TRAINING IN RADIATION PROTECTION FOR INDUSTRIAL RADIOGRAPHERS AND SOME GENERALS ON RADIATION PROTECTION CULTURE IN AUSTRIA

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Summary

In Austria, training in the field of industrial radiography is done according to two regulatory systems, namely the: „Society of Non-Destructive Materials Testing“ as well as the radiation protection laws and associated regulations.

The training procedure for gamma-radiographers requires completed job training and is structured in 3 modules, formulated by the society of non-destructive materials testing. Every gamma- as well as x-ray application has to be evaluated by an authorized radiation protection specialist with a well defined minimum of working experience in the field.

The Austrian Research Center in Seibersdorf (ARCS) is one of the institutes that offer the full course of radiation protection training in Austria. Based on a basic training module, several special courses can be accomplished, each including a standardized test.

Collaboration with researchers in the field of radiation protection guarantees the best possible information about new development and techniques for the trainers working at ARCS. Due to high Austrian standards in radiation protection, no accidents with dangerous doses have been registered so far.

However, opening of the eastern markets puts a lot of economic pressure on companies who work in the field of non-destructive materials testing, especially in gamma-radiography. New training centers open up, offering low cost education, resulting in less reliability based on the application of safety standards.

Therefore, an international standard harmonizing the requirements for industrial radiography seems desirable.

1. Introduction

Industrial radiography is responsible for a significant number of high dose cases exceeding annual dose limits and is thus responsible for serious radiological accidents[1]. For instance, a serious radiological accident occurred in Peru in February 1999 when a welder picked up an ^{192}Ir industrial radiography source and put it in his pocket for several hours. His wife and children were also exposed [2]. In Austria, about 200 people work in the field of non-destructive materials testing with ionising radiation. Due to high Austrian standards in radiation protection, no accidents with detrimental health consequences have happened so far. However, opening of the eastern markets puts a lot of economic pressure on companies who work in the field of non-destructive materials testing, especially in gamma-radiography. New training centers open up, offering low cost education, resulting in less reliability based on the application of safety standards. Harmonization and standardisation seems to be an important element to counteract an erosion of the safety culture.

2. Regulations and structure of education in radiation protection in Austria

In Austria, training in the field of industrial radiography is done according to two regulatory systems, namely the: „Society of Non-Destructive Materials Testing“ [3] as well as the radiation protection laws and associated regulations [4].

As a member of the EU, Austria subscribes to EU law. Since March 2000 the EU guideline for the protection of ionising radiation came into force [5], however, new Austrian radiation protection legislation has not passed parliamentary agreement till now. New regulations call for a reduction of annual dose for radiation workers from 50 mSv to 20 mSv on average, that is, a maximum dose of 50 mSv in one year and 100 mSv in five years.

Gamma-radiographers in Austria have to have a certificate of the society of non-destructive materials testing. To obtain the certificate, workers are supposed to complete a three step education program which also contains training in radiation protection. For field work, radiographers have also to complete radiation protection education as demanded by the Austrian law. Such a curriculum based on a basic training course and several special courses can be accomplished at the Austrian Research Center Seibersdorf, the largest research institution in Austria, with each module containing a standardized test. About 75 percent of all industrial radiation workers in Austria complete their education in radiation protection at the ARCS. Trainers at ARCS guarantee the best possible information about new developments and techniques through collaboration with researchers in the field of radiation protection,.

3. Radiation exposure of industrial radiographers in Austria

The need for the application of ionising radiation in materials testing as well as the risk inherent in such applications has received widespread international attention. A *Safety Culture* has developed, based on common elements shared internationally. A major contribution towards a general *Safety Culture* originates outside of the field of industrial radiography and results from the recognition of widely accepted safety standards for transport and application of radioisotopes, as well as the acceptance of internationally agreed maximum exposure levels for the occupationally exposed workforce. Thus, standardisation plays an important role in the perception and avoidance of risk.

