Canada's Nuclear Regulator

National Sealed Source Registry and Sealed Source Tracking System

Annual Report 2014



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National Sealed Source Registry and Sealed Source Tracking System Annual Report 2014

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Executive Summary

This ninth annual report provides information on the registration and tracking of radioactive sealed sources in Canada through the Canadian Nuclear Safety Commission's (CNSC) National Sealed Source Registry (NSSR) and Sealed Source Tracking System (SSTS), from January 1 to December 31, 2014. A sealed source is a radioactive nuclear substance encased in a sealed capsule or in a cover to which the substance is bonded, and is used for a variety of activities, such as medical, industrial, commercial, as well as academic and research applications.

The NSSR is a CNSC-managed national database that maintains inventory information on all categories of sealed sources in Canada. It contains detailed information on high-risk sources (categories 1 and 2) and some information on moderate (Category 3) to low-risk sources (categories 4 and 5). This system, in conjunction with regulatory licensing and compliance operations, increases the safety and security of those sources. The NSSR's high-risk source tracking component, the SSTS, provides licensees and CNSC staff with an efficient, effective way to report and track the movement of high-risk sealed sources.

By the end of 2014, the NSSR contained information on 79,077 radioactive sealed sources from all categories in Canada. This represented an increase of 19.6% over the previous year, mostly due to the growth in the number of domestically manufactured sealed sources in 2014, combined with a slight increase in the number of imported sources. The SSTS was tracking 5,734 Category 1 sources and 39,167 Category 2 sources. The remaining 34,176 sources in the NSSR were in categories 3, 4 and 5, which are not subject to mandatory tracking for every movement but are subject to annual reporting through annual compliance reports that licensees submit to the CNSC. The SSTS registered 79,522 individual transactions of all types throughout the year, a decrease of 10.6% compared to 2013; 93.7% of them were performed through the online interface. The decrease in individual transactions is primarily due to a 50% decrease in the number of receipt and transfer transactions.

The CNSC monitors and tracks unplanned events involving the loss, theft and discovery of sealed sources in Canada. Sealed sources that are found are immediately investigated, to ensure that safety and security are maintained and that the original owners responsible for the material are identified. In 2014, there were 16 reported events involving the loss, theft or discovery of sealed sources, most of them involving low-risk (categories 4 and 5) sources. One reported event involved an exposure device that contained a Category 2 sealed source and was stolen along with the vehicle in which it was stored; both the vehicle and the exposure device were recovered the following day. In 9 of these 16 events, the sealed sources were either found or recovered. Throughout 2014, the CNSC conducted 148 inspections among licensees using the SSTS and found that all of them were compliant with their licence condition for the tracking of categories 1 and 2 sealed sources. The information presented in this report indicates an ongoing commitment by the CNSC and the licensees to the NSSR and SSTS, and reflects the system's effectiveness, ensuring the safe and secure management of sealed sources in Canada.

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National Sealed Source Registry and Sealed Source Tracking System Annual Report 2014

1. Introduction

Sealed sources are radioactive nuclear substances encased in a sealed capsule or in a cover to which the substance is bonded, and are used for a variety of activities, such as medical, industrial, academic and research, as well as commercial applications. The Canadian Nuclear Safety Commission (CNSC) was the first nuclear regulator among G8 countries to develop a National Sealed Source Registry (NSSR) and to implement an online Sealed Source Tracking System (SSTS). In addition, enhanced controls were established for the import and export of high-risk sealed sources.

The CNSC manages Canada's national inventory of high-risk radioactive sealed sources by means of the NSSR. The safety and security of these sources is increased through effective control and tracking. This report provides information on the registration and tracking of high-risk radioactive sealed sources in Canada through the NSSR and SSTS systems, for the period of January 1 to December 31, 2014. The report also describes developments and improvements made to the systems during the same period.

This is the ninth annual report for the NSSR and SSTS. Previous annual reports can be found on the "Reports on Sealed Source Tracking System" CNSC Web page.

2. About the NSSR and SSTS Data

The SSTS is a secure information management computer program used to populate the NSSR, and allows licensees to report their source transfers online. The NSSR enables the CNSC to build an accurate and secure inventory of sealed sources in Canada, starting with those that are classified as high risk. The information is as current as the licence reporting allows (e.g., reporting within two days of receipt and seven days in advance of any transfer).

Sealed sources are classified by the International Atomic Energy Agency (IAEA) into five different categories (for more information on the categorization of sealed sources, see Appendix A or consult the "Sealed Source Tracking" CNSC Web page). Categories 1 and 2 are designated as high risk (or risk-significant), Category 3 sources are designated as moderate risk, and categories 4 and 5 sources are designated as low risk. The CNSC has focused its efforts to accurately capture data about these sources, commensurate with their risk levels. Subsequently, the NSSR contains detailed information on categories 1 and 2 sealed sources in Canada such as serial number, isotope, activity and current location, as well as information on sources in categories 3, 4 and 5 that is updated annually from licensee's inventory information received through their annual compliance reports (ACRs) and validated by the CNSC for accuracy and consistency. The information received from ACR inventories is compiled in tables for tracking purposes.

