European ALARA Network
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Issue 11 - August 2002

European ALARA Newsletter

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Editorial Board

Editorial

As a result of recommendations from our Network, several European projects were recently set up: EURAIDE (European Accident and Incident Data Exchange); SMOPIE (Strategies and Method for Optimisation of Internal Exposure of Workers from Industrial Natural Sources); EASN (European ALARA Sub-Network for research reactors). The co-ordinators of these projects present in this issue their objectives and scope as well as potential links with the other members of the Network.

The feedback from our 5th Workshop in Rome on industrial radiography appears to be very positive. The recommendations and conclusions from that Workshop have been published in many countries and they have been widely distributed among non destructive testing societies members. I then, would like to remind you that all our publications may be duplicated, translated and reprinted in other documents or publications. You will find in that issue a questionnaire regarding our Newsletter and its distribution: please do not hesitate to fulfil it and send it back.

Our sixth Workshop on Occupational Exposure Optimisation in the Medical Field and Radiopharmaceutical Industry, that will take place in Madrid this October, has prompted significant interest. The International Society for Radiographers (ISRRT) will be directly involved; all European radioisotopes manufacturers for the medical sector will be present, as well as representatives from all professions in the medical field and regulatory bodies from all European countries.

Following the interest in accident case published in the previous issues, several accidents (in radiotherapy in Panama and Poland) and incidents (in decommissioning in the Czech republic) are described here with the lessons to be learned in order to avoid the re-occurrence of such events. Finally, a first article on NORMS presents the radiological protection aspects of the use of enhanced natural radioactivity in the case of mineral insulation wool.

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Coordinated by CEPN, on behalf of the EC DG-RESEARCH
European ALARA Newsletter ISSN 1270-9441

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Radiation Protection Aspects of Mineral Insulation Wool with Enhanced Natural Radioactivity

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❑ Introduction

Many scrap yards in The Netherlands have installed portal radiation monitors at the entrance for control on radiation sources in the scrap. If these monitors are triggered by a scrap load, the material is refused and the appropriate Dutch Inspectorate is informed about the incident. Over the last few years a series of these alarms were caused by a mix of 'clean' scrap and insulation material with enhanced concentrations of natural radionuclides. In all these cases the scrap was not accepted, usually returned to the owner and the incident was reported. The incidents covered a variety of small to very large dismantled installations which had in common that mineral wool had been used for thermal insulation of doors, tanks, ovens, and piping. The accumulation of cases has led to a study to find out the origin and potential scope of the slag wool problem. The radiological aspects of this problem are discussed in this paper.

❑ Radioactivity in the Slag Wool

A survey on mineral wool production in the Netherlands [1] gave strong evidence that the slag wool has most likely been produced from a by-product (slag) of tin smelting between the years 1948 and 1960. Analytical data of the slag wool are summarised in Table 1.

Table 1: Natural radionuclides in slag wool samples from Dutch installations. Concentrations in Bq/g

Type of data	U-238 and Ra-226	Pb-210	Th-232nat	Ratio Th-232 / U-238	Ratio Pb-210 / Ra-226
Number of results	40	32	40	40	32
Maximum	6.2	3.8	16	4.2	1.0
Minimum	2.6	1.7	5.9	1.8	0.4
Average	4.0	2.9	11.2	2.8	0.8
Stand. dev.	0.8	0.5	2.1	0.5	0.1

It appears that the concentrations of the radionuclides from the decay chains of both U-238 and Th-232 cover a relatively small range and that Pb-210 is depleted relative to U-238 and Ra-226. The average ratio Th-232/U-238 is about 3. From the average ratio Pb-210/Ra-226 of 0.8 an average age of about 50 years can be derived if it is assumed that virtually all of the Pb-210 was volatilised at the time of the slag or slag wool production.

❑ Radiological Aspects of Dismantling Installations with Slag Wool

In the new Dutch Radiation Protection Decree, clearance and exemption levels for U-238, Th-238, and Ra-226 are set at 1 Bq/g for reporting and at 10 Bq/g for authorisation. It is clear that the material falls under the regulations, and in many cases also exceeds the authorisation levels. The Dutch authorities require the removal of the slag wool from already disused objects or from the still remaining parts of the installations being dismantled. The removal has to be supervised by qualified radiation protection experts under precautions against internal exposure not unlike those taken at removal of asbestos.

The presence of slag wool in installations being dismantled involves external exposure as well as internal exposure by inhalation of slag wool particles. External dose rates on the surface of slag wool insulated equipment does not exceed 1 µSv/h and an average dose rate at working distance of 0.3 µSv/h seems to be a good estimate for dose assessments. The radiation doses resulting from internal exposure depends strongly on whether the radioactive character of the slag wool has been recognised before dismantling was started. As is shown in Table 2 the dose coefficient for inhalation of slag wool particles with average and high nuclide concentrations ranges between 1 and 1.5 mSv per gram inhaled. The main contribution to internal exposure comes from the Th-232 decay chain.

On the basis of the data for internal and external exposure described above dose estimates can be made for three different exposure scenarios defined in Table 3. It is assumed that slag wool removed from the installation is either temporarily stored remote from the working place or is disposed of frequently.

