Investigation of NORM activities in Sweden

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Abstract. Work activities where workers and the public may be exposed to naturally occurring radioactivity have been investigated in Sweden by the Swedish Radiation Protection Authority (SSI). Investigations were made as a summary of earlier measurements in Sweden and in other countries, inspections and measurements as well as interviews. Sweden has few sites for production of material containing naturally occurring radioactive substances, but such material occurs in many workplaces. The steel industry is the main activity where raw material is used in production. The concentration of radioactive substances in the raw material is however low. SSI found that for the majority of activities, doses to workers and the public are low as long as regulations from the Swedish Work Environment Authority regarding dust, ventilation and welding are followed. Two fields will need further actions though: peat ash and filters from drinking water treatment. For peat ash the next step is to look at the possibilities of regulating peat mining to avoid high concentrations of uranium in ash. For deposits of naturally occurring radionuclides in pipes and discarded filters from drinking water treatment, handling and disposal procedures, regulations, criteria and routines still have to be developed.

1. Background

In 1999, 15 environmental quality objectives were adopted by the Swedish Parliament. Another objective, on biodiversity, was adopted in November 2005. These objectives describe what quality and state of the environment are sustainable in the long term and provide a coherent framework for environmental programmes and inititatives at national, regional and local level. SSI is responsible for the objective “A safe radiation environment”. The objective has three interim targets of which one concerns ionizing radiation; by 2010 environmental concentrations of radioactive substances emitted from all human activities will be low enough not to represent a threat to human health or biological diversity. Radiation doses will be limited as far as reasonably possible. The maximum radiation exposure to the public (absorbed dose) due to human activities will not exceed 1 mSv per person and year. The additional individual dose to members of the public will be lower than 0.01 mSv per person and year from each individual activity.

The reason for the investigation made by SSI is the European Council Directive (96/29/Euratom) for the health protection of the general public and workers against dangers of ionizing radiation, which has integrated work activities into the scope of the Directive. Member States must identify work activities where exposure to natural radiation may arise. The Member States can then decide about which work activities should be subject to national control.

In 2003 the Swedish Government Committee on Management of Non-Nuclear Radioactive Waste proposed regulations regarding NORM to be included in the Swedish Radiation Protection legislation. Previously, the production, handling and waste management, including final disposal, of such products had not been subject to legal regulations. The Committee proposed that the producer that utilizes raw material containing naturally occurring radioactive substances must have the full financial responsibility for future depositing of the waste. The government accepted this proposal which is reflected in the Government Bill on Nuclear Safety and Radiation Protection from 2006. The Bill states that this kind of material must be regulated by the Radiation Protection Act, which has been the case since July 2006. The Bill also states that in cases where a work activity gives rise to wastes containing concentrations of natural radionuclides above levels of clearance/exemption, the company responsible for the activity is identified as the responsible ‘producer’. The financial responsibility for the waste management lies of course with the producer. The main problem to solve at the moment is how to dispose of the NORM waste in a correct way, from a radiation protection point of view.

2. Work activities

2.1. Ash

In 2005, SSI issued regulations and general advice on the handling of wood-fuel ash contaminated by ^{137}Cs. The use of peat in the production of energy may also produce ash with enhanced concentrations of naturally occurring radionuclides. Peat mining is today authorized by the Swedish Geological Survey — the Act on Nuclear Activities specifies a limit on the handling of materials containing uranium for nuclear fuel. The limit is 200 ppm uranium, equivalent to 2470 Bq/kg of ^{238}U. This regulation is applied for limiting mining from a radiological point of view. As this is not a judicially sound basis for the regulation, SSI is planning to investigate if a regulation could be introduced based on the Radiation Protection Ordinance. So far SSI has assessed the doses that might be caused by different exposure pathways. Discussion will take place whether to regulate peat mining or the handling of the ash. The decision will be founded on an optimization between costs and dose averted.

2.2. NORM residues

The Swedish drinking water regulations include action levels for radon in drinking water at 100 and 1000 Bq/L and a recommendation for uranium in drinking water at 15 µg/L. Some of the equipment for drinking water treatment available on the market, such as filters of different kinds, may be enriched with radionuclides in such a concentration that the used equipment needs to be handled, and disposed of with care from a radiological point of view. The volume of enriched used water treatment filters is growing and several issues have to be solved — handling and disposal procedures, regulations, criteria and routines still have to be developed. This is the case for all NORM waste, but is particularly important when it comes to filters from water treatment, be it filters from drinking water treatment plants or filters from drilled wells for households. SSI will further investigate how a final repository for used filters and deposits containing enhanced concentrations of naturally occurring radioactive nuclides will be arranged.