3. Major Developments in 2014 and Future Improvements

3.1 System enhancements

The CNSC implements ongoing system improvements, to address issues and ensure proper system maintenance (for example, updates to the source activity decay calculator, category identification and licence number look-up table). As enabling tools are created and modified, the internal documentation associated with the NSSR and SSTS is also revised. In 2014, the CNSC released a new version of the Sealed Source Tracking System (SSTS) that included coding changes to the system's database environment; this release had no impact on system users.

3.2 Registration of categories 3, 4 and 5 sources

In addition to the information included in the National Sealed Source Registry, the CNSC is maintaining data on all categories of sealed sources used in Canada. The data is based on inventories submitted by the licensees in their annual compliance reports (ACRs). In 2014, the CNSC concluded an initiative to streamline the information collected in these reports and replaced its previous static forms with fillable ones. These improvements should facilitate the completion of ACRs by licensees, as well as the compilation of inventory data for categories 3, 4 and 5 sealed sources by the CNSC.

4. Performance Management

4.1 Performance measures and verification

In order to gauge the effectiveness of the SSTS program and verify the accuracy of data in the system, CNSC inspectors physically cross-reference data in the SSTS against the licensees' actual inventory of sealed sources. Routine CNSC compliance inspections include requirements to verify sealed source tracking information. Inconsistencies are immediately addressed, to ensure accuracy in the data. These inconsistencies include errors in source serial numbers and reference dates, as well as the use of non-standard terminology when identifying sealed source assemblies.

In 2014, 148 inspections were conducted among licensees for which mandatory tracking of high-risk sealed sources is required as a condition of their licence. All of them were found to be compliant. These inspections covered the accuracy of the data related to sealed source transfers within Canada. It also covered the accuracy of the licensees' inventory at their location at the time of inspection.

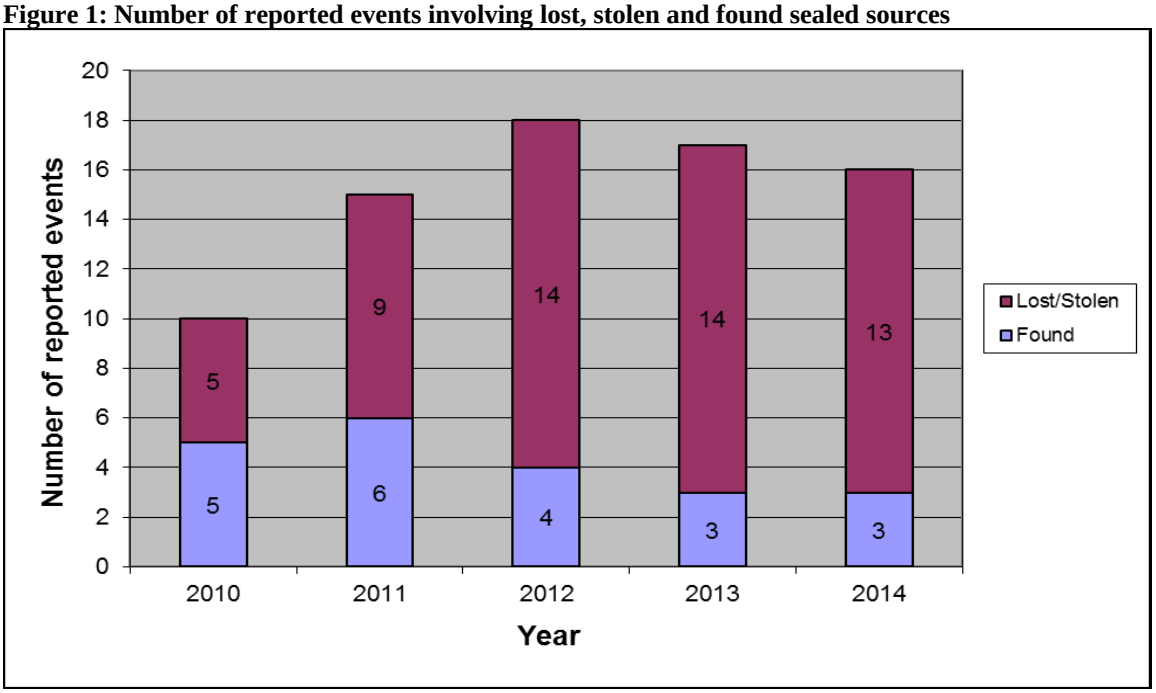
For more information on the inspection results of Canadian licensees using nuclear substances relative to radiation protection, operating performance and sealed source security, readers are invited to consult the Annual Regulatory Oversight Report on the Use of Nuclear Substances in Canada: 2014 posted on the CNSC website.

