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THE UNIVERSITY OF MISSOURI RESEARCH REACTOR: EXPANDING AND RE-LICENSING A NUCLEAR FACILITY

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The 30-year old University of Missouri Research Reactor (known as MURR) is the largest and most powerful nuclear research reactor on a university campus in the United States. In the year 2001, MURR's operating license with the Nuclear Regulatory Commission will come up for renewal. The university is also seeking out state, federal and private funds to expand the reactor. The reactor thus presented a timely target for journalistic inquiry. Interviews, site visits and documents from relevant agencies were used to paint a journalistic portrait of the facility.

The most pressing issues at the reactor were found to involve radioactive waste storage, personnel management problems, and dwindling monetary support. The reactor's areas of strength were found to be in its relation to nuclear medicine and in the wide array of disciplines that use the facility. Each of these areas was investigated.

The storage of radioactive waste was found to be a national problem. The university is ready to expand its on-site storage of low-level radioactive waste, but is hoping for a national solution that will take pressure off of MURR and allow the waste to be stored off-site. Management problems were traced to the illegal punishment by administrators of two scientists who pointed out safety concerns. The NRC is still investigating some of those concerns, but they should not threaten re-licensing. Monetary problems were traced to international competition and an unwillingness on the part of the American public to support high-cost technology projects.

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INTRODUCTION

It's known among peers as the crown jewel of the country's university-based nuclear reactors. The 30-year-old University of Missouri-Columbia research reactor is the largest and most powerful on any campus in the United States, supporting an array of projects from archaeology to zoology.

The reactor's biomedical program, for example, supplies pain relievers for cancer patients and could someday assure a national supply of drugs used in medical testing. Optimistic researchers even hint at a future in which reactor-based drugs provide cures for some types of cancer.

But officials here are acutely aware that other gems in the nation's nuclear crown have disappeared due to a lack of support from university administrators, state and federal government agencies and a public that is nervous about radiation. University reactors have dwindled from more than 70 in the 1970s to 34 today.

"Nuclear engineering programs and research reactors are declining at a rapid rate, jeopardizing the goal of preserving the nuclear energy option for the 21st century," says Jay Kunze, University of Missouri professor of nuclear engineering.

In 2001, the Nuclear Regulatory Commission operating license for the reactor expires. Officials at the reactor, known as MURR (Missouri University Research Reactor), hope not only to renew the license, but to convince the state and federal governments to invest about $40 million for new equipment, building expansion and a power increase. Reactor officials are confident about the outcomes, but know the reactor will come under intense scrutiny.

"We'll look at everything," says Al Adams of the NRC's Washington, D.C.

office. "A re-licensing is equivalent to a new operating license."

The NRC inspectors will concentrate on technical items, such as the soundness of equipment, Adams says. But insiders at MURR point to other concerns that they feel are the real problems the facility has to deal with before it is ready for the re-licensing:

- Radioactive waste storage. For now, the waste is piling up in the reactor basement and elsewhere on campus. As at nuclear facilities across the country, the problem awaits a national solution.
- A recent series of management problems. Reactor administrators were fined by the NRC and U.S. Department of Labor for violating federal whistle-blower protection laws when two scientists who had pointed out safety concerns were punished.
- High operating costs and dwindling monetary support. Even much-touted medical programs at MURR have received little of the federal support that researchers say is needed.

If MURR is successful, it will survive in what has become a hostile environment for nuclear reactors in the United States.

THE KINGDOM OF THE NEUTRON

The idea to build a reactor center at MU was initiated by university President Chester Ellis in 1956, at a time when nuclear power was seen as a panacea for the country's energy needs. The government was slowly disseminating the nuclear research that was produced during development of the atomic bomb and wanted to develop a corps of engineers, scientists and educators to back the promise of nuclear energy "too cheap to meter."

Universities were recruited to supply an educated work force and to build reactor-based laboratories that could push nuclear applications into new areas. Construction in Columbia was completed in 1966. By 1974, the reactor was running at 10 megawatts of power, making it the country's most powerful campus reactor. By contrast, the Callaway Nuclear Power Plant, 30 miles to the east, operates at 3,300 megawatts.

The MU reactor is housed in an innocuous building on the southern edge of the campus in Columbia, a university-dominated city of 75,000 in the center of the "Show Me" state. Its biggest distinction is a 20-foot tall, steam-belching, cooling tower. Inside, behind a set of steel doors and shielded from the rest of the building by one-foot thick concrete walls is the reactor core, the heart of the operation. What casual visitors remember most vividly is the eerie blue glow of the water in the 20-foot deep reactor pool, a phenomenon called Cerenkov radiation.

"A visual sonic boom," is how Ronita Dinger, the reactor's public relations director, explains the sight. During fission in the reactor core, electrons are displaced from water molecules, causing the electrons to move through the water faster than the speed of light. "When the electron decelerates," Dinger says, "it gives off a cone of blue light."

But while visitors are enchanted by an electron-generated phenomenon, researchers are drawn to the reactor for its neutrons. In a research reactor, the neutron is king. A neutron is a part of an atom's nucleus that has a large mass and no electrical charge.

