Source Security Program in the Philippines: A Lost Source Search Experience

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Abstract. The Philippine Nuclear Research Institute (PNRI), the national agency in the licensing & regulations of radioactive materials in the country, is strengthening its capabilities in the security of radioactive sources. Part of this program is the PNRI's participation in the Regional Security of Radioactive Sources (RSRS) Project of the Australian Nuclear Science & Technology Organization (ANSTO). The project has provided equipment & methods training, assistance in the development of PNRI's own training program and support for actual orphan source search activities. On May 2007, a source search for the two lost Cs-137 level gauges of a steel manufacturing company was conducted by the PNRI and ANSTO. The source search are the a) development of instrument and source search training for the team, the National Training Workshop on Orphan Source Searches which was organized and conducted as a result of train-the-trainors fellowship under the RSRS project and b) planning and implementation of the lost source search activity. The conduct of the actual search on warehouses, product yard, canals, dust storage, steel making building, scrap yards and nearby junkshops of the steel plant took one week. The week-long search did not find the lost sources. However, naturally occurring radioactive materials identified to be Thorium, were found on sands, bricks and sack piles that are stored and/or generally present in the warehouses, yard and steel making building. The search activity had therefore cleared the facility of the lost source and its corresponding hazards. The NORM found present in the plant's premises on the other hand brought the attention of the management of the needed measures to ensure safety of the staff from possible hazards of these materials. Currently, the course syllabus that was developed is continuously enhanced to accommodate the training needs of the PNRI staff particularly for the emergency response and preparedness. This component of the source security program is thus geared to sustain the capabilities of the Institute by developing the skills of its personnel and its readiness in the future.

KEYWORDS: source security, regional cooperation, lost radioactive source, source search, NORM, industrial gauge, Cs-137

1. Introduction

As part of its program to enhance the security of radioactive sources in the country to ensure the safety of members of the public from exposure to ionizing radiation, the Philippine Nuclear Research Institute (PNRI) participated in the Regional Security of Radioactive Sources (RSRS) Project of the Australian Nuclear Science and Technology Organisation (ANSTO).

Among the activities of the project are a) training program on the use of radiation detection equipment which has been provided by the US National Nuclear Security Administration, b) Orphan Source Search fellowship program for the PNRI staff to develop its skills on the methods, instrumentation and techniques on orphan source searches, c) course development and implementation of training that is tailored to the needs of the Institute and d) support for the conduct of an actual orphan source search.

This collaboration which began in February 2006 became timely when two Cs-137 level gauges have been lost by a PNRI (steel manufacturing company) licensee. A robbery incident was reported wherein scrap metals and the two sources have been stolen from the facility. Following the reports, an orphan source search team was trained on use of the newly provided equipment. After several stages of planning and coordination with the licensee, the source search was conducted on May 2007.

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2. The Lost Source

The two lost sources are Cs-137 pellets which are contained in rods that are used as gamma ray mould level controller for molten steel. The rod measures about 12 inches (1ft) and is encapsulated in a stainless steel container. Figure 1 shows the rod source and assembly drawing. A more detailed data on the source and the corresponding radiological impact assessment is as follows:

Table 1: Source term for the two lost Cs-137 level gauge devices

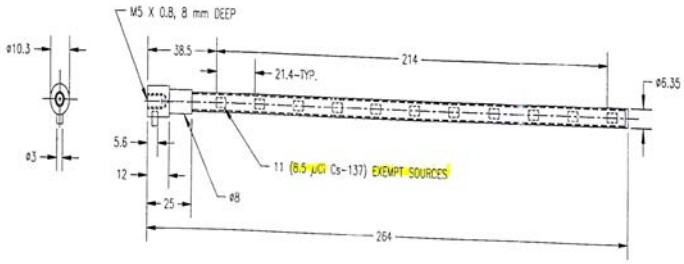
Source	Cs-137
Activity	Two (2) rods containing a total of 22 pellets of Cs-137 0.3145 MBq/pellet Total activity = 6.919 MBq
Usual Physical Form	Crystalline powder and incorporated into seeds, rods or disks in small amounts

The Cs-137 industrial gauge is a Category 5 source. This means that if not safely managed or controlled, it could temporarily injure someone who handled it or were otherwise in contact with it or who were close to it for a certain period of time.