4.2 Event mitigation

The NSSR and SSTS are essential to the maintenance of the safety and security programs for high-risk sealed sources. It is important for the CNSC to track and ensure that the licensees make all necessary efforts to mitigate the impacts of any events involving sealed sources. Current regulations require all licensees to immediately report lost or stolen nuclear substances to the CNSC, along with written descriptions of any actions taken (or proposed to be taken) to recover the missing material. All events involving sealed sources are investigated and followed-up by the CNSC, to ensure that the licensees take all the necessary actions to mitigate the impacts of the event. If an event involves the loss or theft of a sealed source or radiation device, the CNSC informs national and international stakeholders who may assist with the recovery.

Information on lost and stolen nuclear substances can be found in the CNSC's *Report on Lost or Stolen Sealed Sources and Radiation Devices*, available on the CNSC website. The report lists all the lost, stolen and found sealed sources and radiation devices in Canada, as reported to the CNSC. As shown in Figure 1 there were 16 events involving 44 lost, stolen or found sealed sources in Canada during 2014 and more details are provided below the figure. In summary, three of these 16 events were related to finding sealed sources and radiation devices (shown in blue in the figure). These three events involved two Category 4 sources and four Category 5 sources. Of the other 13 events, the material was recovered for six (which comprised one Category 2 source, five Category 4 sources and three Category 5 sources), partly recovered for one (which comprised one Category 3 source and one Category 5 source that were recovered, while 13 Category 5 sources are still missing). The remaining six events are still under investigation (which comprised four Category 4 sources and 10 Category 5 sources).

Figure 1: Number of reported events involving lost, stolen and found sealed sources



Over the reporting period:

- There were no events involving **Category 1** sealed sources.
- One event involved a **Category 2** sealed source that was reported as stolen along with the vehicle in which it was stored. The exposure device and the vehicle were recovered by the licensee the following day. The investigation concluded that the exposure device was not accessed.
- Two events occurred at the same medical facility, involving a total of 22 sealed sources. One event involved the loss of one **Category 3** sealed source and 14 **Category 5** sealed sources, while the other event involved the loss of seven **Category 5** sealed sources. The Category 3 sealed source and one of Category 5 sealed sources have been recovered, while the remaining 20 sealed sources are still missing. The licensee has implemented corrective actions to prevent a reoccurrence of this type of event. The actions were reviewed and found satisfactory by the CNSC.

- Six events involved **Category 4** sealed sources. Category 4 sources are considered low risk, and are unlikely to be dangerous to persons[1].
    - Lost: There were two events involving the loss of Category 4 sealed sources and in both cases the sealed sources have been recovered. In one case, a sealed source was reported missing following a transfer. The investigation concluded that the sealed source had not been returned to its transport package following a training session. The event presented a low risk to the public and the environment. The other event involved a portable gauge containing two sealed sources that was reported lost during transport after having fallen off a vehicle. The portable gauge was recovered the following day and found to be intact, still in its transport package. In both cases the licensees have implemented corrective actions to prevent a reoccurrence.
    - Stolen: Three events involved stolen portable gauges. Each of the gauges contained two sealed sources. In two cases, the portable gauge was stolen while it was stored in a vehicle. Local authorities were notified and both events are still under investigation. For the remaining event, the portable gauge was stolen at a licensee's location along with other goods. The gauge was recovered three days later, in good condition, and was inspected prior to being returned to service. The licensee implemented corrective actions to prevent reoccurrence of this type of event. The CNSC reviewed the actions and found them to be satisfactory.
    - Found: There was one event where two disused Category 4 brachytherapy sealed sources were found in the licensee's machine shop. The sealed sources were moved to a secure location to ensure that they posed no risk to workers or the public. The licensee implemented corrective actions to ensure proper inventory control of the sources.
- In addition to the two events mentioned in the Category 3 sealed source paragraph above, seven other events involved **Category 5** sealed sources. Category 5 sources are considered very low risk, posing no personal danger to persons (due to their low activity, short half-life or their radiological nature).
    - Lost: There were four events of lost sealed sources, all together involving five sources. In two of these cases, the sealed sources have not been recovered. In one case a liquid scintillation device was reported missing following an unauthorized transfer for disposal. The other case involved the loss of a source used for instrument calibration. The licensee concluded that the sealed source was likely discarded in normal waste inadvertently. The other two events involved the loss of sealed sources later found to have been stored in the wrong location. These two cases involved sources that were sufficiently low activity to be exempt from licensing. Despite this, their loss was reported to the CNSC, as well as their subsequent recovery.
    - Stolen: There was one event where an x-ray fluorescence analyzer – a radiation device containing one sealed source – was reported stolen while it was stored inside a vehicle. Local authorities were notified and the event is still under investigation.
    - Found: There were two events where a total of four sealed sources were found. In one particular case, three calibration sources were found at an unlicensed location. The sources were collected by a CNSC staff member and were disposed of in accordance with CNSC regulations. The other event involved a vehicle carrying scrap metal that triggered an alarm at a radiation portal monitor installed at a metal recycling facility. The source of radiation was identified as a dewpoint detector – a radiation device containing one sealed source. The

[1] IAEA, *Categorization of Radioactive Sources*, RS-G-1.9, (2005), Table 3.

