Canada's Nuclear Regulator

National Sealed Source Registry and Sealed Source Tracking System

Annual Report 2015



July 2016

Canadian Nuclear Safety Commission
Commission canadienne de sûreté nucléaire

Canada

National Sealed Source Registry and Sealed Source Tracking System Annual Report 2015

PWGSC catalogue number CC171-4E-PDF
ISSN 1926-3279

Également publié en français sous le titre: Rapport annuel 2015 sur le Registre national des sources scellées et le Système de suivi des sources scellées

Document availability
This document can be viewed on the CNSC website. To request a copy of the document in English or French, please contact:

Canadian Nuclear Safety Commission
280 Slater Street
P.O. Box 1046, Station B
Ottawa, Ontario K1P 5S9
Canada

Tel.: 613-995-5894 or 1-800-668-5284 (in Canada only)
Facsimile: 613-995-5086
Email: cnsc.information.ccsn@canada.ca
Website: nuclearsafety.gc.ca
Facebook: facebook.com/CanadianNuclearSafetyCommission
YouTube: youtube.com/cnscccsn
Twitter: @CNSC_CCSN

Publishing history July 2016 Edition 1.0

Executive summary

This report provides information on radioactive sealed sources in Canada that were registered and tracked through the National Sealed Source Registry (NSSR) and Sealed Source Tracking System (SSTS) in 2015. A sealed source is a radioactive nuclear substance encased in a sealed capsule or in a cover to which the substance is bonded. Sealed sources can be used for a variety of activities, including medical, industrial, commercial, and academic and research applications.

A national database managed by the Canadian Nuclear Safety Commission (CNSC), the NSSR maintains inventory information on all five categories of sealed sources in Canada. While the most detailed information is provided for high-risk sources (Category 1 or 2), the NSSR does contain some information on moderate-risk (Category 3) and 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 tracking component for high-risk sources, the SSTS, provides licensees and CNSC staff with an efficient and effective way to report and track the movement of high-risk sealed sources.

By the end of 2015, the NSSR contained information on 92,831 radioactive sealed sources in Canada. This represented an increase of 17.4 percent over the previous year, primarily because of a large number of depleted sources being returned to manufacturers. Of those, the SSTS was tracking 6,748 Category 1 sources and 45,673 Category 2 sources. The remaining 40,410 sources in the NSSR were Category 3, 4 or 5, which are not subject to mandatory tracking for every movement. The SSTS registered 82,705 individual transactions of all types throughout the year — an increase of 4 percent compared with 2014 — with 76,549 (92.6 percent) performed through the online interface.

The CNSC monitors and tracks unplanned events involving lost, stolen and found sealed sources in Canada. Sealed sources that are found are immediately investigated to ensure safety and security are maintained and that the original owners responsible for the material are identified. In 2015, there were 17 events involving a total of 36 sources reported as lost, stolen or found, all involving low-risk (Category 4 or 5) sources that posed negligible to low risk to the environment or the public. In 4 of these events, the 11 sealed sources involved were either found or recovered; in one other, three of the five sources involved were recovered. In nine of the remaining 12 events, the 17 sources involved have not been recovered and the investigation is still ongoing. Finally, the remaining three events involved the loss of three Category 5 sources. The sources could not be located following extensive searches and these events have since been closed.

Throughout 2015, the CNSC conducted 134 inspections of licensees using the SSTS and found that 91 percent were fully compliant with their licence condition for the tracking of Category 1 and Category 2 sealed sources. The CNSC tracked all identified instances of non-compliance to ensure they were adequately addressed by the licensees in question. The majority of non-compliances related to the tracking requirements for high-risk sealed sources were administrative in nature (e.g., incorrect addresses or device information, incorrect locations of devices or sources).

The information presented in this report indicates an ongoing commitment by the CNSC and its licensees to the NSSR and SSTS. It also reflects the system's effectiveness at ensuring the safe and secure management of sealed sources in Canada. As a result of the NSSR and SSTS, the CNSC has confidence in the overall safety and security of sealed sources in Canada.

Table of contents

National Sealed Source Registry and Sealed Source Tracking System Annual Report 2015

1. Introduction

Sealed sources are radioactive nuclear substances encased in a sealed capsule or in a cover to which the substance is bonded. They can be used for a variety of activities, including medical, industrial, commercial, and academic and research applications. In 2006, the Canadian Nuclear Safety Commission (CNSC) became the first nuclear regulator among G8 countries to develop a National Sealed Source Registry (NSSR) and implement an online Sealed Source Tracking System (SSTS). These two systems were soon followed by the establishment of enhanced controls for the import and export of high-risk sealed sources.

The CNSC uses the NSSR to manage Canada's national inventory of high-risk radioactive sealed sources. 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 for the period of January 1 to December 31, 2015. It also describes developments and improvements made to these systems throughout the year.

