# USA PERSPECTIVES
## SAFETY & SECURITY OF RADIOACTIVE SOURCES

BY GRETA JOY DICUS

The worst US nuclear power plant accident, the accident at the Three Mile Island in 1979, resulted in release of radioactive materials to the environment. No member of the public, however, was exposed to radiation in excess of radiation dose limits from this accident. In fact, no exposure to a member of the public has ever exceeded the dose limits as a result of operation of, or accidents at, the 103 licensed nuclear power plants in the United States. This statement, however, cannot be made with respect to US operational experience with licensed radioactive sources.

US operational experience with radioactive sources includes minor mishaps as well as accidents that resulted in radiation injuries or radioactive contamination. The major applications in which serious accidents have occurred are irradiation, industrial radiography, and medical therapy.

Another area of concern are radioactive sources that are lost, stolen or abandoned and enter the public domain in an uncontrolled manner. In such cases, there is a potential for radiation exposure to members of the public and contamination of property. It is this aspect of operational radiation safety for radioactive sources that is the subject of this article.

### SCOPE OF THE PROBLEM

In contrast to the 103 licensed nuclear power plants in the United States, there are about 157,000 licenses that authorize the use of radioactive materials subject to the US Atomic Energy Act, as amended. Of these, 22,000 are for use of licensed materials pursuant to specific licenses. The other 135,000 authorize the use of radioactive materials contained in devices, such as nuclear measuring gauges or self-luminous signs, pursuant to general licenses. About 1.8 million devices containing radioactive sources have been distributed as generally licensed. Other types of devices containing radioactive materials -- such as self-luminous watches and ionization-type smoke detectors -- may be distributed under license to persons exempt from licensing. These contain small quantities of radioactive material and are not the subject of this paper.

The US Atomic Energy Act, as amended, does not cover all radioactive materials. Radium sources are excluded from the Act, as are radioactive sources used by the US Department of Energy (DOE).

The Act provides for states to enter into agreements with the US Nuclear Regulatory Commission (NRC) under which they regulate and license users of radioactive materials. Thirty states have entered into such agreements. They regulate and license about two-thirds of the licensed users of radioactive materials. Information on incidents and events occurring under jurisdiction of the NRC and agreement-states is collected, analyzed and reported by NRC staff.

Each year, the NRC receives about 200 reports of lost, stolen or abandoned radioactive sources and devices. It is important to note that such reports are received only when licensees recall that they have a source, know that it is lost or stolen, know that there is a requirement to report the loss or theft, and make that report.

### REPORTED CONSEQUENCES

In some cases, the loss of control of radioactive sources resulted in radiation overexposures of unsuspecting members of the public. For example, in 1979, an unshielded 1 GBq (28 Ci) iridium-192 industrial radiography source was accidentally left at a temporary job site in California. A worker, not knowing what it was, picked it up and placed it

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*Ms. Dicus is Chairman of the US Nuclear Regulatory Commission in Washington, DC.* *The assistance of NRC staff in the article's preparation is greatly appreciated. Full references are available from the author.*

into a back pocket of his trousers. The dose to his buttock exceeded 200 Sv (20,000 rem). In 1992, a 0.14 GBq (3.7 Ci) iridium-192 brachytherapy source was accidently disconnected from the cable attaching it to a remote afterloader while it was emplaced in a patient. The source eventually became dislodged from the patient together with surgical dressings. The discarded dressings containing the source were sent to a disposal facility which routinely conducted radiation surveillance of incoming waste. Radiation from the source was detected and it was thus discovered. The patient died from complications resulting from the overdose and 90 members of the public were accidentally exposed to the source.

In 1996, industrial radiography devices were stolen and sold as metal scrap. During transfers of the devices, a 1.5 GBq (40 Ci) cobalt-60 source was dislodged from one of the devices and fell to the ground near the offices of a scrap metal processing facility. Workers and customers at the facility were exposed to the source as were law enforcement officers who were investigating the theft resulting in whole body doses to these individuals up to 0.1 Sv (10 rem). One worker who handled the source received an overexposure to an extremity.

Damage to property in the form of radioactive contamination has also occurred and has become a special concern of the US metal recycling industry when radioactive sources that have been lost, stolen, or abandoned become mixed with metal scrap destined for recycling. Since 1983, US steel mills accidentally melted radioactive sources on twenty occasions. Radioactive sources have been accidentally melted on eleven other occasions at facilities that melted aluminum, copper, gold, zinc or lead scrap. *(See table, this page.)* While radiation exposures of mill workers and the public have, thus far, been low and below regulatory limits, the financial consequences have been large because of the costs resulting from decontamination, waste disposal and lost revenue during temporary shutdown of the mill. US steel mills have incurred costs averaging US $8 to $10 million as a result of these events and, in one case, the cost was US$ 23 million.

