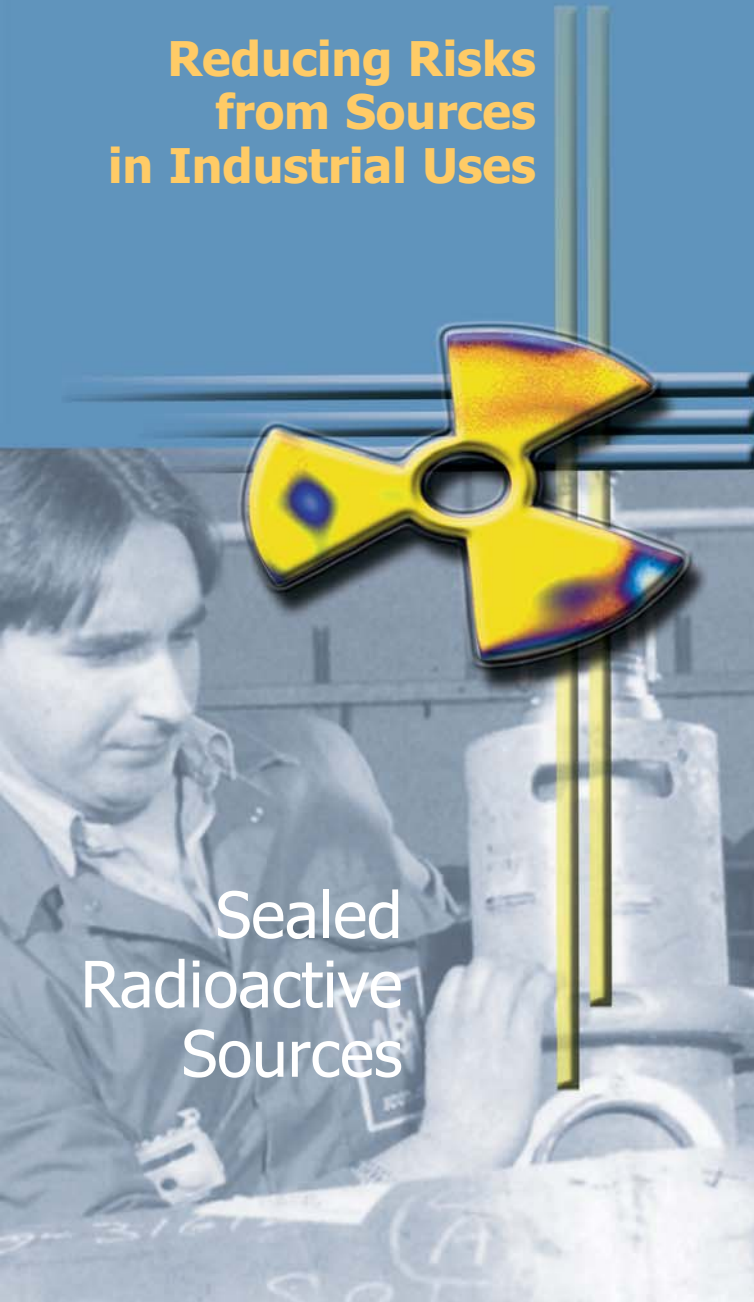
IAEA
International Atomic Energy Agency

Reducing Risks from Sources in Industrial Uses



Sealed Radioactive Sources

Introduction

In November 2000, a worker set off a radiation detector on his way into work at a French nuclear power plant. Fearing that the worker might have somehow been contaminated at the plant, a thorough check for contamination was made. The results sparked concern not just in France, but also around the world. The worker himself was not contaminated, but parts of the metal bracelet of his watch were found to be radioactive. Further analysis revealed that the steel pins in the bracelet were contaminated with traces of cobalt-60, a radioactive form of cobalt.

The watches had been imported from Hong Kong, where they had been assembled. The source of the contamination was later traced to a small plant in China that had provided the steel for the bracelet pins. It is thought that a teletherapy head, a device used in radiation treatment of cancer patients, had been inadvertently melted down as scrap at this plant. In France, the watches were sold through a large multinational, department store, raising fears that the watches could also have been on sale in Europe, Asia, and South America. Fortunately, an investigation by nuclear regulatory authorities around the globe did not find any similar watches in distribution. But had one contaminated watch not been detected at a French nuclear plant, many people might have been exposed to low doses of radiation. The one hundred kilograms of contaminated steel found at the plant in China might never have been discovered and could have been used to make other consumer products.

Sealed radioactive sources are used widely in medicine, industry, and agriculture. When used as designed, these sources have far-reaching benefits. When these sources are lost or make their way into untrained hands, the consequences can be equally far-reaching, and unfortunately even deadly. How can loss and accidents be prevented? How can

contaminated materials be detected before they make their way into consumer or other products?