From dose assessment, the effective dose from external exposure that maybe received at 1 meter distance from the rod is E_{eff} = 1.48 μSv/hr. The 1-mSv annual limit for the public maybe exceeded if the individual is continuously exposed to it for 30 days.

Accordingly, for the case where the encasing or container is ruptured, the exposure due to ingestion of all the rods would give a committed effective dose of about 90 mSv. Even if only 2% of the total 6.919 MBq is for instance ingested, the annual limit of 1-mSv to the members of the public would still be exceeded. Inhalation of the 1% of the total activity of the Cs-137 source would result to a committed effective dose of about 4.8 mSv, exceeding annual limit. If the pellets of the Cs-137 powder are spread to contaminate a 1-m^2 area, the total external that maybe received is about 0.014 mSv/hr.

Figure 1. The Cs-137 rod source used in mould level controllers and the canister that contains them. To the right is the assembly drawing of the source.



3. Planning for the Source Search

3.1. Staff Training

The PNRI staff had undergone several training relating to methods and instrumentation in orphan source searches. On 27 February – 3 March, 11 personnel underwent the Orphan Source Search Methods and Equipment Workshop at Sydney, Australia under the Regional Security of Radioactive Source (RSRS) Project of the Australian Nuclear Science and Technology Organization (ANSTO). Under this project, several relevant equipment was provided including training for use of the instruments and practical techniques on source searches.

To sustain the proficiency and competence of the staff on orphan source searches and radiation monitoring in general, a train-the-trainors workshop was again conducted under the project with the primary objective of developing a training program tailored to the needs of PNRI and to be conducted by its own staff.

The training module that was developed from the RSRS project is then conducted to selected PNRI staff on April 2007 as a national workshop in preparation for the actual search. The intensive training which focused on use of the instruments, planning, and methods of the source search include hands-on training, lectures, and several practical exercises with different scenarios that provided the participants the feel of performing in an actual field. From the feedback and comments of the participant, essential needs and key issues were also identified and addressed.

3.2. Planning Committee, Team Members, and Responsibilities

Planning on the actual search of the steel facility began after the national training workshop. Based on the performance and skills of the participants, a team is selected both from PNRI and from ANSTO. A team of 10 PNRI and 4 ANSTO personnel were designated for the source search. All of the members have undergone the training which was conducted in preparation for the search. The roles of the member were determined according to their performances from the exercises.

The search team's primary responsibilities are in the preparations of the materials and equipment needed for the search, designing a sample plan for the search, conduct of searches in accordance with the sample plan, and location and securing of the found sources. In particular the team members' specific roles are as instrumentation specialist, documentation specialist and map maker, health physicist and safety and strategy specialist.

