Radiation Protection in Industrial Radiography: Training and Inspection

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Abstract

Industrial radiography involves strong radiation sources. It is therefore important that the operators are well instructed on how to use the equipment involved, and which radiation safety procedures have to be followed. This is even more important in the case of mobile radiography.

In the Netherlands the operators of industrial radiography equipment have to be trained on radiation protection by an acknowledged training institute. The subjects to be treated have been described in a guideline of the Dutch authorities. Without a diploma, one can not be an operator.

Röntgen Technische Dienst bv (RTD) is the largest non destructive testing company in the Netherlands, and has its own training department which provides courses on industrial radiography, and radiation protection.

Next to training it is important that inspections are carried out regularly by independent safety inspectors to verify that operators work according to the procedures. At RTD inspections are carried out unannounced.

The results of RTD's policy will be given.

Introduction

Industrial radiography (IR) is a justified application of ionising radiation since there is a net benefit. There is no other method of non destructive testing (NDT) that produces the same valuable and accurate information about certain types of material defects. If these defects are not detected the consequences for public health, and the environment can be very severe. Without IR safe transport, storage, and process of dangerous chemicals would not be possible. Further IR is an irreplaceable method to insure the reliable fabrication of steel constructions for buildings, and bridges. Moreover, safe air traffic depends on IR.

However IR also accounts for approximately half of all the reported accidents for the nuclear related industry.

The IAEA classified the primary causes of these accidents in eight categories [1]:

1. Inadequate regulatory control
2. Failure to follow operational procedures
3. Inadequate training
4. Inadequate maintenance
5. Human error
6. Equipment malfunction or defect
7. Design flaws
8. Wilful violation

This paper focuses on the first three categories. It describes the regulatory control, and training system in the Netherlands, and it describes the operational procedures on Radiation Protection that have to be followed within Röntgen Technische Dienst bv (RTD).

The paper ends with presenting the results of the policy of RTD by summarising the dose records of operators working at RTD.

Regulatory control in the Netherlands

In the Netherlands a policy on IR is developed by the relevant authorities in co-operation with the NDT companies that has lead to an adequate, and workable system of regulatory control.

To perform IR, a company must have a license in accordance with the Dutch Nuclear energy Act. In this license requirements are stated regarding:

- the organisation of radiation protection within the company, and the level of expertise of radiation protection officers, and operators;
- the encapsulated radioactive sources, and x-ray equipment;
- the way in which IR is performed, i.e. that it may only be performed by crews consisting of at least two persons, that controlled areas have to be established and supervised during operation, and that maximum dose rates may not be exceeded;
- the storage facility for radioactive sources;
- the exposure of the environment, i.e. the general public; and
- obligatory checks, registrations and reports: e.g. regular checks of the shielding, and radiation levels of x-ray tubes, contamination control on gamma sources, and record keeping of the radiation dose received by the operators, and the environment.

Both the Labour Inspectorate, and the Environmental Inspectorate can perform announced or unannounced inspections to verify if IR is performed according to the applicable law and regulations, and the license that has been granted to the company.

It should be noted that unlike most other countries, in the Netherlands IR is performed only by a limited number of bigger companies. These companies have the infrastructure, and human resources to implement the requirements stated in the license. It is our conviction that this is an inevitable condition for the safe performance of IR.

In the Netherlands no separate license is required for the transport of gamma sources used in IR, but these transport have to be carried out in accordance with the rules stated in the ADR.

Training of operators of Industrial Radiography equipment

According to the Dutch Radiation Protection Ordinance [2], someone who applies radioactive sources or x-ray equipment must have expertise on the risks of ionising radiation, the ways of protection against these risks, and the activities that are carried out with the sources, and equipment. A guideline has been drawn up by the Dutch authorities for the recognition of courses on radiation protection [3]. According to this guideline radiation experts are classified in five levels, ranging from level 5 (lowest) to level 1 (highest). For the levels 5 to 2 the subjects, and the objective for each subject are prescribed, not only for the theoretical part, but also for the practical part. At the end of the course the students have to pass an exam that is approved by a committee in which members are present that represent the Dutch authorities.

In licenses that are granted to companies the minimum level of expertise to perform certain activities with ionising radiation are prescribed. Operators of IR equipment should at least have a diploma in radiation protection at level 5.

At this moment refresher courses are not obligatory, but in the future when registration of radiation experts will be introduced, they most probably will.

Already since 1960 RTD has its own training department, not only to train (future) NDT operators on NDT methods, including IR, but also on radiation protection. The last mentioned course, that is also open for other students than RTD's employees, is recognised by the Dutch authorities. The big advantage of having future operators trained at RTD is that these courses are given by teachers that have field experience, and therefore have knowledge of the specific radiation protection problems that are associated with IR, and the solutions for these problems.

Policy of RTD: operational procedures

Some facts about RTD

RTD bv, established in 1937, is a Dutch company that belongs to the RTD group. This consists of companies that operate from offices around the World.

