Journal of Harbin Engineering University
ISSN: 1006-7043

Vol 45 No. 7
July 2024

Radiation Sources in Cambodia (Data Collection and Analysis)

UONG BUNAL
Tomsk polytechnic university, russia

1 Introduction to radiation source in Cambodia

The study and analysis of radiation sources are crucial for understanding their application, regulation, and impact on public health and industry. In Cambodia, the utilization of radiation spans various sectors including medical, industrial, and research fields. Radiation sources are used in diagnostic radiology, cancer treatment, non-destructive testing, food irradiation, and environmental monitoring. However, the availability of data on radiation sources in Cambodia is limited. This scarcity is partly due to the sensitive nature of the information, which is tightly controlled by governmental authorities such as the Ministry of Health. Consequently, comprehensive and reliable data on the use and distribution of radiation sources remain sparse and challenging to obtain.

Despite these challenges, it is essential to undertake a detailed analysis to ensure the safe and effective use of radiation in Cambodia. This chapter aims to present an overview of the current utilization of radiation sources, analyse the regulatory framework and safety measures in place, and provide forecasts for future developments in this field. The objective is to compile and analyse the available data, supplemented by insights from interviews with key stakeholders and a review of relevant publications. The methodology section will detail the data collection techniques employed, including the limited surveys, interviews, and literature reviews conducted. Given the restricted access to primary data, this study also leverages international databases and case studies to contextualize the Cambodian scenario.

Subsequently, the chapter will explore the current applications of radiation in the medical, industrial, and research sectors. This includes an examination of the regulatory framework governing radiation use in Cambodia, highlighting both the strengths and weaknesses of the existing policies. The chapter will also identify the safety measures in place to protect workers and the public from potential radiation hazards. Looking ahead, this chapter will provide a forecast of future developments in the use of radiation sources in Cambodia. This includes anticipated trends in medical and industrial applications, as well as potential advancements in research and technology. By analysing these trends, the chapter aims to offer valuable insights for policymakers, practitioners, and researchers.

Finally, the chapter will discuss key publications and research contributions related to radiation sources in Cambodia. This includes an overview of significant research findings and their impact on policy and practice. Despite the challenges in data availability, this chapter seeks to provide a comprehensive and insightful analysis that underscores the importance of continuous monitoring, regulation, and innovation in the use of radiation sources in Cambodia.

2 Principles of Radiation Protection and Materials

The primary safety objective is to protect radiation workers and the surrounding environment from the harmful effects of ionizing radiation. The main principles of radiation protection include:

- **System of Radiation Protection**: This includes justification, optimization, and dose limitation as specified in ICRP 103.
- **Regulatory Requirements**: Compliance with IAEA/GSR Part 3 standards.
- Designation of Controlled and Supervised Areas: In accordance with national regulations.
- Dose Limits and Investigation Levels.
- Other Related Principles.

The essential regulatory requirements for protection from ionizing radiation are detailed in IAEA/GSR Part 3. To achieve safety objectives without unnecessarily restricting operations or hindering industrial activities that pose radiation risks, a radiation protection system based on fundamental principles is essential. These principles are realized through the following requirements:

- **Justification of Practices**: Any application of radiation must be justified.
- **Dose Limitation**: Dose limits for workers and the public are established, with the expectation that doses received under normal operations will be significantly below these limits.
- **Optimization of Protection and Safety**: All doses should be kept "as low as reasonably achievable (ALARA)," considering economic and social factors.

IAEA/GSR Part 3 specifies that occupational exposure doses should not exceed:

- An effective dose of 20 mSv per year, averaged over 5 years, with a maximum of 50 mSv in any single year.
- An equivalent dose to the lens of the eye of 150 mSv.
- An equivalent dose to the extremities (hands or feet) or the skin of 500 mSv per year.

The table above provided contains information about the dose rates of different radionuclides at various organizations in Cambodia shows that the dose rates vary across the organizations, suggesting differences in the nature and intensity of radiation sources.

Table 1. dose rates using of some organization in Cambodia

No.	Organization	Radionuclide	Dose Rate
1	Khmer-Soviet Friendship Hospital	Co-60	9.86 uSv/h
2	Chip Mong INSEE Cement Corporation	Cf-252	5 uSv/h
3	Sihanoukville Port Autonomous	Co-60	4 uSv/h
4	Laboratory of the Ministry of Public Works and Transport	Cs-137, Am-241/Be	8 uSv/h
5	Mohibar Engineering (Cambodia)	Cs-137, Am-241/Be	17 uSv/h

Co-60 and Cs-137 are common radionuclides used, each with its associated dose rate. Mohibar Engineering has the highest dose rate (17 µSv/h), indicating potentially higher radiation exposure levels compared to the other organizations. Based on the table, the Khmer-Soviet Friendship Hospital has the highest dose rate of 9.86 uSv/h due to the presence of Cobalt-60. The Chip Mong INSEE Cement Corporation has a dose rate of 5 uSv/h due to the presence of Californium-252. The Sihanoukville Port Autonomous Laboratory of the Ministry of Public Works and Transport has a dose rate of 8 uSv/h due to the presence of Cesium-137 and Americium-241/Beryllium. Finally, Mohibar Engineering (Cambodia) has the highest dose rate of 17 uSv/h due to the presence of Cesium-137 and Americium-241/Beryllium. While most organizations exhibit satisfactory radiation safety practices, the higher dose rate at Mohibar Engineering warrants immediate attention. Strengthening monitoring, training, and regulatory compliance measures will contribute to ensuring the safe use of radiation sources across all organizations.