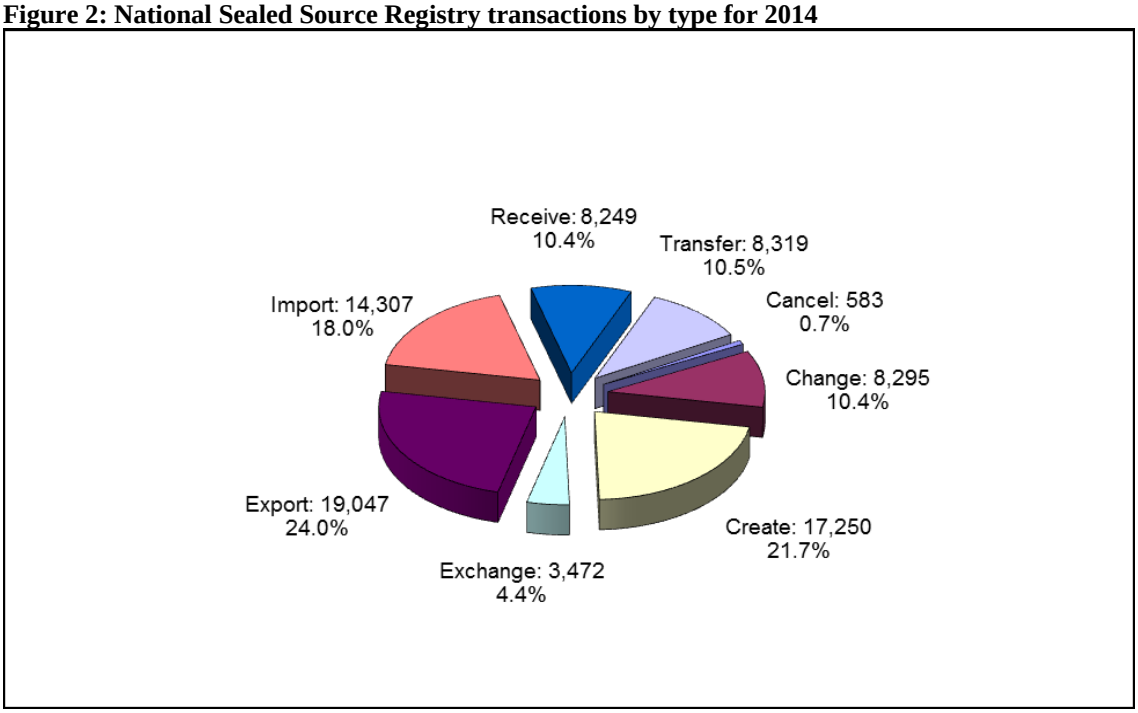
radiation device was retrieved and subsequently transferred to a company licensed to possess such a device.

5. Operational Data

5.1 National Sealed Source Registry statistics

During 2014, the NSSR continued to be populated with sealed source information for all categories, as licensees reported their transactions via the online interface or by other means (such as fax, email or written submissions by regular mail). The following operational data encompasses the entire NSSR and SSTS. Figure 2 shows all the transactions reported in 2014, which include transfers, receipts, imports, exports, cancellations, changes, creations and exchanges.

Figure 2: National Sealed Source Registry transactions by type for 2014



Types of transactions

Receive: Sources received by licensees at licensed locations.

Transfer: Sources transferred within Canada between licensees and licensed locations.

Cancel: Transaction cancelled due to unforeseen circumstances (export and shipment cancellations and delayed transfers).

Change: Data change or correction (e.g., to reference date of source activity).

Create: Creation of a new source manufactured in Canada, or recording of sealed sources in secure storage awaiting disposal.

Exchange: Replacement of one source for another in a radiation device or prescribed equipment, at a licensed location.

Export: The transfer of a sealed source from Canada to a foreign destination.

Import: The transfer of a sealed source into Canada from a foreign destination.