To start a nuclear reaction, uranium-235 atoms are bombarded with neutrons. When struck, a uranium atom splits, giving off heat energy and radiation and releasing more neutrons. They, in turn, strike and split other uranium atoms, creating the chain reaction known as nuclear fission. Power-producing nuclear reactors capture fission's heat to produce steam that turns turbines, which generate electricity. But heat is a nuisance inside a research reactor. Instead, scientists at MURR want access to the neutrons, which they use as activators to make other materials radioactive, as probes to explore the state of matter, as tracers to examine biological processes and identify materials, and as waves to explore the fundamental properties of matter.

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"It's a remarkable tool, a tool that has always amazed me in its versatility and its simplicity," says senior research scientist Steve Morris. For 23 years, Morris has worked in an area of the reactor that has done duty from fighting crime to studying ancient civilizations.

When Morris first arrived at the reactor, he did forensic work using a technique called neutron activation analysis. He testified at dozens of court cases in Missouri and around the country.

Morris, who resembles a bespectacled Newt Gingrich, recalls one case out of St. Louis in which the murder weapon was a root beer bottle. Police caught a suspect and found tiny slivers of glass in his boot. But St. Louis has a lot of broken glass on the streets. To make a connection, police turned to the reactor.

"We gathered up dozens of root beer bottles from the St. Louis area, the same type that was used in the assault," Morris says. "We started analyzing the bottles to see just how unique they were."

Morris and his students crushed hundreds of bottles, placing small quantities into containers which were then placed near the reactor's core for a minute, becoming "activated" by neutron bombardment. The neutrons caused changes in the samples, allowing Morris to precisely measure the concentrations of signature elements, producing a "trace element fingerprint" for individual bottles.

Morris testified that the glass from the murder weapon matched the glass at the scene of the crime and in the suspect's socks. The suspect was found guilty. "I've had occasion since then to look at the cases I've testified on," Morris says, "and none of mine have been overturned."

After a couple of years, however, the federal money that paid for the forensics program dried up, and Morris looked to other interests. He soon settled on trace-element analysis for the study of nutrition, which he has worked on since.

The technique is the same, but instead of exposing crushed glass to neutrons, Morris irradiates things like heart tissue, allowing him to trace the uptake of elements such as selenium. By pinpointing where the selenium lodges, researchers can begin to define what, if any, role the element plays in the heart.

Archaeologists also use MURR for activation analysis.

Master's student Donna Glowacki, for example, looked at whether neutron activation analysis was an appropriate tool to study the Anasazi people who lived in the American Southwest about a thousand years ago.

Glowacki collected pottery shards and clay samples from four sites in and around the Mesa Verde cliff dwellings in Colorado. "By exposing the pottery and clay samples to neutrons in the reactor, I was able to determine where the clay for different pottery was collected," she says. The chemical fingerprints also allowed her to show that some pottery was moved from its site of origin. Such information can provide clues about the Anasazi's movements, indicating trade patterns and routes. And when it comes to understanding the Anasazi, Glowacki says, every piece of information helps.

Glowacki received her degree in 1995 and was immediately hired at the Crow Canyon Archaeological Center, 10 miles from Mesa Verde. She continues to use the MU reactor for her work, and hopes to someday base a doctoral thesis on analysis done there.

NUCLEAR MEDICINE: FROM IMAGES TO "CRUISE MISSILES"

Tyler Archer was only 14 days old when he was introduced to nuclear medicine. Alerted by Tyler's jaundiced condition, doctors at MU's University Hospital and Clinics injected a radioactive drug into his bloodstream to check his liver function.

As Tyler sucked on a sugar-coated pacifier, the drug coursed through his veins and the radioactive isotope technetium-99 collected in his liver and surrounding organs, emitting gamma rays that were detected by a special camera. Tyler's parents, Beth and Chuck Archer, watched a monitor as a computer turned the radiation into pictures of their son's liver and surrounding organs.

"In Tyler's case, we were looking for the dye to trickle down to the intestine from the liver. It didn't," recalls Beth Archer, who has learned a lot more about medicine than she had ever planned.

The nuclear scan--a kind of inside-out X-ray--pinpointed Tyler's problem, a condition called biliary atresia in which the bile ducts fail to let digestive enzymes leave the liver. The condition is fatal if untreated.

Based on the test results, surgeons gave Tyler a stoma, a bypass that routed his bile around the faulty ducts, buying Tyler precious time as doctors prepared him for a liver transplant. Several weeks later, surgeons spent 12 hours giving Tyler a new liver--and hope for a normal life.

Tyler is thriving now, a solidly-built boy with wide, sky-blue eyes. Chuck Archer had not heard much about nuclear medicine before Tyler was born, but he's thankful the test was available, allowing doctors to make a crucial and timely diagnosis about his son.

Some people worry, however, that the United States is addicted to a foreign supply of radioisotopes. The technetium-99 used in Tyler's test, for example, was made at a Canadian reactor that produces about 80 percent of the world's supply. European reactors produce the rest.