3.3. Site Overview and Search Boundaries

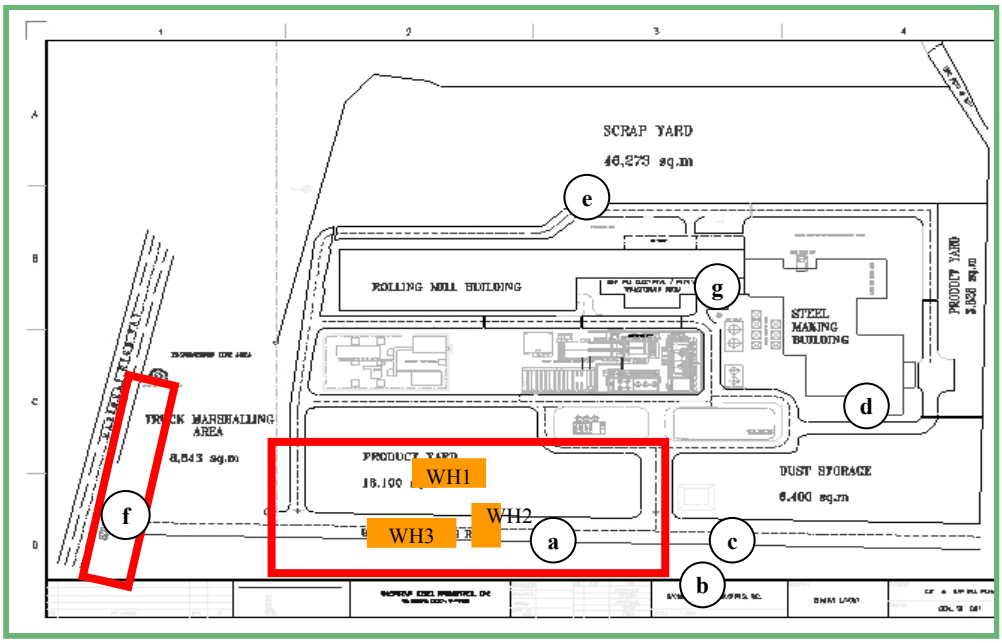
The steel company is a reinforced bars steel production plant. The facility is located at Calaca, Batangas, Philippines with a total land area of approximately 10 hectares (355 m $\times$ 272 m). Figure 2 shows the layout and façade of the site compound.

The plant is a PNRI licensee that uses several Cs-137 mould level controllers. In 2001, the company filed for an indefinite shutdown and the two spare Cs-137 rods which are encased in their lead-shielded vaults were stored in a warehouse along with other assorted metals, bricks and devices. On August 5, 2006, the sources were reported lost including the other scrap metals in the storage area.

Both field and building are searched. These search areas include the entire compound of the facility and the several junkshops nearby the facility. Included in the site search list are: a) product yard where the warehouse is located, b) the drainage system of the compound beside the access road, c) dust storage field beside steel making building, d) the inside of the steel making building where the Cs-137 rods used to be installed, e) a portion of the scrap yard, f) grass area beside the guard house at the main gate, g) and the administrative building where the offices of the employees are, h) five junkshops which are nearby the facility. The search list is prioritized according to the possible pathway of the

source if indeed the rods were stolen and when the sources were only misplaced or hidden within the compound.

Figure 2. Areas in the steel compound where the search was performed. Included also are 1st – 3rd levels of the administrative building.



3.4. Instrumentation, equipment and resources

Several instruments are used by the team to conduct the search for the lost source. The list includes:

5 units – Canberra Radiagem 2000 kits with a portable survey meter and 2"×2" NaI(Tl) gamma probe per kit
4 units – Canberra Inspector 1000 gamma identifier digital survey meter with 2"×2" NaI(Tl) gamma probe and portable multi-channel analyzer (MCA)
1 unit – Canberra Tele SHDE high dose rate gamma G-M telescopic probe
1 unit – NE PDR 4 portable dose ratemeter (back up instrument)
1 unit – Exploranium 1.5"×1.5" NaI(Tl) portable MCA gamma IDENTIFINDER (back up instrument)

For possible source recovery on site, 2 lead pots, handling tongs and gloves were brought. CAUTION tapes, ropes, pegs and spray paint were used to mark the grid areas. For safety precautionary measures, heavy duty and rubber gloves, hard shoes, hard hats, masks, insect repellant, first aid kits, sunscreen, caps, jackets, disposable raincoats were also prepared. Radios were also used for communication between the groups during actual search. Other items brought were drinking water, water cooler, holsters, spare batteries, duct tapes, utility boxes, rubber boots, paper towels etc.

3.5. Search Plan

Direct radiation measurement is the technique adopted for the search. No samples were taken because the rod sources of interest are sealed sources enclosed in stainless steel containers. A systematic sweep direct radiation survey according to a grid size is employed during the search inside the administrative buildings and in the grounds.

