to the workforce." A 1988 study done for the DOE by a private contractor said the plutonium could "represent a significant internal dose concern even at very low mass concentrations."

Plant records draw an instructive comparison that underlines the hazards posed by plutonium: The 12 ounces of plutonium in the black powder delivered more than twice as much radiation into the environment as the 61,000 pounds of uranium that flowed out of the plant in waste water into the Ohio River between 1952 and 1987.

### Bosses Took Threat

#### With a Grain of Salt

In the noisy, cavernous buildings where uranium was processed, workers did not receive the warnings. The conditions there were "extremely dusty . . . sometimes to the point where it was very difficult to see or breathe," said Garland "Bud" Jenkins, 56, a 31-year-veteran uranium worker and one of the three employees involved in the lawsuit against Lockheed Martin.

To protect their skin from the uranium dust, workers wore cotton coveralls and gloves. But respiratory protection was optional -- old Army gas masks, which fit poorly and were seldom used, former and current workers said.

At lunchtime, workers brushed black powder or green uranium dust off their food. "They told us you could eat this stuff and it wouldn't hurt you," said Al Puckett, a retired union shop steward. To dramatize the point, he said, some supervisors "salted" their bread with green uranium dust.

The workers took the dust home at shift's end.

"We frequently discovered that our bed linens would be green or black in the morning, from dust that apparently absorbed into our skin," Jenkins said.

Exposure to uranium dust decreased after the late 1970s, when the plant stopped receiving the black powder and began processing a more refined form of uranium. In 1989, the DOE adopted more stringent worker safety rules.

By then the plutonium had permeated the land around the plant. In the 1960s and 1970s, when the powder spilled, workers would shovel it up and wash the remnants into the nearest ditch, Jenkins said. More than a dozen ditches flow directly from the plant onto state property and private lands.

There are no nationwide limits for plutonium in soil; cleanup standards depend on modeling the degree of public access to the contaminated spot. But the DOE has set cleanup limits at nuclear blast sites in the South Pacific of 15 picocuries of plutonium per gram of soil.

Contractors measured plutonium at levels up to 47 picocuries in ditches outside the plant and 500 picocuries on plant grounds.

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Those measurements were made after the first evidence of environmental problems outside the plant surfaced in 1988, when a county health inspector found technetium and chemical carcinogens from the plant in a farmer's well. The discovery of the poisoned wells prompted a multimillion-dollar ground-water cleanup under the Environmental Protection Agency's oversight.

Although plant managers posted creeks and ditches with warning signs in the early 1990s, the signs do not refer to plutonium or any other radioactive contaminants. Some warn of possible contamination with cancer-causing chemicals; others merely caution against eating local fish.

Lawsuit Alleges

Deliberate Dumping

In addition to the substances that flowed or spilled out of the plant through the drainage ditches, the employees contend in their lawsuit that a wide variety of contaminated substances were deliberately dumped into the environment. Spilled black powder and empty radioactive waste containers allegedly were placed in dumpsters and trucked to a sanitary landfill on DOE property licensed only for trash and garbage. Rubble from demolished buildings and contaminated railroad ties allegedly were dumped in nearby woods and fields. Slag from uranium smelters was put in abandoned concrete bunkers in a state wildlife area outside the plant, according to the lawsuit.

"There was only one dumpster for all waste, whether radioactive, hazardous, toxic or ordinary," Jenkins said.

Plant records describe at least two dozen unlicensed radioactive debris piles on state lands outside the plant. Last year, ground-water tests turned up technetium directly beneath the sanitary landfill.

A 1990 DOE audit of **Paducah** found inadequate controls over waste disposal and a faulty system for tracking contamination that forced managers to rely on "word of mouth."

Charles Deuschle, 56, a health physics technician and the third employee in the lawsuit, said he was "shocked" when his surveys discovered radioactive contamination in such places as the plant's cafeteria.

