Radiation Safety Practices of Industrial Radiography license holders in South Africa

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Abstract
Compliance with lawful regulations and licensing conditions in industrial radiography has been identified to be problematic by the International Atomic Energy Agency (IAEA). In South Africa the Department of Health (DoH), Directorate for Radiation Control is legislated to license and monitor the safe utilization of all ionizing radiation. In this work, we first highlight two ‘early’ well documented cases of radiation overexposure and review more recent – not so well documented cases and trends that are evident. All reported cases of industrial radiography overexposure indicate that a lack of proper education and training contributes significantly to these incidents. Further, unrealistic workloads and service providers appetite for profits has also been a major factor.

Monitoring and periodic auditing of license holders is identified as a fundamental shortcoming. Staffing of the Directorate for Radiation Control and its ability to prosecute negligent license holders is a possible corrective action that needs urgent attention. Communication and sharing of information between the Radiation Control Directorate and the dosimetry service agencies (South African Bureau of Standards (SABS) – Radiation Protection Services (RPS) and NTP Radioisotopes (Pty) Ltd) must be strengthened. In the long term, a repositioned / separate regulatory body is suggested.

Keywords: radiation overexposure, Industrial radiographer, radiation dose, radiation incidents.

1. Introduction

A study of accidents and incidents is essential for the regulator to assess and tighten all loops holes that may exist in radiation control. It is also essential for the users of NDT radiography, so that they can reflect on their practices and ensure a reliable and safe delivery of inspection.

Act 15 of 1973 provides a legal framework for the use of radioactive material, classified as group IV hazardous substances.

Regulations relating to group IV hazardous substances, published under Government notice R247 in the Government Gazette 14596 of 26 February 1995, further clarify all aspects relating to and amongst others, application for authority to posses and conditions attached there to.

A key aspect of these regulations is found in chapter 3, regulation 6 of the schedule. It addresses the need to appoint a radiation protection officer (RPO) and an acting radiation protection officer (acting RPO).

Regulation 6, read in conjunction with regulation 2, sub regulation (1) (b) (v) & (vi), clearly requires the particulars (name, address, occupation, qualification, and experience) of the person being considered for the RPO position.

Henceforth, all will thus be controlled, monitored, and recorded through the knowledge and on behalf of the RPO.
It therefore stands that without fulfilling this crucial requirement, the application for authority will not be considered. This is emphasised in regulation 2, sub regulation 3 (a).

The Directorate of Radiation Control has compiled two documents that are premised and advance the ALARA principle. They are:


In everyday radiographic testing, the measures that are basic to controlling exposure dose such as, time, distance and shielding are usually ignored, whence the occurrence of overexposure. Personal monitoring mechanisms such as the wearing of TLD badges, having a pocket dosimeter, carrying a calibrated and working survey meter are overlooked. Allowed maximum permissible doses as stated in the above documents are ignored, or no recording of such incidents becomes a norm.

It is with the above background that this paper therefore aims to initiate a discussion and find ways to reduce radiation incidents and accidents. It also aims to create an enabling platform for the reporting of all radiation incidents and accidents, and a medical follow up of the persons affected.

2. Radiation accidents and incidents

Safety measures in industrial radiography rely heavily on human behaviour that is, taking the necessary precautions when working with radioactive material. For example, the use of a properly calibrated and working survey meter and in the case of an industrial radiography incident the effective implementation of emergency procedures is paramount to containing over exposure, particularly to non-radiation workers and the general public.

The main causes of accidents in industrial radiography are; failure to follow procedures, lack of proper training, insufficient regulatory control, inadequate maintenance of equipment and hence its malfunction, and at times wilful violation [1].

A pro-rata overexposure limit over a wearing period (28 days) must be applicable, according to the general information for the use of personal dosimeters, supplied by the RPS.

The general pro-rata value of 4 mSv is determined as follows:

\[
\text{50 mSv allowed maximum accumulated dose per year} \div \frac{13 \text{ personnel dosimeter wearing periods per year}}{\approx 4 \text{ mSv}}
\]

Codes: coding for type of accident [2]

- A—Radiation accident (unspecified or other)
- A-os—Orphaned source accident
- A-s — Accidental exposure to source

Public: Codes indicating case involved known exposure to the public (i.e. non-employees).