Table 2: Dose coefficients (DC) for inhalation of nuclides from slag wool based on 5 µm AMAD and Type Slow

Nuclide	DC in Sv/Bq	Average conc. Bq/g	DC in Sv/g inhala	High. conc. Bq/g	DC in Sv/g inh.
U-238 – Ra-226	$6.4 \cdot 10^{-5}$	4	$2.6 \cdot 10^{-4}$	6	$3.8\ 10^{-4}$
Pb-210 – Po-210	$8.1 \cdot 10^{-6}$	3	$2.4 \cdot 10^{-5}$	4	$3.2\ 10^{-5}$
Th-232 – Po-212	$6.3 \cdot 10^{-5}$	11	$6.9 \cdot 10^{-4}$	16	$1.0\ 10^{-3}$
Total			$9.7 \cdot 10^{-4}$		$1.4\ 10^{-3}$

Table 3: Scenario conditions and parameters for external and internal exposure to slag wool at dismantling of installations

Scenario	Radio-activity?	Size of the plant	Exposure h/y	Slag wool dust conc. mg/m^3	Breathing rate m^3/h
A	No	small	20	1	1.2
B	Yes	big	200	n.r. [1]	n.r. [1]
C	No	big	400	2	1.2

[1]) n.r.: not relevant because of assumed respiratory protection

The results of the scenario calculations are presented in Table 4. They show that under unfavourable conditions but average activity concentrations the radiation exposure of demolition workers is estimated at about 1 mSv/a. For the maximum concentrations given in Table 1 the estimated exposure does not exceed 2 mSv/a.

Table 4: Estimated radiation exposures to slag wool at dismantling of installations

Scenario	External exposure mSv/a	Internal exposure mSv/a	Total exposure mSv/a
A	0.006	0.024	0.03
B	0.06	------	0.06
C	0.12	1.0	1.1

The results show, as is the case in many exposure situations to NORM, that awareness of the problem resulting in adequate protective measures (respiratory protection, dust prevention) is a prerequisite to reduce the occupational doses to very low levels.

❑ Costs

It is obvious that the costs associated with the discovery of the radioactive nature of the slag wool, due to radiological control measures and disposal, are considerable. Under the Dutch regulations, the slag wool has to be transported to the Central Organisation for Radioactive Waste (COVRA) for storage, at high costs. This is illustrated in three of the Dutch cases. They have in common that the slag wool was detected, as usual, by a scrap dealers' radiation detection system and that the costs for transfer of the slag wool to COVRA are based on a realistic estimate of about 18 Euro per kg.

Greenhouse steam generator

The slag wool from this relatively small steam generator was suspected of exceeding the 100 Bq/g level on the basis of readings with hand-held radiation monitoring equipment. The estimated COVRA costs were of the order of 18,000 Euro, exclusive of the costs for removal of the slag wool under radiological control and packing it into the standard 100 litre COVRA drums.

Bakery oven

Upon detection of radioactive slag wool during dismantling of a bakery the already advanced dismantling was continued under radiological control and the total amount of scrap mixed with slag wool was transported from the site for removal of the slag wool and packing into COVRA drums. This resulted in about 100 COVRA drums, for which the costs were estimated at about 105,000 Euro, without the significant costs of getting the slag wool separated from the scrap and into the COVRA drums.

Power plant

Slag wool had also been used for insulation of piping and huge boilers in a big fossil-fuelled power plant. It took many months first to collect slag wool from radiologically uncontrolled dismantling and to finish the dismantling under radiological control. In total 36 tons of slag wool compressed and packed in plastic bags resulted from the exercise. They are still stored at the site. The costs of transferring the slag wool to COVRA after packing it into drums are estimated at about 650,000 Euro.

❑ Origin of the Slag Wool

A survey has been carried out on the origin and potential extent of the slag wool problem [1]. In an early stage of the survey it appeared that the radionuclide concentrations and the ratio between radionuclides of the U-238 and Th-232 decay series matched well with slag from a Dutch tin smelter stored at COVRA after shut down of the smelter. Further inquiries revealed that producers of mineral insulation wool indeed have used slag from the Dutch tin smelter during a limited period of time, probably between 1946 and 1960. The bulk of mineral wool produced over those years was made from other raw materials, slag from steel production and basalt with much lower concentrations of natural radionuclides. The survey estimates the total amount of mineral wool produced with slag from tin smelting at between 800 and 2200 tons.

❑ International Aspects

Up to now no evidence exists that the use of mineral wool from tin slag has drawn attention internationally for the same reasons as in The Netherlands. Tin production has taken place on a large scale in the past in Western Europe, particularly in the United Kingdom and Spain [2]. Most of the ore originates from South East Asia where low grade tin ore is processed by physical methods to obtain a concentrate (casserite) and a by product (amang). Tin ore not only contains the tin bearing casserite but also other heavy minerals including ilmenite ($FeO.TiO_2$), zircon ($ZrSiO_4$) and monazite ([Ce, La, Y, Th]PO_4) which all contain the naturally occurring radioactive elements thorium and uranium [3]. The potential for significant radiation exposure of workers and the public in the tin mining, ore preparation industry and tin smelter in Malaysia has been recognised [3], [4], [5].

