

the CMI's focus areas. "We're going to be engaged in some very high-end chemistry, chemical computation, and lab testing techniques to improve the separation of rocks," says King. "Then there are increasingly sophisticated kinds of chemistry involved in separating rare earths from the rocks in which they're embedded."

Beyond rare earths

The CMI hopes to resolve rare-earth issues "in reasonably short order," King says, and move on to other "near-critical materials," such as lithium. Demand for the light metal is expected to soar with the production of lithium-ion batteries for electric vehicles.

Other research efforts around the world address specific critical element challenges. Recovering and recycling precious metals is the focus of an international collaboration of researchers at the University of York, the University of British Columbia, and Yale University. Andrew Hunt, a chemist at York, says the three-year project, funded by the G-8 nations' Research Councils Initiative on Multilateral Research Funding, is exploring the use of phytoremediation to recover platinum-group metals from in-ground or aqueous waste streams such as mining and electronic wastes, landfills, and wastewater.

The research involves increasing the uptake of metals by plants that are then harvested and converted to a charcoal-like material. The carbonized matter containing the metals is then used directly to catalyze carbon-carbon bond formation employed widely in the pharmaceutical industry. Much of the research is devoted to finding plant species that are fast-growing "hyper-accumulators" of the metals, and investigating the biological routes of metal uptake. Although platinum-group metals and gold are the initial focus, Hunt says that the collaboration also hopes to broaden into the recovery of rare earths.

The development of permanent magnets not containing rare earths is the focus of numerous US and international research collaborations. Several of those focus on the use of manganese composites.

King says Japan has several ongoing efforts. "Early on it created a program that it called urban mining, which is actually a recycling program. They're mining scrap heaps." Japanese appliances like refrigerators and air conditioners have rare-earth magnets in their motors, and recycling those rare earths is part of the pro-

gram. And Japan's National Institute for Materials Science has created a program for advanced strategic materials that's comparable to some of the research at Ames, he adds.

An opaque market

A critical materials initiative begun last year at Curtin University in Perth, Australia, will focus on advising governments and industrial clients on what lies ahead for the supply and prices for rare earths, says its head, Dudley Kingsnorth, a widely recognized authority on the metals. "We can put a virtual team together which can look at all the steps in the supply chain. Then we can assess the economic and technological barriers for a company to be independent of China in the case of rare earths."

Due to China's dominance of rare earths, little information about supply is publicly available, and the sector can be volatile. China halted rare-earth shipments to Japan in 2011. As a result,

prices surged for permanent magnets and electric motors used in hybrids and wind turbines. And the popularity of iPods and mobile tablets created a sudden unforeseen demand for cerium, which is used to polish the high-quality glass screens.

As new mines continue to come on line in the US, Australia, Malaysia, India, and Kazakhstan, China's share of the rare-earth supply will decline from a high of 95–97% in 2010 to 70–75% over the next three or four years, Kingsnorth predicts. Many of the heavier rare-earth elements, notably dysprosium, terbium, europium, and yttrium, are expected to remain scarce and expensive, however, with no new production expected for at least six years. The latter three are used in lighting phosphors. Fluorescent lamps, already segregated from other wastes due to their mercury content, offer a promising opportunity for recovery and recycling.

David Kramer

Tighter security ahead for nuclear materials in health care

New requirements in 2014 will formalize the controls on radiological sources that have been implemented since the 11 September 2001 terrorist attacks.

The Nuclear Regulatory Commission (NRC) was set to issue a final rule requiring physical protections for "byproduct materials"—highly radioactive elements that might be used to make a dirty bomb—as PHYSICS TODAY went to press. Produced in nuclear reactors and accelerators, the materials are widely used in hospitals for radiotherapy and in irradiators for both research and treating blood for transfusions. High-activity isotopes for medical applications include cesium-137, cobalt-60, iridium-192, and strontium-90.

Cesium-137 in the form of cesium chloride is considered particularly attractive to terrorists because of its fine-powder consistency, penetrating gamma radiation, and widespread availability in lightly guarded settings such as hospitals, blood banks, and universities. Experts have warned that a radiological dispersion device—a dirty bomb—could render a large portion of a city uninhabitable for long periods and create widespread panic and economic havoc. Considerable

contamination could be accomplished simply by dispersing CsCl from a tall building or airplane.

The new NRC rule would establish regulations for physical protection measures, fingerprinting, and background checks. The rule is designed to replace security orders that the NRC has issued since 9/11 to cover many types of radiological materials. Unlike rules, orders take immediate effect, are issued with little or no input from stakeholders, and apply only to the licensees to whom they are issued. A rule will apply uniformly to all current and future licensees of the materials.

Originally approved by NRC commissioners in March 2012, the rule makes numerous changes to the orders, such as requiring that individuals who are deemed "trustworthy and reliable" by the facility management complete certain security training and mandating that each licensee review its access programs at least once a year. The Office of Management and Budget, which reviews all new regulations, as-



This cesium-137 irradiator at an unnamed hospital lacks adequate security protections, says the Government Accountability Office.

sented to the rule in January. It will take effect one year after its publication in the *Federal Register*, and the 37 states that have agreements to administer NRC regulations will have three years to implement it.