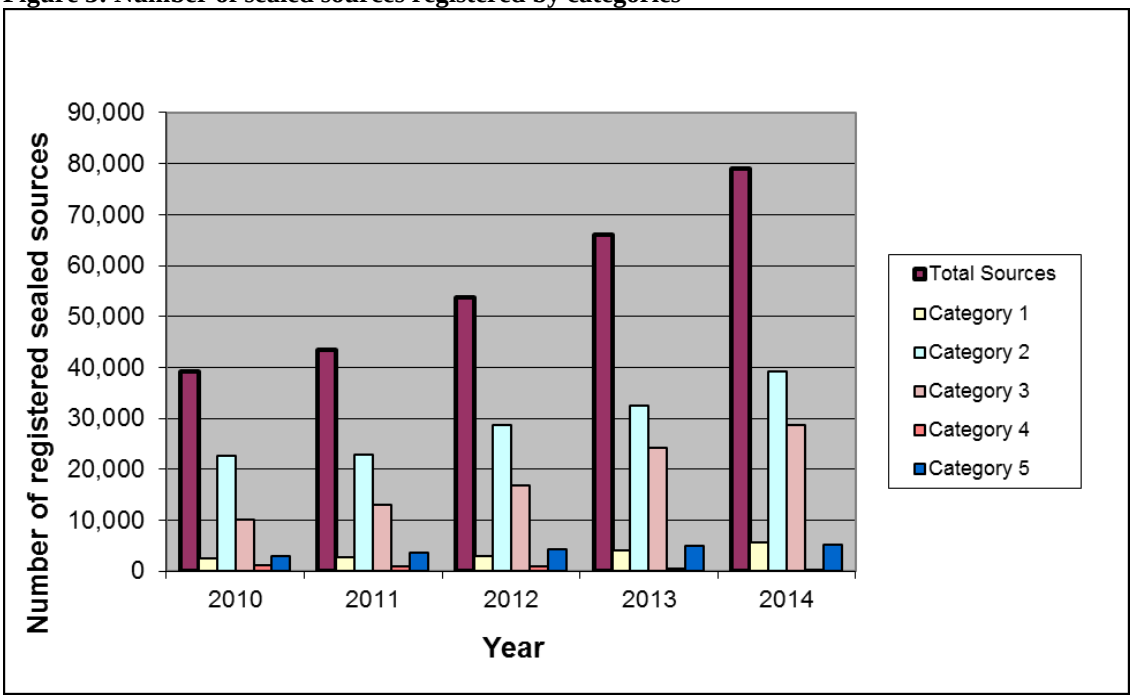
Table 1 and Figure 3 show the total number of sources in the NSSR as of December 31 of each year, as well as their breakdown by IAEA category[2]. The number of categories 1 and 2 high-risk sources (subject to mandatory source tracking) varies with the number of sources created, imported and exported by licensees. In 2014, there was a 23.2% increase in the number of these high-risk sources compared to 2013. This was primarily due to an increase in the number of sealed sources manufactured in Canada but also due to a large number of sources having been returned to the manufacturers following the decommissioning of prescribed equipment. Furthermore, the total number of categories 3, 4 and 5 sources has continuously increased over the years, as the activity of higher-risk sources naturally decayed to lower categories.

Table 1: National Sealed Source Registry statistics

	2010	2011	2012	2013	2014
Number of sources in NSSR (all Categories) in Canada	39,263	43,371	53,660	66,139	79,077
Number of Category 1 sources tracked in Canada	2,608	2,777	3,034	3,993	5,734
Number of Category 2 sources tracked in Canada	22,541	22,778	28,585	32,466	39,167
Number of Category 3 sources recorded in the registry	10,051	13,092	16,814	24,242	28,701
Number of Category 4 sources recorded in the registry	1,094	1,006	917	484	224
Number of Category 5 sources recorded in the registry	2,969	3,718	4,310	4,954	5,251

[2] IAEA, *Categorization of Radioactive Sources*, RS-G-1.9 (2005).

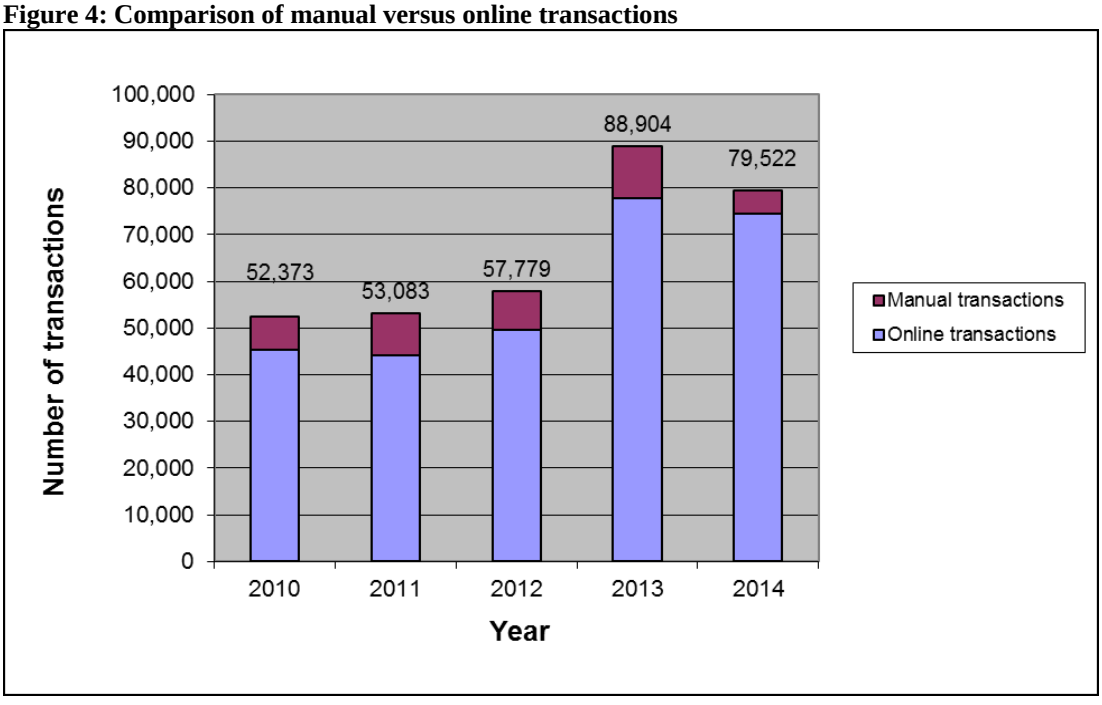
Figure 3: Number of sealed sources registered by categories



