SAFE USE OF RADIATION SOURCES IN INDUSTRIAL RADIOGRAPHY
A SURVAY IN HAZARDS EVALUATION IN IRAN

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Abstract: The use of radiation source of various types and activities is widespread and led to dramatic advances in industry, medicine and agriculture. Although the other techniques of NDT methods have also been developed and widely implemented, the unique details of data obtained by radiography and the fingerprint as a film, have caused radiography to be more appreciated and preferred for the volumetric inspection of products. Simplicity in application and accepted results of radiography using radiation sources is the major reason to consider these sources most predominant in Iran.
Radiography (RT) covers more than 80% of our NDT field, and about 90% of RT techniques are using radiation sources. So, consideration of safe use of radiation sources is reasonable and vital. Effective measures have to be established and implemented to protect, personnel, people and environment from harmful hazards of radiation sources.
In this paper, some hazard potentials of application of these sources are discussed according to the national regulations and international recommendations. Advantages and limitations in implementation of regulations are pointed out. Then an applicable quality structure concerning safety is introduced.
Emphasizing on the key elements, an emergency case "Radiation Accident in industrial radiography with single overdose exposure" is selected as a case study. Causes, consequences and health state of the victim with the respected medical care are discussed. This accident was reported to the International Atomic Energy Agency (IAEA).The case was followed then accordingly.

Introduction: Radiography is a routine daily work in our inspection fields. Now over …inspection companies with RT functions have been registered in our National Radiation Protection Department (NRPD). More than radiographers are involved in this practice. Benefits of film production for the applicant, Radiation Hazard Concerns for Regulatory Authority shall be carefully balanced. The consequence of a Radiation accident can vanish the sweet taste of good results of Radiography
Different strategies made by (NRPD) during last 15 years of implementing Radiation Protection Act in Iran. Radiography Test was used much before but mostly by foreign companies with least involvement of local operators. In the first years we faced with numbers of experienced operators without training from one side and less knowledge of RT techniques in the NRPD in the other side, while expecting the operators to observe Radiation Protection Principals. Serious efforts made in this respect to develop and establish a Radiation Protection System, which is vital. This system is established with following objects:

- To introduce the Radiation Protection Principles
- To expect the good engineering practice,
- To deal with the events and consequences, and
- To improve the procedures

Results:

1. . **General**: The system emphasise on the management of effective implementation of Radiation sources. Even there are several parameters involved in protection from unnecessary or excessive exposures, but none of them are sufficient to be effective without an integrated system. The system shall include both the Regulatory and the Applicant.

2. **Potential loss of control over radioactive sources in radiography:** Investigation on the records show that the most cases of unnecessary or excessive exposures could be occurred in following areas:
   - Transportation
   - Radiography process
   - Source change
   - Projector service
   - storage
   - Loss due to sabotage, theft, terrorism,…

3. **Essential elements of national infrastructure:**

3.1 National Regulations and International Recommendations:

Radiation Protection act was enforced in 1989. Respected regulations developed on this basis considering recommendations of (IAEA) emphasizing on the justification of the practice. According to the Basic Safety Standards (BSS) Radiographic activities is under supervision of (AEOI) and the applicants shall obtain respected licenses. Regular monitoring is performed by the inspectors to the premises. Results are fed back to the procedure developments.

3.2 Professional Societies and Work Procedures:

Good engineering practices require defined work procedures. These procedures need to be verified through the appropriate body. The inspection companies are encouraged to establish professional society and develop working procedures and written practices.

3.3 Quality Structure:

Management is responsible for development of a suitable quality structure. All the personnel shall bear responsibility for implementation of the requirements.

Requirements were identified in the Regulatory Authority first. Necessary measures were taken to fulfil the needs including sufficient training in Radiography.

The licensees asked for a quality system including:

- Personnel Qualification
- Radiation Protection monitoring devices and equipments
- Safe storages and premises
- Working documents and,
- Emergency planning

3.4 Safety Culture:

Accidents may not be prevented but mitigation of the consequences and frequencies of repetition can be well controlled by a stringent quality system leading to a Safety Culture. It is achievable by declaring the safety policy, preparing and updating radiation protection procedures and good performance. Non-conformities to be identified, corrected on time and preventive measures be taken. Adequacy of safety standards, optimization of procedures could be achieved in this respect. Evaluation of radiation protection monitoring indicates effective progress in recent years. Decreasing the annual effective doses of Radiographers in spite of increasing the number of operators, less accident reports with increasing near miss reporting are evidences of bright signs in building safety culture. Valuable lessons are gained from accidents occurred in the past.

4. **An accident case study:**

Early morning of July 24, 1996 a radiation accident happened at a construction site in a Gamma radiography practice. The accident was a single overdose of non-radiation worker. The accident had a victim with serious radiation damage. The accident left

some consequences continued up to now. Analyses of the accident with root cause study confirmed the necessity of paying more attention to quality system in radiography centres. The case was reported to IAEA and published in 2002 under the title of "The Radiological accident in Gilan"

4.1 Identification of accident:

Type of accident: overdose due to external exposure of Ir-192 radioactive source
Cause : fall-out of the source from radiographic Gamma projector
Consequences : severe radiation damage to the victim.