"I saw conditions that would never have been tolerated in any other nuclear location where I have worked," Deuschle, who came to **Paducah** in 1992, said in court documents.

Internal plant surveys included in the suit found high levels of radiation on street surfaces, manhole covers and loading docks and in locker rooms as recently as 1996.

The plant's current managers maintain that all significantly contaminated areas have been addressed. "Hot" surfaces have been coated with absorbent paint, and warning signs have been posted, they said. Rope fences keep passersby away from radioactive equipment rusting in the open. Drain pipes and fire hydrants are coated with warning paint. Two dilapidated buildings where the black powder was once processed are padlocked. In 1997, regulatory oversight of the plant was transferred to the Nuclear Regulatory Commission, which declined to comment on allegations in the sealed lawsuit.

Even the employees involved in the suit concede that safeguards have improved recently. But they insist that problems remain. This spring, elevated radioactivity was found in a parking area near the administration building, plant documents show.

Soil collected from a ditch outside the plant's fence by The Post in June and analyzed at a commercial lab contained 2.6 picocuries of plutonium, slightly higher than the NRC's suggested guideline for cleaning up nuclear sites.

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The Post, using two hand-held detectors, also found sharply elevated radiation levels in the debris piles on the state wildlife lands. One such area was an unmarked pile of rotting railroad timbers near fishing ponds and campgrounds.

### Public Reports Tell

#### Only Part of the Story

Environmentalists, plant workers and neighbors claim that plant officials play down the hazards.

"They cloak it in jargon," said Mark Donham, a member of a citizens advisory board that meets monthly with plant cleanup officials. "You have to order the documents and then spend hours and hours looking at them to learn anything."

DOE officials say the facts and figures about the plutonium contamination inside the plant have been duly recorded since 1991 in thick inspection reports. But these are kept in archives rarely visited by the public.

In the annual environmental reports that circulate to the public, the contamination is described as "trace" amounts of "radionuclides," a catchall term that can include mildly radioactive uranium as well as highly radioactive plutonium.

A 1991 "site investigation" report, done by the plant's contractor and stored in the archives, shows much higher levels of plutonium than the annual environmental reports. The DOE said the reports use different methods and measure different things.

The result has been that the DOE can claim full disclosure about the contamination while plant workers and neighbors remain in the dark, said Owens, the attorney for the plant's neighbors.

"The company has engaged in a cynical disinformation campaign that centered on downplaying risks and presenting confusing and misleading information," he said.

Inside the plant, the first disclosure of plutonium to workers came around 1990 after managers summoned top union leaders to discuss the results of tests ordered after the state found the poisoned wells.

"They took it seriously," a union official, speaking on the condition of anonymity, said of Martin Marietta's presentation. But "the health effects weren't viewed as serious. We just vehemently stressed that the contamination should be cleaned up."

Plant managers insist that workers today are fully aware of the potential hazards. USEC cites worker training programs that it says include a briefing on plutonium and other radioactive hazards at the plant.

But officials with the union's Washington office contend workers still don't know a fraction of what they were exposed to. "What we're seeing now," said Daniel Guttman, former staff director of the federal Advisory Committee on Human Radiation Experiments, "is the outcropping of the glacier."

### Deficient Monitoring

#### Compounded the Risk

The health effects for **Paducah** workers remain an open question.

The DOE said 442 **Paducah** workers were tested in 1997 and only 8 percent displayed measurable amounts of radiation. It said screening tests since 1992 have found no evidence of plutonium exposure in workers.

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But the greatest exposure to workers would have occurred before the enhanced monitoring that began in the late 1980s.

In 1990, the DOE audited safety practices at **Paducah** and found scores of deficiencies in radiation monitoring and worker protection. The audit team said **Paducah** failed to properly monitor radiation to workers' internal organs -- even though plant managers had been repeatedly warned to do so.