A study by Baxter et al. summarises unpublished reports on a large tin smelter in Northern England [6]. Although the report focussed mainly on discharges of and exposures to Po-210 volatilised from the raw material, it contains interesting information on the scale of the slag production at the site. Average annual intake of raw materials was 82,000 tons and the average annual output of waste slag was 60,000 tons. The slag from a storage tip on the site was sold periodically for road construction or cover for a domestic refuse site. Some was deposed of in a local landfill site and some sold to a local abrasive manufacturer. Cleaning up the site at demolition involved disposal of demolition debris and waste slag in a landfill site or the local authority waste disposal site.

At another former site of a tin smelter in the UK in Bootle near Liverpool radiation levels over 10 times normal background where detected on rocks in the river estuary [7]. The rocks appeared to be made up of waste slag from the local smelting works. It is interesting to note that the critical group of members of the public where likely to be dog owners exercising their animals in the beach area. Because of development plans for the site of the former tin smelter a survey was carried out which revealed dose rates up to

10 µSv/h at 1m above the surface. It was found that that the area was covered with slag and rubble to depth of about 1.5m. About 1000 m^2 was covered with about 1900 tons of a more active black slag. The concentration of U-238 in four samples of this black slag ranged from 5.0 to 6.2 Bq/g and the Th-232 concentration ranged from 12.1 to 14.7 Bq/g. The average Th-232/U-238 ratio was 2.4 ± 0.2. The total activities were estimated at 11.3 GBq U-238 and 26.9 GBq Th-232. The authors advised to fence off the area and clear the area under radiological control of the workers and to find a disposal route for the excavated slag and rubble.

In a Radioactivity Information bulletin the UK DETR provides an estimate of 30 million tonnes of glass like tin slag has been used as aggregate for general civil engineering in North West England and adds that the potential for harm from this material is likely to be low [8].

❑ Discussion and conclusions

Decommissioning slag wool insulated installations has caused no excessive radiation exposures, even when the radioactive character of the material was still unnoticed. However, respiratory protection should be a standard measure against avoidable exposure during demolition. The main aspect of the slag wool problem is the excessive cost of disposal, when the material is considered as radioactive waste. It would be difficult to justify these costs to individuals and society on the basis of the radiation exposures being avoided by this disposal route. The very stable glassy character of the slag wool allows other disposal options such as landfills or repositories used for non-radioactive wastes, or mixing the slag wool with other slags for reuse in road construction. Apparently such radiologically and economically acceptable solutions can be found when the scale of the problem is large enough, as it is in the UK.

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ALARA NEWS

6th European ALARA Network Workshop on "Occupational Exposure Optimisation in the Medical Field and Radiopharmaceutical Industry"

23-25 October 2002, CIEMAT facilities, Madrid, Spain

Its aim is to focus on possible improvements to optimise radiological protection for workers. It intends to be a forum for the exchange of information and experience between a restricted number of participants.

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http://www.ciemat.es/convocatorias/eventos/alara/index.html

3rd European Forum of "Radioprotectics"

2-4 October 2002, La Grande Motte, France

Radioprotectics is a term used to describe the various means and methods implemented in the nuclear industry, to enhance radiological safety and sciences and techniques developed in that sense. This 3rd forum organised by the French Association for Radiation Protection Sciences and Techniques (ATSR) is devoted to "radiological protection and logic of decommissioning".
The seminar proposes this year a specific session on optimisation studies. Several examples of the implementation of the optimisation during decommissioning operation will be presented (in French).
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9th Symposium on Neutron Dosimetry

28 September-3 October 2003, Delft, The Netherlands

This symposium will provide a forum for presenting and discussing recent developments in neutron dosimetry for radiation protection, radiobiology, and radiotherapy as well as in dosimetry of other nuclear particles (e.g. protons, heavier ions). The last symposium on neutron dosimetry was held in 1995. Since then, significant progress has been made and there are areas of research and applications which are receiving increased interests, e.g. aircrew and space dosimetry, radiation protection at high energy accelerators, electronic personal dosemeters, proton and heavy ion therapy, radiation induced effects in semi conductors and computational dosimetry. The symposium will also provide a forum for representatives of regulatory organisations and industry to discuss their needs.
Information available at: http://www.iri.tudelft.nl/~neudos9
Email: zoetelief@iri.tudelft.nl

EASN: the European ALARA Sub-network on Nuclear Research Reactors

P.Deboodt

The EASN on Nuclear Research Reactors may be considered as a "spin-off" of the European ALARA Network. EAN produces, among other publications and working groups, recommendations arising from workshops that are annually organised. One of these recommendations pointed out the need to pay more attention to the nuclear research centres and, especially, for the nuclear research reactors.

Indeed, these installations show very specific properties as far as the manpower, the operations and the nature of their uses are concerned. Radiological protection has to bear in mind such characteristics.

So the main objective of the EASN is to provide an opportunity to all the members for exchanging information on topics related to radiological safety in the research reactors. The kick-off meeting has taken place on 22 April 2002 at the CEPN office in Paris. Six countries were represented and three other have indicated their strong interest. A second meeting is already planned. This meeting will be devoted to the decommissioning of nuclear research reactors and to the problems that are related to such operation. For example, the treatment of liquid waste, the issue dealing with the free release of materials, the global management of radiological (and non-radiological) risks will be examined. In order to provide support to the discussions, a visit of the BR3 (Belgian Reactor 3) at the SCK/CEN is planned. This reactor is still under decommissioning and the problems as mentioned here above have lead to solutions, which should provide very useful information to the participants.