For the subject area radiography, standardisation has been carried even further. An international standard (EN 473) covers the qualification and certification of persons involved in materials testing with ionising radiation. Therefore, a number of elements may be identified as integral parts of the aforementioned *Safety Culture*:

- ➢ Standardisation
- ➢ Training
- ➢ Certification
- ➢ Experience

It shall be emphasized that Good Radiography Practice (in analogy to Good Laboratory Practice) is a complex topic and a cursory discussion will not reveal the full scope of the matter. However, a number of necessary (but maybe not sufficient) elements shall be addressed.

Standardisation has already been mentioned both in relationship to general safety of ionising radiation as well as to aspects of qualification of radiographers. This is an important fact to offset the effects of market pressure, i.e. more profit with less qualified workers. Especially in

Europe, where (product) liability does not have the implications as compared to the US, *a priori* standards have much more significance than *a posterioi* law suits.

In order to achieve qualification as delineated in the above mentioned standards, training is an important requirement. In Austria a general radiation protection training course is an essential requirement to establish familiarity with the basics of ionising radiation and the application thereof. Additional special topics are offered as dedicated seminaries to radiographers wishing to establish their qualification.

Certification of acquired skills goes far beyond testing. An examination – as the final item of a training course – may resemble the capacities of the chosen training institute only. To achieve more uniform training results, Austria has established a scheme of accreditation. The Austrian Society for Non-Destructive Testing serves as the independent body assessing the performance of aspiring radiographers and awards them with proper certification, provided all requirements are complied with. This national tool enforces not only proper minimum requirements for qualifications, it provides also a platform for discussion and modification of national curricula.

However, the most important element of all is experience and the sharing thereof. Current dose records indicate a high safety awareness – on closer inspection certain potentials for improvement may be identified. These shall be elaborated later. Let us turn before to an important element of experience, the near misses, the accidents that got just avoided. Codes of practice, general and specialised training, standard operating procedures, 'Good Radiography Practice' – these all are elements to avoid accident situations and unjustified radiation exposures. All these help to minimise risk, however, risk cannot be eliminated entirely. Equipment does malfunction, people have their bad days – sometimes a confrontation with a potentially hazardous situation cannot be avoided. A great number of these situations are dealt with before the show up in the dose records, which testifies to the high level of qualification of the radiographers. A number of European initiatives emphasize the lessons learned from accidents and near-accidents by making this information available in data bases. Nevertheless, a few observations based on an Austrian 3 year dose survey among radiographers shall be made.

In Austria, all radiation workers have to wear thermoluminescence dosimeters to check occupationally received doses. Nearly all dosimeters used by industrial radiation workers are analysed by the accredited and certified laboratory at ARCS monthly.

Table 1 shows the doses received from radiographers of four different Austrian companies in the time from Jan 1997 to Nov 1999. Close to 1400 dosimeters have been analysed at this time. The radiographers of company 1 accomplish approx. 85 percent of materials testing in workshops with shielded rooms, 15 percents in the field. For the workers of companies 2, 3 and 4 the fraction of workshop and field work is entirely reversed, about 15 percent of the testing is done in workshops and about 85 percent in the field. Not surprisingly, the average and maximum doses received by workers in company 1 are much lower than the others. The mean value of the doses is about 2,5 times lower as the mean value of the doses received in company 2. But the mean value of the doses from company 2 are about 1,5 times lower than the values from company 3, although both of these companies radiographers work about 85 percent in the field. The dose exposure of the workers from company 2, 3 and 4 is higher during the warmer months and lower during winter time. This can be explained with the fact, that during cold periods construction sites are closed and demand for materials testing in the field is low.

