Romanian regulatory infrastructure and radiological incidents mitigation in the industrial radiography and well logging practices

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Abstract. The radioactive sources are frequently used in the category 2 practice of industrial radiography and category 3 practice of well logging. Therefore, the Romanian Regulatory Authority (CNCAN) keeps under strict control these sources by setting up appropriate regulations on safety and security, a system of authorization which requires proper training for the personnel, adequate maintenance for the used equipment, reporting of any incidents. The traceability of the radioactive sources is ensured by the authorization system and by updating the national inventory which is part of the regulatory program. CNCAN usually uses the following main methods to verify the licensee’s operational safety performance: specific authorization limits and conditions of operation, inspections and/or review of written reports asked from the operators. Several times the provisions of the regulatory system were reviewed and improved to update them with the view of meeting the standards in force. The analyze based on the records of the incidents reported in the period from 1999 to 2007 indicates that the number of the incidents and the overexposures occurred decreased. Fifteen events in industrial radiography were reported in this period and ten radioactive sources Am-Be were lost in well during the subsurface operations. Four sources with the activity within a range from 129.5 GBq to 247.9 GBq were abandoned underground and immobilized from inadvertent intrusion. In these events no severe professional overexposure was reported in the national doses registry and no impact on the public health and safety and on the environment was noticed.

KEYWORDS: regulatory; infrastructure; industrial radiography; well logging.

1. Introduction

Romania has a long tradition in using radioactive sources in industrial radiography and well logging. First law and regulations were issued in 1971. Since then the national policies in relation to radiation protection have been reviewed to ensure that they continue to substantially reflect world best practice complying with the international recommendations and requirements [1].

The objective of the Romanian specific regulations is to set out a number of provisions that, properly applied, would prevent the risks connected with the manufacture, use, storage, transport, transfer and disposal of the radioactive sealed sources and would reduce the likelihood of accidents involving such sources. The aim of this paper is to emphasize some specific regulatory actions which have been taken by CNCAN in order to straight the control of radioactive sources and to mitigate the radiological incidents.

2. Regulatory activities

The Law no. 111/1996 on regulation, authorisation and control of nuclear activities [2] defines the powers and responsibilities of the independent regulatory body (CNCAN) in order to ensure a safe deployment of activities and a minimization of the consequences of possible accidents involving inadequately controlled radiation sources. The responsibility for authorization, regulatory review and assessment, inspection and enforcement and for establishing regulations in the field of ionizing radiation with applications in industry is assigned to the Ionizing Radiation Division within CNCAN.

In order to discharge its regulatory obligations and to ensure the safety and security of the radioactive sources CNCAN follows the international standards for maintaining an operational system of notification, authorization, inspection and enforcement [3].

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2.1 Regulations

Based on the provisions of the law, CNCAN is empowered to issue specific regulations for detailing the general requirements for the correct management of radiation sources and to ensure the radioprotection. The radiation safety regulations concerning the two practices taken in discussion are covered by:

- Norms for licensing of use of radiation sources outside the authorized enclosure, approved by Order no. 73/11.02.2002 of the President of National Commission for Nuclear Activities Control, published in Romanian Official Gazette no. 297/07.05.2002 [4].
- Norm on operational radiation protection for the deployment of the industrial radiography with the ionising radiation published in the Official Law Bulletin, Part I, no. 873 of 09/12/2003 [5].

2.2 Authorization process

The authorization process is designed to manage the control of the radioactive sources from the moment these are placed in use to their final disposal. This process interacts with all the other regulatory mechanisms in place. The main characteristic of the authorization process is to emphasize the responsibilities of the holders of such sources. The authorization is required prior to the start of the practice and is issued for each activity intended to be deployed. The assessment process is based on a graded approach directly linked to the associated risk involved by the practice. The written conditions and the validity period of the authorization are issued taking into account the specificity of the activity for which is granted.

The authorization for the use of the installations equipped with radioactive sources is granted if the applicant demonstrates that:

- the responsibilities for the authorization holder, radiological safety officer and workers are defined.
- the training and competencies of the staff are adequate.
- the equipments fulfil the required performance criteria by the international standards.
- the work instructions and operational procedures are available.
- the appropriate arrangements for ensuring the maintenance of equipments are in place.
- the emergency procedures including the communications links are available.

The components of radiation protection programmes include the individual monitoring of occupational exposure and the workplace monitoring requirements. As a general rule, all the authorizations issued by CNCAN specify requirements for incident reporting and emergency preparedness arrangements. It is recognized that the likelihood of radiological accidents is increased when the radioactive sources are used outside the authorized enclosure. Therefore, in addition to these general requirements, specific provisions are set in place and will be briefly described below.