This is the tenth annual report for the NSSR and SSTS. Previous annual reports can be found on the CNSC website.

2. About the NSSR and SSTS data

In 2004, the International Atomic Energy Agency (IAEA) published the *Code of Conduct on the Safety and Security of Radioactive Sources*. CNSC staff who participated in the meetings to draft the Code realized there were three major issues – source tracking, registration and export licensing – that needed to be addressed for Canadian practices to conform to the Code's provisions. Consequently, CNSC staff began developing projects to address these gaps, beginning with the implementation of the NSSR and SSTS in January 2006 and an import/export licensing program for high-risk sealed sources in 2007.

The SSTS is a secure information-management system used to populate the NSSR. It also allows licensees to report their source transfers online. The NSSR enables the CNSC to maintain an accurate and secure inventory of sealed sources in Canada, with a particular focus on those 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 IAEA into five different categories: Category 1 and Category 2 sources are considered to be high risk (or risk-significant), Category 3 sources are considered to be moderate risk, and Category 4 and Category 5 sources are considered to be low risk. (For more information on how sealed sources are categorized, see Appendix A or consult the CNSC website). The CNSC has placed particular emphasis on capturing data on high-risk sources, with the NSSR housing detailed information — such as the serial number, isotope, activity and current location — for Category 1 and Category 2 sealed sources in Canada. Information on moderate- and low-risk sources is updated annually using the inventory data included in licensees' annual compliance reports (ACRs) and validated by the CNSC for accuracy and consistency.

3. Major developments in 2015 and future improvements

3.1 System enhancements

The CNSC makes ongoing system improvements to address any identified issues and ensure proper system maintenance. These include, for example, updates to the source activity decay calculator, category identification and licence number look-up tables. As enabling tools are created and modified, the internal documentation associated with the NSSR and SSTS is also revised. In 2016, the CNSC will release a new version of the SSTS that will include changes to the software's code to resolve a number of system bugs.

3.2 Registration of moderate- and low-risk sources

In addition to the information on high-risk sources gathered though SSTS reporting, the CNSC also maintains data on moderate- and low-risk sealed sources used in Canada. This data is based on the inventories submitted by licensees in their ACRs. In 2014, the CNSC concluded an initiative to streamline the information collected through ACRs and replaced its previous static forms with ones that can be completed electronically. These changes have made it easier for licensees to complete their ACRs, which helps the CNSC by facilitating the compilation of inventory data for Category 3, 4 and 5 sealed sources.

3.3 International engagement

At an international meeting held in Vienna in November 2015, the CNSC delivered a presentation on Canada's implementation of the IAEA *Code of Conduct on the Safety and Security of Radioactive Sources*. The purpose of this meeting was to explain the objectives and benefits of the Code and its supplementary document, *Guidance on the Import and Export of Radioactive Sources*, with an emphasis on encouraging IAEA Member States to express political support for these voluntary, non-binding instruments to assist in global efforts to ensure the safety and security of radioactive sources worldwide. The CNSC's presentation provided an overview of its own experience with the Code and the Guidance, describing the process that was used in their implementation, the continuous improvement initiatives that have since been undertaken, and their overall safety and security benefits from the perspective of a major exporting Member State. The presentation can be found on the CNSC website.

4. Performance management

4.1 Performance measures and verification

To gauge the effectiveness of the SSTS and verify the accuracy of the data in the system, CNSC inspectors physically cross-reference SSTS data against 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. Typically administrative in nature, these inconsistencies may include errors in source serial numbers and reference dates, or the use of non-standard terminology when identifying sealed source assemblies.

In 2015, 134 inspections were conducted among licensees whose licence conditions require mandatory tracking of high-risk sealed sources. These inspections covered the accuracy of the data related to sealed source transfers within Canada. They also covered the accuracy of licensees' on-premise inventory of sealed sources at the time of the inspection.

Of the licensees inspected, 122 (91 percent) were found to be compliant. The remaining 12 licensees that were initially found to be non-compliant have since adequately addressed the issues identified during their inspections.

For more information on the inspection results of Canadian licensees using nuclear substances relative to doses to workers, radiation protection, operating performance and sealed source security, refer to the *Annual Regulatory Oversight Report on the Use of Nuclear Substances in Canada* posted on the CNSC website.