In most countries, radioactive materials and activities that produce radiation are regulated. Those working with sealed radioactive sources are required not just to have proper authorization, but also the needed training and support to deal with unexpected circumstances that may arise when a source is used. Despite these measures, accidents continue to occur. Serious or life threatening injuries from overexposure to radiation have been reported to the International Atomic Energy Agency (IAEA).

Among its many activities to improve the safety of sealed sources, the IAEA has been investigating the root causes of major accidents since the 1980's and publishes findings so that others can learn from them. There are growing concerns today about the possibility that an insecurely stored source could be stolen and used as a radioactive dispersal device. To improve both safety and security, information needs to be in the hands of those whose actions and decisions can prevent a source from being lost in the first place.

A national waste management organization is instrumental in collecting sources, processing sources and in rendering sources safe by storing them in a facility until disposal becomes possible. It is hoped that this booklet will provide those using sources in industrial settings with this information and, thereby, reduce accidents and injuries from sealed radioactive sources.

Lessons to be learned

The following are but a few of the accidents that have occurred in the last 20 years, where lapses in good practice, human error, or lack of knowledge have resulted in serious injuries and deaths. A review of the root causes of these accidents reveals a worrying similarity.

Fatalities in Morocco. In 1984, a serious accident resulting in eight deaths occurred in Morocco when an iridium radiography source became disconnected from the drive cable and was not returned to the shielded container. The disconnected source eventually dropped to the ground where it was picked up by a passerby and taken home. The tiny source was too small to have warning markings, although the exposure device itself was marked with the international radiation symbol (trefoil). Over several months, several family members and relatives were exposed and died; the clinical diagnosis was "lung haemorrhage". Only after the last family member died was radiation suspected as the cause.

Investigation determined that this accident might have been averted had a radiation survey been performed after the radiography to confirm that the source had properly returned to the fully shielded position.

Contamination in Spain. In May of 1998, an unnoticed caesium-137 source was melted in an electric furnace of Acerinox, a stainless steel factory located in Los Barrios, Spain. As a consequence, the vapours were caught in a filter system resulting in contamination of the 270 tonnes of dust already collected. The dust was removed and sent to two factories for processing as a part of their routine maintenance. One factory received 150 tonnes that they then used in a marsh stabilization process, increasing the mass of the contaminated material to 500 tonnes and contaminating the marsh. The first warning of the event was in early June from a gate monitor that alarmed on an empty truck returning from delivering the dust. Several days later elevated levels of caesium-137 were also detected in Southern France and Northern Italy.

The radiological consequences of this event were minimal, with six people having slight levels of

caesium-137 contamination. However, the economic, political and social consequences were major. The estimated total costs for clean up, waste storage, and interruption of business at the affected companies exceeded $25 million US dollars.

The root causes of this accident were the loss of control over the caesium source and the fact that the steel factory did not detect the lost source in the load of scrap metal when it was received.

Serious Injury in Peru. In February 1999, a section of pipe was being repaired at the Yanango hydroelectric power plant in Peru. While the repairs were being completed, a gamma radiography device was left unsupervised and locked with the drive cable, but not the guide tube, connected inside the pipe. At some time during the day, the iridium source became detached from the device. A welder picked up the unshielded source, put it in the back pocket of his pants, and later returned home. By the time the source was discovered to be missing, some nine hours had elapsed and both the welder and his wife were exposed to radiation. The most serious injury was to the welder from direct contact with the source, which resulted in the amputation of one leg and lengthy hospitalization.

Investigation determined the root causes to be inadequate supervision of the source at the work site and lack of training by the person responsible for the radiography. The welder was unaware of radiation hazards. The design of the source device was also found to permit the lock to be removed with an ordinary screwdriver, hence the source could be easily removed. How the source in this instance came to be detached from the device was never conclusively determined.

Common industrial uses of sealed radioactive sources

Industrial uses of sealed radioactive sources account for a significant number of accidents reported to the IAEA. Industrial sources are used in a wide variety of applications and often in mobile equipment.

One of the most common industrial uses of radioactive sources is in gamma radiography, used in non-destructive testing of welds, such as those in gas and water pipelines. In gamma radiography, the source is housed in a shielded device and will be moved through a guide tube to a collimator inside the pipe. Controlled beams of radiation are emitted from the source (usually iridium-192) through the weld and onto photographic film. The resulting radiograph will show any flaws in the weld.

Industrial radiography source. This type was used in the USA during the 1930s and 1940s to inspect welds and metal casting.

Sealed radioactive sources are also used in a variety of portable gauges. Nuclear gauges can be used to measure density, thickness, or moisture, or to identify materials, all based on how the radiation emitted from the source interacts with the material under study. They all use a source in a shielded container to emit radiation that is then measured by at least one detector. Such gauges are commonly used in measuring the uniformity in road construction and in well logging. Well logging involves characterizing the properties of underground formations, such as potential oil or water

wells, according to their reaction to the radiation emitted by the logging source.