Researchers at MU are working on a new way of creating technetium-99, one that will not depend on the Canadian reactor as a source. As conceived, the new production method would produce significantly less radioactive waste. The amount of waste generated in the current production process is the main reason that reactors in the United States no longer make technetium-99.

But success with the new method is not assured and, even if it comes through, will not be commercially viable for many years. A 1994 report from the Institute of Medicine, a branch of the National Academy of Sciences, concluded that the United States should have its own source of technetium-99, which is used in some 36,000 tests daily. The MU reactor is cited in the report as a possible source.

"The U.S. has really been falling behind in radioisotope production," says Wynn Volkert, a scientist at Columbia's Truman Memorial Veterans Hospital and also an MU professor who works at the reactor developing cancer-fighting radioactive drugs. Volkert, chairman of the national Society of Nuclear Medicine's Committee on Isotope Availability, worries that if something shut down the Canadian reactor, even for a short time, the U.S. supply of technetium-99--which is used in 18 FDA-approved drugs--would be in jeopardy.

The easiest way to envision how these drugs and other radiopharmaceuticals work is to think of technetium-99 as a magnet that can be stuck onto different kinds of substances. In Tyler Archer's case, the technetium-99 was attached to a sulfur substance that his liver filtered out of his bloodstream. Other drugs seek out the brain, lungs or other organs. Imaging equipment then reads the gamma rays given off as the radioactive components decay. One of nuclear medicine's biggest advantages over other types of imaging--X-rays, CAT scans, MRIs--is that it allows doctors to better study the function of internal organs by presenting a continuous, real-time picture.

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Another class of radioisotopes gives off beta rays, which, unlike gamma rays, penetrate only a few millimeters into tissue. But because beta rays give off all their energy in such a small space, they are capable of destroying cancer cells and are thus useful for therapy. The problem in using beta ray emitters has always been to find ways to contain the energy they release--a destructive power that doesn't discriminate between healthy cells and cancerous ones. Amolak Singh, chief of nuclear medicine at MU, likens the beta emitters to "cellular-level cruise missiles" that target cancer and other tumors.

Singh was part of a team that developed the drug Samarium-153 EDTMP, used to relieve the pain that cancer patients feel when cancer spreads to bones. "The pain from bone tumors is sometimes so severe patients wish they were dead," Singh says. While Samarium-153 EDTMP is not a cure for cancer--it destroys too much bone marrow to be given in large enough doses to knock out the tumors--it reduces pain by decreasing the pressure on nerve endings.

Drugs that use radioisotopes for therapy have advantages over traditional methods that use an external beam of radiation--they do not induce as many side-effects such as hair loss and nausea. Samarium-153 EDTMP is in the last stage of clinical trials in the United States before going to the FDA for approval as a prescription drug.

"We can give a radiopharmaceutical like Samarium-153 EDTMP to relieve pain for the rest of the patients' lives, whether it be four months or four years," Singh says.

The reactor was indispensable in creating the drug, says Volkert, who was part of the development team. "Without it we would never have done the project."

Reactor research scientist Gary Ehrhardt gets excited talking about the future of this kind of treatment. "We think there could be a revolution in treating cancer using radioisotopes," he says.

Ehrhardt's group recently made its first shipment of another isotope, rhenium-186, to Germany, where its ability to combat a type of cancer in children will be tested. Ehrhardt dreams that drugs built around radioisotopes will someday be used to wipe out most types of cancerous tumors. But he worries that the leap from dream to reality won't be possible without a government subsidy to ensure a steady supply of radioisotopes for research.

Echoing similar complaints from others in nuclear industries, Ehrhardt blames what he terms "unreasonable fear" on the public's part for the failure of the United States to produce sufficient radioisotopes. "It's unfortunate that we've gotten into a mode in this country where fear of chemicals, radiation, and so on controls what we do."

Even the most ardent nuclear opponents hedge when it comes to nuclear medicine. "I simply don't know how to come down on that issue," says Kay Drey, one of Missouri's best known and staunchest anti-nuclear activists. For 20 years, Drey has battled nuclear power plants and radioactive waste sites. Ehrhardt says the cumulative affect of such opposition ends up hurting nuclear medicine, whether Drey intends it to or not.

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The world market for radioactive drugs is about $1 billion per year, but private companies in this country are reluctant to face the protests and regulatory hurdles posed in building new facilities or remodeling old ones. The United States, Ehrhardt points out, wasn't always dependent on the Canadians for technetium-99. In the 1950s, the government produced the entire domestic supply of the isotope. Private industry took over in the 1960s, and the government took on the role of regulator, imposing ever-tougher rules.

The last U.S. company to produce technetium-99 shut down in 1989. "The perceived liabilities, costs and licensing uncertainties deter private sector development," noted a 1994 Department of Energy report.

Ehrhardt notes that "companies are reluctant to put millions of dollars into a new product if they cannot be guaranteed a supply of the raw materials." The energy department said it will seek congressional approval to start producing more radioisotopes--including technetium-99--by upgrading some of the reactors it operates. But because the department's own budget for nuclear research has been cut year after year, the agency is unable to provide much support for university reactors.

