RADIOACTIVE SOURCES: USE, SAFETY AND SECURITY

ansto

Australian Government

PURPOSE:

THIS PUBLICATION AIMS TO FAMILIARISE YOU WITH THE USE, SAFETY AND SECURITY OF SEALED RADIOACTIVE SOURCES. IT DESCRIBES THE TYPES OF INDUSTRY WHERE THESE SOURCES MIGHT BE FOUND AND OUTLINES A RADIOACTIVE SOURCE CATEGORISATION SCHEME THAT CAN TELL YOU HOW DANGEROUS A SOURCE IS. THIS INFORMATION IS INTENDED TO RAISE AWARENESS THAT RADIOACTIVE SOURCES ARE WIDELY USED AND MUST BE APPROPRIATELY SECURED AND SAFELY USED TO PREVENT HARM, WHETHER UNINTENTIONALLY OR MALICIOUSLY.

Activity of a source

1 Ci = 37 000 000 000 Bq
= 37 000 megabecquerels (MBq)
= 37 gigabecquerels (GBq)

1 000 Ci = 37 000 000 000 000 Bq
= 37 terabecquerels (TBq)

WHAT ARE RADIOACTIVE SOURCES USED FOR?

Radioactive sources are used for a wide variety of beneficial purposes in industry, medicine, agriculture, environment, mining, research and education. For example, by doctors to treat cancer, by industrial radiographers to check welds in pipelines, or by specialists to irradiate food to prevent it from spoiling.

Professionals who work routinely with radioactive sources are able to do so safely because of their skills and training, and because they are knowledgeable about the safety features and design of equipment that they are using. When these sources are lost or stolen however, they can fall into the hands of people who do not have such training and knowledge. In such circumstances, radioactive sources may be a serious risk to anyone who comes too close to them, touches them, or picks them up, particularly if they are damaged. Serious injuries and even deaths have occurred when a radioactive source is found and the person handling the source is not aware of the risk.

Vulnerable sources are usually under regulatory control, but the control is insufficient to provide assurance of long term safety and security. A vulnerable source is one that could relatively easily become orphaned.

Orphan sources are not under regulatory control either because they have never been under regulatory control, or because they have been abandoned, lost, misplaced, stolen or transferred without proper authorisation

What is a radioactive source?

A radioactive source contains a quantity of radioactive material that is permanently sealed in a capsule or closely bonded in an inert substance, so that under normal usage, no radioactive material can escape. The radioactive material itself emits radiation that can cause burns, sickness or even death if not properly controlled.

Radioactive sources have many different shapes and sizes depending on how they are used. They can be as small as the tip of a needle or as large as a paint can. Each source is characterised by the type of radioactive material it contains, referred to as the **radionuclide** (for example, cobalt-60) and by the amount of radioactive material (a quantity called the source **activity**). The activity of sources is given in units called the **becquerel (Bq)**. This unit replaces an older unit known as the **curie (Ci)**. The most hazardous sources typically have activities of a few gigabecquerels or above.

Example of radiation warning symbol

How do I know if something is radioactive?

To inform people of the presence of radiation, radioactive sources have special labels. The trefoil is the international symbol that appears on all containers, materials or devices that have a radioactive component. The word "radioactive" and the number I, II or III may also appear on the packaging used to transport radiation sources.

Why is the safety and security of a radioactive source important?

When radioactive sources are safely managed and securely protected, the health and safety risks to workers and the public are minimised and the benefits significantly outweigh any associated hazards. If, however, there is a loss of control of a radioactive source for some reason (for example, as the result of an accident or a malevolent act) and the source becomes unshielded or its contents dispersed, people could be exposed to radiation at dangerous levels. In this regard Orphan sources and Vulnerable sources are of particular concern.

Example of new supplementary warning sign for category 1 and 2 sources

How dangerous are radioactive sources?