- X—exposure among public
2.1 Reported cases of radiation accidents and incidents before the year 2000

Table 1. Cases from the rest of Africa [2]

<table>
<thead>
<tr>
<th>Date</th>
<th>Location</th>
<th>Type</th>
<th>Code</th>
<th>Dose (rem/rad)</th>
<th>Deaths</th>
<th>Injuries</th>
<th>Public</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 May 1978</td>
<td>Sasolburg, Transvaal, South Africa</td>
<td>Lost radiography source</td>
<td>A-os</td>
<td>100-140rem</td>
<td>1</td>
<td>6</td>
<td>X</td>
<td>Ir-192</td>
</tr>
<tr>
<td>19 March 1984</td>
<td>Casablanca, Morocco</td>
<td>Lost radiography source</td>
<td>A-os</td>
<td>-</td>
<td>8</td>
<td>3</td>
<td>X</td>
<td>Ir-192</td>
</tr>
</tbody>
</table>

Table 2. South African cases [2]

<table>
<thead>
<tr>
<th>Date</th>
<th>Location</th>
<th>Type</th>
<th>Code</th>
<th>Dose (rem/rad)</th>
<th>Deaths</th>
<th>Injuries</th>
<th>Public</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 January 1977</td>
<td>Sasolburg, Transvaal, South Africa</td>
<td>Lost radiography source</td>
<td>A-os</td>
<td>116rad</td>
<td>0</td>
<td>1</td>
<td>X</td>
<td>Ir-192</td>
</tr>
<tr>
<td>1989</td>
<td>Witbank, Transvaal, South Africa</td>
<td>Radiography accident</td>
<td>A</td>
<td>225rem</td>
<td>0</td>
<td>1</td>
<td>X</td>
<td>Ir-192</td>
</tr>
<tr>
<td>1990</td>
<td>Sasolburg, Transvaal, South Africa</td>
<td>Lost radiography source</td>
<td>A-os</td>
<td>10-55rad</td>
<td>0</td>
<td>4</td>
<td>X</td>
<td>Co-60</td>
</tr>
</tbody>
</table>

2.1.1 The silent killer (unknown radio isotope) [3]

One evening in 1998, a radiation assistant on the Saldanha Steel construction site was ordered to wind in the isotope and collect all radiography equipment that had been used that day. He carried the heavy isotope container about eight floors down the tower with the guide tube coiled around his neck. Carrying a faulty survey meter or no other monitoring instrument, he was not aware that the radioactive source had become dislodged. Instead of being inside the container, it was inside the guide tube.

For 20 minutes his body was exposed to gamma rays. It is estimated that the radiation assistant received 20 times more radiation than the maximum dose allowed in one year. The first signs that severe radiation had set in, was his vomiting and thereafter being extremely thirsty. His health took a turn for the worst, and finally led to the amputation of his breast.
2.2 Reported cases of radiation accidents and incidents post the year 2000

Table 3. Cases from the rest of Africa [2]

<table>
<thead>
<tr>
<th>Date</th>
<th>Location</th>
<th>Type</th>
<th>Code</th>
<th>Dose (rem/rad)</th>
<th>Deaths</th>
<th>Injuries</th>
<th>Public</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 May-</td>
<td>Meet Halfa, Qaluobiya,</td>
<td>Lost radiography source</td>
<td>A-os</td>
<td>2.5-15rem</td>
<td>2</td>
<td>5</td>
<td>X</td>
<td>Ir-192</td>
</tr>
<tr>
<td>3 July 2000</td>
<td>Egypt</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>August 2000</td>
<td>Dakar, Senegal</td>
<td>Accidental exposure to</td>
<td>A-s</td>
<td>-</td>
<td>0</td>
<td>4</td>
<td>X</td>
<td>Ir-192</td>
</tr>
<tr>
<td></td>
<td></td>
<td>radiography source</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>23 March 2008</td>
<td>Rades, Tunisia</td>
<td>Lost radiography source</td>
<td>A-os</td>
<td>200rem</td>
<td>0</td>
<td>1</td>
<td>X</td>
<td>Ir-192</td>
</tr>
</tbody>
</table>

2.2.1 A report compiled by a level III NDT practitioner [4]

As of 01 November 2011, information [ISO 9001 verifiable], was obtained from the Curriculum Vitae (CV) of 122 radiography performing personnel that were stored by company A. The personnel had been involved in radiographic testing with a total of 35 different NDT companies, all assumed as Licence Holders.

On analysis of the information sourced from the above CV’s, the following facts were established:

- 58% of the personnel did not have a DOH winding licence which was a direct non-compliance with reference 1 clause 2.4 [5].
- 43% of the personnel had not been registered as radiation workers (No South African Bureau of Standards (SABS) BIN number or Landauer (limited period use)) which was a direct non-compliance with reference 1 clause 7.2.1 [5].

During interviews of 20% of the personnel that were registered, it was further established that they had never seen a life dose record despite generally working on contract, and having been released, from at least, on average, 3 different companies (Licence Holders) which was direct non-compliance with reference 1 clause 2.11 [5].

In addition just about every other conformance issue related to reference 1 had been ignored, waived or broken, mostly the latter.

Many of these personnel have been ‘authorized’ by NDT level 3’s to carry out radiography under a company’s written practice.

Many had received statutory overdoses during a wearing period, up to 128 mSv well above the allowed dose limit for 5 years, without the mandated investigations, reports and corrective actions including discarding or amending dose records with the Directorate for Radiation Control.