mSv/ month	Company 1 (avg 9 worker)			Company 2 (avg 5 worker)			Company 3 (avg 17 worker)			Company 4 (avg 8 worker)			Avg	Max	Min	Num
Date	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min				
Jän-97	0,12	0,21	0,07	0,61	1,53	0,07	0,49	2,84	0,08	0,46	0,94	0,13	**0,42**	**2,84**	**0,07**	**39**
Feb-97	0,10	0,16	0,05	0,68	1,71	0,05	0,31	1,37	0,05	0,36	1,01	0,06	**0,30**	**1,71**	**0,05**	**40**
Mär-97	0,18	0,36	0,06	0,49	1,63	0,07	0,70	3,80	0,08	0,76	1,45	0,09	**0,53**	**3,80**	**0,06**	**45**
Apr-97	0,17	0,32	0,08	0,41	1,16	0,07	0,76	2,19	0,08	0,78	1,50	0,09	**0,56**	**2,19**	**0,07**	**44**
Mai-97	0,17	0,61	0,07	0,29	0,86	0,05	0,94	7,21	0,06	0,57	1,28	0,09	**0,57**	**7,21**	**0,05**	**45**
Jun-97	0,28	1,29	0,06	0,66	2,08	0,05	0,70	2,92	0,08	1,10	2,45	0,12	**0,64**	**2,92**	**0,05**	**44**
Jul-97	0,16	0,37	0,06	0,52	1,38	0,06	1,34	14,47	0,08	0,89	2,51	0,09	**0,81**	**14,47**	**0,06**	**45**
Aug-97	0,46	2,78	0,06	0,90	2,29	0,05	0,80	4,52	0,05	0,60	2,00	0,12	**0,68**	**4,52**	**0,05**	**46**
Sep-97	0,30	1,69	0,06	0,50	0,80	0,07	1,00	3,93	0,05	0,76	1,93	0,12	**0,73**	**3,93**	**0,05**	**41**
Okt-97	0,12	0,19	0,07	0,43	1,26	0,09	1,19	3,96	0,08	0,68	1,78	0,08	**0,73**	**3,96**	**0,07**	**38**
Nov-97	0,17	0,29	0,08	0,21	0,56	0,07	0,62	2,13	0,05	0,91	2,73	0,12	**0,50**	**2,73**	**0,05**	**41**
Dez-97	0,16	0,38	0,07	0,24	0,44	0,09	0,48	1,85	0,08	0,55	1,23	0,14	**0,36**	**1,85**	**0,07**	**41**
Jän-98	0,14	0,25	0,07	0,27	0,67	0,06	0,18	0,58	0,06	0,45	1,78	0,11	**0,23**	**1,78**	**0,06**	**38**
Feb-98	0,10	0,12	0,06	0,29	0,85	0,06	0,19	0,56	0,05	0,37	1,14	0,09	**0,22**	**1,14**	**0,05**	**32**
Mär-98	0,22	0,58	0,05	0,47	0,81	0,07	0,34	1,40	0,07	0,72	1,83	0,14	**0,40**	**1,83**	**0,05**	**40**
Apr-98	0,12	0,18	0,08	0,26	0,49	0,06	0,40	1,74	0,06	1,04	2,67	0,11	**0,43**	**2,67**	**0,06**	**37**
Mai-98	0,13	0,24	0,06	0,46	1,34	0,07	0,66	4,76	0,06	1,01	2,64	0,15	**0,59**	**4,76**	**0,06**	**39**
Jun-98	0,15	0,34	0,05	0,47	1,27	0,07	0,63	3,96	0,07	0,79	1,83	0,10	**0,51**	**3,96**	**0,05**	**40**
Jul-98	0,21	0,71	0,06	0,56	1,08	0,07	0,64	2,57	0,06	0,58	1,27	0,11	**0,51**	**2,57**	**0,06**	**35**
Aug-98	0,18	0,39	0,06	0,60	2,09	0,08	0,65	2,53	0,05	0,69	1,08	0,12	**0,53**	**2,53**	**0,05**	**39**
Sep-98	0,18	0,39	0,09	0,22	0,40	0,06	0,74	2,55	0,07	0,81	1,98	0,12	**0,54**	**2,55**	**0,06**	**36**
Okt-98	0,12	0,17	0,08	0,49	0,93	0,06	0,67	2,42	0,06	0,79	1,72	0,10	**0,54**	**2,42**	**0,06**	**39**
Nov-98	0,13	0,27	0,06	0,43	1,67	0,06	0,39	1,36	0,07	0,79	2,75	0,10	**0,43**	**2,75**	**0,06**	**37**
Dez-98	0,14	0,20	0,08	0,36	0,95	0,06	0,25	0,68	0,05	0,42	1,12	0,09	**0,27**	**1,12**	**0,05**	**35**
Jän-99	0,25	0,95	0,07	0,42	0,94	0,07	0,52	3,01	0,08	0,64	3,36	0,11	**0,46**	**3,36**	**0,07**	**39**
Feb-99	0,12	0,18	0,05	0,27	0,58	0,06	0,28	1,14	0,05	1,08	4,52	0,09	**0,39**	**4,52**	**0,05**	**36**
Mär-99	0,11	0,14	0,06	0,39	0,77	0,09	1,01	5,31	0,07	0,74	2,18	0,07	**0,69**	**5,31**	**0,06**	**35**
Apr-99	0,10	0,13	0,06	0,42	1,10	0,06	0,34	1,17	0,07	0,87	1,81	0,08	**0,41**	**1,81**	**0,06**	**37**
Mai-99	0,10	0,19	0,05	0,46	1,36	0,05	0,66	6,81	0,06	0,96	2,49	0,08	**0,59**	**6,81**	**0,05**	**39**
Jun-99	0,17	0,54	0,06	0,32	0,77	0,07	0,86	4,60	0,05	0,91	2,11	0,07	**0,66**	**4,60**	**0,05**	**41**
Jul-99	0,22	0,56	0,07	0,29	0,52	0,06	1,15	11,69	0,05	0,74	2,00	0,06	**0,74**	**11,69**	**0,05**	**39**
Aug-99	0,12	0,24	0,06	0,72	1,74	0,10	0,86	6,41	0,07	1,20	4,52	0,08	**0,80**	**6,41**	**0,06**	**39**
Sep-99	0,25	1,00	0,07	0,77	1,98	0,08	0,58	2,28	0,05	1,77	6,57	0,08	**0,86**	**6,57**	**0,05**	**39**
Okt-99	0,14	0,21	0,08	0,82	2,11	0,05	1,14	9,43	0,07	0,65	1,01	0,10	**0,78**	**9,43**	**0,05**	**37**
Nov-99	0,08	0,10	0,06	0,96	1,56	0,05	0,43	1,42	0,05	0,48	0,93	0,08	**0,45**	**1,56**	**0,05**	**34**
	0,18	**2,78**	**0,05**	**0,47**	**2,29**	**0,05**	**0,66**	**14,47**	**0,05**	**0,78**	**6,57**	**0,06**	**0,54**	**14,47**	**0,05**	**1371**