Along the canals (drainage), a random survey was conducted but more measurements were taken at the area where a pool of water at the near end of the canal. Inside the plant, only particular structures are monitored, e.g. ladles, furnaces, bay area and portions of a sand stock area.

4. Conduct of the Source Search

The search on the steel plant was conducted on 28 May – 01 June 2007. A briefing from the plant is delivered on the first day and search on administrative building started afterward. The remaining of the day is then spent marking the search area boundaries. The rest of the week is then spent for searching the source according to the site area search plan. The following are the details of results of the search.

4.1. Pre-search Measurements

The sources lost were the spare ones and the three rods that were being used before the shutdown were stored in another warehouse. Dose and count rate measurements were conducted on the remaining rod sources with and without their shielded canisters to determine the detection sensitivity of the instruments used. Table 2 is the summary of the measurements.

Table 2. Source monitoring measurements for the Cs-137 level gauge

Survey Point	Dose rate (μSv/hr)	Instrument Used
At surface contact with rod	~ 35	Canberra Inspector 1000 (SN:08051246)
At 1m from rod	0.4	
~5 m from source (rod outside the canister)	2× bkg	
~1 m from source (rod inside the canister)	2× bkg	
Background	0.02	

The dose rate at contact of the rod is ~35 μSv/hr and 0.4 μSv/hr at 1 meter away. With the rod outside the canister, the instruments could detect twice the background radiation readings at a distance ~ 5m away from the source. With rods inside the canister, the 2× background gamma radiation levels are detected at 1m away.

With the above measurements, the grid spacing used during the area sweep was 2 m^2 for each search member, i.e. member has surveys the grid area at 1 m from the body on both sides.

4.2. Site Measurement Results

The specific site areas searched were according to Section 3.3. The following are the results for each site area.

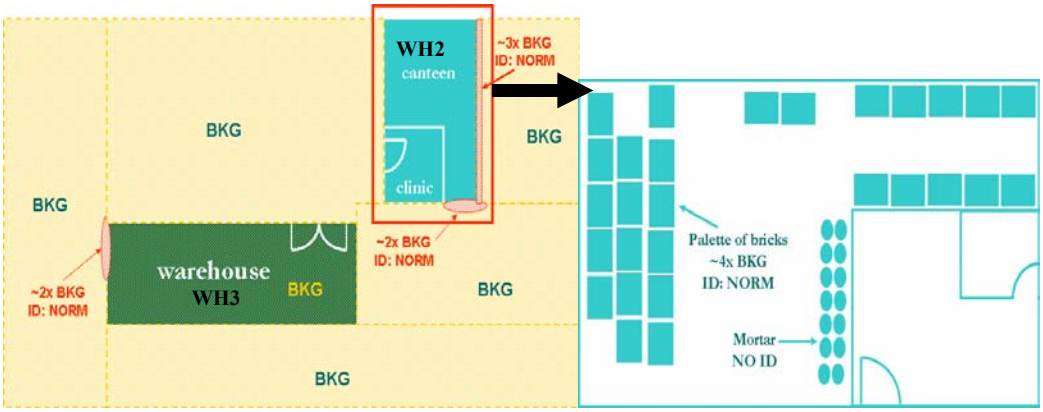
Product yard: The product yard is the area where the sources were reported to have been lost. The area has 3 warehouses and the sources were stored at WH2 (please see Figure 2). Bags of sand and bricks are stored in WH1 and WH2 while some machinery is in WH3. There is uneven terrain and lots of vegetation surrounding the area. The results of monitoring and search are illustrated in Figure 3. Generally, radiation levels at areas outside the warehouses (i.e. vegetation and empty lot area) are within background. However, inside the warehouses readings of up to 4× the background were found on stacks of bricks and sandbags. The materials were identified to be thorium (NORM) with a maximum dose rate of up to 1.2 μSv/hr.

Canal: The canal was approximately 6-8 ft deep and is the pathway of rainwater from the product yard and dust storage areas. Several portions of the canal were monitored and natural thorium was identified.

