RADIATION INCIDENT IN "POLIMERI" DEVNYA, ACTIONS AND SAFETY MEASURES: A CASE STUDY

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Abstract

After the great discovery of Henri Becquerel, the term "radiation" begins to acquire meaning. Since that time (nearly a century ago) the perception for radiation oscillated between extremely negative and extremely positive. Today, we are aware that the radiation can be harmful but also it can be extremely useful. Enjoying the benefits, provided by the radiation, we must be informed, attentive and disciplined. Otherwise the radiation can lead to disastrous consequences.

Key words: *radiation, incident, safety, measures*

Introduction

Today, radiation is used everywhere in our live - in medicine, in agriculture and industry. Near the end of the last century one of the most important applications of the radiation were the signaling devices for inaccessible places and conditions where direct use of other methods was difficult, for example at high temperatures and pressures, within poisonous substances, etc. By measuring of the absorption of radioactive radiation one can control automated processes. Radioisotope sources combined with suitable detectors are used for automated control of industrial processes, e.g. radioactive level gauges and level switches for gases, liquids and bulk materials. In the past radioisotopes were used quite often in the industrial applications in Bulgaria. Some of them, though a very small number, are still in use in some industries today.

Measuring devices using radioisotopes

According to Lilkov [1], the measuring devices using radioisotopes constitute a measurement system of two parts: a radioactive emitter and a detector placed at certain distance. Often, these elements are placed against each other. In this layout, the detector detects the radiation from the source. The radiation passes through the sample material and the thickness, the level of filling or the density of the sample are measured from the absorption.

The principle of operation of this type of devices is based on the dependence between the intensity of the radiation emitted from a point source placed at distance **r** from the detector and the thickness of the absorbing layer **d** between the source and the detector.

$I(x) = I_o e^{\mu x} (1/r^2)$, where I and I(x) denote the radiation intensity emitted from the source and the radiation passed through the layer, respectively.

A construction of a liquid level gauge is shown in Figure 1. In Figure 2 the device is used for liquid materials (crude oil, caustic soda, etc.) or for bulk materials (sand, cement, crops, etc.). Both devices are based on measuring of the absorption of the radioactive rays passing through the respective substance. The device in the first figure is used as level gauge in the container by detecting the change in the density of the detected beam. The device in Figure 2 is used as level switch for signaling of a reached level in the container.

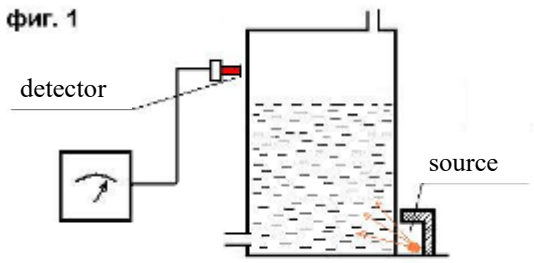

Figure 1. Level gauge

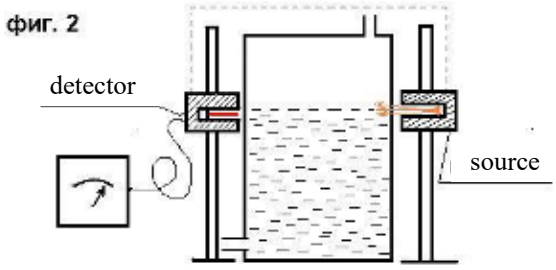

Figure 2. Level switch

Information about the radiation incident

In 2012 in the manufacturing company Polimeri AD, situated in the industrial area of the town of Devnya near Varna was declared a radiation incident. Three radioactive sources of radioactive Cs-137 have been stolen. These sources were used for signaling of reached level in storage tanks for liquid materials in the workshop Chlorine and Chlorine Products. At the moment when the radiation incident happened the author of this paper was employed as inspector in the department "Radiation control" at the Regional Health Inspection – Varna and participated directly in all activities and security measures taken during the incident and in the aftermath.

The company where the radioactive sources have been stolen had a reduced production activity when the incident happened. After the incident, the company was declared insolvent and subsequently it was closed. At that time the property protection was seriously neglected. This negligence provoked the criminal offence, which was revealed on 9th of September 2012, but has been committed on 5th of September 2012 according to the police records. The criminal offence has been committed by several Roma inhabitants living in the town of Devnya. The purpose were not the radioactive sources specifically but their protective containers made of lead. Later, these lead containers were found in a scrap metal junkyard.

Figure 3. Level gauge in the workshop "Liquefaction" - Polimeri AD, Devnya

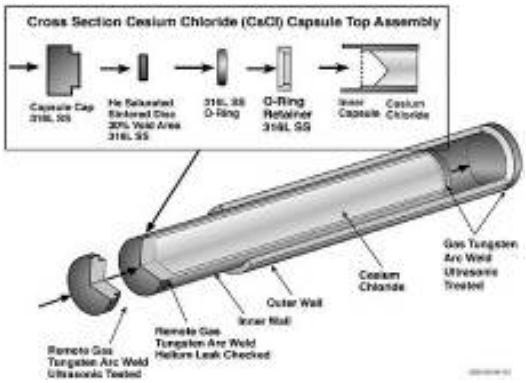

Figure 3a. Capsules of C-137.