Table 1: Doses received by radiographers of 4 different Austrian companies from Jan 1997 to Nov 1999. Company 1 works predominantly in the workshop, whereas companies 2,3, and 4 wok primarily in the field.

Not only the location of materials testing is an important parameter for the level of the received doses. There are also other components. It must be assumed that the safety culture in a company is a very important parameter which influences received doses. One important element of a safety culture is education and training of the employees. Another significant influence factor is the pressure at work, the stress level workers in different companies are subject to. If workers have ‘enough time’ for each gamma-radiographic picture they have the possibility to take more measures to ensure the ALARA principle. For instance, the use of collimators reduces radiation exposure of the worker(s) drastically. To use such collimators time is needed for installation before exposure. Another important parameter is the activities of the sources involved. Sources with high activity need short exposure times. Therefore more exposures can be accomplished in the same working day, consequently attaining low prices for single exposures. On the other hand, the radiation exposure of the workers increases by the use of sources with high activity, not only during exposure but also during transport of the source. Consequently, higher than reasonably achievable doses may result.

As can be seen in table 1, some workers received in one month a dose comparable to the new annual average of 20 mSv, which is acceptable as a mean value over 5 consecutive years by the new EU regulations (see e.g. company 3, Jul 1997, 14,47 mSv; Jul 1999, 11,69 mSv). This being one of the reasons, the Austrian Standards Institute (OENORM) created standards for radiation protection for gamma-radiography. In this standards, a monthly dose limit of 20/12 mSv is recommended as the limit of the monthly dose received by radiography workers [6].