5.2 Number of transactions and online usage

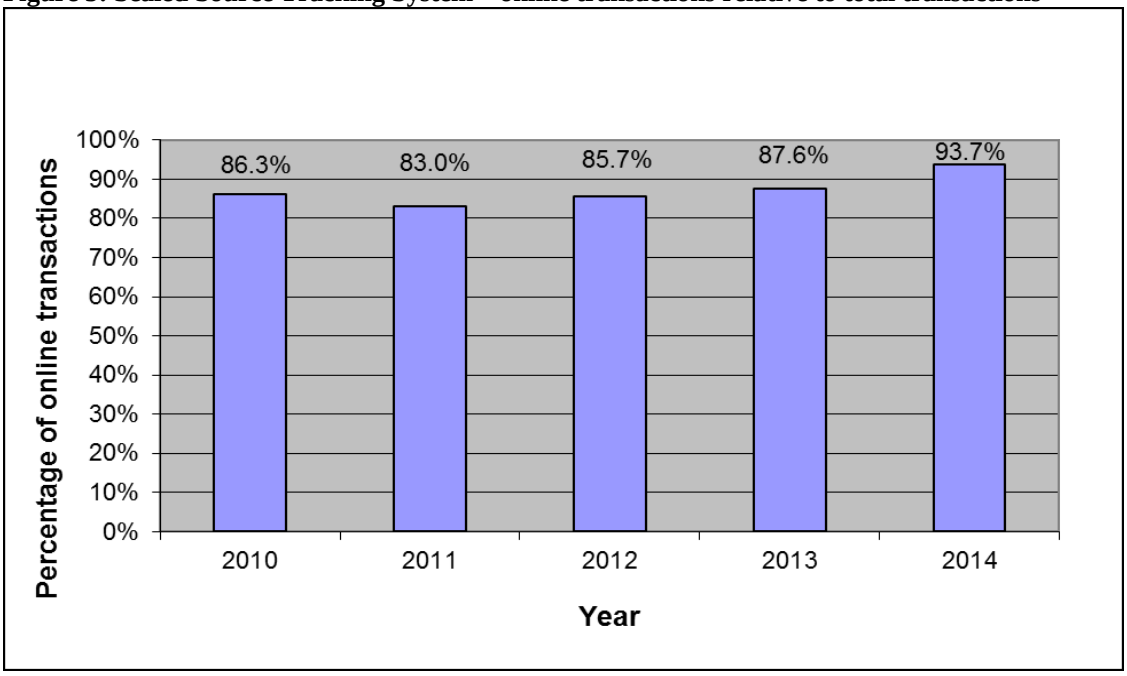
Figure 4 shows the total number of transactions, as well as the comparison of manual transactions (conducted by fax, mail and email) versus those conducted online. In 2014, there were a total of 79,522 transactions, representing a 10.6% decrease from the 88,904 transactions recorded in 2013. This was primarily due to a lesser number of sealed sources transferred for long-term storage purposes compared to 2013, resulting in a 50% decrease in the number of receipt and transfer transactions in 2014.

Figure 4: Comparison of manual versus online transactions



With respect to online usage, Figure 5 shows that 93.7% of these transactions were performed via the online interface in 2014. The relative increase in the percentage of online transactions is a result of the decrease in the total number of transactions and not necessarily an indication that use of the online interface is increasing. There were 4,976 transactions conducted by fax, mail and email in 2014, representing a 54.9% decrease from the 11,028 transactions of that type in 2013.