The 1994 National Academy of Sciences report recommended that the U.S. Department of Energy increase funding for radioisotope production and develop a national isotope strategy. Of all U.S. reactors, the report said, only the MU reactor "is currently producing a substantial number of radionuclides for use in research and radiopharmaceuticals." James Adelstein, a professor of medical biophysics at Harvard University and chairman of the study, says the MU reactor "is a model of the kind of facility we would like to see the country have."

An infusion of government money would allow the MU reactor to expand its laboratory space and buy equipment to process radioisotopes, says reactor director James Rhyne. "It would also allow us to produce some isotopes that are less in demand but useful in research," he says. Reactor supporters argue that a government subsidy is needed because the quantities involved in research are not commercially viable.

Volkert hopes the science academy report is the glow at the end of the tunnel for his research area. "I believe we will begin to develop a lot more therapy with radioisotopes over the next 10 years," Volkert says. "When therapeutic agents are developed, we are going to have to depend on foreign supplies. The issue is, do we want to rely on the rest of the world for the production of these radioisotopes?"

WASTE: THE ACHILLES' HEEL

Dave Spate has seen a lot of low-level radioactive waste go through his hands. For almost 30 years, he's buried it, burned it, stacked it, stored it and shipped it. These days Spate, an MU health physicist, watches as that waste builds to record levels on campus, hostage to a national policy that can't come to grips with the byproducts of the 50-year-old nuclear age.

"I keep adding more and more drums," says Spate. "It hasn't leveled out at all."

The disposal of radioactive waste is seen by many as the Achilles' heel of the country's nuclear industry. The United States has yet to come up with a method of storage, especially for high-level nuclear wastes such as spent fuel from reactors, that satisfies all concerns. While research reactors such as MURR produce much less waste than power reactors, they are equally vulnerable to storage problems.

The Columbia reactor doesn't produce any high-level radioactive waste. MURR's fuel is removed while it can be used elsewhere and is sent to a federal facility for reprocessing. The biggest disposal problem at MURR, and across the Columbia campus, is with low-level waste.

Low-level radioactive waste is commonly defined by what it's not--it isn't spent nuclear fuel or other radioactive residues from power reactors and nuclear weapons programs. Such high-level waste is more dangerous for much longer periods of time--tens of thousands of years--and is thus subject to stricter rules and greater controversy.

Missouri's one nuclear power plant generates more than half the state's low-level waste. The Callaway plant has room on site to store all its waste until 1999, company officials say, by which time they hope a regional storage facility will be built. If not, they have room to expand.

In years past, MU kept its volume of waste under control by packing much of it into 55-gallon drums and shipping them to a disposal site in Barnwell, S.C., the same site used by the Callaway plant. But on July 1, 1994, following changes in federal laws, Barnwell locked its gates to all but a few states. Missouri's radioactive waste producers--and those in 31 other states--had nowhere to turn, so the NRC gave them permission to store waste on site, a situation no one is comfortable with from a health and regulatory standpoint.

Experts disagree about the effects low doses of radiation have on health, but the NRC and other federal agencies enforce strict rules about its storage and handling. Missouri is in the hunt with five other states for a regional disposal site. For now, MU stockpiles its waste in two old barns and a large shed in Reactor Park and in the basement of the research reactor.

The university's storage space will be filled by the end of 1996, says Jim Beckett, director of MU Environmental Health and Safety, adding that the university will have to build another storage building, at an estimated cost of $250,000.

When--and if--a regional radioactive waste dump is found, it likely will be expensive for users. The price to dispose of a 55-gallon drum of low-level radioactive waste soared from about $25 in the 1970s to about $1,000 each for the last drums the university shipped. The high disposal cost makes some people worry about the future of radiation-dependent research.

"When researchers can't tell what the price and availability of waste storage and shipment will be in the future, they may not be able to do the research," says Ron Kucera, director of special projects at the Missouri Department of Natural Resources. "What happens to research at places like the University of Missouri? It will be a shame if legitimate research is harmed because of this."

Truman Memorial Hospital's Wynn Volkert says his work is already hampered by waste storage problems. "Basically we won't do certain experiments because we don't have the storage space," says Volkert, who runs a small lab in the hospital basement.

The MU reactor, which manages its low-level waste separately from the rest of campus, used to ship about 70 to 80 55-gallon drums per year to Barnwell, says reactor health physics manager John Ernst. Echoing others, Ernst says that storing waste in the building's basement "is not an ideal situation."

"Now, because of our small size, people will occasionally have to move the barrels around to do work in some areas," Ernst says. "It could potentially limit what people could do."

It is difficult to gauge the affect the storage problem will have on the NRC relicensing process. If the storage issue is not solved, it probably will not prevent MURR from getting a license, Rhyne says, but it could limit the reactor's activity. That, in turn, could make potential partners in the expansion hesitant to invest.