**Accidental Meltings of Radioactive Materials in the USA**

| Year | Metal | Location | Isotope | Activity (GBq) |
|---|---|---|---|---|
| multiple | gold | multiple | Pb-210, Bi-210 Po-210 | unknown |
| 1983 | steel | Auburn Steel, NY | Co-60 | 930 |
| 1983 | gold | unknown, NY | Am-241 | unknown |
| 1984 | steel | U.S. Pipe & Foundry, AL | Cs-137 | 0.37-1.9 |
| 1985 | steel | Tamco, CA | Cs-137 | 56 |
| 1987 | steel | Florida Steel, FL | Cs-137 | 0.93 |
| 1987 | aluminum | United Technology, IN | Ra-226 | 0.74 |
| 1988 | lead | ALCO Pacific, CA | Cs-137 | 0.74-0.93 |
| 1988 | copper | Warrington, MO | accelerator | unknown |
| 1989 | steel | Bayou Steel, LA | Cs-137 | 19 |
| 1989 | steel | Cytemp. PA | Th | unknown |
| 1990 | steel | NUCOR Steel, UT | Cs-137 | unknown |
| 1991 | aluminum | Alcan Recycling, TN | Th | unknown |
| 1992 | steel | Newport Steel, KY | Cs-137 | 12 |
| 1992 | aluminum | Reynolds, VA | Ra-226 | unknown |
| 1992 | steel | Border Steel, TX | Cs-137 | 4.6-7.4 |
| 1992 | steel | Keystone Wire,IL | Cs-137 | unknown |
| 1993 | steel | Auburn Steel. NY | Cs-137 | 37 |
| 1993 | steel | Newport Steel, KY | Cs-137 | 7.4 |
| 1993 | steel | Chaparral Steel, TX | Cs-137 | unknown |
| 1993 | zinc | Southern Zinc, GA | depleted U | unknown |
| 1993 | steel | Florida Steel, FL | Cs-137 | unknown |
| 1994 | steel | Austeel Lemont, IL | Cs-137 | 0.074 |
| 1994 | steel | US Pipe & Foundry, CA | Cs-137 | unknown |
| 1996 | aluminum | Bluegrass Recycling, KY | Th-232 | unknown |
| 1997 | aluminum | White Salvage Co., TN | Am-241 | unknown |
| 1997 | sleel | WCI, OH | Co-60 | 0.9(?) |
| 1997 | steel | Kentucky Electric, KY | Cs-137 | 1.3 |
| 1997 | steel | Birmingham Steel, AL | CS-137/Am-241 | 7 Bq/g |
| 1997 | steel | Bethlehem Steel, IN | Co-60 | 0.2 |
| 1998 | aluminum | Southern Aluminum, AL | Th | unknown |

*Note:* Table is compiled from database maintained by James Yusko, CHP, Pennsylvania Dept. of Environmental Protection, 400 Waterfront Drive, Pittsburgh, PA, 15222-4745, USA.

## INITIATIVES & CONCERNS

The response of the US metals recycling industry has been multifaceted. With the assistance of NRC staff, industry trade organizations developed and then published educational materials in the form of information brochures and recommended procedures for their members. Many scrap metal recycling facilities and metal making mills have posted a warning poster published by the NRC to inform their workers about the problem.

The most prevalent protective action taken by the industry has been the installation of radiation surveillance systems at metal mills and scrap processing

**Unshielded Radioactive Sources Found in the US Public Domain**

| Year | Location | Isotope | Quantity (GBq) |
|---|---|---|---|
| 1992 | Waste disposal site, Ohio | Ir-192 | 150 |
| 1994 | Scrap yard, Kentucky | Cs-137 | 7.4 |
| 1994 | Scrap yard, Illinois | Cs-137 | 14 |
| 1996 | Scrap yard, California | Cs-137 | 0.37 |
| 1996 | Scrap yard, Texas | Ir-192 | 1,500 |
| 1996 | Incinerator, New York | Cs-137 | 2.8 |
| 1996 | Foundry, Alabama | Unidentified | |
| 1996 | Scrap yard, West Virginia | Unidentified | |
| 1997 | Steel mill, Ohio | Cs-137 | 19 |
| 1997 | Construction site, Pennsylvania | Cs-137 | 0.22 |
| 1997 | Scrap yard, Pennsylvania | Am-241 | 3.7 |
| 1998 | Scrap yard, Florida | Am-241/Cs-137 | 1.5/0.3 |
| 1999 | Highway, Tennessee | Cs-137 | 0.3 |

*An unshielded caesium-137 found buried in gravel at a metal scrapyard in Illinois. The scale is in inches.*

facilities to detect radioactive sources that may be in incoming shipments of metal scrap. These systems are sophisticated in design, very sensitive, and correspondingly expensive. They have been successful in identifying over 400 radioactive sources or devices containing radioactive sources in US scrap metal since 1983 with over half of the discoveries occurring in the last five years.