The overall appearance of the sources as part of the stolen level switches is shown in Figure 3. The photograph shows the source of the level gauge, placed in a tank in the workshop Liquefaction. The stolen sources and the shown source in the photograph are identical. The only difference is the layout of the emitter and the detector. The stolen sources were placed on one level with the detector on both sides of the tank. The source in the photograph is mounted on top of the tank and the detector is mounted on the bottom part of the tank.

The capsule (Figure 3a) containing the radioactive source Cs -137 is made of stainless steel having following overall dimensions: length 20.8 cm and diameter 2.6 cm. [2] It looks like a large pen. The source is placed in a protective lead container weighting 70 kg. The lead container is mounted on a special metal platform, attached to the respective part of the tank.

Actions and safety measures during the radiation incident

After the theft has been revealed, the person responsible for radiation protection, together with one of his colleagues, went to the Roma residential area. Immediately, the Nuclear Regulatory Agency in Sofia was informed. By means of a device for dose control the stolen radioactive sources have been found, released from their lead shielding. An alarm signal was sent to the division of the Fire Department, which was responsible for radiological emergencies. Specialists were sent to the respective places and the two zones were marked by means of warning tape for the radioactive danger.

In the first zone a dose rate limit of 100μSv/h was measured and in the second one - 1μSv/h, emitted by the stolen sources. On 10th of September the Regional Health Inspection in Varna was notified. That morning the authority sent on site a team of specialists from the Radiation Control Department. The team consisted of the author of this paper as a physicist, a physician - radiation biologist and a health inspector. Based on the initial received information an action plan was forged which was later refined in the course of the events. In Devnya the team formed an emergency staff specifically for this radiation incident. In the course of the activity of this staff information was collected for all the previous actions taken by the police, the Fire Department, the Municipality of Devnya and Polimeri AD. It was found that the stolen three radioactive sources with dismantled lead protection containers have been hidden in the Roma residential area at two different places. Some persons were detained by the police in connection with the criminal offence. Upon completion of the meeting of the emergency staff the physician of the radiobiology team of Regional Health Inspection – Varna, together with the manager of the hospital in Devnya went to examine the detainees in the police headquarter.

Figure 4. Preslav Street, Residential area Gabena Mahala, town of Devnya at the time of removal of the radioactive material

The other two members of the team of the Regional Health Inspection Varna together with the representatives of the police, the Fire Department, the Municipality of Devnya and Polimeri AD went to the Roma residential area. The author of this paper measured safe values of dose rate of the radioactive background. This area was marked with signaling band. Lots of houses of the inhabitants of the residential area are situated there. By the help of the police department the inhabitants were evacuated from the zone of danger (Figure 4).

The next action was removal of the sources out of the residential area and transferring them into the repository for temporary storage of radioactive waste "Polymers AD" - Devnya. For this purpose, protective lead containers and special tools were needed. None of the present members of the emergency staff had the necessary tools. Support was sought from Nuclear Regulatory Agency in

Sofia, but because of the large distance from Sofia to Varna, material support could be expected towards the end of the day. Then support was sought from the Department of Nuclear Medicine and Therapy of University Hospital St. Marina Varna. The hospital owns this kind of containers but they were found to be small.

Support was sought from the private company Multitest OOD Varna, which works with radioactive sources. The manager of the company reacted immediately and sent two specialists equipped with the required means in order to withdraw and transport the radioactive sources into the repository of Polimeri Devnya.

Figure 5. Equipment of a specialist from Multitest OOD

Figure 6. Radiation measuring device (on the top of the photograph). Clamp for handling of radioactive sources (on the bottom of the photograph)

Figure 7. Vehicle of Multitest OOD

Figure 8. Container for transportation of the radioactive sources

Figure 9. Bags with lead spheres for radiation protection of the sources

All pictures are taken by the author with the kind support of the manager of Multitest OOD.

The specialists of Multitest OOD and the Fire Department found the stolen sources and took them out of the residential area. For the whole operation, the equipment owned by Multitest OOD was used (Figures from 5 to 9).

Two of the radioactive sources were found buried in a sunflower field at a distance of about 40 m from a house in Preslav street No.7. The third source was found near the wall of the toilet in the yard of the neighboring house. The toilet is situated about 10 m from the house. The source was thrown between metal scrap pieces. All three radioactive sources were found intact and their metal packaging was not damaged. After the withdrawal of the radioactive sources a dosimetric control was performed on the places where the sources have been found. The background value was measured at all places where the sources have been stored.