Radiation-measuring equipment was either missing or not properly calibrated, the report said, and workers weren't being tested for the kinds of radiation known to exist at **Paducah**. Whether the plant's equipment and personnel were even capable of detecting exposure to plutonium and other transuranics was "questionable," the audit said.

Bolstering claims by workers that they had been left in the dark about radioactive hazards, the report found no mention of transuranics in plant safety procedures.

"Onsite environmental radiological contamination conditions are largely unknown," the report said. "A formal program with well-defined monitoring, sampling and analysis requirements does not exist."

Independent experts are investigating **Paducah** as part of two national studies of environmental and safety issues in the U.S. nuclear weapons complex. Both studies are relying primarily on data supplied by the plant. Officials brought in two years ago to review past radiation hazards told The Post they were not informed that **Paducah** workers may have been exposed to significant amounts of plutonium.

Neither was Harold Hargan, a plant worker for 37 years. Hargan was one of about six workers who he says were told in 1990 that a test had found plutonium in their urine.

"It surprised me. Hell, it surprised the doctor," Hargan said. "Everybody knew there was no plutonium at **Paducah**."

### What Happened Inside the Plant

Uranium is a naturally radioactive element that comes mainly in two forms, or isotopes: uranium-238 and a small amount of uranium-235. Only U-235 is fissile, or capable of being split in a nuclear chain reaction. To make bombs or nuclear fuel, uranium must be "enriched" by increasing the proportion of U-235.

### The Mission: Uranium Enrichment

1. Uranium ore from mines is milled in a process to extract uranium oxide, known as yellowcake. The yellowcake is sent to **Paducah**.

2. At the **Paducah** plant, yellowcake is burned with hydrogen to form uranium dioxide, a black powdery substance called "black oxide."

3. The black oxide is mixed with hydrofluoric acid to make uranium tetrafluoride, known as greensalt.

4. The greensalt is burned with fluorine to make uranium hexafluoride

Since the late 1970s, **Paducah** has purchased uranium hexafluoride from other companies. Today, the enrichment process begins here.

5. Finally comes the gaseous diffusion process for which the plant is named: The liquid uranium hexafluoride is heated

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and passed through a series of barriers, which separate and concentrate the U-235 isotope. The low-enriched uranium is condensed to a solid and packed into drums for shipping.

The enriched uranium is shipped to another plant for further enrichment to make commercial nuclear fuel. In the past, some was converted to highly enriched uranium for bombs.

4%-5% U235 Nuclear fuel for power plants

90% U235 Nuclear weapons

Enormous amounts of uranium are left over after enrichment.

The processes used at **Paducah** also can move backward, turning uranium hexafluoride back into greensalt, or into depleted uranium metal for use in armor-piercing munitions or armor plating.

Uranium hexafluoride mixed with magnesium yields greensalt, uranium metal and slag.

### Contamination Spreads

Beginning about 1953, uranium from spent nuclear fuel was sent to **Paducah** to be enriched. Each shipment contained small amounts of plutonium and other radioactive contaminants.

### Worker exposure

Processing uranium generated large amounts of contaminated airborne dust inside the buildings. Also, radioactive material often was spilled, then swept up by hand, hosed into gutters or placed in regular trash receptacles, whistle-blowers say.

Workers carried uranium home on their skin and clothes.

### Metals Recovery

Old nuclear warheads were dismantled at **Paducah**, where the radioactive material was extracted and gold and other precious metals were recovered.

The recovered gold was melted into bars. Whistle-blowers allege some was shipped away without being measured for radiation.

Tens of thousands of drums used to ship uranium are stored outdoors at the plant. Many drums still contain radioactive material.

This "depleted" uranium -- still radioactive -- is stored in tens of thousands of cylinders in open lots.

The plant continues to store significant amounts of various recovered metals deemed too contaminated to ship.

The concrete-like gray slag, a contaminated

byproduct of the process, allegedly was trucked to sanitary landfills and dumped in public areas near the plant. Large amounts of contaminated slag remain on the site.