In order to limit the unjustified practice with mobile gammagraphy outside the authorized enclosure the regulations provide special requirements. It is not permitted to perform gamma radiography using a mobile unit without having an authorized enclosure or, in case of well-logging, without having special authorized storage. The application related to practices performed with ionizing radiation outside the special authorized enclosure shall exclusively refer to the specific work assemblies which are going to be performed inside an area or a well determined place (oil well, site), during a period not allowed to exceed one year. The documentation submitted has to contain at least information related to justification and optimization of the activity, description of radiation sources (indicating for each source, the serial number, the radionuclide and the maximum activity during the proposed working period), exact demarcation of areas or places in which the activity is intended to be performed and presentation of the layouts, measures ensuring the compliance with dose limits provided by the regulations, proposed measures and description of their application methods in view of forbidding public access into the area demarcated for performing the activity, monitoring system for staff and environment, measures taken to prevent the lost or theft of sources, arrangements for authorized
transport, intervention plan in case of radiological emergency, list of the personnel involved. To perform the activity of working with sealed radioactive sources outside the authorized enclosure, the applicant has to obtain CNCAN approval, within 30 days from the date of submitting the documentation. The outside work is allowed only under the supervision of a radiological safety officer having a valid work permit level 2 granted by CNCAN.

Other specific regulatory mechanisms are in place in order to ensure that the radioactive sources are properly managed after the termination of the use. Therefore, when the owner of the equipment containing radioactive sources temporary ceases the use activity he has to obtain an authorization to hold it without the permission for usage. The holder is not allowed to keep radioactive sources with short half time (Ir-192). For the radioactive sources with long half time period (Co-60) the holder has the obligation to perform periodically leakage tests. Also, in order to discourage the unjustified long term storage of the equipments the validity of the authorization is limited to 2 years and the fees for authorization are doubled.

For ceasing the activity, the authorization holder shall prove the transfer of radioactive sources as radioactive waste and the absence of areas contamination or shall to obtain the authorization for transfer of the equipments to another authorised user.

2.3 Inspection

Review and assessment activities performed within the authorizing processes involve the planning of the inspection and its follow-up verification, before granting the authorizations for the use of radioactive sources. The inspection regime is legally established in the Law on the safe deployment of nuclear activities, no. 111/1996 republished. The inspections are planned and unannounced. There are also special (e. g. reactive) inspections ordered by CNCAN management, on a short time basis.

The types of inspection that CNCAN is legally empowered to conduct are:
- with a view to the issuing of the requested authorization;
- in the validity period of the authorization, periodically (as planned) or unannounced;
- based on notification from the authorization’s holder;
- when information exists, on activities that might be improperly deployed (including reactive inspections in response to events, incidents or accidents).

CNCAN uses the following main methods to verify the licensee’s operational safety performance:
- specific authorization limits and conditions of operation, which are verified during inspections and/or review of written reports (annual reports, dosimetry results, incident reports, following inspection requirements, etc.) asked by CNCAN;
- periodical inspections, or follow-up inspections planned to verify that written requirements, warnings or directives, as communicated to the licensee, have been timely met;
- reactive inspections, following specific information/notification.

A scale system with performance indicators from A to E is used in order to adapt the inspection frequency and to inform the authorized user regarding the need to improve his safety performance. These performance indicators are used as a specific set of circumstances that aid in early identification of radiation users with potential for degraded safety performance. Inspection findings are fed back into the regulatory process by written reports, following procedural instructions and forms.

2.4 Enforcement

Ionizing radiation applications’ regulatory enforcement regime is legally established by the law [2]. The enforcement actions are graded in order to make them commensurate with the established non-compliance as follows:
- for deviations or violations having minor safety significance: written requirements, warnings, and directives;
- for more serious violations (e.g. imminent radiological hazard): suspension of authorization, contravention penalties;
- in the event of very serious non-compliance: revocation of the authorization contravention penalties and/or prosecution through the legal process.

In addition, the inspectors can require licensees to take disciplinary actions against its employees if there are deemed by the inspectors to have been responsible for the violation of a regulatory requirement.

2.5 National registry of radiation sources and doses

The data base used by CNCAN is a useful information management tool related to the regulatory activities mentioned above and includes the control of radiation sources and occupational doses registry. All the data concerning applicants, authorizations, radiological safety officers, reports, notifications, inspections, sanctions are recorded since 1999 in the database and used for the assessment process and to propose regulatory actions. The national inventory of sources and devices is based on the holders inventories checked during the inspections and updated permanently, when issuing a new authorization, when modifying an existing one, or when renewing an authorization. The inventory of radioactive sources used in industrial radiography and well logging practices is presented in Table 1.

Table 1 Number of radioactive sources used in industrial radiography and well logging practices

<table>
<thead>
<tr>
<th>Source Category</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industrial radiography</td>
<td>234</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Well logging</td>
<td>0</td>
<td>54</td>
<td>8</td>
<td>8</td>
</tr>
</tbody>
</table>

The specific reports asked through the regulatory conditions from the suppliers of the radioactive sources, the users and the approved dosimetry services and the storage and disposal facilities are also recorded in the database and used to make cross checks. The cross checking between the data sets is performed in order to identify potential discrepancies and it enables CNCAN staff to undertake appropriate further actions, i.e. request of an inspection on site, or request clarifications from the users or laboratories. In cases of radiological incidents, the holder of the authorization has to submit a notification of the incident to CNCAN. This notification should be followed later by an incident detailed report which provides more details on the equipments overexposures involved. All the information received is stored in the database.