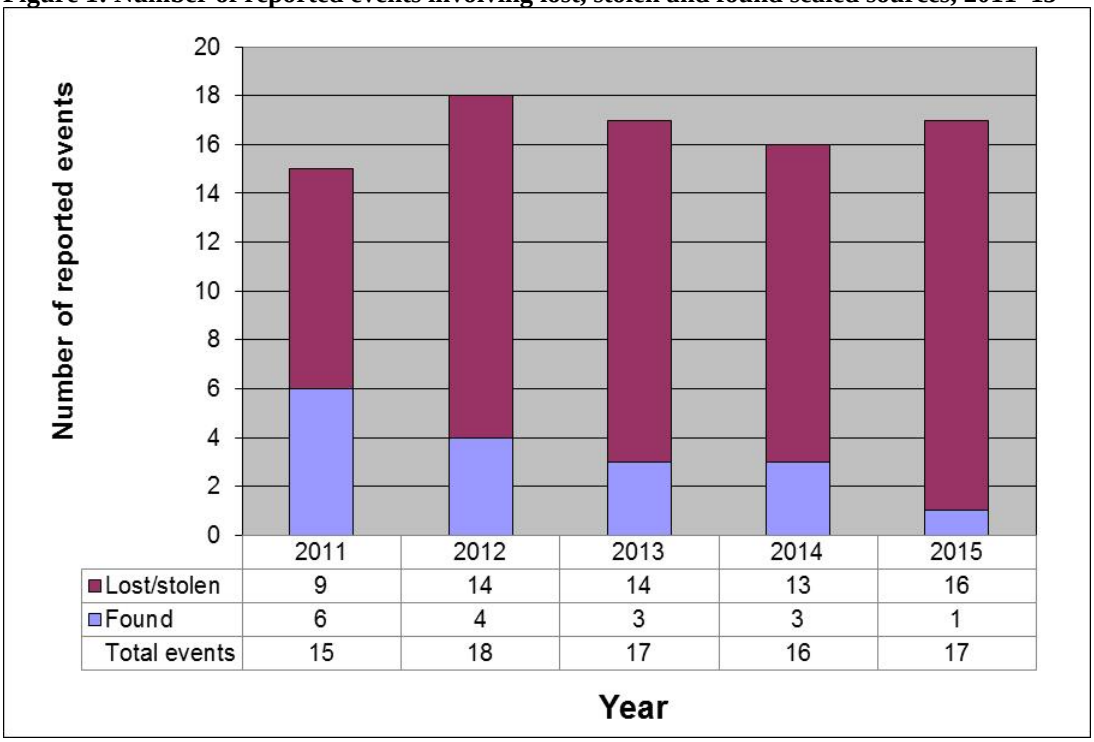
4.2 Event mitigation

Both the NSSR and SSTS are essential to maintaining the safety and security of high-risk sealed sources. Current regulations require all licensees to immediately report lost or stolen nuclear substances (including sealed sources) to the CNSC. They must also submit written descriptions of any actions taken (or proposed to be taken) to recover the missing nuclear substances. To ensure licensees are taking all necessary actions to mitigate the impacts of lost or stolen nuclear substances, the CNSC investigates every such event. If an event involves the loss or theft of a sealed source or radiation device, the CNSC also informs local, national and international stakeholders who may assist with the recovery. A listing of all events reported to the CNSC related to lost, stolen and found nuclear substances in Canada can be found in the *Lost or Stolen Sealed Sources and Radiation Devices Report*, available on the CNSC website.

The International Nuclear and Radiation Events Scale (INES) is a tool for communicating the safety significance of nuclear and radiological events to technical communities and the public. Every event reported to the CNSC is classified in accordance with the INES, based on its safety significance rating.

As shown in Figure 1, there were 17 events involving 36 lost, stolen or found sealed sources in Canada during 2015. One event involved the finding of a Category 5 sealed source within a radiation device. In 3 of the remaining 16 events, all 10 Category 4 sealed sources involved were recovered. One additional event involved the loss of five Category 4 sources, three of which were recovered. (The two missing sources are still under investigation.) A further nine events involving a total of 17 sources (six Category 4 and 11 Category 5 sources) are still under investigation. Finally, three events involving three Category 5 sources (specifically, radioactive seeds used in nuclear medicine) have been closed following unsuccessful searches; given the radiological nature of the substances involved, these sources have decayed to a point where they do not pose any residual risks. All 17 events posed negligible to low risk to the environment or the public.

Figure 1: Number of reported events involving lost, stolen and found sealed sources, 2011–15



	2011	2012	2013	2014	2015
Lost/stolen	9	14	14	13	16
Found	6	4	3	3	1
Total events	15	18	17	16	17

Over the 2015 reporting period:

- There were no events involving **Category 1, 2 or 3** sealed sources.
- Seven events involved **Category 4** sealed sources. These are considered low-risk sources and are unlikely to be dangerous.[1]
    - **Lost:** There were 2 events involving the loss of 11 Category 4 sealed sources. Both events presented negligible risk to the public and the environment.
        - Six fixed gauges containing one sealed source each were lost, and all have since been recovered. The event was reported after an inspection of a licensed facility found that the facility had been abandoned and the gauges were unaccounted for. The sealed sources were recovered 25 days later during an inspection of another licensee, which revealed that this licensee had purchased the radiation devices from the original licensee before it abandoned the facility.
        - Five sealed sources were determined to be missing during an inventory check by CNSC staff. Three of the five missing sources have been recovered; the other two missing sources are still under investigation (although it is believed they were likely disposed of during cleaning).