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The waste that Spate and others now store on campus includes plastic gloves, paper towels, clothing, beakers, liquids and filters that get contaminated with radioactivity during experiments from a variety of academic disciplines in about 200 labs.

About once every two weeks, for example, a small cardboard box containing the radioactive tracer phosphorous-32 is delivered to Jacque Evenson's laboratory in MU's Gwynn Hall. Evenson, a microbiologist with the "Food in the 21st Century" project, handles the package in a ritual designed to prevent contamination, beginning by checking the outside of the box with a

Geiger counter. If it's radiation-free, which she says has always been the case, Evenson signs a receipt and takes charge of the material.

She then slips on a pair of plastic gloves, stands behind a clear plastic shield and carefully opens the package, reaching through a light haze of dry ice vapors to pull out a blue, egg-sized container. Inside the lead-lined "blue pig" is a small vial of radioactive P-32.

The MU reactor produces a large amount of the country's P-32, shipping the radioactive isotope to companies such as DuPont that use it to make tools for microbiologists involved in gene sequencing, gene splicing and similar work. Evenson uses the phosphorous to radioactively tag DNA. She studies the body's metabolism of the element selenium and, ultimately, what nutritional role it plays. "The P-32 makes the experiment possible," she says.

Similar scenes are repeated daily by researchers across campus. Every step of the way they create little piles of radioactive waste that Dave Spate and others haul off to storage, at the rate of about three barrels per week. Evenson discards her gloves, some tissues she used to wipe the box, the packing material, the vial and some liquids.

Phosphorous-32 is the most common, and among the least troublesome, of the dozens of radioactive materials used on campus. With a relatively short half-life of 14 days, items contaminated with phosphorous-32 have to be held in a storage area for only 140 days to comply with NRC regulations, which require storage for 10 half lives. Then it can be thrown away as ordinary trash. Other low-level waste has a much longer half-life, meaning it has to be stored in a secured site for as long as a few hundred years.

In Missouri, academic users produced about 17 percent of the state's 3,200 cubic feet of low-level waste in 1993, with the University of Missouri being the biggest single producer. Nationally, academics accounted for only about 1.5 percent of the total 792,000 cubic feet disposed of at commercial sites that year, according to U.S. Department of Energy figures.

People who work regularly with radioactive material say the waste storage problem arises largely from the public's "irrational" fear of radiation. They say the amount of radioactivity from low-level waste is well within health limits established by the federal government and hint that those limits may be too conservative.

The health effects of large radiation doses are fairly well known. A one-hour dose of about 450 rems--the standard unit to measure radiation doses to humans--causes death within 60 days to 50 percent of those exposed. The health effects from doses of radiation below 100 rems, however, are not as clear.

Anyone working with radioactive material on campus is required to wear some type of dosimeter, a device that measures exposure. The NRC says no worker can receive more than 5 rems per year, a dose seen as too high by some and too low by others. Low-level radioactive waste at MU typically emits about .5 to 200 millirems per hour. A millirem is one-thousandth of a rem. For comparison, a chest X-ray gives about a 10 millirem exposure and naturally occurring radiation exposes people in the United States to an average of about 125 millirems per year.

The NRC inspects MU's waste sites several times a year to ensure that the waste is properly stored and is not emitting unacceptable doses of radiation. Inspection records for MU show the university has had no problems with storage.

Rhyne and Beckett agree that the university will have to plan for increased storage space if the reactor expands its operations before the country comes up with a reasonable solution to storage problems.

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The closing of the Barnwell dump was a consequence of the federal Low-level Radioactive Waste Policy Act, which requires states to take charge of disposing of their own radioactive waste. Three states--Washington, Nevada and South Carolina--had protested being forced to take the waste produced throughout the nation.

Despite forming regional compacts to deal with the problem, 31 states, including Missouri, are still without disposal sites. Radioactive waste dumps have faced opposition just about everywhere they have been proposed, delaying siting and construction. Missouri joined the Midwest Compact, which designated Michigan as the group's first host for a radioactive waste site. But in 1991, after seeing no progress from the Great Lakes state, the compact booted Michigan out. Ohio was then tagged as host because it is the compact's largest radioactive waste generator after Michigan.

Ohio is still struggling to designate a site.

Ron Kucera, Missouri's state representative to the compact, says it likely will be at least the year 2000 before Ohio creates a dump, and even then there is no guarantee that the compact will hold together. Ohio representatives have talked about pulling out of the compact and creating a smaller one or going it alone. If the Midwest Compact--which also includes Indiana, Iowa, Minnesota and Wisconsin--does last, Missouri likely will become the host state after Minnesota, in about 40 years.

MU's Beckett understands that most people don't like the idea of low-level waste being stored near their home. "I wouldn't want it in my back yard either," Beckett said, "but the reality is it has to be in some location.'"

For now, that means MU's own back yard.

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Even when trying to come up with solutions to the waste problems, the Missouri reactor has run into trouble. In April 1990, the reactor center won a multi-million dollar contract from Rockwell International to explore ways to reprocess spent nuclear fuel, a project known by its acronym, TRUMP-S, which stands for Transuranic Management by Pyropartitioning Separation.