3 Radioactive material in Cambodia

Cambodia has so far made limited use of radioactive materials, as illustrated in Table 1. However, a sharp increase in usage is anticipated in the near future. This expected rise is driven by the expanding applications of radioactive materials in various sectors. Specific applications include:

- **Civil Engineering:** Radioactive materials are used to determine soil moisture and density during construction works. Currently, there are three Troxler Portable Gauges available in this sector; one is operational, while the other two are not in working condition.
- **Beverage Industry:** Radioactive materials help control the liquid levels in containers such as cans of Coca-Cola, beer, and other beverages, ensuring consistent product quality and volume.
- **Cement Industry:** Radioactive materials are used to measure cement density, which is

crucial for maintaining the quality and strength of the final product.

- **Tobacco Industry:** Radioactive materials assist in determining the density of tobacco, which is essential for product consistency and quality control. The growing integration of radioactive materials in these industries highlights the need for continued research and development in control systems. This will not only enhance the precision and efficiency of industrial processes but also drive economic growth and technological advancement in Cambodia. Additionally, ensuring proper maintenance and operation of existing equipment, as well as investing in new technologies, will be key to supporting this growth.

Table 2. Radioactive materials used in Cambodia.

Organization	Application	Source	Activity
Hospital	brachytherapy	^{137}Cs	1.70 GBq
	teletherapy	^{60}Co	198 TBq
	linear accelerator	6 MeV	-
Construction	soil density	^{137}Cs	0.33 GBq
	soil moisture	^{241}Am/Be	1.48 GBq
Company	liquid level	^{241}Am	1.57 GBq

The data reveals distinct applications of radioactive materials across different sectors. In the medical field, hospitals primarily use them for therapeutic purposes such as brachytherapy and teletherapy, focusing on patient care. Conversely, in construction, these materials find utility in soil density and moisture measurements, emphasizing quality assessment in building projects. Interestingly, while both sectors utilize radioactive materials for soil analysis, there's a notable difference in activity levels, with moisture measurement employing a higher activity level, potentially indicating its greater significance in construction processes. Moreover, the comparison between hospital and industrial usage highlights contrasting priorities: patient treatment versus industrial process control. The significant contrast in activity levels between teletherapy, which involves Cobalt-60 with a substantially higher activity level, and liquid level control, which employs Americium with a lower activity level, underscores the varying quantities required for different applications, reflecting their respective importance and scale.

4 Categories of Radioactive Sealed Sources

When selecting an appropriate source, it is important to consider the source's physical properties, its application, the shielding provided by the device, portability, security, and other relevant factors. Understanding these aspects is essential for the planning, handling, and management of a disused radioactive sealed source (RSS). Table 2 outlines the five categories of RSSs.

1. **Extremely dangerous:** Even relatively short exposure (a few minutes to an hour) to these materials can cause permanent damage, including death.
2. **Very dangerous:** Short exposure (hours to days) to these materials can cause permanent damage, including death.
3. **Dangerous:** Exposure (days to weeks) to these materials can cause permanent damage, including death.
4. **Unlikely to be dangerous:** It is unlikely that anyone would suffer a fatal accident from this source. However, this amount of radioactive material is still dangerous if not safely managed or securely protected, especially with prolonged exposure (up to many weeks).
5. **Most unlikely to be dangerous:** No one could be permanently damaged by this source. This amount of radioactive material, if dispersed, could not permanently injure anyone.

The dangerous RSSs (Categories 1, 2, and 3) are utilized as irradiators for radiation processing in various applications, including consumer products, food, healthcare, blood/tissue, radioisotope thermoelectric generators (RTGs), teletherapy machines, industrial radiography, high-dose brachytherapy, logging, and some industrial gauges. Conversely, less dangerous RSSs (Categories 4 and 5) contain radionuclides with long half-lives, such as 226Ra with a half-life of 1,600 years and 239Pu/Be with a half-life of 24,100 years. Despite their low activity levels, these sources pose potential long-term waste management issues.

Table 3. Applications of RSSs for industrial gauges.

Application	Radionuclide	Half-life	Category number
Industrial gauges	^{60}Co	5.3yr	3
	^{137}Cs	30.1yr	3 or 4
	^{252}Cf	2.6yr	3 or 4
	^{85}Kr	10.7yr	4
	^{241}Am	432yr	3 or 4
	^{244}Cm	18.1yr	4
	^{147}pm	2.6yr	4

There are various types of industrial gauges that use radioactive material, with the most common being level and thickness gauges used in process control. These gauges present significant disposal challenges due to their large numbers and widespread use. The RSSs used in industrial applications primarily fall into Categories 3 and 4 (Table 3).

References

[1] T. Mungkola and D.-M. Lee, "Methodology for Establishing National Strategy for Radiation Safety of Nucleonic Gauges in Cambodian Industry," in Proc. Transactions of the Korean Nuclear Society Autumn Meeting, Gyeongju, Korea, Oct. 26-27, 2017.

[2] IAEA, Technical data on nucleonic gauges, IAEA-TECDOC-1459, Vienna, 2005.

[3] ICRP, The 2007 recommendations of the international commission on radiological protection, ICRP Publication 103, 2007.

[4] IAEA, Radiation protection and safety of radiation sources: international basic safety standards, No. GSR Part 3, Vienna, 2014.

[5] IAEA, Fundamental safety principles: No. SF-1, Vienna, 2006.

[6] IAEA, Governmental, legal and regulatory framework for safety: No. GSR Part 1, (Rev 1), Vienna, 2010