A bewildering assortment of commercial radiation detection equipment is available to the metal recycling industry. In 1996 the Steel Manufacturers Association, a trade association representing many US steel makers, sponsored field tests of commercially available equipment.

Radiation surveillance is also widely conducted by operators of facilities that handle or dispose of non-radioactive wastes, since their facilities are not authorized to dispose of licensed radioactive materials. Their surveillance programmes have occasionally found radioactive sources mixed in incoming waste shipments.

Since 1992, unshielded radioactive sources have been reported found in the US on thirteen occasions since 1992. *(See table and photo, this page.)* Unshielded sources present a greater potential for radiation exposure. Additionally, since they are no longer protected by the shielding, they are more susceptible to physical damage that may lead to breaching of the containment and release of the radioactive material. In some cases, dose reconstruction is not possible because the history of the source and its whereabouts before discovery are not known.

Another concern of the metal recycling industry arises after radioactive sources are discovered in metal scrap. These are often called "orphan sources." Such sources, when found, become the responsibility of the finder who did not want the source in the first place and is probably not prepared to take possession of it. Nonetheless, past practice has been to ask such persons to temporarily secure the source, often with the assistance of qualified experts. In some cases, manufacturers' markings on the device or source itself enable identification of, and possible return to, the initial licensee or to the manufacturer. In other cases, this is not possible, and transfer must be made either to a willing recipient or for disposal. There are, of course, costs associated with these activities.

This is not a satisfactory arrangement and steps have been taken to alleviate it. The Conference of Radiation Control Program Directors, Inc. -- an organization representing government radiation control programmes, with support from the US Environmental Protection Agency (EPA) and NRC -- is investigating the feasibility of a formal programme to recover orphan sources and provide for their eventual disposition. The DOE is developing a programme that will permit transfer to them of certain transuranic sources.

In cases when an orphan source presents an immediate threat to public health and safety for which no responsible party can be found, the DOE will recover and secure the source at the NRC's request. The NRC and DOE signed a Memorandum of Understanding to facilitate such requests.

Radioactively contaminated products imported into the US have been found on ten occasions. *(See table, this page.)* The sources of contamination in most of these cases are probably radioactive sources that became mixed with the raw materials used to make the products. Although none of these cases resulted in significant exposures of the public in the US, their unexpected appearance in the marketplace can raise concerns about the effectiveness of regulatory programmes to assure the safety and security of radiation sources.

## REGULATORY ACTIONS

The great majority of radioactive devices in the US are used under general licenses. A key feature of these devices is their robust design which permits their use by persons having minimal training in radiation safety. General licensees do not have to apply for a license because it is provided in the regulations. Inherent in the general license programme is the concept that general licensees will maintain control and accountability of the devices and dispose of them properly. Because of the robust design of the devices, there is no routine inspection programme and no other regulatory mechanism to periodically contact general licensees. Not surprisingly, absent such contacts, some general licensees' programmes have deteriorated. Warning labels and signs became obliterated as a result of exposure to adverse environments or improper maintenance, and as personnel knowledgeable about the devices retired, were discharged or otherwise left the licensees' employment. The predictable consequence is that some of these devices enter the public domain in an uncontrolled manner, typically by being discarded with scrap metal.

In 1992, the NRC approved formation of a state Working Group to define the problem and develop recommendations for Commission action. In 1998, in response to the Group's report, the Commission directed that rulemaking and other measures be taken to, *inter alia*, provide more routine contacts with selected general licensees to remind them that they are responsible for accounting, control and proper disposal of licensed material. In an application of risk-informed regulation, the selection of general licensees that would be subject to the rule was based on consideration of the radioisotopes being used, their quantities and their potential for personnel exposures or for contamination of property. *(See table, this page.)*

An important point to be made is that the Commission could not have justified making this decision - which has fiscal and staffing implications - without the collection and analysis of operational data to support it.

**Radioactively Contaminated Products Imported into the USA**

| Product | Contaminant | Year Found | Origin |
|---|---|---|---|
| Steel & iron | Co-60 | 1984 | Mexico |
| Steel | Co-60 | 1984 | Taiwan, China |
| Steel | Co-60 | 1985 | Brazil |
| Steel | Co-60 | 1988 | Italy |
| Steel | Co-60 | 1991 | India |
| Ferrophosphorus | Co-60 | 1993 | Kazakhstan |
| Steel | Co-60 | 1994 | Bulgaria |
| Furnace dust | Cs-137 | 1995 | Canada |
| Lead | Pb-210 Bi-210, Po-210 | 1996 | Brazil |
| Steel | Co-60 | 1998 | Brazil |