Almost immediately, statewide anti-nuclear activists launched their most intense assault ever on the facility. They claimed that the project would place the city of Columbia in danger because scientists would use a small amount of plutonium.

A coalition of environmental groups and private individuals challenged the project in court and in the public arena. Kay Drey got involved in the battle from her home near St. Louis. Drey is best known for having led the fight against the Callaway Nuclear Power Plant in the 1970s and 1980s. That effort, while not completely successful, did help prevent Union Electric from building a second reactor at the site.

About the TRUMP-S project, she says, "I couldn't believe the university wanted to handle plutonium," adding she had not previously been much concerned with MURR because of the relatively small power level.

Over the course of a year, numerous public hearings were held about TRUMP-S. Local papers ran dozens of articles highlighting both the fears of project opponents and the explanations of reactor defenders. Among other concerns, opponents theorized an all-consuming fire at the reactor that would spread plutonium through the air, killing hundreds, possibly thousands, of residents.

An administrative judge for the Nuclear Regulatory Commission put a hold on the project, ultimately delaying it for over a year.

Steve Morris, the reactor scientist who started out in forensic work, put his attention to details to work in leading the reactor's fight to keep the project. He spent countless hours working to protect the project, filling 12 filing cabinet drawers with legal documents and other data.

In April 1991, the university prevailed, but not before spending nearly $300,000 in legal fees and taking a bruising in the public relations battle. Ruling in favor of the reactor, Judge Peter Bloch threw aside nearly every assertion by the citizens' groups. The scenarios painted by opponents, Bloch said, could only occur under the influence of "black magic." In summarizing his 175-page findings, Bloch wrote that the safety of TRUMP-S experiments "should not be measured by the extreme scenarios that may be hypothesized."

Opponents tried other legal maneuvers while the project was ongoing, but none was successful. The last ruling on the case was handed down early in 1996 in favor of the reactor. To MURR workers, the victory was sweet, but the battle simply affirmed what they already knew: being involved in anything nuclear is to be forever exposed to criticism.

"Early on in his business you accept the fact that your work is going to be scrutinized at a level other people are not held to," says associate reactor director Charlie McKibben. What McKibben and others feel was overlooked in the entire debate over TRUMP-S was the project's goal of reducing the volume of high-level radioactive waste by recycling some of the radioactive elements in spent nuclear fuel.

A CHILLING EFFECT

Every office in the country has its internal politics and management conflicts, but the stakes involved increase dramatically at a nuclear reactor. Here, such conflicts can easily cross the line from idle chatter around the coffee pot to potential safety problems that become the subject of public debate and NRC scrutiny.

In the past three years, MURR managers have been slapped with fines and other sanctions by the NRC and U.S. Department of Labor for punishing two scientists who were pointing out safety concerns. Although no one is known to have been injured because of the management problems or the safety problems cited by the two scientists, the management conflicts at the reactor are, in themselves, a serious problem.

The NRC has an ongoing investigation into claims by other reactor employees, who say that upper managers have created a "chilling effect," a fear that reporting safety concerns will result in punishment. Managers at a reactor are expected by the NRC to maintain an open environment in which all employees feel free to bring up safety concerns, says agency spokesman Jan Strasma.

One of the whistle blowers was Steve Morris, the soft-spoken MURR veteran who had been the reactor's interim director for 18 months and led it through the challenges from TRUMP-S opponents. In 1991, James Rhyne, an internationally recognized physicist from the National Institute of Standards and Technology, took charge of MURR.

Rhyne came to MU knowing that the people at the reactor had worked together a long time, developing what he calls a "family" environment.

"It is a very effective way of operating things," he says, "but it is also then somewhat hard for an outsider to come in and make changes in that family arrangement. I was told to upgrade the quality of the staff and the requirements for promotion."

Rhyne reorganized the reactor administratively, naming four faculty members as group leaders, marking the first time that faculty became involved in reactor administration. Morris, who is not a tenured faculty member but a research scientist, disagreed with many of the changes Rhyne was making, and spoke up openly at staff meetings. He was particularly concerned that Rhyne would try to slow or stop the commercial work done at the reactor.

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In an average year, the reactor ships about 2,000 radioactive parcels.

In July 1992, a labeling error in the shipping program caused two packages to be sent to the wrong customers, a serious error as the two packages were significantly different in their radioactivity, meaning workers could have been exposed to doses higher than they were prepared to handle. Luckily, no exposures occurred as a result of the mistakes.

It was the second such error in a matter of months, raising a red flag with the NRC. Reactor administrators called together a task force to look into the root causes of the shipping errors.

One of the people asked to serve on the task force was Kurt Zinn, a scientist who had earned his doctorate working in Morris' lab. Zinn argued that the task force should not just look at packaging and labeling of radioactive material, but should also review the procedures used to determine the exact radiation level of each shipment. According to later court testimony, Zinn's desire to review those procedures was seen as disruptive by some reactor administrators, who asked Zinn not to press the issue. Some people feared that identifying additional problems to the NRC at that time would have caused the regulators to temporarily shut down the reactor.