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

- **Stolen:** There were five events involving stolen portable gauges containing two Category 4 sealed sources each. All five events involving stolen Category 4 sources were given an INES Level 1 (anomaly) rating. Events where the sealed sources have not been recovered pose a low potential risk to the public and the environment.
    - In three events, the vehicle in which the portable gauge was stored was stolen. Two of the three portable gauges were recovered, and the remaining portable gauge is still missing. Local authorities were notified and this event is still under investigation.
    - A portable gauge was stolen from a work site while the worker was not paying attention. The gauge has not been recovered and this event is still under investigation.
    - A portable gauge that was locked in its carrying case was stolen from a locked vehicle. Local authorities were notified and the event is still under investigation.

- Ten events involved **Category 5** sealed sources, which are considered very low risk and pose no danger because of their low activity, short half-life or radiological nature.
    - **Lost:** There were 8 events involving a combined total of 11 lost sealed sources. None of the sealed sources involved in these events have been recovered. All eight events presented negligible risk to the public and the environment.
        - In two separate events, a licensee reported that one sealed source was missing from its designated location following a verification of its sealed source inventory. These events are still under investigation.
        - One sealed source was reported missing by a licensee following an unsuccessful search. This event is still under investigation.
        - Four static eliminators, each containing one sealed source, were declared lost by a licensee following their receipt. The transport company provided the licensee with a receipt of delivery; however, the licensee was unable to locate the devices within its facility. This event is still under investigation.
        - An event was reported after a servicing company noticed that the liquid scintillation counter being serviced did not contain the sealed source. An extensive survey of the area was performed but the source could not be located, leading to the conclusion that the source had been removed from the device before the company took possession of it for servicing. The servicing company then contacted the licensee originally in possession of the device to perform a search for the source. This search was unsuccessful. This event is still under investigation.
        - The last three events involved three radioactive seeds used in nuclear medicine. In two of the three events, a seed was not accounted for after pathology. In both cases, it was concluded that the seeds were probably disposed of after surgery (as the radioactivity was not high enough to trigger alarms) or the vial containing the radioactive seed was misplaced. The last event was reported when a seed, which was visually confirmed to be in the vial by a worker after it was used, could not be located when it was transferred for decay within the storage area with the other seeds. The

sources could not be located following extensive searches and these events have since been closed.

- **Stolen:** There was one event involving three check sources reported as stolen after a CNSC inspection. The sources have not been recovered. Police conducted an investigation and have determined that this event was a theft and the event remains under investigation. The event presented negligible risk to the public or the environment.

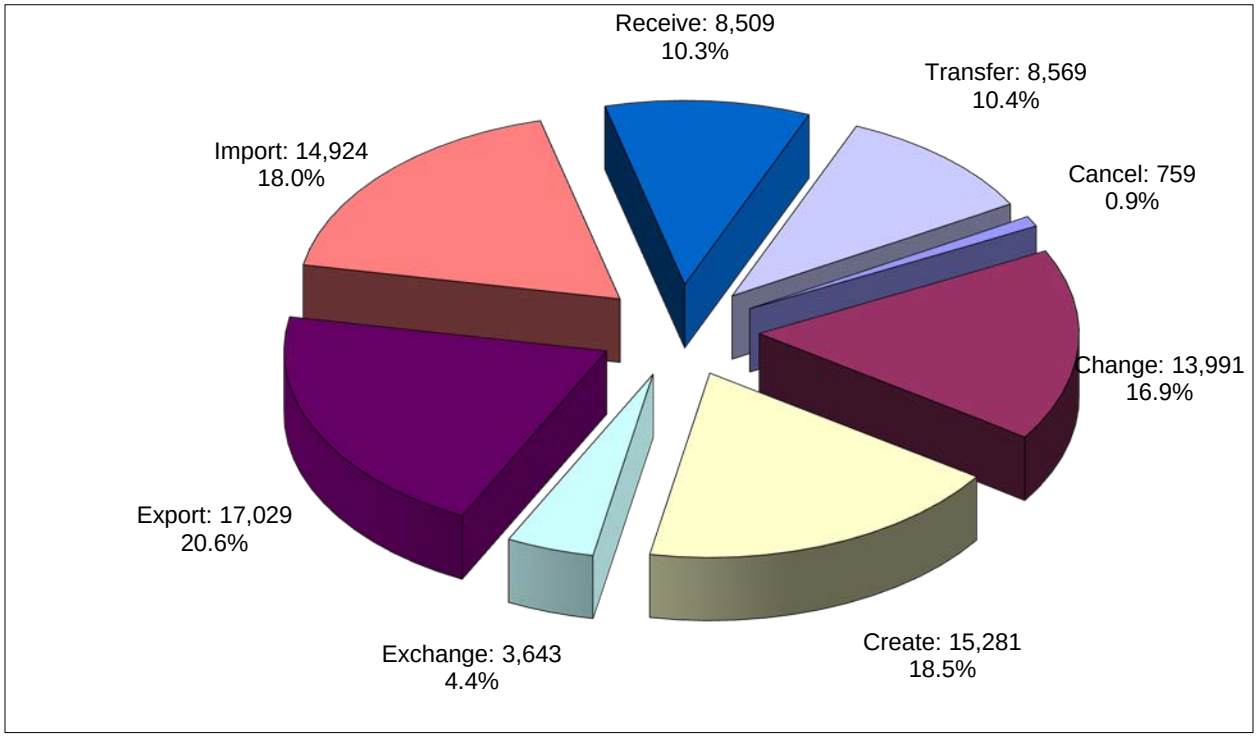
- **Found:** There was one event reported where a device containing one Category 5 sealed source, reported missing in 2007, was found in a storage locker. The event presented negligible risk to the public or the environment.

