Paper 10

Industrial radiography
A UK radiation fatality and resultant initiatives to improve standards

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Abstract

Dosimetry data for the past 10 years has indicated that annual doses to industrial radiographers are not reducing as rapidly as those observed in other industries. The death of a radiographer in 1992 heightened concerns and raised the question of the adequacy of working practices and training. A review of the two primary schemes in the UK for the certification of industrial radiographers, Personnel Certification in Non-destructive Testing (PCN) and American Society for Non-destructive Testing (ASNT), revealed out-of-date syllabuses for radiation protection with no reference to ALARA or optimisation. NRPB, in consultation with HSE, subsequently carried out a comprehensive revision of the radiation protection training requirements of both schemes and is currently producing standard training course notes covering the syllabuses for the use of NDT training organisations.

These moves alone may not be sufficient to improve standards in the industry. Awareness amongst client organisations also needs to be raised so that radiographers have sufficient time and facilities to work safely. The focus of inspections by radiation protection organisations and enforcers may also need to be changed to encourage the use of better safety and warning systems.

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Introduction

The emphasis on ALARA and optimisation in the Ionising Radiations Regulations, 1985, has made a significant impact on radiation doses over the past 10 years. Two reports issued by the Health and Safety Executive (HSE) over this period have analysed the information on the Central Index of Dose Information (CIDI) and revealed reducing dose trends to classified persons, in most work areas. The first of these reports[1], which analysed occupational exposure doses for the period 1986 - 1991, revealed a definite and sustained downwards trend in both mean (2.3 mSv to 1 mSv) and collective dose for all classified persons. There was also a very significant reduction in the proportion of classified persons with an annual dose in excess of 15 mSv (from 4% to 0.4%). However, it was noted that, in contrast to these general trends, the mean dose in industrial radiography showed no real downward trend, going from 1.8 mSv to 1.7 mSv in the six year period . Although the total number of industrial radiographers fell considerably in this period, the percentage of radiographers who received doses in excess of 5 mSv rose by over 30%, and the proportion with a reported dose in excess of 15 mSv more than doubled to 50 persons. The report concluded that downward dose trends had occurred in all industries except two, industrial radiography and non-coal mining, and that HSE effort would be focussed in these areas.

The second report[2], which covered the period 1990 -1996 revealed a continuing general reduction in mean annual dose to classified persons, from 1.9 mSv to 1.3 mSv over the six year period. While the percentage of industrial radiographers receiving annual doses in excess of 5, 15 and 20 mSv also fell over this period, the mean annual doses in the industry increased from 1.4 mSv to 1.6 mSv. The report acknowledged that significant improvements had taken place in the industrial radiography sector but that improvements could still be made and the HSE enhanced enforcement strategy remained relevant.

The dose information from these two reports is summarised in table 1.

Table 1 - CIDI dose trends 1986 -1996

	1986 *	1991 *	1996 **
Number with doses greater than 5 mSv - all classified persons - industrial radiographers	 6579 (14%)+ 302 (7%)+	 2958 (7%)+ 202 (7%)+	 1511 (5%)+ 91 (6%)+
Number with doses greater than 15 mSv - all classified persons - industrial radiographers	 1911 (4%)+ 57 (1%)+	 147 (0.4%)+ 50 (2%)+	 183 (0.6%)+ 9 (0.6%)+
Number with doses greater than 20 mSv - all classified persons - industrial radiographers	 1032 (2%)+ 42 (1%)+	 78 (0.2%)+ 24 (1%)+	 132 (0.5%)+ 6 (0.4%)+

* Data excludes classified persons with zero recorded dose.
** Data excludes classified persons with doses of less than 0.1 mSv.
\+ Percentage of the total number of workers in the work category.

The conclusions of the first report indicated that working practices in industrial radiography were not being effectively optimised to restrict exposure, and this view was reinforced by the outcome in 1993 of a fatal accident enquiry into the death of a retired industrial radiographer, from radiation induced illnesses (Mr A). This case focussed national attention on the standards of radiation safety in the radiography industry and prompted a comprehensive review by NRPB and HSE of working practices and training programmes for industrial radiographers.