A radioactive source is considered to be dangerous if it could be 'life threatening' or could cause a permanent injury that would reduce the quality of life of a person exposed to it. Permanent injuries include burns requiring surgery and debilitating injuries to the hands. Temporary injuries such as reddening and irritation of the skin are not considered to be dangerous. The extent of any such injuries will depend on many factors, including:

- the type of radioactive material contained in the source
- the activity of the source
- how close a person is to the source and for how long
- whether the source is shielded
- whether or not its radioactive material has been dispersed and caused the contamination of skin, or has been inhaled or ingested.

Example of radiation device label showing type of radionuclide, activity and date

How are radioactive sources categorised?

The International Atomic Energy Agency (IAEA) has developed a system to categorise radioactive sources, ranking them in terms of their potential to cause immediate harmful health effects if the source becomes vulnerable or orphaned. Under this categorisation system, two types of risk are considered: the risk of handling or being close to the source, and the risk associated with radioactive material being dispersed from a source by fire or explosion. Radioactive sources are classified into five categories based on this assessment, where Category 1 sources are potentially the most dangerous and Category 5 sources are most unlikely to be dangerous.

EXTREMELY DANGEROUS

CATEGORY 1 SOURCES

A disused medical teletherapy source

A teletherapy source in operation

Teletherapy head accident: Samut Prakarn, Thailand, 2000

A company in Bangkok possessed several teletherapy devices without authorisation from the Thailand Office of Atomic Energy for Peace. In the autumn of 1999, the company relocated the teletherapy heads from a warehouse it had leased to an unsecured storage location. In late January 2000, several individuals obtained access to this location and partially disassembled a teletherapy head containing 15.7 TBq of cobalt-60. They took the unit to the residence of one of the individuals, where four people attempted to disassemble it further. Although the head displayed a radiation trefoil and warning label, the individuals did not recognise the symbol or understand the language. On 1 February 2000, two of the individuals took the partially disassembled device to a junkyard in Samut Prakarn.

While a worker at the junkyard was disassembling the device using an oxyacetylene torch, the source fell out of its housing unobserved. By the middle of February 2000, several of the individuals involved began to feel ill and sought assistance. Physicians recognised the signs and symptoms and alerted the authorities. After some searching through the scrap metal pile, the source was found and recovered. Altogether, ten people received high doses from the source. Three of those people, all workers at the junkyard, died within two months of the accident as a consequence of their exposure.

Source: IAEA

Category 1 sources

Category 1 sources are considered to be extremely dangerous if not used or stored and secured properly. Such sources are normally used in specially designed facilities and equipment that provide sufficient shielding from radiation. If a Category 1 source became unshielded, it would be likely to cause permanent injury to a person who handled it or who was otherwise in close proximity to the source for more than a few minutes. It would probably be fatal to be close to this amount of unshielded radioactive material for a period in the range of a few minutes to an hour.

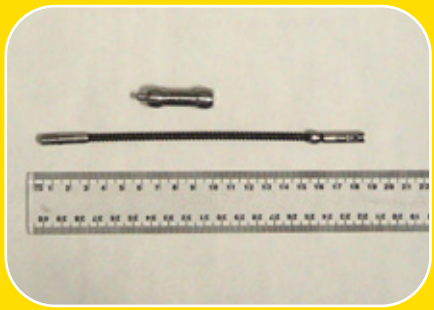
If a Category 1 source was breached and the enclosed radioactive material was dispersed, it could possibly – although it would be unlikely - permanently injure or be life threatening to persons in the immediate vicinity. However, there would be little or no risk of immediate health effects to persons beyond a few hundred metres away from the centre of the dispersal, but any contaminated areas would need to be cleaned up in accordance with international standards. For large sources the area to be cleaned up could be a square kilometre or more.