5. Operational data

5.1 National Sealed Source Registry statistics

The NSSR continued to be populated with sealed source information for all categories in 2015, with licensees reporting 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 sources contained in the NSSR that have been entered through the SSTS. Additionally, the CNSC continues to enhance the NSSR to include information for Category 3, 4, and 5 sources that are not required by license conditions to be entered into the SSTS. Licensees report their annual inventory of sealed sources through the required ACRs. Figure 2 shows all the transactions reported in 2015, which include transfers, receipts, imports, exports, cancellations, changes, creations and exchanges. (See the following page for definitions of these transaction types.)

Figure 2: National Sealed Source Registry transactions by type, 2015



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 (e.g., export and shipment cancellations, 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.

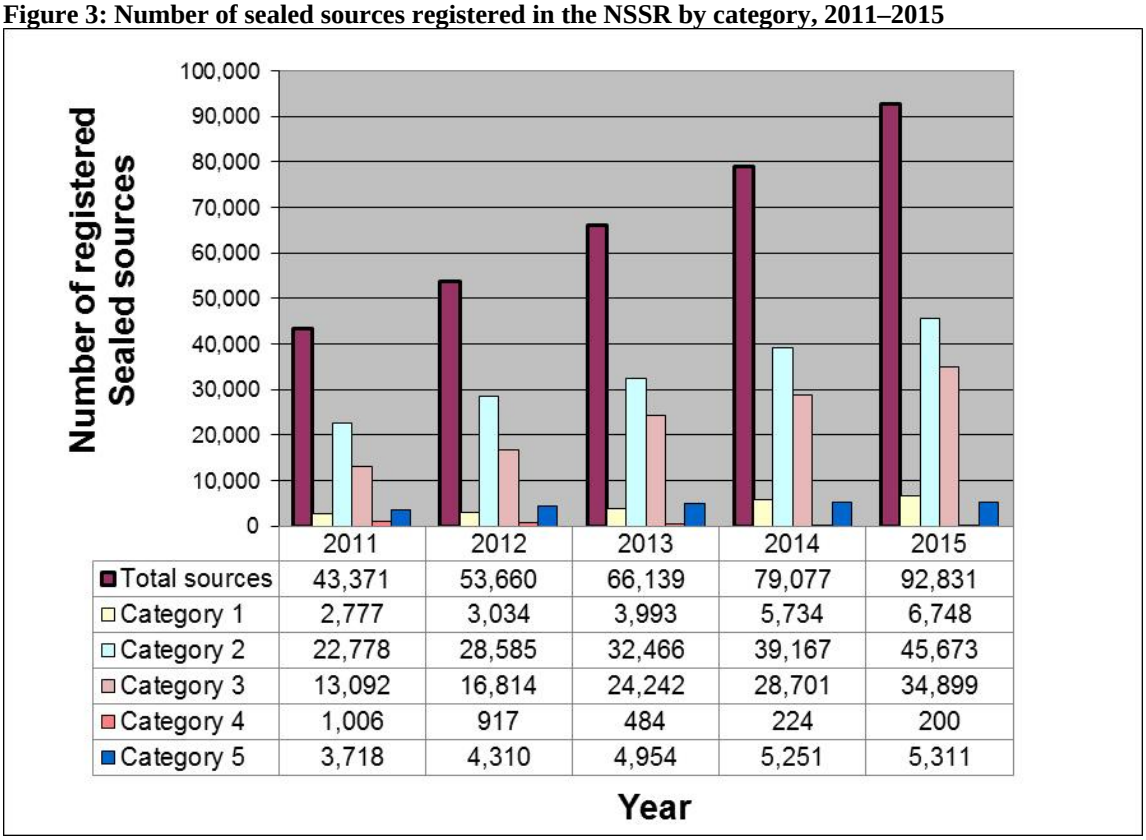
Exchange: Replacement of one source for another in a radiation device or prescribed equipment at a licensed location.