This second meeting specifically illustrates the intended EASN approach. The members of the EASN have strongly indicated that each meeting must provide the opportunity for discussing general problems as encountered with the nuclear research reactors but also to pay more attention to one specific topic.

More specifically, information will be collected on dose distribution for the workers, on special procedures and also on other points such as emergency preparedness, management of the waste, level of the safety culture, and so on. Within a few months, all this information will be provided making use of a database which will be made available for each participating country. More information may be obtained by mail to pdeboodt@sckcen.be or hanne.troen@risoe.dk

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EURAIDE: European Union Radiation Accident & Incident Data Exchange

R.Czarwinski, J.Croft, C.Lefaure

One of the concluding statements of the 2nd European ALARA-Workshop concerned the feedback from incidents and accidents. It was considered, to be one of the most important areas for future development, both in terms of feedback to the users and resource allocation by competent authorities.

To address this the European Commission set up a pilot study (EURAIDE) to evaluate how a future data exchange system could meet the above needs within the European Union and to identify how it could link with initiatives and existing recording and reporting systems operated by national competent authorities and other international organisations. It should also take into account the potential future enlargement of the EU.

The specific objective of that pilot study is to evaluate the feasibility of:

- facilitating the establishment of national radiation accident and incident database where there are none and encourage the compatibility of such databases;
- establishing a European network to exchange radiological protection feedback from accidents and incidents;
- establishing summary reports of relevant accidents and incidents with the aim of identifying lessons to be learned, so that they can be used in radiation protection training programmes;
- upgrading the radiological safety in the countries applying to join the EU, by integrating them into the above efficient feedback exchange system.

Furthermore a management scheme of the planned incident and accident data exchange should be proposed.

To perform the mentioned objectives a questionnaire was created and sent out to 31 member and applicant states of the European Union. A few responses have already been received and we would like to encourage the remaining recipients to fill that short questionnaire and send it back to one of the contractors. A workshop with all contributors will take place to evaluate all results and to identify further work required in order to establish and to operate over several years the data exchange.

The project is led by Mr John Croft / NRPB (UK) and is being carried out in collaboration with two subcontractors Ms. Renate Czarwinski / BfS (Germany) and Mr. Christian Lefaure / CEPN (France).

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NORM III – 3rd International Symposium on NORMs (Naturally Occurring Radioactive Materials)

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Wide ranges of Non-Nuclear Industries are processing large volumes of raw materials containing radionuclides from natural origin. During processing the concentration of these natural radionuclides may be enhanced. Naturally Occurring Radioactive Materials (NORM) is often found in the waste streams of these industries. Many of these industries were neither aware of these problems neither about the regulatory initiatives that were being developed about this topic by international authorities. Therefore there was a great need in creating a forum for discussion between industries and regulators. This was one of the major aims of the series of three "NORM" symposia that have been held up to now.

The initiative to organise NORM-symposia was taken by KEMA in 1997. The first edition "NORM I" in Amsterdam highlighted the extent of the NORM-waste problem. At "NORM II" organised in 1998 by SIEMPELKAMP the experience in industry indicated that exposure to workers and public can be controlled to levels below 1 mSv/y. As to waste management the need for practical recycling or disposal solutions was clearly put forward.

At the "NORM III" conference, organised by FANC in Brussels in 2001, the status of the implementation of the Basic Safety Standards at national level was addressed, showing a (still) high degree of variability. This is quite alarming since, as already put forward at "NORM II", the world-wide trade of raw material with NORM necessitates an international harmonised approach.

In a series of technical session's radiation protection items relevant for different sectors of NORM-industries were presented, with special attention to waste management problems and the impact on the environment. The presentations showed clearly a progress in the systematic assessment of work activities, raw materials, industrial products, by-products and residues that can affect the exposure of workers and members of the public to natural radiation sources.

Due to the important social and economical impact that new regulations may have, the problem of radiation protection in NORM-industries was also looked at from a broader point of view, incorporating communication, legal and philosophical considerations. So, transdisciplinary considerations should be included in future meetings on NORM. More detailed information on the "NORM III" symposium are contained in the proceedings which are available on CD.
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The next symposium "NORM IV" will be held in 2004 in Katowice (Poland).

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The Panama and Poland Radiography Accidents

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Radiotherapy accidents are exceedingly rare, and millions of people benefit every year from this treatment. However, recently two accidents involving radiotherapy have occurred.