4. Standardized regulations of education and training in radiation protection in the EU

Starting in the last years, some companies from the former eastern countries have begun to offer low cost gamma-radiography in Austria. This has increased the pressure on Austrian materials testing companies. The main reason for the low prices may be found in low wage costs in this countries. It has to be avoided that this pressure leads to neglecting the accepted safety culture, especially the ALARA principle.

Standardization and harmonization is an important tool in safeguarding the safety culture, and much has already been accomplished in this area. However, looking beyond national borders, standardised curricula or qualification criteria are still far away. This originated – at least to some extent – in the Euratom Treaties of Rome (1957), granting autonomy to national legislation in the field of radiation protection. Mutual acceptance of qualified experts is still emerging. This framework of international consensus is especially important where market pressures impinge on safety culture, allowing free traffic of goods (and services) without detailing the conditions subject to which products (or services) are offered. Efforts both on a common understanding of a safety culture as well towards harmonization in this area are desirable and will be supported by Austrian experts.

5. Multimedia based radiation protection training

The problems mentioned above confront the radiation protection training with a lot of new challenges. New EU-guidelines require a regular training repetition, commercial pressure requires an increased safety culture as well as modern training methods, which impart the knowledge to the radiation workers fast and easily. Multimedia based training methods are tools which can – in principle – measure up to this expectations. Modern computer- and information technologies expect the trainer – beyond his professional knowledge – to deliver well prepared instructions using this modern equipment. The radiation protection academy at ARCS uses a multimedia presentation in their radiation protection training. Tools include the well known overheads as well as flip chart, animated power point presentation and special computer programs like simulated experiments in the field of nuclear physics and radioactivity. The aim is not simply a better presentation, the didactics of radiation protection training itself guide the use of educational tools. Two examples shall be given:

- Example 1: The basic course on radiation protection is meant to impart the fundamental concepts of nuclear physics. For instance, the exponential function is not – due to different educational background – known by every participant. A computerised simulation with flexible parameters is used to illustrate the concepts of radioactive decay, half life and activity as well as their interdependence.

- Example 2: The chart of the nuclides is especially important for students attending the course on gamma-radiography as well as for students attending the course on open radionuclides. Training at ARCS is supported by an electronic chart of the nuclides illustrating the connection between the periodic system, the chart of nuclides, and decay processes (decay chains).

The radiation protection academy at ARCS is working on a few pilot projects which can fulfil the expectations mentioned before. One of this projects is producing a computer based online radiation protection training course as an addition to a real training course. In the future, participants of a radiation protection training course at ARCS have the possibility to check their knowledge about radiation protection and repeat the contents of the training course online, without travel cost and without time spent in travelling to a training centre. Students participating in this virtual course may perform their own (virtual) experiments, test their knowledge and training skills individually. Last but not least, virtual experimentation improves the efficiency of real experiments, using the effect of repetition. However, it must be emphasized that these possibilities are viewed as an important add-on to classical training, not as a replacement.

6. Conclusion

Safety culture in industrial radiography in Austria enjoys widespread acceptance as reflected in the absence of hazardous dose levels in the records of the workforce. A scheme of accreditation and acceptance supports the curricula for radiographers. Overall qualification rests on a number of pillars, namely standardization, training, certification, and experience. This system has recently come under pressure originating from the free exchange of services (also in the field of radiography) across national borders. Under such instances, deficiencies in international harmonization of minimum requirements (e.g. in training) tend to create problems.

However, though dose records of representative Austrian companies performing radiography indicate a generally good application of safety culture, application of radiography in the field poses higher risks as compared to work performed primarily in a workshop. Besides this basic difference, pressure at work might lead to the application of higher activity sources or to the omission of time consuming procedures (e.g. usage of collimators) that result in higher dose than otherwise possible.

Innovative approaches in training and sharing information as well as experience are seen as important tools to maintain safety culture. Harmonization and international consensus on minimum requirements will benefit the emergence of a uniform safety culture.

7. References

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