It is known that industries using large amounts of water may have problems with deposits of naturally occurring radionuclides in pipes. This has been found in pipes from paper industries in Sweden. Deposits are usually found when pipes are transported to scrap metal yards.

The iron and steel industry uses raw material from mines in two plants in Sweden. The concentrations of naturally occurring radionuclides are low in the raw material, but blast furnace slag contains enriched concentrations of these radio nuclides. The gamma dose rate on the surface of the slag is up to 0.4 µSv/h and the concentration of ^{226}Ra is 250 Bq/kg. The slag is reused as filling material for road construction and also for buildings. Preventive measures to avoid radon concentrations above the action level of 200 Bq/m^3 for indoor air should be taken when slag is used for building construction. Liquid discharges have not been investigated but since water treatment exists due to environmental regulations the discharges are considered low. Atmospheric discharges of ^{210}Po and ^{210}Pb from off-gas and treatment systems are also considered to be very low. Soil sample analyses from around one of the steal industry areas did not show any increase in the environmental concentration of these radionuclides.

2.3. Thoriated welding electrodes

Thoriated tungsten welding electrodes are used by both professional welders and hobby welders. Different studies on exposure from thoriated electrodes show that both the welding as well as the grinding of the electrodes may give rise to an exposure from thorium and its decay products. According to the Swedish Welding Commission, there is knowledge about the risk from thoriated welding electrodes among welders. Work environmental regulations state that separate ventilation must be used when welding but not for grinding. Wet grinding equipment is available on the market that reduces the dispersion of dust and particles. New environmentally friendly electrodes without thorium are available on the market and a slow change to these electrodes is in progress. Still, thoriated electrodes are used slightly more often than the environmentally friendly electrodes,

according to the major retailers of welding equipment in Sweden. SSI might consider encouraging a faster change to new electrodes on the market.

2.4. Zircon sand

Zircon sand is used for its high temperature properties in iron and steel foundries and in fine ceramics. Zircon is neither mined nor milled in Sweden. The exposure from the use and storage of zircon has been investigated and is considered low. The gamma dos rate from a bag of sand is up to 3 µSv/h, but the time spent close to the bag is short. The use of zircon in industries may volatilize ^{210}Po and ^{210}Pb and dust can be inhaled. It was observed that industries that use zircon sand have an interest in avoiding dusty environments due to other health aspects. As long as the Work Environment regulations for dust are followed, the risk from naturally occurring radioactive nuclides is low.

2.5. Historical waste

Historical waste from industry processes is found in several places in Sweden. Large amounts of burned alum shale are found in piles in areas where alum shale mining has occurred. The red coloured material is widely used as filling material on tennis courts and sports grounds. Before awareness of the hazards with radon emanation from the material had been raised, houses were built upon the material, with high radon concentrations indoors as a result. Residues from mining and the steel industry can also be found, as well as phosphogypsum from the phosphate industry. This material can be used for road construction but should be avoided as building material for house construction. The untouched historical waste is not considered hazardous from a radiological point of view.

2.5. Radon in workplaces

Radon in indoor air is the most common exposure to naturally occurring radionuclides in Swedish workplaces. Since 1997, an action level for workplaces above ground of 400 Bq/m^3 has been in place. Radon in mines has been controlled since 1972 and today there is an action level for radon progeny of 2.5 MBq·h·m^{-3} in a year (equivalent to a radon concentration of about 1500 Bq/m^3 for a 1600 h annual exposure time). Radon in mines is measured continuously and reported to the Work Environment Authority. If the radon exposure in a mine is found to be too high, a change in work tasks by the mine workers is required for a certain period.

A random selection of workplaces above ground was measured for radon during 2005 and 2006. The mean concentration of 209 measurements in 85 work places was 82 Bq/m^3. Two percent of the measurements showed radon concentrations above the action level, all in basements or on the ground floor. A separate study is ongoing for radon in schools and pre-schools. The action level for schools is 200 Bq/m^3 according to General Advice from the National Board of Health and Welfare. Preliminary results show that about 10 % of schools and pre-schools are estimated to have radon concentrations above 200 Bq/m^3. A summary of measurements made in schools and pre-schools until 1999 estimated that 16 % of the schools had radon concentrations above 200 Bq/m^3. In earlier studies, enhanced radon concentrations were found in water treatment plants and churches.

2.6. Aircrew

SSI is actively working in the area of protection of aircrew from cosmic radiation. SSI has initiated plans to regulate the situation for air crew members from a radiological point of view. The estimated doses to Swedish air crew are comparable to doses to workers at nuclear power plants.

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