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.

Figure 3 shows the total number of sources in the NSSR as well as their breakdown by IAEA category.[2] The number of Category 1 and 2 high-risk sources (subject to mandatory source tracking) varies with the number of sources created, imported and exported by licensees. In 2015, there was a 16.8-percent increase in the number of these high-risk sources compared to 2014. This was primarily due to a large number of depleted sources having been returned to their manufacturers. Similarly, the increase in Category 3 sealed sources is primarily due to the return of sealed sources no longer suitable for use in prescribed equipment.

Figure 3: Number of sealed sources registered in the NSSR by category, 2011–2015



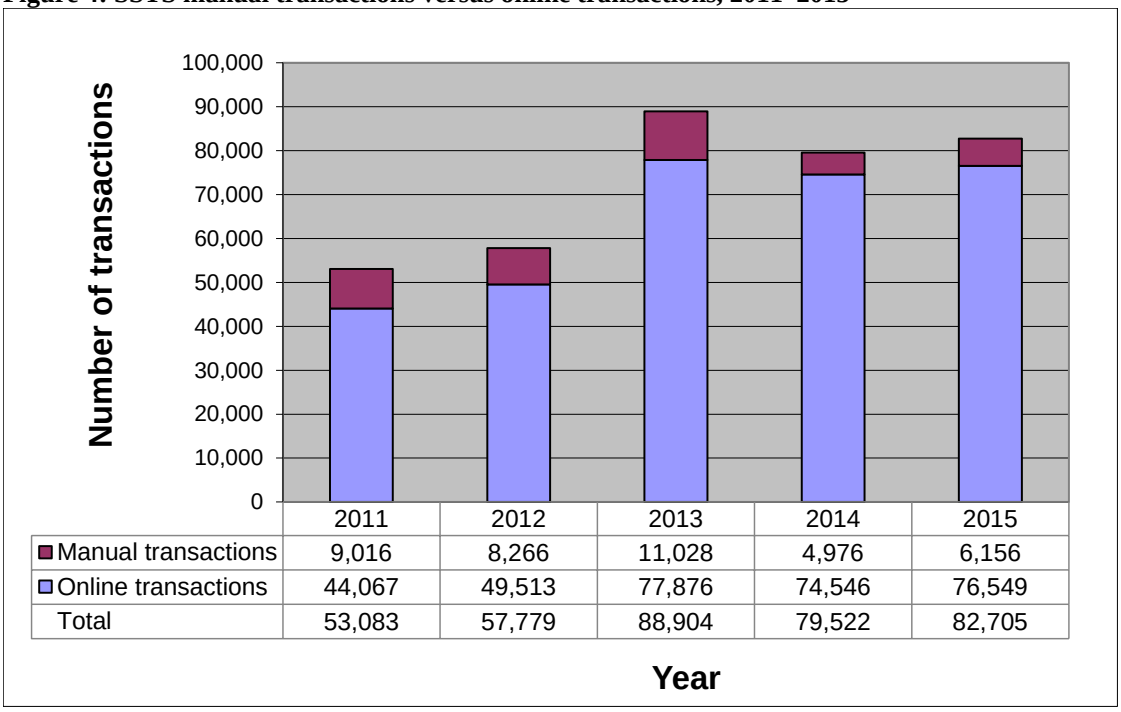
	2011	2012	2013	2014	2015
Total sources	43,371	53,660	66,139	79,077	92,831
Category 1	2,777	3,034	3,993	5,734	6,748
Category 2	22,778	28,585	32,466	39,167	45,673
Category 3	13,092	16,814	24,242	28,701	34,899
Category 4	1,006	917	484	224	200
Category 5	3,718	4,310	4,954	5,251	5,311

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

5.2 Number of transactions and online usage

Figure 4 shows the total number of transactions made through the SSTS, broken down into manual transactions (i.e., those conducted by fax, mail or email) and those conducted online. A total of 82,705 transactions were recorded in 2015, which represents a 4.3-percent increase over the number of transactions recorded in 2014.