Upset and unsure about what to do, Zinn approached his mentor, Morris. With Morris' backing, and, according to court testimony, despite Rhyne's objections, Zinn looked broadly at the shipping program and discovered more problems, including a case where certain radioactive isotopes were completely unidentified in the shipping labels.

Because of Zinn's work, the NRC issued a national notice for all facilities that shipped radioactive material, citing MURR's experience as a warning: "Improper identification of isotopes in a sample could present a hazard to personnel who handle or package the samples for shipment, may result in incorrect shipping papers and package labeling which could be misleading during shipping emergencies, and could cause unnecessary or incorrect exposure."

While NRC officials were pleased with Zinn's efforts, reactor administrators were not, according to court testimony. With Rhyne in the lead, the whistle blowers say, administrators embarked on a campaign to discredit and intimidate them. In February 1993, Zinn was denied consideration for promotion. At the same time, a researcher with a similar track record was granted a promotion.

A month later, on March 11, 1993, NRC inspectors visited the reactor to check on the progress of the shipping program. Two hours after inspectors left Columbia, Rhyne demoted Morris and disbanded his research group.

Soon after, Morris and Zinn filed complaints with the U.S. Department of Labor and the NRC, citing the federal Energy Reorganization Act and saying they had been illegally punished for their stand on the shipping investigation. The federal law prohibits discrimination against workers at nuclear facilities who point out safety problems.

Inspectors from the labor department sided with Zinn and Morris on their case. The university denied any wrongdoing and insisted on a formal hearing, which was held in September 1993, before administrative law Judge Theodor Von Brand. After two days of testimony and review of a variety of documents supplied by the two sides, Von Brand, found for the whistle blowers.

The judge's decision credited Zinn's persistence on the shipping task force with helping identify a serious problem. The judge went on to say that "the level of hostility arising out of Dr. Zinn's actions was high." For example, Von Brand wrote, assistant reactor director Bill Reilly circulated a memo about Zinn in which Reilly's "hostility to the whistle-blower process is patent." Von Brand quoted from Reilly's memo: "I am sufficiently enlightened that the process cannot be impeded, although in carrying it out one man's hero can be another man's Benedict Arnold... A charlatan needs only to don the cloak of sanctimony provided by the whistle-blower process to carry out a devious agenda with impunity."

Still, the university would not back down, appealing Von Brand's decision to the Secretary of Labor.

In September 1994, the NRC imposed the maximum $8,000 in penalties on the reactor, telling officials there they needed to show concrete steps toward removing the so-called "chilling effect." In a letter to the university, NRC regional administrator John Martin said he was worried that even after Von

Brand's decision, actions and statements by reactor officials "may have contributed to an atmosphere of intimidation."

The NRC also cited the reactor for problems in its shipping program, but has since said that MURR has made significant progress in clearing those up.

Secretary of Labor Robert Reich issued his final ruling in favor of Zinn and Morris in January 1996.

But by then, Morris says, his victory was hollow.

Zinn and his wife, Tandra Chaudhuri, who was also a reactor scientist, had filed a separate federal court case. After what they say was continued harassment, the couple settled out of court with the university in January 1995, agreeing to leave MU for a payment of $300,000. "We wanted to settle the whole thing so that we could get back to our work," says Chaudhuri, who studies ovarian cancer. "After all this, there was no way things would ever be normal for us here."

"It's a shame," Morris says, "that the university lost two such promising young researchers. While I'm happy we were vindicated, I would say it's definitely bittersweet."

Upper level university administrators have not wavered in their public support for Rhyne and other reactor officials, though the smoke has still not cleared at the reactor.

An outside team of nuclear reactor administrators visited MU in the summer of 1994 to examine the safety climate. That team found "a significant chilling effect and a fear of retaliation" at the reactor. Of 146 employees interviewed by the task force, "31 reported a chilling effect and of those, 17 reported a fear of retaliation," according to the group's final report.

And the NRC, according to spokesman Strasma, is still investigating other claims of intimidation as of January 1996. That investigation stems in part from a letter, obtained under a Freedom of Information Act request, from four employees to the NRC in December 1994. The four said they fear retaliation if they bring up safety or personnel problems with managers. They said their fears were connected to the whistle-blowing episode.

"It is our intent in this letter to point out that, for some of us, the 'chilling atmosphere' still exists and the 'episode' is still playing out,'" wrote the four, who declined to discuss their concerns publicly, saying they await NRC action.

University Chancellor Charles Kiesler will say little publicly about the safety climate, and continues to support Rhyne.

"We seek to have a climate that encourages all employees to raise concerns about safety without fear of reprisal or retribution," Kiesler wrote in a Feb. 10, 1995, memo to reactor employees. "You are welcome to bring safety concerns to my attention."

The NRC, according to spokesman Al Adams, is unlikely to hold up an operating license based solely on management issues. However, he says, a license could be renewed from a technical standpoint, meaning all the equipment is up to standard, but the facility could be prevented from running its reactor if management problems posed a safety threat.