In 2000, in Panama city, a radiotherapy accident was responsible for the dramatic overexposure of 28 patients. The accident was related to the misuse of a Treatment Planning System (TPS). In the centre involved, patients treated for pelvic tumours received irradiation using a conventional four-beam "box" technique. The anterior and posterior fields were shaped with four blocks in the angles, (conventional so-called "diamond" shape). In mid-2000, one of the radiation oncologists decided to add a fifth block in the superior and medial part of the anterior and posterior beams. The prescription of this fifth block posed a problem to the physicist in charge, since the TPS in use required digitisation of the contours of the blocks one by one, and limited the number of blocks that could be introduced to only four. Therefore a new method was devised to overcome the TPS limitations of four blocks; instead of digitising the blocks individually (as indicated in the TPS menu), i.e. one block at a time, the staff members endeavoured to enter the contours as one complex block, with a first loop following the inner boundaries of the block (for example clockwise), then with a second loop following their outer boundaries. This method of using the TPS was neither recommended nor forbidden by the TPS manual. If the second outer loop was drawn in the opposite direction to the inner one (i.e. counter clockwise in the present example), the computer calculated a correct treatment time. However, if the outer loop was drawn in the same direction as the inner one (clockwise in this example) the computer accepted the data, but calculated a wrong treatment time by about +100%, thus doubling the dose to the patient.

This last problem occurred for 28 patients treated in the last months of 2000. Neither the physicists nor the technologists noticed that the treatment times were (very) significantly longer for some patients, whereas the types of treatment were similar. Although the early radiation effects (essentially diarrhoea) were obviously much more severe than usual for those overexposed patients, this did not trigger, at least initially, any particular survey.

In November 2000, however, the severity of the symptoms observed for some patients led the radiation oncologists to ask the physicists to re-check the charts. This was done, but no abnormality was detected, the implicit assumption being that the computer calculations were correct. The problem became clinically obvious in the first months of 2001, with the unexpected death of a few patients and very severe complications (see below) occurring in some others.

However, it was only in March 2001 that the physicists identified the problem with the calculation of treatment times.

In May 2001, a group of experts sent by the IAEA Emergency Response Centre elucidated the various causes of the accident. At that time, 8 patients already had died. For five of them, available data were sufficient to conclude that the deaths were directly related to the radiation injuries (mainly gastro-intestinal). For 2 patients, insufficient data were available to draw any conclusions. For the last patient, death was most likely due to progression of the cancer. The experts examined all 20 surviving patients: 9 of them showed marked or even catastrophic complications.

This unique accident emphasizes the risks of incorrect or inappropriate use of a TPS. It also underlines the need to regularly check the calculated treatment times. In addition, the unusual treatment times given for some patients, as well as the unusually severe early radiation symptoms, should have triggered earlier investigations.

On February 27, 2001, in Bralystock (Poland), an unexpected power failure suddenly stopped a linear accelerator working with 8 MeV electron node. When the power returned, the treatments were resumed for five patients irradiated for breast cancer (One was treated on her breast, while the four others were irradiated in the chest well, after a mastectomy).

No recalibration was performed before resuming the treatments. Very unusually, two patients complained from a strange feeling of burning at the end of their session, so that the physicist immediately checked the dose-rate: it was than found to be 10 to 20 times higher than expected. The five patients developed areas of radionecrosis in the treated areas in the following months, with the patients treated first showing lesions less severe than the last ones, suggesting a progressive deterioration of the accelerator function during the treatment of the five patients. At present, one patient is dying from liver metastases. Two patients show an impressive fibrotic retraction of the treated area, together with superficial radionecrotic lesions. Two patients (the last treated ones) present with a complete destruction of their chest wall, down to the pericardium. One of these two patients is presently hospitalised at the Paris Institut Curie, in France, for a complex two-step surgery, involving first a transfer of an omentum flap, to be secondly covered by a free-skin graft. Surgery is also planed for the other patients.

This unusual accident emphasizes the need for a complete and systematic recalibration of a linear accelerator when it has stopped unexpectedly, whatever the reasons.

Of note, the ICRP just released its publication N°86, on "Prevention of Accidental exposures to patients undergoing Radiation therapy".

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Contamination of Workers with 241Am during Dismantling of Glove-boxes in the Czech Republic

(case no 12)

During June and July 2001 three dry glove boxes, which served before as part of a line for manufacturing radioactive sources (smoke detectors) from pulverised 241AmO, were dismounted and processed as radioactive waste. This operation was carried-out in the Nuclear Research Institute, plc at Rez (NRI), the Czech Republic. The manufacturing company declared the activities in glove boxes prepared for waste process as 150, 180 and 50 MBq of 241Am respectively. Before the transport from the manufacturing factory in Prague to the NRI at Rez, where boxes were processed as rad-waste, the contamination on the walls and the inside installation was fixed by lacquer. All dismounting procedures took place in the Fragmentation and Decontamination Centre (FDC) of NRI in three time periods; the data critical operations being June 21st, July 3rd and 10th of July 2001. On the beginning of the operations, the boxes were separated from each other and the external and internal surfaces were monitored. The operations comprised the removal of the covering foil, the opening of the box and its dismounting. The material was then fragmented, i.e. cut in pieces by hydraulic shears and saw machine. The fragmented radioactive waste was put into steel drums and conditioned by cementing as rad-waste.

Before the daily operations started the system for monitoring the volume activity of air in the working area was switched on and the locally adaptable exhaustion for FDC area was put in operation. At particular steps the surface contamination was measured using both wipes and direct measurement. The workers should use the protective aids appropriate to the character and hazard of this working activity, including respirators.