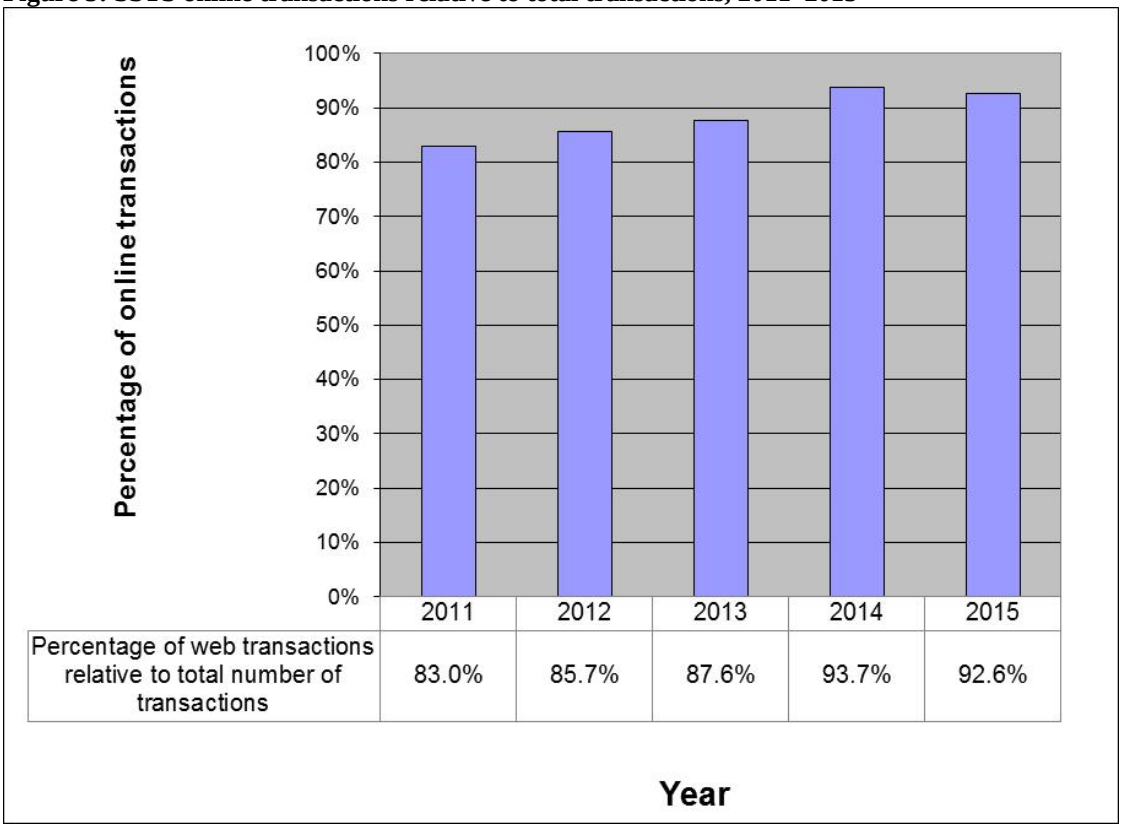
Figure 4: SSTS manual transactions versus online transactions, 2011–2015



	2011	2012	2013	2014	2015
Manual transactions	9,016	8,266	11,028	4,976	6,156
Online transactions	44,067	49,513	77,876	74,546	76,549
Total	53,083	57,779	88,904	79,522	82,705

Figure 5 shows that 76,549 (92.6 percent) of the transactions made through the SSTS were performed via the online interface in 2015. After a steady increase since 2011, the percentage of total transactions made online decreased slightly in 2015, dropping by 0.9 percent compared with the previous year. However, the total remains more or less consistent with the numbers recorded in 2014.