SURVIVING IN LEAN TIMES

As the MU Research Reactor heads into the home stretch for license renewal and an expansion, some people are watching its progress as an indicator of the national climate toward big science projects.

"The government set up 60 or 70 research reactors at university campuses and supported them well, initially," says Bernard Wehring, chairman of the National Organization of Test, Research and Training Reactors. "But the support has gone away over time." Wehring has been involved with research reactors for 32 years, currently as director of the University of Texas-Austin's reactor.

"The Missouri reactor is the crown jewel of this country's university reactors," Wehring says. "It's very economical and very productive, even though it has very little support from the government. It would be a shame to see it closed down."

But the government has not backed many major science projects in the past decade, as witnessed first by the shutdown of the super-conducting supercollider. After funding for that program crashed, legislators agreed to fund the Advanced Neutron Source, a nuclear reactor. But, in the past year, that project, too, died. And it's been nearly eight years since a committee of the National Research Council recommended that the federal government invest in university-based research reactors. The report raised hopes at MURR and other reactors around the country, but little has changed for the positive in the ensuing years. Sought-after funds from the DOE have not appeared as that agency has had to protect its own projects.

At the same time that financial support within the United States is hard to find, foreign competition increasingly threatens the service component of the reactor's annual $8 million budget. Roughly 25 percent of the budget comes from state appropriations, 25 percent from research grants and Department of Energy fuel assistance, and 50 percent from sales of reactor services.

The dependence on service applications sets MURR apart from other university reactors, most of which have done limited, if any, work-for-hire. It is also, many believe, the key to MURR's successes. "The University of Missouri is unique in that respect," says Wehring. "Here at the University of Texas we are under a policy not to do them."

Services at MURR include the production of radioisotopes used for research and in commercial products, mainly radiopharmaceuticals; irradiation of silicon that is used as a power rectifier in electronic products such as televisions; and, coloration of gemstone topaz. The topaz is brought to MURR as clear crystals, which are exposed to radiation that causes them to turn shades of blue. The work is tedious and labor-intensive. Tens of thousands of stones are processed each year, and, to comply with the NRC, must be individually tested for radioactivity before the reactor can release them. The tasks are easily taught, however, and a handy supply of student workers keeps the topaz operation in motion 24 hours per day, seven days per week.

Why use a high technology facility like MURR to produce colored rocks? Because, director Rhyne says, topaz production brings in about $1 million per year. Service areas bring in a total of about $2.5 million to $3 million more per year than they cost, he says, with the profit supporting reactor operations that are essential for research.

International competition, however, has begun to cut into the profit margin, says Steve Gunn, reactor services engineer. The biggest competitors, he says, are in the countries of the former Soviet Union. Gunn, who oversees the reactor's service operations, says the center needs to expand and get new equipment in order to stay competitive.

Rhyne points out that the center is limited not by the reactor as a neutron source, but by physical space needs. Rooms originally built as storage closets have long ago been turned into lab and office space. Plans for an expansion and upgrade, which have been in the works for more than 10 years, took a major political step forward in 1995 when the University of Missouri's governing Board of Curators placed the $20 million building expansion at the top of the capital projects wish list for the four-campus system. In MURR's seemingly never ending good news-bad news world, however, ill tidings were not far behind. MU Chancellor Kiesler dealt what some at the center say was a devastating blow by cutting $800,000 from the fiscal year 1995-96 budget.

Kiesler says the move does not mean he has changed his desire to upgrade the reactor, but simply reflects what he tells all departments: no budget deficits allowed. Rhyne says the budget cut resulted from a realization that topaz income was going to be much less than projected and from the end of some major federal grants, with no replacements.

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"The future for university-based research reactors is bright--outside the U.S.," says William Vernetson, reactor director at the University of Florida in Gainesville. "The rest of the world thinks they're great." Vernetson blames the lack of public support for nuclear research facilities on the "general degrading of our country's willingness to lead in areas of high technology. We don't have the will to lead."

In the short term, MURR director Rhyne remains hopeful. The government's unwillingness to fund new, high cost science and technology projects may actually benefit the MU reactor, he says. "There is a feeling now that with so little being built from scratch, existing facilities such as MURR have to be supported and shored up," he says.

"But in the longer term, I hope the United States comes around and realizes that we are very likely to become a Third World country, technologically, if we don't support new developments in our scientific infrastructure."

No one will predict when, or if, the building expansion will actually be approved, but Rhyne is moving forward with the assumption that the expansion and re-licensing will happen. The reactor's biomedical group, for example, has asked the DOE and DuPont to co-sponsor with the reactor a $4 million per year facility to produce radioisotopes for medical uses. The project is to be housed in the yet-to-be approved south side building addition.

"The project would bring increased visibility to MU, provide more opportunities for graduate students, allow us to pursue additional research grants and satisfy our basic mission," Rhyne says. "That mission is to provide to the MU faculty and students research opportunities that are not available anywhere else in the world."

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