In the year 2000 RTD bv had 235 gamma camera's, 356 x-ray tubes (maximum 320 kV), and one 8 MeV linear accelerator at its disposal to perform IR. Most gamma camera's are filled with ^{192}Ir sources, that at the moment of purchase have an activity of about 1.7 TBq. Sources are replaced when the activity is reduced to less than 0.08 TBq.

During the financial year 1999/2000 481,938 films were exposed.

The number of IR operators permanently employed at RTD bv is about 100.

Handbook Radiation Safety

Every new IR operator receives a handbook on radiation safety that describes the basic rules of RTD. These basic rules are an implementation of the requirements stated in the license, and other regulations. A very important rule states that during the performance of IR, an operator continuously shall use a good-working doserate monitor in order to perform control measurements. The operator must consider the monitor as his sixth sense. Further it is RTD's policy that operators must wear both a TLD meter, and a pendosemeter. The advantage of a pendosemeter compared to electronic personal dose meters is that it will never show a value that is significantly lower than the actual dose received. The reading of the pendosemeter must be recorded every day by the operator on his timesheet. In case the reading of a pendosemeter is out of scale, the TLD meter of an operator should be read out immediately in order to establish whether this is due to a high radiation dose or a malfunction of the pendosemeter.

Site inspections

Like any kind of repetitive job, also with IR the risk exists that operators trust too much on their own routine, become careless, and finally fail to follow the basic rules. Therefore the greatest challenge for an IR company is to keep its operators alert. For this RTD has implemented a system of work place-, or site inspections. During these inspections either supervisors from the department Operations, or (independent) safety inspectors from the department Safety & Environment perform unannounced visits during which they check if the operators work according to the basic rules. A standard checklist was developed for this purpose. The penalty for not obeying the rules depends on the severity of the violation, and can lead to a bad result during the yearly assessment of an employee, or even to dismissal from RTD in case of wilful or repeated violation.

In the year 2000 the department Safety and Environment, and the department Operations performed respectively 283, and 358 site inspections. Regarding radiation safety 18 violations were found by the department Safety and Environment, and 6 by the department Operations. The most frequent violation was that operators used a doserate monitor of which the calibration had expired.

Results of RTD's policy: dose records of operators

Tables 1, and 2 give information about the number of radiological workers at RTD bv, and the doses received by them [4]. A distinction is made between category A workers, and category B workers. Operators of IR equipment belong to category A. The number of category A workers is larger than the number of operators, because this also includes non-permanent employees, and other workers. Further, it should be noted that the radiation doses received by the workers are not only directly from IR, but can also be due to working in environments with a high radiation , e.g. nuclear power plants.

The TLD-meter of a radiological worker is read out monthly. The department Safety and Environment sends a letter to a person if a single readout is higher than 1.5 mSv. The number of letters sent in 1998, 1999, and 2000 were respectively 16, 7, and 13. The exceeding of the dose of 1.5 mSv was usually small, and the main causes were prolonged working with radiation sources, and mistakes by operators.

The results of RTD's policy show that continuous effort leads to low radiation doses even for operators that work with strong radiation sources.

Table 1: Collective, and average dose of radiological workers at RTD bv

	Number of persons				Collective dose (in mSv)				Average dose per person (in mSv)			
Year	1997	1998	1999	2000	1997	1998	1999	2000	1997	1998	1999	2000
Cat. A	406	474	401	439	919	574	561	565	2.26	1.21	1.40	1.28
Cat. B	48	48	48	72	2	2	1	9	0.04	0.04	0.02	0.12
Total	454	522	499	511	921	576	562	574	2.03	1.10	1.25	1.12

Table 2: Distribution of the collective dose over the radiological workers of RTD bv

Dose range (D in mSv)	Number of persons			Percentage		
	1998	1999	2000	1998	1999	2000
D≤2	440	342	418	80.0	76.2	81.9
2<D≤6	92	90	79	16.7	20.0	15.4
6<D≤20	18	16	14	3.3	3.6	2.7
20<D≤50	0	1	0	0.0	0.2	0.0
D>50	0	0	0	0.0	0.0	0.0
Total	550	449	511	100.0	100.0	100.0

References

[1] International Atomic Energy Agency. *Lessons learned from accidents in industrial radiography*. Safety Reports Series No. 7, ISBN 92-0-103098-3, Vienna, 1998.

[2] Besluit stralingsbescherming ("Radiation Protection Ordinance"), Besluit van 16 juli 2001, houdende vaststelling van het Besluit stralingsbescherming, Staatsblad 397, 6 september 2001 (in Dutch).

[3] Richtlijnen voor de erkenning van opleidingen deskundigen radioactieve stoffen en toestellen, zoals gepubliceerd op 20 november 194, Stcrt. 227 (in Dutch).

[4] Röntgen Technische Dienst bv. Jaarverslag 2000 Veiligheid & Milieu. Rotterdam 2 March 2001. (Yearly report on Safety and Environment, in Dutch).