Gamma-emitting industrial radiography sources, used to radiograph thick metal and to penetrate confined areas. A small metal capsule at one end of a flexible cable houses 1.1–3.7 TBq (30–100 Curies) of iridium-192 or cobalt-60.

Preventing loss of sources

While proper training and experience will reduce the risk of radiation exposure when sealed radioactive sources are used, the vast majority of serious accidents in industrial use are due to a source that has been lost or stolen.

Industrial gamma radiography sources are at risk of loss because they are mobile and used in less controlled settings. Proper maintenance of equipment and good operational practices and procedures can reduce the risk of a source being lost in the first place. A source should be transferred to the waste operator or returned to the manufacturer as soon as it becomes disused.

Gamma Radiography

- Maintain equipment properly as recommended by the manufacturer, particularly the mechanical moving parts, to reduce the likelihood of a source failing to retract into the shielded position.

- Check routinely for crank problems, for signs that the cable is kinked, or for problems with pigtail coupling.

- Follow manufacturers instructions for routine maintenance.
- Always have a survey meter present when working with the source. Test the survey meter prior to each use to make sure it is working properly and regularly service it.
- Store sources in a secure storage facility when not in use. Store keys separately from the source device.
- Check the source device before leaving for the work site to make sure the container is locked. Monitor with a survey meter to confirm the source is in the shielded position.
- Never transport a source container with the key in the lock.
- Use radioactive sources only in a controlled area with barriers, warning signs, and shielding in place. Use a survey meter to monitor the area during exposure.
- Use sources when few or no other workers will be in the area (lunch breaks, after hours, etc). Advise managers and workers when a radiation exposure is to be done.
- Sources that are no longer in use should be returned to the supplier if possible or to the national waste operator in the country.

Industrial radiography accidents occur usually because the radiographer (or other qualified operator) does not make a proper radiation survey. Only through the proper use of a survey meter can the radiographer know the actual location of the source and prevent accidents.

Making a proper survey

Using a survey meter, a radiographer can make an initial survey of the device when removed from storage to confirm that the source is not exposed. This also provides a baseline for comparison with later surveys. Any unusual readings should be investigated.

The radiographer should observe the survey meter while exposing the source during operation. A drastic increase in radiation intensity should be seen as the source emerges from the shielded container. As the source moves through the guide tube, the radiation intensity should steadily decrease.

Nuclear Gauges and Well Logging

- Store sources securely when not in use.
- Maintain good records of sources in storage.
- Conduct a regular physical inventory of all sources.
- Maintain and service all radioactive sources according to manufacturer's instructions. In particular, owing to the harsh conditions of use, the equipment should be regularly inspected to make sure that the labelling of the source is still visible.
- Conduct a proper survey before and after use of the source, including around the storage site, in the transport vehicle, and at the site where the source is used.
- Make a proper survey with a survey meter to locate a lost source.
- In well logging, the greatest potential for an accident is loss of the radioactive source down the well. In the event that a source is lost, reasonable attempts should be made to remotely retrieve the source from the well, and the responsible regulatory authority should be notified to make a safety assessment. Care should be taken not to damage

the source during recovery. The site should be monitored for contamination after retrieval. Damaged sources should be transferred to the waste operator for long term management.

- Take measures to minimize the risk of sources being stolen during storage and transportation.

Emergency Planning

All users of sealed radioactive sources should have a contingency plan in place for emergencies, such as a damaged, lost, or stolen source. The plan should detail who is responsible, who must be contacted, and how to get outside assistance to deal with the emergency if necessary.

Waste Management

A disused sealed radioactive source is an accident waiting to happen, if it is not stored securely, conditioned, or disposed of properly. When a source no longer has a useful purpose, it should be disposed of permanently, and not stored at the user's premises. Keeping old sources just in case (for such uses as back-up to a current source, etc.) is not a good practice. They can be forgotten, or lost or stolen.

Interim storage may be acceptable: if the facility is secure to prevent loss or theft; the source is properly conditioned so as to improve its shielding and stability; and proper records and periodic physical checks of the sources in interim storage are made. Given the possibility that such a source could be stolen and used for wrong purposes, good security must be assured.

When a source no longer has any use, the responsible regulatory authority should be notified and arrangements made for its management, either by

— returning it to the manufacturer for disposal when feasible; or

— transporting the source to the waste operator.

In Conclusion

The most effective means to prevent accidents with sealed radioactive sources is to adopt work habits that reduce the likelihood of a source becoming lost. The onus is on those professionals using sources to take the necessary steps to protect the public, the environment, and themselves from the serious consequences of an accident, each and every time they work with a radioactive source. Sources no longer in use should be transferred to the national waste operator as soon as possible.

Cover photo: Industrial radiographer wearing TLD badge (thermoluminescent material in a special holder).

For more information about sealed radioactive sources or radiation in general, contact your local regulatory authority. Information is also available on the International Atomic Energy Agency's website *http://www.iaea.org*

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