In the course of dismounting operations the dust particles with 241Am were incidentally released and due to violation of the radiation protection requirements (non-systematical use of personal protective aids, no full observance, keeping off approved radiation protection procedures) several workers were internally contaminated. Subsequently this contamination spread through the whole building. On 10th July after the dismounting operations concerning the third box and subsequent waste treatment were finished, the chief of the FDC was informed about the result of the evaluation of the filter of the device for volume activity measurement in air in the FDC. The value of filter activity exceeded the monitoring programme determined intervention level and the chief of the FDC ordered to immediately stop all the working activities in FDC area. On 11 July the measurement of respirators used by workers revealed a considerable contamination, reaching in the worst case 1kBq 241Am (later amended to 2,7kBq). The chief of the FDC evaluated the situation and declared at 16.30 an extraordinary event of the 1st grade (in the terms of the Decree of SUJB No. 219/1997 Coll.).

On 12 July the notification of as extraordinary event was transmitted to the State Office for Nuclear Safety (SUJB) and the media were informed. The worker suspected of the highest internal contamination (W1) was directed to the National Radiation Protection Institute (NRPI) for where the first in vivo investigation was performed and the data were reported as preliminary results to SUJB. The necessity for highly conservative estimate was considered because it should serve as a guide for possible remedial steps. From the first two in vivo measurements the body burden of 241Am was estimated at about 5kBq and considering the date July 10th as the time of intake, the committed effective dose (E50) was assessed in the order of one Sv. The evaluation was based on the presumption that inhalation (with particles of AMAD 5 µm, class M) was the main mechanism of internal contamination and that the deposit was located in lungs only.

In addition in other seven people similar internal contamination of 241Am was ascertained. It was, however, recognised that the first obtained results of measurements were overestimated due to the contamination which remained on the body surface in spite of thorough showering before measurements and absence of positive response of surface monitors. The collection of stool and urine was carried-out. The repeated in vivo investigations (WBC, head and knees) and evaluation of the first excreta results reduced the doses initially estimated, so that at the time of notification of the event to IAEA on 17 July the maximal committed effective dose was quantified as 350 mSv.

The follow-up of the workers with measurable contamination continued. The decrease of the results in vivo measurements below detection limits during several weeks confirmed the interference of early findings with surface body contamination. Eighteen other employees were screened on WBC. Whole body counting, measurement of head and also measurement of knee in some cases were performed. No measurable internal contamination was found in this screened group.

A final evaluation in January 2002 was based on excretion data and points to the committed effective dose (E50) of 50 mSv in W1, and to E50 in the range of (5 – 185) mSv in W3-W8. The excretion analysis suggested, that in some workers repeated intakes might occur, eg. partly already on June 21 and July 3 (in the two first operations). This uncertainty complicated the interpretation of excretion results. The worker W2 did not fit fully with the patterns typical for subjects presented above. In this case clearly measurable activity was found with lung measurement and this activity did not decrease considerably in the course of time so that it was supposed that no external contamination was present on the trunk. The committed effective dose in this case was calculated by combining the in vivo (lung) results and the excretion data. The estimated E50 of the worker W2 was 130 mSv. The whole body measurements in the event involved workers will be continue with the half-year period to precise the present time obtained results.

On the basis of first results, some workers seemed to be qualified for treatment by DTPA infusions. The worker W1 was hospitalised on 13 July and was treated by two doses of 1g Ca-DTPA. Five more workers (W2-W6) were given two doses of Ca-DTPA on 20 and 22 July. The tolerance of the treatment was good, no adverse effects were observed. After the assessment of the intakes had been amended, no continuation of the treatment seemed to be justified.

Lessons learned:

- After any hazardous operation with open sources it is necessary to control daily the personal clothing and protective aids, including respirators and change them as frequent as appropriate – the obligation to use such personal protection during hazardous operation is self-evident.
- Very important input data on calculation of a possible release of radioactive material at the workplace could be obtained from the activity measurements of the filters of ventilation system, together with the record of ventilation rate and precise intervals of collecting period. The results must be available before the next task at the workplace is started.
- Contamination of the body surface may considerably interfere with the in vivo measurements of alpha emitters. The sensitivity of a portable alpha monitor may be to low to detect any activity which is latter ascertained with a long term whole body measurement in shielded conditions. In this respect the role for early onset of collecting stool and urine in suspected subjects could not be overlooked, as well as the preparedness to apply express methods which are able to differentiate surface and internal contamination in event involved workers.

Point of view of the State Office for Nuclear Safety

The inspection of SUJB concluded that the considerable underestimation of the hazard of the dismantling and fragmentation of dry glove boxes contaminated by 241Am caused this extraordinary event first of all. This working task should have been prepared in more detail especially as radiation protection procedures were concerned. Besides some important elements of the periodic safety control were lacking including the thorough and regular documentation of all indices and circumstances important for protection. Some gaps in the responsibility of the Radiation Protection Officer of the plant could be identified. Based on these findings the SUJB decided to penalise the NRI by a fine amounting to 150 000 Czech Crowns (about 5000 US $). SUJB preliminary classified that event on the INES Scale at level 2 and notified it to IAEA. Final classification from the point of view of released activity should correctly correspond to level 1. The estimated effective dose in one radiation worker exceeded (more than two times) the annual dose limit and in some others reached just this level which corresponds to INES level 2. SUJB conservatively confirmed former event classification on the INES Scale at level 2.