CATEGORY 1 SOURCES

Examples of source usage		Typical radionuclides (with scientific abbreviation)	Typical activity range
Irradiators	Used to sterilise foodstuffs, cosmetics, medical products and supplies, and for other specialised applications such as research applications or for blood irradiation.	Cobalt-60 ^{60}Co	56 to 560,000 TBq 1500 to 15,000,000 Ci
		Caesium-137 ^{137}Cs	37 to 190,000 TBq 1000 to 5,000,000 Ci
Teletherapy	Used for cancer therapy and commonly found in medical institutions, such as hospitals or clinics.	Cobalt-60 ^{60}Co	37 to 560 TBq 1000 to 15,000 Ci
		Caesium-137 ^{137}Cs	19 to 56 TBq 500 to 1500 Ci
Fixed multi-beam teletherapy	Used to focus gamma radiation from an array of over 200 sources on brain lesions. (gamma knife) These are commonly found in hospitals or clinics.	Cobalt-60 ^{60}Co	150 to 370 TBq 4000 to 10,000 Ci
Radioisotope thermoelectric generators	Used to provide low amounts of electric power. These devices are used primarily for military purposes and space exploration, but have also been used to supply low levels of power in remote areas (eg. for beacons).	Strontium-90 ^{90}Sr	330 to 25,000 TBq 9000 to 680,000 Ci
		Plutonium-238 ^{238}Pu	1 to 10 TBq 28 to 280 Ci

Industrial radiography of pipes using Iridium-192

An industrial radiography source in its portable container



An industrial radiography source on its "pigtail"

VERY DANGEROUS

CATEGORY 2 SOURCES

Industrial radiography source accident: Morocco, 1984

A 1.1 TBq iridium-192 source became disconnected from its drive cable. Through lack of appropriate monitoring, the disconnection was not noticed and the source fell out of the guide tube and was lost. It looked like an interesting item and was picked up by a member of the public and taken home. Due to the loss of control of the source from March to June, eight people died.

Category 2 sources

Category 2 sources are considered to be very dangerous if not used or stored and secured properly. If a source of this category was not safely managed or securely protected, it could cause permanent injury to a person who handled it or who was otherwise was in contact with it for a short time (minutes to hours). It could possibly be fatal to be close to this amount of unshielded radioactive material for a period of hours to days.

If a Category 2 source was breached for some reason and the enclosed radioactive material was dispersed, it could possibly – although it would be unlikely - permanently injure or be life threatening to persons in the immediate vicinity. There would be little or no risk of immediate health effects to persons beyond a hundred metres or so away, but any contaminated areas would need to be cleaned up in accordance with international standards.

CATEGORY 2 SOURCES

Examples of source usage		Typical radionuclides (with scientific abbreviation)	Typical activity range
Industrial radiography	Used to test the integrity of various materials, as well as for testing welds in pipes and tanks in the petrochemical industry.	Cobalt-60 ^{60}Co	0.41 to 7.4 TBq 11 to 200 Ci
		Iridium-192 ^{192}Ir	0.19 to 7.4 TBq 5 to 200 Ci
		Selenium-75 ^{75}Se	3 TBq 80 Ci
		Ytterbium-169 ^{169}Yb	0.093 to 0.37 TBq 2.5 to 10 Ci
		Thulium-170 ^{170}Tm	0.74 to 7.4 TBq 20 to 200 Ci
High/medium dose rate brachytherapy	Used for cancer therapy and commonly found in medical institutions, such as hospitals or clinics.	Cobalt-60 ^{60}Co	0.19 to 0.74 TBq 5 to 20 Ci
		Caesium-137 ^{137}Cs	0.11 to 0.3 TBq 3 to 8 Ci
		Iridium-192 ^{192}Ir	0.11 to 0.44 TBq 3 to 12 Ci

Industrial gauges containing radioactive sources installed on pipes for process measurements

DANGEROUS

CATEGORY 3 SOURCES

Theft of well logging sources: Nigeria, 2002
In December 2002, two americium-241/beryllium sources used for well logging were stolen from an oil company truck while it was in transit in the southern Niger Delta region. Such sources are typically of about 0.7 TBq activity. Public announcements, police efforts and increased border vigilance were all instigated in an attempt to find the sources. Health care workers were also warned to keep a lookout for anyone with prolonged nausea or skin burns. Some eight months later the sources were detected in a scrap metal shipment in Europe.