**Isotopes and Quantities Selected for Increased Regulatory Oversight**
**(in US generally licensed devices)**

| Isotopes | Quantity (MBq) |
|---|---|
| Cs-137 | 370 |
| Co-60 | 37 |
| Sr-90 | 3.7 |
| Transuranics | 37 |

## EMERGENCY RESPONSE IMPLICATIONS

When serious radiation emergencies occur, the demands upon responding national, state and local authorities can become overwhelming. In such cases, prior arrangements for interagency and intergovernmental assistance are essential. Periodic exercises are needed to familiarize responders with the plan and with each others' responsibilities and assets and to identify weaknesses in the plan. Responses to emergencies resulting from the loss or theft of radioactive materials or the discovery of radioactive sources in the public domain present response challenges that are substantially different from those encountered when responding to emergencies resulting from events at nuclear reactors.

Recognizing this, beginning in 1997, US federal agencies led by the EPA and NRC initiated emergency response exercises involving radioactive sources. These exercises were conducted under the US Federal Radiological Emergency Response Plan (FRERP) and the National Contingency Plan in conjunction with other Federal agencies, state and local

*Above: The labels and warnings are obliterated in this nuclear gauge containing caesium (hemispherical object in the center). It was found by an Arkansas, USA, steel mill in an incoming shipment of metal scrap.* *Other Photos: In a 1999 emergency response exercise in North Carolina, USA, a radioactive source was assumed to be shredded at a scrap processing plant where processing equipment shreds ferrous scrap (center left). It simulated an actual event that occurred in 1998 when an americium-241 source was similarly shredded in Pennsylvania, USA. The exercise involved state radiological protection personnel (left), local government authorities for hazardous materials and state radiological emergency response crews and vehicles (top).*

*(Credit: NRC)*

governments, and with the support of the private sector.

Two exercises have been conducted, the first in 1997 and the second in 1999. Both involved "table top" and field segments. The first exercise simulated the discovery of a large unshielded gamma source at a municipal waste disposal facility. The second exercise took place at a metal scrap processing facility and simulated the breaching by metal scrap processing equipment of an americium-241 source and the resulting contamination of the equipment and a worker.

The accomplishments of and recommendations resulting from the first exercise were published in 1998. A report on the second exercise is being prepared. A principle finding of the exercises was the need to conduct additional exercises in different parts of the country. By engaging the principle parties in responding to such emergencies, the exercises broaden awareness of the problem, familiarize responders with each others' responsibilities and assets, and should improve the quality of their responses in actual emergencies. US federal assets that can be called upon include an aerial radiation survey capability that can aid in locating lost or stolen sources and specialized equipment for the recovery of sources.

In 1998, the FRERP was activated and these assets put to use to respond to the theft of 19 caesium-137 brachytherapy sources from a North Carolina hospital. Federal assets that were utilized in the response to support the state included DOE aerial and ground radiation monitoring searches and coordination with the Federal Bureau of Investigation on the criminal investigation. While the sources have not been recovered, actions were taken to rule out situations having the greatest likelihood for potential exposures to the public.

## STRONG OVERSIGHT

The NRC has over forty years of experience in regulatory oversight of the use of radioactive sources. Its experience with the safety and security of radioactive sources reaffirms the principle that a strong, effective national regulatory programme is needed to oversee the use of radiation sources.

The NRC's programme to review and analyze reports of and other information on losses, thefts, abandonments, and discoveries of radioactive sources helped to identify and characterize a problem with safety and security of radioactive sources in devices used under the general license programme.

In response, the NRC approved a staff plan to jointly conduct with the agreement-states a focused review of the problem and develop recommendations for action. The review was conducted in open, publicly announced meetings and included invited participation of stakeholders, i.e., persons and organizations affected by or having an interest in both the problem and potential regulatory solutions.

The Working Group recommended that the NRC: 1)increase the frequency of contacts between the NRC and its general licensees and, 2) incorporate a risk-informed approach by focusing on general licensed devices having the greatest potential for exposures to the public or contamination of property when lost, stolen or abandoned.

The Commission agreed with the recommended risk-informed approach and directed staff to undertake rulemaking and other changes that will address the problem, making efficient, effective use of the NRC's limited resources.

Also, recognizing that situations in which radioactive sources are lost, stolen or abandoned have the potential for serious radiation exposures or radioactive contamination of property, NRC and EPA staffs have initiated emergency response exercises that focus on this kind of event.

In summary, a large number of radioactive devices are in use in the USA and their safety record overall is very good. When used properly by trained personnel with effective regulatory oversight, the many uses of radioactive sources are safe and provide a net benefit to society.

If problems occur, such as overexposures or contamination of property, it is essential that they are promptly reported to the regulatory authority. If necessary, appropriate emergency response measures can be taken, and the problems analyzed. In that way, effective, risk-informed regulatory measures can be activated to assure the continued safety and security of radioactive sources. ❑