SMOPIE: Strategies and Methods for OPtimisation of Internal Exposure of workers from industrial natural sources

J.van der Steen

Up to now, and in contrast with external exposures, relatively few efforts have been devoted directly to implementing the ALARA approach for internal exposures. However, internal exposure is in many cases the dominant potential exposure pathway in industries dealing with natural radioactivity, although this is not always recognised. The exposure situations differ considerably with respect to work place conditions, radionuclides involved and the physical and chemical forms of the matrices in which the radionuclides are incorporated. Following a recommendation of the third European ALARA Network Workshop to pay more attention to a systematic ALARA approach for internal contamination, specifically in NORM industries, the European Commission ordered the SMOPIE project under the 5th Framework Programme (contract no FIGM-CT2001-00176). The project is carried out in close co-operation between scientific institutes and industry. The scientific input in the study comes from NRG (The Netherlands), CEPN (France), IRSN (France) and NRPB (United Kingdom). The industrial input is mentioned in table 1. The project started in November 2001 and will be finished in November 2003.

Industry	Process	
Thermphos International B.V. Flushing, The Netherlands	Elementary phosphorus production from phosphate ore	^{210}Po, ^{210}Pb
Kerr-McGee Rotterdam, The Netherlands	TiO_2 production from rutile	^{238}U, ^{232}Th
COMURHEX Malvesi, France	UF6 production from uranium ore concentrates	238U
Johnson Matthey Zircon, United Kingdom	Zircon sands processing	^{232}Th
Huntsman Tioxide United Kingdom	TiO_2 production from rutile and beneficiate	^{238}U, ^{232}Th, $^{226,228}Ra$

The main objective of the study is to recommend monitoring strategies and methods for optimising internal exposure in a wide range of situations of predictable occupational exposures. This will be achieved by means of the following steps:

- To prepare a summary of information on the number of workers exposed to internal contamination and the dose levels involved;
- To carry out a number of different case studies of real internal exposure situations, in close co-operation with the industries involved;
- To identify and categorise the main characteristics of the exposure situations based on the case studies;
- To evaluate the potentials and limitations of monitoring strategies and methods in relation to optimisation of internal exposure situations;
- To derive recommended monitoring strategies and methods for optimising internal exposure in the main exposure situations.

The study covers a broad variety of practical situations, including the generation of (and exposure to) dust, whether the exposure is continuous or discontinuous, whether it is worker induced or process induced and the variability of doses between workers. The characterisation of these practical situations will be carried out in case studies describing real exposure situations encountered in different industries involving natural radionuclides. These case studies are performed in close co-operation between the scientific institutes and their industrial partners. The partners, the industrial processes and the main natural radionuclides of concern are mentioned in table I.

At each of the industrial facilities, all exposure situations with significant potential internal exposures provide separate cases. The reporting of the case studies will be based on standardised formats. The objective requires the identification of the main exposure characteristics of the exposure situations described by the case studies and then to combine them in a limited number of exposure categories with common characteristics relevant to the implementation of ALARA in internal exposure of workers to natural radionuclides.

Parallel to the case studies an extensive review and critical evaluation is being carried out of monitoring strategies and methods that, in principle, are applicable in the optimisation of internal exposure situations. The critical review will pertain to potentials and limitations of strategies and methods and to new developments with respect to monitoring tools. There are various monitoring techniques available to allow the assessment of internal doses, such as static air samplers (SAS), personal air samplers (PAS), whole body or lung counting and analysis of excreta. Efforts will be made to show how the characteristics of these techniques fit with the specific needs of the optimisation of radiation protection.

For more details on that research programme or if you have an ALARA experience in managing internal exposure, do not hesitate to contact J. Van der Steen. (vandersteen@nrg-nl.com)

PRESENTATION OF A SOFTWARE TOOL TO ESTIMATE EFFECTIVE DOSES FOLLOWING INTAKES OF RADIONUCLIDES ACCORDING WITH THE METHODOLOGY ESTABLISHED IN PUBLICATION 78 OF ICRP

INDAC (Internal Dose Assessment Code), a computer program, allows the user to estimate and record doses following an intake of radionuclides. The code uses the methodology established in ICRP-79, which brings together the recommendations of ICRP-60 and the respiratory tract model of ICRP-66.

Some of the most important changes of ICRP-60 regarding the intakes of radionuclides are:

- Reduction of the annual effective dose limit from 50mSv to 20 mSv.
- Inclusion of five age groups of members of the public plus a group for workers.
- Extension of the integration time for dose calculation to 70 years for children.

The former model of ICRP-30 can easily be adapted to accommodate changes a) and c), but not b), because it was not designed to be applied to members of the public.

ICRP has issued a new respiratory tract model in Publication 66 (1995), which deals with the retention and clearance of radionuclides after an inhalation.

This same lung model has been adopted by European Union in its, recently approved, Directive 96/29/EURATOM of 13 May 1996. This Directive is compulsory for all members states before the year 2000.