The case

Mr A was an experienced industrial radiographer who worked for much of his career at an oil refinery complex in Scotland. He qualified as a radiographer in 1974, having attended the required training courses, and worked with radiation sources, primarily iridium-192, until his retirement on ill health grounds in 1990. The first indication of radiation induced injury occurred in 1984 when he developed a sore and ulcerated finger. However, he did not seek medical treatment for this condition, which apparently healed itself, and it was not until 1988 when he went to his doctor with further hand injuries, that he was diagnosed as suffering from radiation dermatitis. His hand continued to deteriorate and in 1990 the index finger and tip of his third finger were amputated after they became gangrenous. He subsequently retired through ill health and died 2 years later, aged 61, of bronchopneumonia, aplastic anaemia, radiation induced acute myeloid leukemia, radiation dermatitis and radiation induced myelodysplasia. Subsequent analysis of a tooth by electron spin resonance revealed a cumulative dose of nearly 15 Gy. The dose to his hand was estimated to have been in the order of 100 Gy. However, the cumulative dose recorded on his dosemeter records for the period 1974 to 1990 was just 104 mSv.

The subsequent investigation by HSE could find no evidence of a breach of any regulations. Furthermore, at the fatal accident enquiry it was concluded that it could not be determined where, when or how the high radiation exposure had taken place. The report of the enquiry stated that "Mr A was a competent and careful worker who paid due regard to safety matters".

The dose history of Mr A gave no indication of any high radiation exposures during his career and yet the medical evidence indicated conclusively that he must have been exposed to very high radiation dose rates over an extended period of time. The only conclusion that can be drawn from this is that he had not been wearing his dosemeter when he had received the highest doses.

Training standards for industrial radiographers

The lack of any evidence on the cause of the high exposures was disappointing and raised serious questions over the standards of radiation safety amongst industrial radiography companies. The fact that Mr A was a qualified radiographer also cast doubts on the adequacy of radiographer training, primarily the radiation safety component. Experience has shown that a major factor in the majority of industrial accidents involving ionising radiation is inadequate training, and with this in mind HSE and NRPB carried out a review of the training provisions for industrial radiographers in the UK.

Two major certification schemes exist in the UK for the certification of persons in non-destructive testing, the ASNT (American Society of Non-destructive Testing) scheme and the PCN (Personnel Certification in Non-destructive Testing) scheme. The ASNT scheme, which is administered in the UK by the North Atlantic Section of ASNT, provides certification to the internationally accepted ANSI standard. It is an employer based scheme in which the employer determines the level of training required, taking into account the specific radiation application in the company, provides the training and sets and marks the examination. The certification awarded to the worker in this scheme only remains valid while he is working for the employer. ASNT provides guidelines to employers on the establishment and conducting of NDT personnel and certification programmes. This scheme tends to be the more popular one with radiographers working with fixed installations.

PCN in contrast provides a certification scheme which is individual rather than employer based, with the certification remaining valid when the radiographer changes employers. The scheme complies with the European standard for certification bodies[3] and offers examinations covering the main NDT methods and radiation safety in accordance with the relevant European and international standards for NDT personnel qualification and certification[4,5]. The examination papers are set and marked centrally and the examinations are carried out at accredited PCN test centres. Approximately 2,500 radiographers have been certificated under the PCN scheme, which tends to be more popular with radiographers who work on site and those who regularly change employers.

Meetings with the administrators of the PCN and ASNT schemes revealed significant weaknesses in the radiation safety components of both schemes. While PCN provided a standard syllabus for training courses in radiation protection, some aspects of the syllabus were very out of date, and referenced items such as maximum permissible doses and safe dose rates without mentioning optimisation and ALARA. The ASNT scheme, while giving some limited guidance in radiation protection training, did not require radiographers to attend a course in radiation safety or pass an examination in the subject. These weaknesses were reflected in the attitudes of some radiographers visited by NRPB on site, who tended to speak in the language of the old Ionising Radiations (Sealed Sources) Regulations 1969, and clearly felt that provided doses were kept below the dose limits there was no problem.

Concern on radiation protection standards prompted HSE to conduct a high profile campaign with NDT companies, with seminars on safe working practices in the industry, more frequent inspections, advice to doctors recommending annual medical examinations rather than medical reviews and guidance on the use of compounds[6]. At the same time, NRPB provided assistance to PCN on the revision of the radiation safety syllabus and the associated examination questions. This resulted in the issuing of updated syllabuses for the two PCN radiation safety qualifications, Basic Radiation Safety and Radiation Safety to Radiation Protection Supervisor Level. These syllabuses are reproduced in Appendix I. Guidance was also provided to ASNT who subsequently issued guidelines for radiation safety training, based on the PCN syllabuses. NRPB is continuing to provide assistance to both organisations and is currently drafting a set of standard course notes that will follow the revised syllabuses and will be available for use by trainers throughout the country.

The right approach?