Figure 5: SSTS online transactions relative to total transactions, 2011–2015

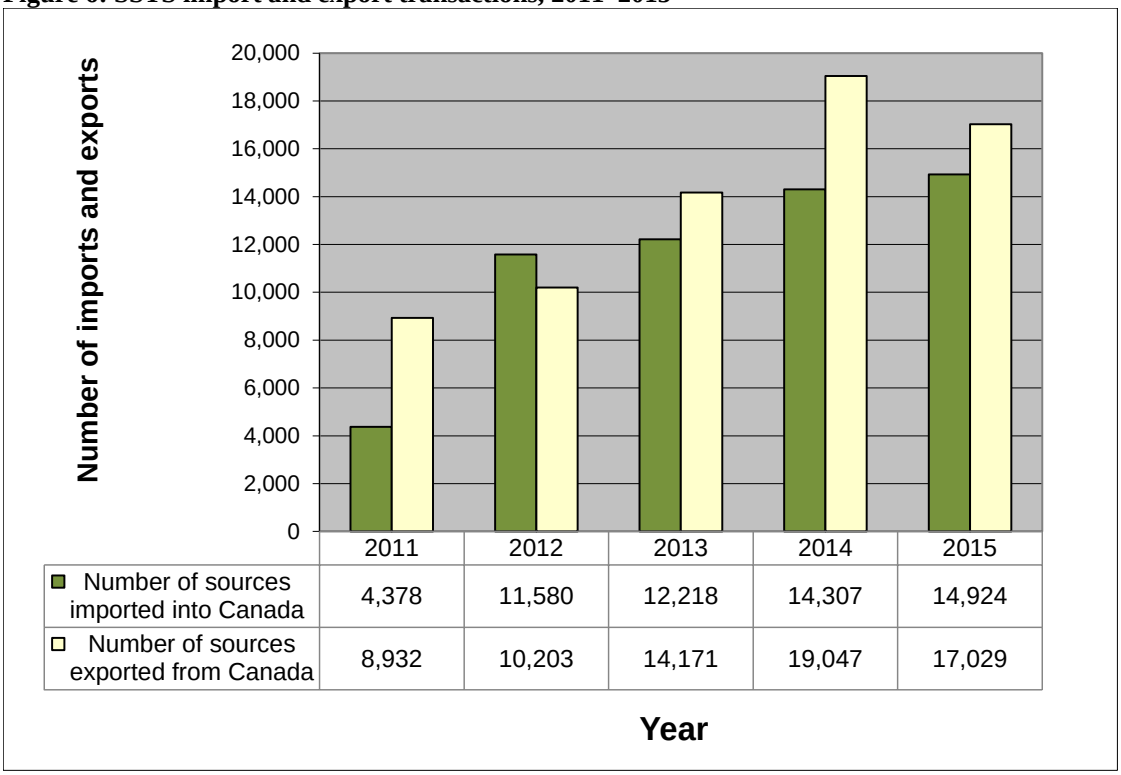


	2011	2012	2013	2014	2015
Percentage of web transactions relative to total number of transactions	83.0%	85.7%	87.6%	93.7%	92.6%

5.3 Import and export transactions

Figure 6 shows the number of import and export transactions in the SSTS for the past five years. Users of nuclear substances in Canada routinely import and export sealed sources (in accordance with their licences). Compared to the previous year, 2015 saw a 10.6-percent decrease in the total number of sealed sources exported from Canada. At the same time, the number of imported sealed sources increased by 4 percent – to its highest value in the past five years. For the most part, these imported sources involved depleted sources that have decayed to a level that is no longer suitable for use in prescribed equipment and were therefore returned to their manufacturers.

Figure 6: SSTS import and export transactions, 2011–2015



	2011	2012	2013	2014	2015
Number of sources imported into Canada	4,378	11,580	12,218	14,307	14,924
Number of sources exported from Canada	8,932	10,203	14,171	19,047	17,029

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 sealed sources in Canada, from their manufacture to their final disposition. Among the G8 countries, the Canadian Nuclear Safety Commission (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.

In addition to the information on high-risk sealed sources included in the NSSR, the CNSC maintains data on all categories of sealed sources used in Canada. The data is based on inventories submitted by licensees in their annual compliance reports. The implementation of electronically fillable forms in 2014 made it easier for licensees to complete these reports, which in turn helps the CNSC by facilitating the compilation of inventory data for Category 3, 4 and 5 sealed sources.

Data from the NSSR and SSTS show that the number of sealed sources in Canada has risen steadily over the past five years. Most importantly, statistics show a 16.8-percent increase in the number of high-risk sealed sources tracked in the SSTS compared to 2014. This increase is largely due to the number of Category 2 sources that are no longer used in certain prescribed equipment and are being returned to their manufacturers.

To confirm the accuracy of the data in the NSSR and SSTS, the routine compliance inspections conducted by the CNSC include requirements to verify licensees' sealed source tracking information. Inspection results for 2015 show a continued high level of compliance with the requirements for tracking high-risk sealed sources movements, with 122 of the 134 inspected licensees (91 percent) found to be compliant. The CNSC ensured that the 12 instances of non-compliance were adequately addressed by the licensees in question. This high level of compliance indicates an ongoing commitment from the licensees to the NSSR and SSTS. It also reflects the system's effectiveness, which contributes to ensuring the safe and secure management of sealed sources in Canada. As a result of the NSSR and SSTS, the CNSC has confidence in the overall safety and security 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:

- the radiological risk associated with the source
- the nature of the work (or application for which the source is used)
- the mobility of the source
- experience from reported accidents
- 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.

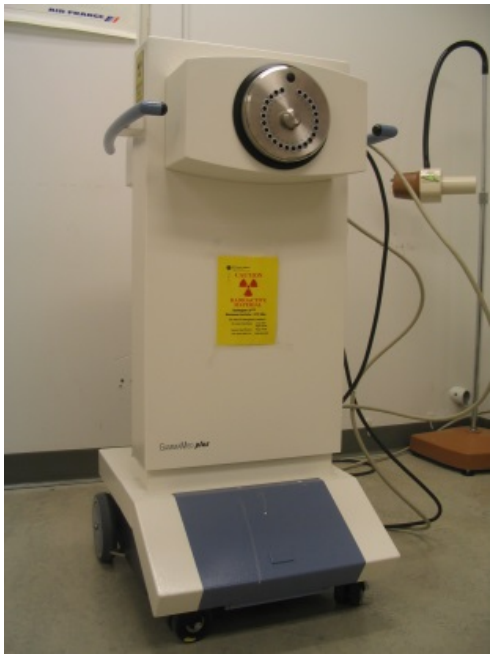
Examples of Category 3 source usage:

- 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