Source: IAEA

Category 3 sources

Category 3 sources are defined as being dangerous. If not safely managed or securely protected, a Category 3 source could cause permanent injury to a person who handled it or who was otherwise in contact with it for some hours. It could possibly – although it would be unlikely - be fatal to be close to this amount of unshielded radioactive material for a period of days to weeks.

If the radioactive material in a Category 3 source was dispersed, it could possibly – although it would be extremely unlikely - permanently injure or be life threatening to persons in the immediate vicinity. There would be little or no risk of immediate health effects to persons beyond a few metres away, but any contaminated areas would need to be cleaned up in accordance with international standards. The area to be cleaned up would probably not exceed a small fraction of a square kilometre.

CATEGORY 3 SOURCES

Examples of source usage		Typical radionuclides (with scientific abbreviation)	Typical activity range
Fixed industrial gauges	Used for process control; for measurement of flow, volume, density, or material presence; and may be placed in locations unsuitable for continuous human presence.	Cobalt-60 ^{60}Co	0.0037 to 0.37 TBq 0.1 to 10 Ci
		Caesium-137 ^{137}Cs	0.00011 to 1.5 TBq 0.003 to 40Ci
		Californium-252 ^{252}Cf	0.0014 TBq 0.037 Ci
Well logging gauges	Used in areas where exploration for minerals is occurring, such as coal, oil, natural gas.	Americium 241/Beryllium $^{241}Am/Be$	0.019 to 0.85 TBq 0.5 to 23 Ci
		Caesium-137 ^{137}Cs	0.037 to 0.074 TBq 1 to 2 Ci
		Californium-252 ^{252}Cf	0.001 to 0.0041 TBq 0.027 to 0.11 Ci

VERY LOW DANGER

CATEGORY 4 and 5 SOURCES

Category 4 and 5 sources

Category 4 sources are unlikely to be dangerous and it is very unlikely that anyone would be permanently injured by these sources. However, this amount of unshielded radioactive material, if not safely managed or securely protected, could possibly – although it would be unlikely – temporarily injure someone who handled it or who was otherwise in contact with it for many hours, or who was close to it for many weeks. Category 5 sources are most unlikely to be dangerous and no one could be permanently injured by these sources. Category 4 and 5 sources if dispersed, could not permanently injure people.

Examples of Category 4 and 5 sources include:

- low dose rate brachytherapy units used for cancer therapy
- thickness gauges used for measuring the thickness of various materials such as paper, plastic and some metals
- fill gauges such as those used in the bottling industry to check that bottles are filled properly. They may also be used in the cigarette industry to ensure appropriate packing density
- portable gauges such as moisture/density gauges. Moisture gauges are used in agriculture to ensure optimal watering, while combination, or density gauges are often used in road construction to ensure that the appropriate compaction is being used for the foundation materials.

What safety and security measures should be in place for these sources?

The safety and security measures that should be in place for radioactive sources depend on their category. For example, Category 1, 2 and 3 radioactive sources should be subject to a high level of technical and administrative controls, which are intended to prevent anyone gaining inadvertent or unauthorised access to them. These controls can best be described as a combination of walls, locks, surveillance, procedures, information control and emergency response, all of which are intended to deter, detect and delay unauthorised individuals accessing the sources. For Category 4 and 5 sources, the measures may not be as stringent, but appropriate controls should still be in place to prevent unauthorised access or theft.

The location, and the safety and security status of all radioactive sources should be known by their authorised owner or user at all times, and by the relevant authority such as the national radiation regulator or Department of Health or Environment.

In summary, the best way of preventing an accident or injury is to prevent radioactive sources from being lost or stolen in the first place. Users should make sure that a source is kept safe and secure at all times and when it no longer has a useful purpose, it must be properly disposed of at a licensed radioactive waste facility.