These changes have come into effect over the last 2 years, and it is too early to say whether they are influencing the thinking and behaviour of radiographers in the field. However, are these changes enough? Will they lead to a reduction in the number of overexposures per year and eliminate serious accidents such as the one described?

Site radiography accident investigations carried out by the author have indicated that, in addition to inadequate training, a primary contributory factor is pressure imposed on the radiographer by the client company in terms of time constraints. Radiographers are often required to carry out radiography in very short time windows, often with little advance notice. Although the radiographic examination and interpretation of castings and fabrications is of critical importance in terms of quality assurance and the safe operation of plants, it is often given a low ranking in terms of notice to the NDT company and available time and facilities. The author has visited fabrication shops with radiographers who have found that the access points to vessels have been unnecessarily welded closed just prior to the visit, creating major difficulties of access and necessitating the radiographer to squeeze in via other ports. This situation can easily result in the radiographer remaining inside the vessel during short radiographic exposures due to difficulties of egress with consequent exposure to high dose rates. Likewise, radiography on installed pipes and vessels in a chemical works or refinery may necessitate working at high levels above ground, and the provision of inadequate access points and scaffolding may force the radiographer to cut corners to get the work done within the required timescale. It follows that the client organisations must be encouraged to provide sufficient time and facilities for radiography to be carried out in a safe manner. At the tendering stage they must also make sure that sufficient time has been allocated by the NDT company to safety procedures.

The adequate training of radiographers and the education of client companies will go a long way to restricting exposure in the NDT industry and ensuring that radiation doses are being kept as low as reasonably achievable. However, consideration should also be given to the adequacy of the equipment and the safety and warning systems currently available. The majority of radiation accidents that occur within the NDT industry are those involving high doses to radiographers as a result of the inadvertent moving or adjusting of films, collimators and workpieces while the radioactive source is still in the exposed position or the X-ray set is still switched on. Regardless of this, the focus of the Ionising Radiations Regulations 1985, and hence inspections and audits of radiography carried out by the relevant authorities, is on prevention of general access to the radiation area, the setting up of barriers at 7.5 _Sv h^{-1} or less, the provision of prewarning and warning signals that are visible at the barrier, and the positioning of notices. While these points do go a considerable way in ensuring the safety of the public and general site workers, they do not always prevent radiographer overexposure. Emphasis on the instantaneous dose rate of 7.5 _Sv h^{-1} has little practical relevance to site radiography, and although a prewarning signal that illuminates or sounds immediately prior to the exposure of a source is undeniably beneficial, the acceptability of simple manually operated systems for gamma radiography permit site radiographers pay lip service to the requirement by providing traffilamp type lights that remain illuminated throughout the work programme. Perhaps more emphasis should go on ensuring that radiographers are using the latest exposure containers with locks and mechanical indications of the source position. The development of automatic pre-warning and warning systems for gamma radiography would be relatively straightforward and should be encouraged, with the objective of the eventual phasing out of manually operated systems. The use of personal alarm dosemeters provides valuable warning of high dose rates and should be considered essential for site radiography work, yet by no means all radiographers use or even have them. The latest developments in exposure containers include containers that are clamped to the workpiece and incorporate a shutter. With these containers the source remains within the container during the exposure, and the inherent shielding built into the device limits the dimensions of the controlled area. However, such equipment is expensive and requires well trained operators, and the need to keep tender prices and hence costs down means that most NDT companies are unlikely to be able to afford the investment. The few companies that do use relatively sophisticated equipment do so because they are required by the client company to do so, and hence all tendering NDT companies build the cost of the equipment into the tender price. The use of such equipment, however, must be the way forward and should be encouraged at every opportunity.

Conclusions

The review of standards of radiation safety in industrial radiography prompted by the incident has resulted in a comprehensive revision of the training requirements for radiographer certification. HSE has also investigated and discussed the working practices used by industrial radiographers and has issued several guidance documents on the subject. These actions have yet to make an impact on standards in the industry and it is likely to be several years before the majority of certificated radiographers have received updated training. However, these changes alone may not be sufficient to restrict doses to radiographers. Many client organisations need to be educated to provide adequate time and facilities for industrial radiography, and NDT companies should be encouraged to use state of the art exposure containers and safety equipment. Only when there has been a major change in the perception of, and approach to, industrial radiography, both amongst the clients, inspectors and NDT companies themselves, will it be possible to say that doses in the industry are truly being kept as low as reasonably practicable.

References

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6 HSE. Industrial radiography. HSE Information Sheet. HSE Books (1996)