Are the makings of a dirty bomb in your neighborhood?

Although regulators say that current protections are adequate, the US government continues to pay for extra security features for facilities that hold radiological materials.

More than 2300 buildings housing radioactive sources that could be used to make a radiological weapon—a dirty bomb—need better protections from thefts of the deadly isotopes, warned a top US Department of Energy official. The National Nuclear Security Administration (NNSA) has installed additional security equipment at 650 of the roughly 3000 US buildings that house equipment containing cobalt-60, cesium-137, and other radioisotopes; agency officials can't say how long it will take to upgrade protections at the remaining facilities.

Officials at the Nuclear Regulatory Commission (NRC), which oversees civilian users of radiological materials, nevertheless insist that current regulations covering the facilities are sufficient to protect the materials, and they note that the NNSA's physical security enhancements are voluntary and go beyond NRC's requirements. Strengthened by a new rule that took effect in 13 states in March of this year (see PHYSICS TODAY, March 2013, page 30), the regulatory regime "provides an appropriate level of security for risk-significant radioactive sources to ensure adequate protection of public health and safety," Mark Satorius, NRC's executive director for operations, told the Senate Homeland Security and Governmental Affairs Committee on 12 June. The 37 states that have agreed to administer the NRC regulations must begin enforcing the new rule no later than March 2016.

Anne Harrington, deputy administrator for nonproliferation at the NNSA, told the lawmakers the agency expects to add security features at 45 more US buildings this year. But she cautioned that budget constraints prevent establishing a timetable for upgrades at all domestic facilities. The NNSA installs such equipment as magnetic door locks, window bars, steel doors, biometric authentication, motion detectors, video cameras, and radiation monitors. Devices designed to lengthen the time required to illicitly remove radioactive material have been installed on 463 of the 1100 or so self-contained irradiators that are used in hospitals, blood banks, and universities for research and for treatment of blood.

In addition to its domestic work, the NNSA has strengthened protections for radiological sources at about 1100 buildings located abroad, Harrington stated. An agency spokesperson said those buildings, located at hospitals, research facilities, and industrial sites, were selected because they contained materials that are considered most attractive to terrorists.

The agency also has rounded up and disposed of more than 36 000 disused and unwanted radiological sources since 2007. One of the NNSA's biggest achievements, she said, has been locating and securing numerous radioisotope thermoelectric generators (RTGs) that had been used by the former Soviet Union to power remote lighthouses. Each contained about 10 000 curies of strontium-90. "These were massive sources. One could have been used for many, many weapons," Harrington testified. Altogether, the NNSA and its international partners have rounded up and disposed of more than 800 RTGs, which are usually located in the open or in minimal structures, according to the spokesperson.

Nearly all self-contained irradiators in the US use ^{137}Cs sources with activities of hundreds to thousands of curies—more than enough, Harrington said, to make a significant radiological weapon. Because the radioactive cesium is in the form of cesium chloride, a readily dispersible powder, the material is considered especially attractive for terrorists. Moreover, the medical, university, research, and industrial facilities where ^{137}Cs irradiators are located are nonsecured environments, Harrington said.

A 2008 National Academy of Sciences report rated radioactive ^{137}CsCl the highest-risk radiological source, and it also noted that the lack of a permanent approved disposal site has resulted in disused quantities being stored in hospitals and in academic settings. The NRC said its regulations provide adequate protections for the ^{137}CsCl sources.

Satorius told senators that the NRC requires personnel measures such as background checks and fingerprinting for individuals who have unescorted access to irradiators and other radiological sources. Although the NRC also requires that physical protections be provided for the sources, they do not prescribe specific equipment such as cameras or alarms. "The NRC believes prescriptive 'one-size-fits-all' regulations may result in either excessive or nonconservative approaches to source security," Satorius said.

Under questioning, Satorius acknowledged that NRC regulations do not bar a person who has previously made terroristic threats from being given unescorted access. A Government Accountability Office report released at the hearing cited an instance in which an individual with two criminal convictions for terroristic threats had been cleared for unescorted access.

A less likely target?

In addition to self-contained irradiators, there are about 60 warehouse-size facilities, known as panoramic irradiators, in the US that are used to irradiate food, medical devices, cosmetics, and plastics. All use cobalt-60 sources with activity levels ranging from 1 million curies to 7 million curies. Collectively, the pano-

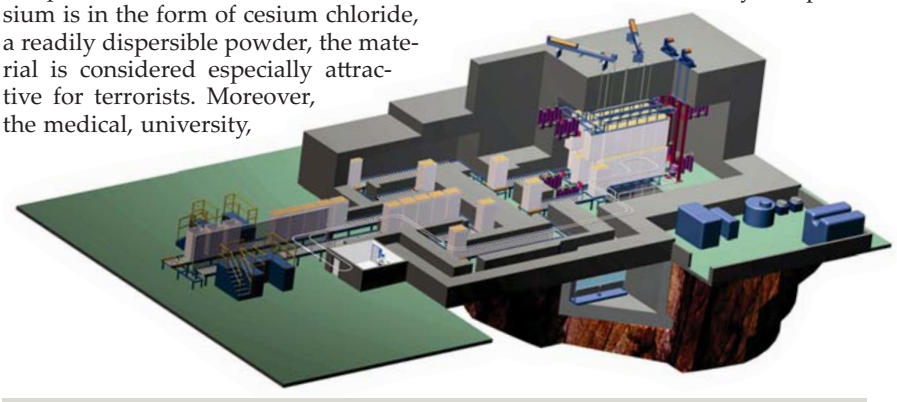

Diagram of a warehouse-size panoramic irradiator used to sterilize food, medical equipment, and other items. The more than 60 panoramic irradiators in the US all contain cobalt-60 as the radiological source. (Courtesy of Nordion, Ottawa, Ontario, Canada.)