3. Specific infrastructure

3.1 The emergency arrangements

The authorization holder has the responsibility of identifying incidents/accidents which could affect the occupational exposed workers and/or public and of preparing an emergency procedure. The emergency procedure shall contain intervention plans for the identified radiological emergencies [5]. A radiation protection qualified expert shall be consulted for the elaboration of the intervention plan. The authorization holder can contract an authorized unit to carry out of intervention in case of radiological emergency. The contract shall clearly stipulate the responsibilities of the two parties.

3.2 Infrastructure for radioactive waste management

When a radioactive source is spent, it becomes radioactive waste that has to be disposed off properly. Depending on the case, the holder of a spent source has the possibility either to return the radioactive source to its manufacturer or to transfer it to the Radioactive Waste Treatment Facility. In either case, the holder of the source has to notify CNCAN for the transfer of the source. If the spent source is returned to the manufacturer, then the source is tracked accordingly upon the issuing or modifying of
the relevant authorisation. If the spent source is not sent to the manufacturer, then the holder of the source has to notify CNCAN for the transfer of the source to the Radioactive Waste Treatment Facility. There are available two Radioactive Treatment Facilities in Romania.

3.3 Infrastructure for services

3.3.1 Training and education

Having regard to the need for an appropriate training of the personnel carrying out the gammagraphy and well logging CNCAN developed regulations to ensure the necessary legal framework for defining the roles, duties and responsibilities for the radiation protection qualified expert, radiological safety officer and workers and to recognize their competencies [6]. The recognition system in place consists in a work permit granted by CNCAN, or in case of workers, by the holder of the authorization and it is based on an examination. The obligation of the authorization holders to employ only personnel with an appropriate work permit for deployment of practices involving radiation sources is required by the Law no. 111/1996 on the safe deployment, regulation, authorization and control of the nuclear activities [2]. The work permits are classified on three levels (level 1 for workers, level 2 for radiological safety officer and level 3 for radiation protection qualified expert. The responsibility for ensuring the training of the personnel belongs to the licensee.

The training courses intended for the initial and refresher training have to be approved by CNCAN. The requirements regarding the necessary topics and durations are provided in specific regulations [6]. There are three training courses providers available in Romania and a list containing them is published on the CNCAN’s web site.

3.3.2 Dosimetry services

The authorization holder shall ensure the systematic individual monitoring of all category A occupational exposed workers. The monitoring shall be carried out by one of the 5 approved individual dosimetric services [5].

3.3.3 Calibration services

Authorization holder shall ensure the endowment with an adequate number of dosimetric area control devices, at least one device for each installation with radioactive source and at least one device for each installation used outside the authorized enclosure. Dosimetric control device shall be metrological checked with the periodicity recommended by the manufacturer, by the laboratories designated by CNCAN as laboratories of metrological checking.

4. Conclusion

The safe deployment of the practices involving the radioactive sources can be assessed by using the national registry of doses and sources as a management and review tool. The periodic analysis of the data, recorded in the data base, and the review of the implementation status of the regulatory programme provide useful information on the necessary future regulatory actions which have to be taken for improvement. Some results on the safety deployment of the industrial radiography and well logging practices are presented in the following figures.

The review of the dosimetric reports collected in the period from 2001 to 2007 highlights the trend in the evolution of the collective, average dose and the number of the exposed workers involved in the different practices. The distribution of the collective doses per dose interval recorded and reported for the exposed workers is presented in Fig.1 in case of industrial radiography practice. The main characteristic of the distribution of doses is the Gaussian shape centred on the interval from 1 to 10 mSv. The distribution of doses in the interval from 10 to 20 mSv placed in the vicinity of the annual dose limit is a characteristic of the collective doses reported at international level.
Figure 1: Collective dose per dose interval in industrial radiography

The distribution of collective doses per dose interval recorded and reported for the exposed workers in well logging is presented in Fig 2. The main characteristic of this distribution is the Gaussian shape centred on the interval from 1 to 5 mSv.

Figure 2: Collective dose per dose interval in well-logging practice

The distribution of the number of occupationally exposed workers in industrial radiography per dose interval is presented in Fig 3. The figure reveals a relative high number of occupationaly exposed workers in the last 3 years with doses in the range of 0 ÷ 0.2 mSv.

Figure 3: Number of workers per dose interval in industrial radiography
The distribution of the number of occupationally exposed workers in well logging per dose interval is presented in Fig 4. This distribution confirms the compliance with the annual dose limit.

**Figure 4:** Number of workers per dose interval in well-logging practice

In the period from 1999 to 2007 the number of incidents and overexposures occurred has decreased. In the same period ten radioactive sources of Am-Be were lost in well during the subsurface operations. Only four sources with the activity within a range from 129.5 GBq to 247.9 GBq were abandoned underground and immobilized from inadvertent intrusion according to the procedure.

The investigation of the reported incidents in industrial radiography showed that these occurred due to the disconnection of the radioactive source from the remote control cable or because the radioactive source remained blocked outside the protection shield of the container. No radioactive source or container deterioration as a result of an accident during transportation was reported. In these events no severe professional overexposure was reported in the national doses registry.

**Acknowledgements**

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