Dust storage: Dust products from the steel making building are brought to this area. The field is composed of an uneven terrain of rocks and vegetation. Radiation level is found to be generally within background. Some radioactivity was detected on rocks and soil scattered in the area and was identified to be natural thorium.

Steel making building: The factory was monitored for the possibility that the source might have been misplaced or accidentally smelted during manufacture. The linings of the factory ladles and furnaces, bay area and the sand storage section and other machineries that are pathways of steel making were searched. Thorium (NORM) was again identified in these areas with radiation levels at ~ 2× to 4× the background.

Figure 3. Monitoring result for the Product Yard



Scrap yard: The scrap yard is a 46,000 m^2 lot where scrap metals are delivered for smelting. The area is at the time empty of scraps and only the portion where the last delivery was brought was searched. A pile of rocks was found to have radiation levels that are ~3× background. The spot is identified to have Th (NORM).

Vicinity of the guardhouse: Area surrounding the background was also monitored. The terrain is sloping and grassy. Radiation level is found to be within background.

Administrative building: The three-storey building where the offices of the employees and supplies are located is monitored. At the farther end of the 2nd floor where the office supplies are stored, radioactivity was detected in a box of mold casts for molten steel. The casts have a dose rate of 0.6 μSv/hr but no radionuclide was identified.

Junkshops: Five junkshops which are nearest the steel facility is also searched in case the canisters were sold to as scrap metals. The source is however not found in these shops and radiation levels are within background.

To note, elevated radiation levels were also detected along one of the bridges in the highway on the way to one of the junkshops. Th (NORM) is identified.

Generally, sand, bricks and sacks of objects containing naturally occurring radioactive materials such as Thorium was found in the search areas. The materials are used as casts and bricks in steel manufacturing so that they are generally present in the grounds, drainage and steel making building. Figure 4 shows some of the source search activities

4.3. Assessment and Lessons Learned

The Cs-137 sources were not found inside the plant, the surrounding area or the nearby junkshops. The search activity had thus cleared the facility of the lost source and its corresponding hazards. However, the presence of the NORM within the plant's premises needs further attention from the management and appropriate actions must be taken to ensure the safety of the personnel from the possible hazards these materials could pose.

The source search at the steel plant is successful, if not in finding the source in the area, but in confidently declaring that the sources are not there. The search is successful in strengthening the working relationship not only between PNRI and ANSTO but among the PNRI staff as well.

The activity provided the team with invaluable lessons and training. However, although the search was considered a success, it is nonetheless important to note these lessons learned and some points for improvement as a guide for a better and more efficient related work in the future.

1. The search site ranged from wet, dense grassy and sunny areas to dusty, dark and enclosed manufacturing buildings each of which pose several hazards to the team. Necessary actions and preparations are essential to ensure the safety of the team.
2. The instrument units used suffered cable and connection problems during the search which maybe accounted from too much humidity and handling among the few. This serves as a learning experience in terms of the type of instrument used whether it is sturdy enough for extreme working environment. Other considerations such as extendible probes of the instruments and has to be made sure that it is robust, stable, light and easy to handle especially if the instruments are held for longer periods of time

Figure 4. Source search activities at the steel plant compound

5. Conclusions

The collaborative activities of PNRI and ANSTO are invaluable elements of the Institute's efforts to strengthen its source security program, particularly in response to radiological incidents. The instruments provided and the training syllabus developed for the staff as a result of the RSRS project was essential in the conduct of the actual source search at the steel plant by putting into test and practice the skills and methods learned from the training program. The source search also cleared the steel facility of the lost source and thereby of the possible hazards it may cause.

The source search experience is an implication of the good collaboration between PNRI and ANSTO through the RSRS project, the capability of the Institute to develop a course and train its own staff, and the competence and readiness of the team on the use of instruments and methods of the source search. It is a good indicator towards a sustainable security program and perhaps of other related projects in the future.

Acknowledgements

The authors wish to thank the support of ANSTO through the RSRS project for the implementation of the above activities