Further analysis showed that some of had exceeded dose limits such as the statutory 50 mSv allowed maximum annual and/or 100 mSv over a 5 year period with no action whatsoever having been taken. The 100 mSv overdose requires actions to be taken as detailed in reference 1 [5]. Where dose records existed these were full of other anomalies such as, working for one company whilst the badge was registered to a different company and missing wearing periods.
3. Discussion

Whilst some of these overdoses had been briefly ‘looked at’ and reports suggest that these were due to carelessness such as leaving badges in jackets, however, these had not been expunged or corrected. Others have been due to excessive work loads and nobody (even the RPO) had bothered to contact end users regarding either workload sharing or possible overdoses to other workers in the vicinity.

The ultimate question then becomes, who must accept a large amount of responsibility for this unacceptable situation? Should the 12 major South African end users on whose sites the activities occurred be held responsible? Obviously these illegal activities are the responsibility of the RPO’s, in cahoots with top management. The following reasons are advanced to help explain the proliferation of these illegal activities.

a) Directorate of Radiation Control has not followed up on reported overdoses particularly to persistent offenders and or companies.
b) End users have not ensured a safe working environment for both contracted NDT and their own staff, including their Safety and Quality responsibilities.
c) Licence Holders have not complied with their responsibilities nor have they ensured or assured compliance by their staff.
d) Authorizing NDT level 3’s do not know or follow the requirements.
e) RPO’s do not know or follow the requirements.
f) Radiographers, Trainees and Assistants do not know the regulations but are fully aware that no-one else does or cares and their illegal actions are justified by life experiences.

In addition a number of those interviewed have carried out such work in other African countries admitting similar illegal conduct.

4. Conclusion

Whilst it is true that the personnel interviewed in the above report were mainly from one province of South Africa, it is hard to believe that the other provinces, and indeed the rest of Africa can be excluded. This is held true due to the fact that NDT services companies operate wherever they are contracted.

The other factor promoting the need for disclosure is that the very personnel who are guilty of the illegal activities feel that they have no option, as refusing to do so will simply mean they lose their employment. They basically all agree that they want to be compliant but if their company’s don’t care, the end users don’t care and the authorities don’t care how can this be achieved?

In the medium term, the following is suggested:

a) Directorate for Radiation Control takes charge as they are supposed to under their mandate.

Reference 1 needs some revision and clarification, to include one very important addition namely:

Each end user is charged with a responsibility to assure that any radiographic activity carried out under their responsibility or on their sites/premises complies fully with these requirements and the proof must be auditable.
b) Directorate for Radiation Control starts a recovery exercise rather than an all out offensive action including criminal prosecution as they have indicated they may do. This does not rule out prosecution where there is evidence of gross endangerment to workers or members of the public but hopefully a ‘Truth and reconciliation process’ may elicit more support from the radiographic fraternity and provide a solution rather that forcing the culprits’ further underground.

c) DOH places every Licence Holder on notice that their licences have been removed suspended until next renewal date or for one year. Within that suspended period each Licence Holder must prove, with independent verification, whether they meet all the requirements, particularly regarding life dose compilations for every radiation worker they have ever used over the past 5 years.

There are recovery factors which can be used for missing records, including contracting iThemba-Labs for some of the work. These records maybe later amended on approval of DOH Directorate for Radiation Control with assistance of the SABS - RPS.

As there will most likely be problems, and keeping personnel employed will be a major motivation factor towards the ideal solution, the following can be done.

i) Ensure all personnel are registered.

ii) Once registered they can be used a trainees, provided they have safety course certificate, albeit under direct qualified supervision.

Once the above is completed the same process should be applied to every individual ‘winding licensed’ radiographer. Their renewals to coincide with them having to undergo a re-training course and provide a complete life dose record.

e) End users must include radiation safety risk assessment and monitoring within their Occupational Safety and Health Act activities.

f) NDT level 3’s must not ‘authorize’ any radiographic personnel until they know that the personnel are fully compliant and pay particular attention to the RPO activity within their company.

It is of prime importance that radiography personnel must work safely, hence, raising the safety levels in industrial radiography that will make this world a safer place for all.

To reduce radiation accidents and incidents in South Africa and Africa as a whole, the formation of an industrial radiographer driven ALARA network with IAEA oversight is necessary. This network would focus its energies on the following:

- Collecting and collating information concerning occupational overexposures.
- Highlighting both good practices and shortcomings and whence recommend the types of actions, for example, training, managerial and behavioural, to be taken to assist the industry, clients and regulatory bodies
- To act as an information sharing forum and whistle blowers for non-complying licence holders.

In the long term, though, autonomous regulatory bodies must be established.
**References**

4. Hugh Neeson, ‘radiography performing personnel that are mainly from the KwaZulu Natal area’, a private report, January 2012
5. Code of Practice for Industrial Radiography – Gamma Radiography Directorate: Radiation Control, IRCP91-2, Revised: October 2010