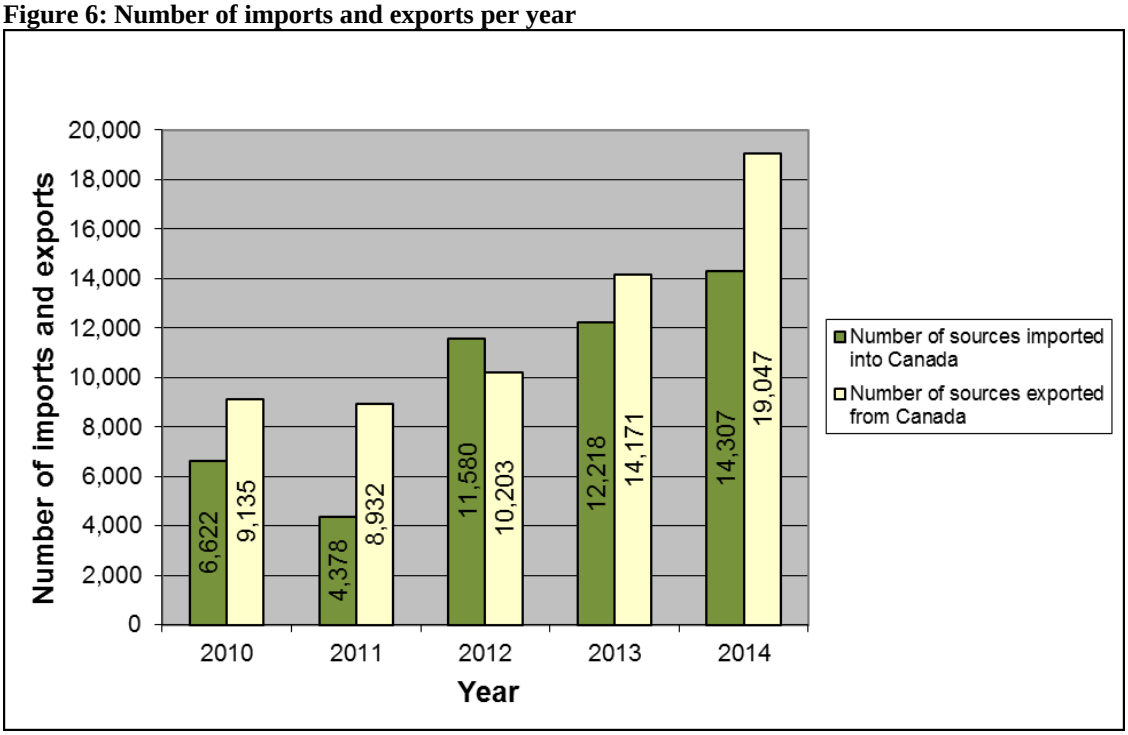
Figure 5: Sealed Source Tracking System – online transactions relative to total transactions



5.3 Import and export details

Figure 6 shows the number of import and export transactions in the SSTS, as of December 31 of each year. Users of nuclear substances in Canada routinely import and export sealed sources, in accordance with their licences. In 2014, there was a 34.4% increase in the number of sources exported from Canada, compared to 2013, as a result of the greater number of sealed sources manufactured in Canada.

Figure 6: Number of imports and exports per year



6. Conclusion

The National Sealed Source Registry (NSSR) and Sealed Source Tracking System (SSTS) contain information on the movement and location of high-risk radioactive sources in Canada, from their manufacture to their final disposition. Among the G8 countries, the CNSC was the first nuclear regulator to implement a national registry of high-risk sealed sources and monitor their movement using an online tracking system.

Statistics show a 23.2% increase in the number of high-risk sealed sources tracked in the SSTS compared to 2013. Compliance inspection results in 2014 show a continued high level of compliance with the requirements for tracking high-risk sealed sources movements. In fact, all of the inspected licensees were found to be compliant. This indicates an ongoing licensee commitment to the NSSR and SSTS, and reflects the system's effectiveness, which contributes to ensuring the safe and secure management of sealed sources in Canada.

Appendix A: Categorization of Sources

Radioactive sealed sources are used throughout the world in medicine, industry, agriculture, research and education, and vary widely in radiological risk. In 2005, the IAEA published a risk-based ranking of radioactive sources and practices, which uses five categories[3]. The category assigned to each practice or radioactive nuclear substance (enclosed in the sealed source) takes into account factors such as the following:

1. The radiological risk associated with the source
2. The nature of the work (or application for which the source is used)
3. The mobility of the source
4. experience from reported accidents
5. Typical versus unique activities within an application

These factors were used to assign sources and practices to one of five categories. If not managed safely and securely, Category 1 sources are considered to pose the greatest risk to human health, while Category 5 sources pose the lowest risk[4].

A.1 Category 1 (very high risk)

Category 1 sources are classified as "personally extremely dangerous".

These sealed sources, if not safely managed or securely protected, would be likely to cause permanent injury (in some cases fatal) to a person handling or coming in contact with them for a period of a few minutes. Exposure would be fatal if a person were close to it in an unshielded manner for a few minutes to an hour. Category 1 sources are associated with licensed activities to which the CNSC's *Class II Nuclear Facilities and Prescribed Equipment Regulations* apply.