Dosimetric control has been performed also in the repository where the container with the radioactive sources were placed. It was found that up to 5 m from the outside fence of the repository there is increased radiation background. The area of increased radiation background was marked and labeled by signaling tape. The company possessing the repository was instructed to take appropriate measures for securing of the repository. The last stored sources had to be placed in appropriate lead containers. So, the radiation level of the repository would comply with the required limits.

Results from the performed inspection of the location of the stolen sources and their documents

The next step was to perform a full inspection on the places where the radioactive sources were stolen from (Figures 10, 11).

Figure 10. Site where the radioactive source was mounted (seen from above)

Figure 11. Site where the radioactive source was mounted (seen from the bottom)

Figure 12. Front side of the fence in the workshop Chlorine and Chlorine Products

Figure 13. Back side of the fence in the workshop Chlorine and Chlorine Products

During the inspection in the workshop "Chlorine and chlorine products" where the radioactive sources were stolen from, following was found: The tanks with the mounted radioactive sources were surrounded by a fence which was not intact and easy to overcome (Figures 12 and 13). The required labels and signaling were existing. There was a signaling equipment mounted over the level of the radioactive sources. Due to this reason, it was not triggered during the theft. Two of the tanks where the stolen devices have been mounted, were empty at the moment of the theft. Therefore, the radioactive beam from their sources has been stopped. Some quantity of the stored liquid was found in the third tank. For this reason, the radioactive source in this tank was still emitting.

Inspection has been performed on the documentation of the stolen radioactive sources. This happened in cooperation with the representatives of the Nuclear Regulatory Agency. According to the license issued by the Nuclear Regulatory Agency each one of the stolen radioactive sources had activity of 96,2 GBq. There was a handover protocol for reception of radioactive sources carrying the year of manufacturing of the level switches – 1978. The period of half-life for Cesium-137 is 30.17 years. Thus, from the date of manufacturing up to the moment of the theft one whole period of half-life has passed and the activity of the sources was reduced to its halve value.

Results from the performed inspection of the other production workshops using radioactive sources

A parallel inspection in all other workshops was undertaken where functional level switches and level gauges with radioactive sources were used. The inspection of the other two production workshops showed following:

Figure 14a. Tanks with level gauges in the workshop "Liquefaction" - the emitters

Figure 14b. Tanks with level gauges in the workshop Liquefaction - the detectors

Figure 15. Tanks with level switches in the workshop Purified Caustic Soda - the emitters

The inspection in the workshop "Liquefaction" (Figures 14a, 14b) found 5 functioning level gauges, mounted on 5 tanks. They were in compliance with the requirements of the radiation protection. The inspection in the workshop Purified Caustic Soda (Figure 15) established the existence of 3 level switches, mounted on two tanks.

Results from the implementation of the safety prescription for temporary storage of radioactive waste

In accordance with the safety prescription for temporary storage of radioactive waste at Polimeri AD the container for the found radioactive sources was exchanged (Figure 16). This exchange was realized by the company Multitest OOD. The exchange was done within 3 minutes. All actions were performed under dosimetric control. High momentary doses of about 500μSv/h were measured. After completion of the operation, again under dosimetric control was performed. It was found that the values comply with the radiation protection.

Figure 16. Sample of a container, where the found radioactive sources were placed for temporary storage

Final actions and safety measures for prevention of new radioactive incidents on the territory of Polimeri AD

After the inspection, due to the existing risk of a new theft, the Nuclear Regulatory Agency decided to revoke the license of the company Polimeri AD. An order was issued for dismounting of all 8 radioactive sources on the territory of the company.

The dismounting and the storage of the devices in the Repository for Temporary Storage of Radioactive Waste of Polimeri AD was done under dosimetric control of the Radiation Control Department of the Regional Health Inspection – Varna. In accordance with the prescription for securing of the temporary repository the storage container of the found radioactive sources was exchanged. Later, all sources stored in the repository of Polimeri AD were transported for burying in the Repository for Radioactive Waste in Novi Han.

Final actions and safety measures to minimize the effects of this radiation incident

An assessment of the received doses has been made for all persons being in direct contact with the radioactive sources. According to that no one has received unacceptably high dose.

A thorough medical examination was performed of the Romani inhabitants, who had direct contact with radioactive sources. They have been held during a month under medical control. No deviation of their health condition has been found.

Conclusions

In order to reduce the possibility for conditions causing radiation incidents it is necessary to tighten the control over the industrial enterprises, working with radioactive sources, namely:

- A stricter monitoring of the characteristic parameter changes of the radioactive element – decreased radioactivity over a period of time;
- A stricter control of the physical and radiation protection for the people in the industrial sites, where radioactive sources are used;
- A stricter control of personnel using radiation sources and the managing staff responsible for the radiation protection;
- Continuous search of new additional measures for radioactive protection of the existing radioactive sources in the company;
- Implementation of more strict measures for the management staff of the industrial companies using radioactive sources in their production process, where these rules for radiation protection have been infringed;
- Update and improvement of the existing legislation and the respective rules for safe use of radioactive sources in the industrial facilities. These rules must comply with the modern equipment.

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