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A self-contained irradiator in a medical facility. About 1100 irradiators, nearly all containing cesium-137, are used in US hospitals, blood banks, and universities for research and for treatment of blood.

ramic irradiators account for 98% of the total radioactivity in all US civilian radiation sources, Harrington said.

Still, panoramic devices are thought less likely than self-contained irradiators to be targeted by terrorists due to their lack of portability and accessibility and the less readily dispersed ^{60}Co metal, says Charles Ferguson, president of the Federation of American Scientists and an authority on radiological materials.

Other potential sources of dirty-bomb materials include radiography cameras used in industry for nondestructive testing and other purposes and typically containing iridium-192. Numerous thefts of those portable devices from trucks and shipyards have been reported over the years. Thieves may have hoped to sell the cameras for scrap and probably aren't aware that they contain radioactive substances, says Ferguson, who has consulted for the NNSA on radiological source security.

In the aftermath of the 9/11 terrorist attacks, the NRC ordered that the cameras be secured by at least two locks during transport. The NNSA is currently working with device manufacturers to develop a GPS-based tracking system for radiography devices and portable sources known as well loggers, used in oil and gas drilling. The agency plans to transfer the technology to one or more commercial manufacturers next year.

Although more recent numbers aren't available, the NRC reported in 2002 that over a six-year period, US businesses and medical facilities had lost track of nearly 1500 pieces of equipment that contained radiological materials. Around 90% of those were small items such as gauges and medical isotopes that decay quickly and posed little or no threat, says Ferguson.

Worldwide, the International Atomic Energy Agency typically receives several hundred reports annually of sources either missing or caught at border crossings, Ferguson says.

A psychological threat

The damage from a dirty bomb is likely to be more economic and psychological than physical, experts say. Because any radioactive material in an explosive device would be dispersed over a wide area, the amount of exposure to an individual would be small. Indeed, the larger the explosion, the less harmful the dose will be, notes Ferguson. But cleaning up and decontaminating the area around a dirty bomb would take years and cost hundreds of millions of dollars, he says. Until that process is completed, the contaminated area would be uninhabitable. If detonated in Wall Street or some other financial area, it could cause significant damage to the economy, Ferguson adds.

Public funding has been financing the NNSA-installed building security upgrades, an agency spokesperson says, because the improvements go above and beyond NRC requirements and "there is no legislative or regulatory driver" that requires the sites to pay for them. The NNSA did not respond to a request to provide the total amount that has been spent for the upgrades.

"If you consider what would happen if one of these devices was broken into and radioactive material dispersed, a potential cost of maybe $1 billion for an event depending on where it takes place, and we spend maybe $10 million, if that, to strengthen these protections, it's a good investment," says Ferguson.

High-risk defined

The NNSA considers two classes of materials to be of high risk. Category 1 materials would likely cause permanent injury to a person in contact with them for more than a few minutes, and exposure to them for a few minutes to an hour would probably be fatal. Category 2 materials are harmful to a person exposed to them for a period of minutes to hours, and exposure lasting from hours to days could be fatal. Some 554 of the US buildings with radiological sources hold category 1 materials, and security upgrades have been completed at 273 of those, according to Harrington.

The threshold quantity of material considered dangerous varies according to whether it is an alpha, beta, or gamma emitter, notes Ferguson, due to the varying degree of risk each form of radiation presents to human health. For americium-241, an alpha emitter used in portable well-logging equipment, 2 curies is considered high risk, he says. For ^{137}Cs, which undergoes beta decay, 100 curies presents a comparable health threat.

At their 2005 summit, the Group of Eight nations agreed to tighten their export controls and improve tracking of radiological sources, a move that has led to greater awareness of the chemicals' transport between nations. At the third biennial Nuclear Security Summit, held in the Netherlands in April, 53 nations committed to secure all of their radiological sources. The US joined 21 other nations in pledging to increase protections for all category 1 materials within two years.

David Kramer

Canada CHIMEs in on dark energy

Teasing out signal from galactic noise is the biggest challenge in using diffuse neutral hydrogen to study the changing structure of the universe.

What is the expansion history of the universe? That is what the Canadian Hydrogen Intensity Mapping Experiment (CHIME) is designed to determine. Located at the Dominion Radio Astrophysical Observatory about 400 km northeast of Vancouver, British Columbia, CHIME is slated to begin operating in late 2015.

Unlike other approaches to mapping the structure of the universe as a function of time (see, for instance, the article by Josh Frieman in PHYSICS TODAY, April 2014, page 28), CHIME won't look for details about individual galaxies. Instead, the idea is to measure the 21-cm line of neutral hydrogen, which traces the positions of galaxies and, in turn, the distribution of matter. The experiment is sensitive over the redshift range of 0.8–2.5, which corresponds to the period from about 7 billion to 11 billion years ago.

CHIME will consist of five parallel, parabolic, cylindrical, mesh reflectors, each 100 m long and 20 m wide. The mesh cells are a couple of centimeters across; the design withstands rain,