### Hazards Inside the Plant

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For decades, plutonium and other radioactive hazards quietly spread through this Kentucky uranium plant, exposing unsuspecting workers to an invisible and potentially lethal threat. Red areas on this diagram denote contamination that was detected around the main work areas in 1992.

'Barrel Mountain': A nearly half-mile mound of large piles of rusted metal scrap and other waste materials, some of it contaminated.

Classified burial ground: This landfill contains nuclear weapons components. Workers who dismantled weapons may have been exposed to beryllium, a highly toxic metal.

Burial pits: Enormous amounts of radioactive material lie in shallow landfills on plant grounds, and some are believed to be leaching into ground water. One pit contains hundreds of barrels of a highly flammable form of uranium stored in PCB-tainted oils.

Waste-water discharges: Company documents acknowledge the release of tens of thousands of pounds of uranium into creeks. Toxic chemicals and metals also were discharged in waste water.

Dirty runoff: Rain washes uranium and other hazards into ditches that flow past outdoor scrap yards. Some of the ditches are posted as radioactive inside the plant fence, while just outside the fence there are no such warnings.

Fouled ditches: Uranium, plutonium and other radioactive materials were flushed into ditches, such as this one, that flow into tributaries of the Ohio River. A test commissioned last month by The Washington Post found plutonium here. Earlier tests of the ditch inside plant grounds found plutonium at a level 100 times above what the government certifies as safe.

One of the most contaminated buildings still in use, C-400 contained chemical solvent tanks for cleaning radioactive equipment. Workers this year found an old canister that contained radioactive technetium at levels millions of times above the safety standard.

Outdoor hazards: Plant officials recently discovered radioactive contamination in this gravel parking lot near the main administration building. Dozens of "hot spots" around the plant grounds mark the sites of old spills or dumps.

Buildings 410 and 420: Hundreds of workers were exposed to radioactive dust in these buildings, which were used to process uranium before enrichment.

Contaminated buildings: Elevated radiation levels have been found in hundreds of areas frequented by workers, including a cafeteria.

Tainted wells: Two large plumes of contaminated ground water extend more than a mile north of the plant into residential neighborhoods. The water is contaminated with chemical and radiological wastes.

Cylinder piles: More than 30,000 metal tanks containing a toxic mix of depleted uranium and fluorine are stacked in open lots. Until recently, some were stored in a nearby residential neighborhood.

Process buildings: The heart of the plant, these stadium-sized buildings now enrich uranium for commercial nuclear fuel. The truck alleys along the sides of each building are contaminated from spills during deliveries.

Chemical spills: Thousands of gallons of toxic chemicals -- including suspected carcinogens -- were released into the environment in a series of leaks and spills. Some ended up in nearby creeks.

Airborne releases: Exhaust fans vented radioactive dust into the atmosphere. Workers say the biggest releases were always at night.

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Switchyards: The plant requires enormous amounts of electricity -- two generating plants are dedicated to its needs. As recently as 1996, the plant also was the nation's largest single emitter of freon, the coolant blamed for damaging the Earth's ozone layer.

SOURCES: "Radiological Survey of Selected Outdoor Areas, Paducah Gaseous Diffusion Plant, Paducah, Kentucky," prepared by Oak Ridge Associated Universities, April 1992; Washington Post research. Satellite photo from U.S. Geological Survey.

#### Spreading Toxins

Radioactively contaminated slag and rubble from demolished buildings was dumped outdoors in more than two dozen places around the plant. For decades, waste water containing uranium, plutonium and cancer-causing chemicals was discharged into ditches and creeks that flow into the Ohio River, three miles away.

**LOAD-DATE:** August 08, 1999

**LANGUAGE:** ENGLISH

**GRAPHIC:** Illustration; Illustration, william mcnulty, patterson clark, jackson dykman; Illustration

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