The NRC rule requires that licensees allow only trustworthy individuals to have access to the materials, verify each individual's identity, install intrusion detection systems, and enhance security for portable and mobile devices. It also requires that licensees coordinate with local law enforcement to respond to actual or attempted theft, sabotage, or diversion of radioactive materials; promptly report incidents to appropriate government agencies; and closely monitor shipments.

A flexible approach

Some experts are concerned that the rule is not sufficiently prescriptive. For example, licensees will be allowed to have an intrusion detection system linked to an onsite or offsite monitoring facility, electronic alarms to alert facility personnel, or a video surveillance system or direct visual surveillance by individuals. The NRC does not approve a licensee's security measures in advance, according to a December report by the Congressional Research Service. Rather, regulators inspect the facility once the measures are in place to determine whether they meet rule requirements.

Charles Ferguson, president of the

GAO Federation of American Scientists, notes that the flexibility is allowed because the variety of medical facilities makes a one-size-fits-all approach impractical. An expert on radiological sources, Ferguson described the rule as a "work in progress and a step in the right direction." An ongoing dialog between the NRC and its licensees is necessary, he says. An opportunity for that dialog will be presented by the commission's guidance to licensees on implementation of the rule. The guidance, he says, should be a "living document."

The Government Accountability Office (GAO), in a September report, recommended that the NRC issue more specific directions on the use of cameras, alarms, and other physical security measures in medical settings. Officials at some of the 26 NRC-licensed medical facilities the GAO visited worried that hospital personnel may lack the experience to judge whether individuals should be allowed unescorted access to radiological sources. Performing background checks on foreign nationals, who are prevalent at many hospitals, is especially problematic, the

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officials told the GAO. Some hospital administrators told the GAO they wanted the NRC to help with background checks.

The GAO found significant security lapses at some of the facilities it visited. At one unidentified hospital, the blood bank, which contained a blood irradiator with about 1500 curies of ^{137}Cs , had the combination to the lock written on the door frame. At another hospital, two ^{137}Cs research irradiators containing 2000 and 6000 curies were housed in a building open to the public. A security camera in the hallway outside the irradiator room was pointed the wrong way, and one of the machines was on wheels. There were no cameras or other security systems inside the room, which was accessed by a swipe card.

The Congressional Research Service report said the “layered defense” approach of the NRC rule reduces the likelihood of a successful terrorist attack: “Vulnerabilities are inevitable: someone deemed [trustworthy and reliable] might not be, security systems could fail, or police might not respond in time. Nonetheless, the ability of one layer to offset weaknesses in others can be expected to improve security, especially as terrorists would not necessarily know where vulnerabilities are or how to exploit them.”

Help with upgrades

In parallel with the NRC’s regulatory process, the Department of Energy’s National Nuclear Security Administration (NNSA) has been funding, installing, and maintaining new security equipment at medical facilities and at other sites using high-risk radiological sources. An NNSA official who requested anonymity says that as of early February the agency has provided physical protection upgrades to more than 500 US civilian facilities that use or store such sources. The official did not provide a breakdown of the number of medical facilities involved in the voluntary program. But the GAO report stated that the NNSA has identified approximately 1500 US medical facilities with high-risk radiological sources as candidates for security upgrades. In total, those facilities contain approximately 28 million curies of radioactive material.

According to the GAO report, the NNSA doesn’t expect to complete the medical facility upgrades until 2025, at a total estimated cost of \$608 million. The average cost so far for upgrades at each hospital has been \$318 000. The

NNSA official said that facilities contribute to the cost of installation “where possible. Otherwise, upgrades are supported by NNSA.” In all cases, the facility management must commit to operate and maintain the upgrades once the warranty period runs out, the official added. The NNSA estimates it will cost participating hospitals around \$10 000 annually to do so. Some hospital administrators have declined to participate in the NNSA program and say that

their security measures are adequate.

A major component of the NNSA program is the installation of in-device security kits on blood and research irradiators and radiosurgery devices called gamma knives. The kits will significantly increase the amount of time it would take intruders to remove the radiological material from hospital equipment and will give law enforcement additional time to apprehend the perpetrators.

David Kramer

news notes

Strength in numbers. The Trento Institute for Fundamental Physics and Applications (TIFPA) opened its virtual doors in January at the University of Trento, in northern Italy. Under the umbrella of Italy’s National Institute for Nuclear Physics (INFN), researchers at three existing local research structures will share equipment and develop joint projects. The physics and engineering departments at the University of Trento, the Trento Provincial Agency for Proton Therapy, and the Bruno Kessler Foundation (FBK)—a multidisciplinary applied research institute—make up the TIFPA team.

The virtual institute’s research palette is wide, from theoretical astrophysics to technology-driven research in sensors, space, supercomputing, and applications of nuclear methods in medicine. “There are several examples

that show the strength of the chain from fundamental research to technology development to technology transfer,” says physicist Roberto Battiston, who moved to the University of Trento for TIFPA and counts himself its first hire. He points to one such example: commercialization of a photon detector that came out of an earlier collaboration between the INFN and FBK.

During tight economic times TIFPA sends a positive message, says Battiston. In fostering collaborations, the virtual institute aims to draw together a “critical mass to improve research capabilities so as to be more internationally competitive in frontier research and applications of economic and social interest,” he says. Excluding permanent salaries, TIFPA’s annual operations budget is expected to be around €1 million (\$1.3 million). **TF ■**

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