4.2 The story:

About 3 am, after termination of radiographic job, while handling the gamma projector to the storage, the source holder dropped from the projector. It was not noticed by the operator. Source was laid down in a narrow channel next to a building and was picked up by a worker on his way to start his daily duties at about 8 am. The holder was shiny and interesting in shape, so he held it in his hand for awhile then put in his blue-suit chest pocket. He started his isolation job with 3 other co-worker. In a short time, much less than an hour, he felt nauseating, and later vomiting. He was taken to a rest area by one of the co-workers. There he took this strange object out, throwing it beneath the bench for later opportunity to take it. This time was reported about 10 am. Meanwhile, the noticed the loss of loss source about 7-8 am. Radiographic team started searching the source individually, hopping to handle the case among them selves. Finally they found the source holder in the rest area at about 12 o'clock when crowded and left the site immediately. Site management was realised the case due to unordinary movements reported. They questioned the team and they declared the case was under control!

AEOI emergency team took immediate actions after being informed by the site manager. Brief survey addressed the victim and suspicious exposed personnel to the radiation. Authorities followed remedial medical care accordingly for 600 site personnel. All found in healthy condition except the victim showed a total dose of about 4.5-5 Gray hole body. At the time of writing this report, the victim of the accident has been followed up for 8 years. His health status is satisfactory, despite severe restriction of movement in his right elbow, which appeared early on, and fibrosis in the left palm, which developed unusually late (4 years after the accident). He survived the acute radiation disease without very severe complications, and fortunately he has a good prognosis for survival. Nevertheless, his ability to work remains considerably limited. Even though there might be further (stochastic) health effects in the future for the exposed person, sufficient information is already available for a report to be written.

4.3 Accident analysis:

- The accident happened early morning when the operators were exhausted and one of the operators had already left for film processing so the team was limited to only one radiographer and a simple worker.
- Use of existed radiation detector or its operational condition is suspicious. Otherwise, the source holder position could be detected immediately.
- Rest position of the source was not monitored in the storage area after termination of the job and handling the projector to the storage area.
- Periodic safety checks of the projector were not performed.
- The projector was defective and probably the operation was continued knowing that the safety pin of the source holder was wearied out.
- The radiography team had no emergency plan or did not follow accordingly and was not prepared for any emergency situation. So;

- Site manager was not informed on time of the source loss
- Regulatory authority was not informed immediately, getting to the emergency case.
- Coming to know that the lost source is in the crowded place, the area was not evacuated.

Discussion: The data collected from the Hiroshima and Nagasaki Life Span Studies are the basis for radiation protection standards issued by International Commission on Radiation Protection (ICRP). There are few references on good engineering practice. In spite of guidelines each country shall define its own strategy and develop the necessary quality system considering the international ICRP standards as the minimum requirements. Safety culture of the country is the main concern similar practice may give different results in different country.

National Radiation Protection Program in Iran started when quite large numbers of radiographers were involved in the radiography with less concern in Radiation Protection Principles. There was also less knowledge of professional radiography among the NRPD experts. So, different expectation of the issue was existed. For an effective program following strategy was observed:

- Short-term radiation protection training courses conducted for radiographers.
- NRPD experts trained in radiographic techniques.
- International standards were adopted in national radiation protection procedures.
- Different categories of programs developed for preliminary, and advanced Radiation Protection Training for operators and Radiation Safety Officers.
- Social issues and technical needs in radiographic practices were studied.
- Professional model training on Radiography was conducted by Regulatory Authority according to the International ISO 9712 standard requirements emphasising on radiation protection concepts in Radiography.
- Establishing a model ranking system of the Radiography Companies considering their capabilities in fulfilment of Radiation Protection requirements.
- Encouraging the operators to report the near miss or accidents right on time and considering this in the ranking system of the companies.
- Continuous upgrading of the monitoring system to realise the needs and feed back them in the specific training programs

Status of Industrial Radiography centers in Iran (2004)

Subject	Numbers
Radiographers	1467
Radiography Centers	108
Gamma Radiography Devices	402
Total Workers (radiographers & other staffs)	2092

Various events (including accidents, incidents and deviation) related to Gamma Radiography Devices in Iran (reported from 1997 to 2003)

Main defect that led to events	No. of events
Connections	50
Guide tube	47
Locking system	68
Source assembly	63
Drive cable	39

Average Annual Effective Dose and Annual Collective Dose Received by Workers in the Industrial Radiography Centers, from 2001 to 2003

Year	Annual Collective Dose (Man.Sv)	Average Annual Effective Dose)mSv(
2001	1.22	1.75
2002	1.24	1.69
2003	2.43	1.65

Conclusions: Safety is a main concern needs continues monitoring and effective upgrading the quality system. The policy of the National Regulatory Authority was modified from restricted regulation observation to consider good engineering practice by including working documents and professional training in the safety aspects beside the Safety and Radiation protection Instruction. Instead of preventive measures, we could introduce correct procedure for job performance, which will fulfil the Safety requirements as well.

References:

1. National Radiation Protection Act of 1989
2. IAEA Safety Series Recommendations, No. 102 1990
3. IAEA Safety Standards Series, Safety Guide No. RS-G-1.4
4. IAEA –TECDOC-1388
5. AEOI Medical Reports
6. Limitations of ICRP Recommendations for Worker and Public Protection from Ionising Radiation