Examples of Category 1 source usage:

- Self-shielded irradiators: Gamma sources are used in these irradiators for experimental purposes or as a means of sterilization. Gamma irradiation kills bacteria by breaking down bacterial DNA and inhibiting cell division. Blood products, for example, are sterilized in self-shielded irradiators.

Image 1: Cobalt 60 gammacell

[3] IAEA, *Categorization of Radioactive Sources*, RS-G-1.9 (2005).
[4] IAEA, *Categorization of Radioactive Sources*, RS-G-1.9 (2005), Table 3.

Gamma knife radiosurgery: An advanced form of surgery, performed with highly focused beams of radiation. As many as 201 radioactive sealed sources create intersecting beams of gamma radiation, which deliver a concentrated dose of radiation to a precise area of the brain. These radiation beams form the “knife”.

Image 2: Elekta gamma knife

Image 3: Gamma knife in use

- Radioactive source teletherapy: External beam radiotherapy (otherwise known as “teletherapy”) is the most frequently used form of radiotherapy. Radiotherapy is the medical use of radiation (produced by a radioactive sealed source mounted inside the machine) as part of cancer treatment or to control malignant cells.

Image 4: Cobalt 60 teletherapy

A.2 Category 2 (high risk)

Category 2 sources are classified as “personally very dangerous”.

These sealed sources, if not safely managed or securely protected, could cause permanent injury to a person handling it, or coming in contact with them, for a short period of time (minutes to hours), or be fatal if close to it in an unshielded manner for a few days. Category 2 sources are associated with licensed activities to which the CNSC’s *Nuclear Substances and Radiation Devices Regulations* generally apply.

Example of Category 2 source usage:

- Industrial radiography is a non-destructive testing (NDT) application that uses gamma radiation from a highly radioactive source, and photographic film, for the detection of internal physical imperfections (such as voids, cracks, flaws, segregations, pores and inclusions) in pressure vessels, pipelines, ships and reactor components. Radiography produces images on photographic film, similar to X-ray images, which show varying densities according to the amount of radiation absorbed in the material.

Image 5: Industrial radiography camera which contains the radioactive sealed source

Image 6: NDT Pipeline inspection, using industrial radiography equipment

A.3 Category 3 (moderate risk)

Category 3 sources are classified as "personally dangerous".

These sealed sources, if not safely managed or securely protected, could cause permanent injury to a person either handling it, or otherwise coming in contact with them, for some hours. Although unlikely, it could be fatal to be close to this amount of unshielded radioactive nuclear substances for a period of days to weeks. Category 3 sources are associated with licensed activities to which the CNSC's *Nuclear Substances and Radiation Devices Regulations* apply.

Examples of Category 3 source usage:

- Industrial gauges: These gauges are usually installed in fixed positions for measuring and process control purposes. These include density gauges, level gauges, belt mass meters, and thickness gauges. The radioactive sealed source is mounted inside the gauge and projects a radiation beam, through the material, and is picked up by a detector to provide a measurement.

Image 7: Industrial fixed gauge

- Brachytherapy delivers a concentrated dose of radiation to cancerous tissue from within. High dose rate (HDR) brachytherapy is the placement of a small, highly radioactive sealed source, for a short period of time, directly into cancerous tissues. The procedure is sometimes guided by ultrasound or 3D computerized mapping techniques.

Image 8: HDR brachytherapy

A.4 Category 4 (low risk)

Category 4 sources are classified as "unlikely to be personally dangerous".

It is very unlikely that anyone would be permanently injured by these sealed sources. However, if this unshielded radioactive nuclear substance is not safely managed or securely protected, although unlikely, it could temporarily injure someone handling it, in contact with it, or who is close to it for several weeks. Category 4 sources are associated with licensed activities to which the CNSC's *Nuclear Substances and Radiation Devices Regulations* apply.

Example of Category 4 source usage:

Low dose rate industrial gauges, such as moisture and density gauges, are used to measure the density of asphalt, soil, aggregate or concrete, as well as the moisture content of soil or aggregate.

Image 9: Portable gauge

Image 10: Portable gauge in use

A.5 Category 5 (very low risk)

Category 5 sources are classified as "most unlikely to be personally dangerous".

No one could be permanently injured by this radioactive nuclear substance. Category 5 sources are associated with licensed activities to which the CNSC's *Nuclear Substances and Radiation Devices Regulations* apply.

Examples of Category 5 source usage:

- Nickel-63 sources, in electron capture detectors, are used in gas chromatography instruments. They detect minute amounts of chemical compounds, such as halogenated organic chemicals in environmental samples. Pesticide levels in foodstuffs, for example, are measured with these detectors.

Image 11: Nickel-63 sealed source used in electron capture detectors

- Low dose rate (LDR) brachytherapy involves exposure to small radioactive sealed sources for a few hours or days. Ocular melanoma is one example of a tumour that can be treated with LDR brachytherapy. In another example, radioactive seeds of iodine-125 are surgically implanted to treat prostate cancer.

Image 12: Low dose rate brachytherapy