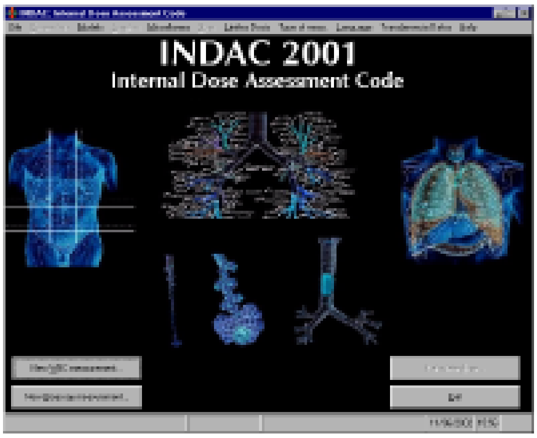
The new respiratory tract model is more realistic about the modelling of deposition and clearance of the inhaled particles, thus providing a more precise evaluation of the dose.

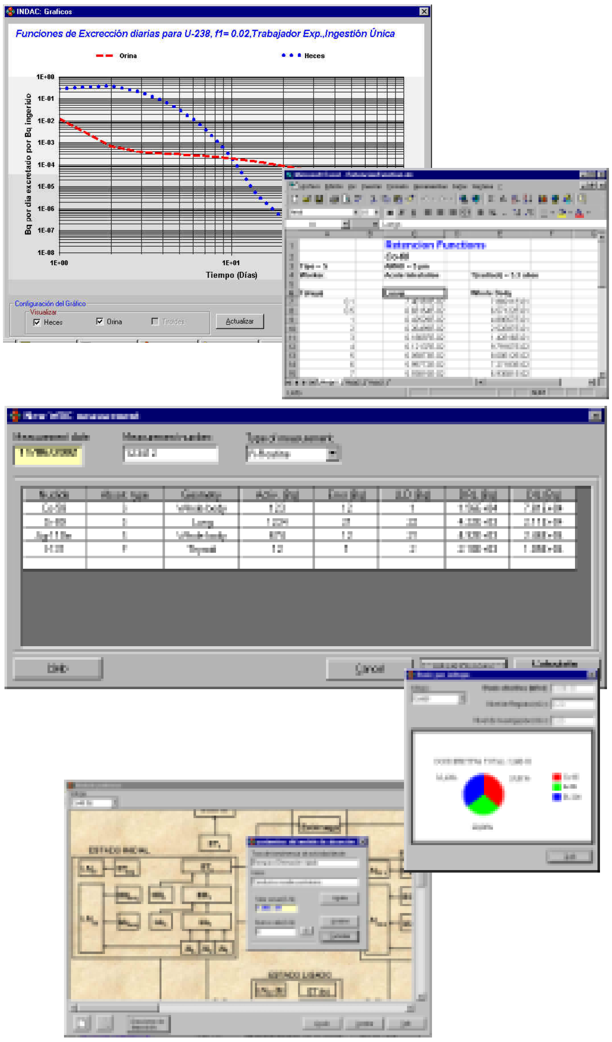
Therefore, the Spanish Nuclear Industry, represented by UNESA, and the regulatory body, the Spanish Nuclear Safety Council (CSN), have started a R&D project to make a computer application to make easier the use of the new model.

These two organizations have chosen IBERINCO as a company responsible to develop the tool.

INDAC (INternal Dose Assessment Code) : A COMPUTER CODE TO ESTIMATE EFFECTIVE DOSE FROM INTAKES OF RADIONUCLIDES ACCORDING WITH THE METHODOLOGY ESTABLISHED IN THE PUBLICATION 78 OF ICRP

INDAC is a computer program, developed by IBERINCO for Windows 9X/NT/2000/XP, that allows the user to estimate and record doses following an intakes of radionuclides. The code uses the methodology establised in ICRP-78, wich brings together the recomendation of ICRP-60 and the respiratory tract model of ICRP-66.





- Acute and chronic intakes, either from inhalation or ingestion.
- The retencion and excretion functions are represented in tables (Microsoft Excel) and/or graphs.
- The user are able to compare the experimental data with the retencion and excretion functions.
- Capability to modify the metabolic model
- Capability to modify the AMAD
- Capability to modify the value of F/M/S for inhalation and f1 for ingestion
- Data Base with the value of the measure activity and the calculate dose
- Complete Report with the results obtained
- Efective Dose and Equivalent Dose for each organ
- Advanced utility that allows the user to calculete dose from several measure with different intake date.
- Version of INDAC in English.

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January 2002

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Feedback on the interest and the use of the European ALARA Newsletter

Short Questionnaire

In order to improve the contents and distribution of this Newsletter we would like to have your opinion on the following issues

- **Which of the contents of the newsletter do you prefer?**

  Please indicate what subjects you are more interested in:

  1. Radiological incidents and lessons learnt
  2. Decommissioning
  3. Dosimetry
  4. Good practices in RP
  5. Please list other subject relevant to you not already envisaged by the newsletter:

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- **Indicate how you would like to receive the newsletter**

  1. Postal mail indicate postal address/es …………………………………..
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  2. E-mail indicate your email address …………………………………..
     …………………………………..
  3. Both

- **So far, the texts have only been provided in English. Has this been a serious problem**

  1. No
  2. Yes but not very important
  3. Yes it is very serious problem and it should be translated into ______________________(specify language)

- **Please feel free to give us any opinion, criticisms or suggestion you may have about this newsletter and/or of the EAN activities:**

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  Please send the form by Fax: +33 1 40 84 90 34

  Thank you.