What should I do if I find a radioactive source?

Radioactive sources that are not properly controlled, or have been lost or stolen, could be found in many places, including industrial sites, hospitals, construction sites and agricultural premises. Any disused premises of this type should be considered as a possible location of a radioactive source. Of particular concern are sources that are sometimes lost when old equipment is thrown away. Lost or discarded sources can end up in scrap metal yards, so people who collect scrap metal need to know how to recognise a sealed radioactive source.

If you think you know the whereabouts of a radioactive source that is orphan, vulnerable or otherwise potentially not safe and secure, you should keep away from the source and immediately contact local police, local hospital or medical authority, or the government regulatory authority responsible for radiation and radioactive sources. **Do not pick up the source or try to move it!**

How can I find out more about this subject?

Consult the relevant radiation protection authority, or Department of Health or Environment in your country. More information can also be found in the following International Atomic Energy Agency publications (see www.iaea.org):

- *Categorization of Radioactive Sources, Safety Guide RS-G-1.9,* IAEA, Vienna (2005) http://www-pub.iaea.org/MTCD/publications/PDF/Pub1227_web.pdf
- *Code of Conduct on the Safety and Security of Radioactive Sources*, IAEA/CODEOC/2004, IAEA, Vienna (2004) http://www-pub.iaea.org/MTCD/publications/PDF/Code-2004_web.pdf
- *Security of Radioactive Sources — Interim Guidance for Comment*, IAEA-TECDOC-1355, IAEA, Vienna (2003) http://www-pub.iaea.org/MTCD/publications/PDF/te_1355_web.pdf
- *Sealed Radioactive Sources – Brochure Series,* IAEA, Vienna, September 2005. http://www.iaea.org/Publications/Booklets/SealedRadioactiveSources/index.html

What is Australia's Regional Security of Radioactive Sources Project?

Participants from South East Asian countries using radiation monitors at a Workshop on Searching for Orphan Radioactive Sources at ANSTO

The Australian Nuclear Science & Technology Organisation (ANSTO) is leading a regional project on the security of radioactive sources for South East Asian and Pacific countries. The main objective of the Regional Security of Radioactive Sources (RSRS) Project is to enhance and maintain the control and security of radioactive sources throughout their life-cycle within the region. The Project commenced in July 2004 and operates in partnership with regional countries and relevant similar programs of the International Atomic Energy Agency and the US Department of Energy's National Nuclear Security Administration. The RSRS Project's activities are improving the security of radioactive sources in regional countries by:

- Improving regulations and regulatory infrastructure, inventory control, and the implementation of requirements for radioactive source security;
- Training and development in physical protection and security management of radioactive sources including in the facilities in which they are used and stored;
- Building the level of regional countries' expertise and resources for orphan source searches and for emergency response; and
- Addressing situations involving vulnerable or orphan sources.

Further information on the regional project on source security, or on the safety and security of radioactive sources generally, can be obtained from ANSTO's Project Leader, Regional Security of Radioactive Sources Project.

Contact details

T +61 2 9717-3260
F +61 2 9717-9266
E rsrs.project@ansto.gov.au
PMB 1, Menai 2234 NSW, Australia
www.ansto.gov.au

The Australian Nuclear Science and Technology Organisation (ANSTO) is Australia's nuclear research and development agency. We deliver market-leading products and services to public and private sector organisations in medicine, mining, aerospace, minerals, agriculture, manufacturing and the environment.

Our 900+ staff primarily conduct these activities at ANSTO headquarters, located on the outskirts of southern Sydney. This site contains the nuclear research reactor, OPAL, as well as many other leading-edge scientific facilities and instruments. We also operate the National Medical Cyclotron, an accelerator facility at the Royal Prince Alfred Hospital, near central Sydney.

Printed on paper made from recycled organic waste

Australian Government

Australian Nuclear Science and Technology Organisation

www.ansto.gov.au

May 07