Releasing the sites of nuclear installations

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The scale of future nuclear installation decommissioning challenges may be judged from the fact that over 500 nuclear power plants have been constructed and operated worldwide. OECD/NEA member countries account for more than 80% of the total number of plants, and most of these (some 350 plants with an average age of about 20 years) will need to be decommissioned in the next few decades. Recent planning indicates[1] that decommissioning activities will peak around the year 2015.

Decommissioning activities involve a number of steps which help lead to the ultimate goal of releasing facilities and sites from regulatory control. To date, considerable experience has been acquired in the clearance of materials and buildings. However, releasing the sites of nuclear installations from radiological control has been practised in a limited number of decommissioning projects only, as most decommissioning projects have not yet advanced to a state where release of the site is imminent or because the sites are, or will be, re-used for nuclear activities.

An attempt to address the different topics involved when releasing a site from radiological control has recently been undertaken by the OECD/NEA Working Group on Decommissioning and Dismantling (WPDD). The results of the study are expected to benefit a number of decommissioning projects where the release of the site is planned or has already started. This article summarises the main findings of the study, which can be found in the NEA publication entitled *Releasing the Sites of Nuclear Installations: A Status Report* [2].

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Main topics to take into account when releasing a site

The NEA status report identifies a number of topics and considerations relevant to the release of sites. The report emphasizes the role of the concepts of clearance and release, and provides guidance on establishing release criteria. Other topics covered are the development of a plan for the final survey, including determination of "nuclide vectors" (see explanation below), measurement techniques, subtraction of background radiation levels, the statistical criteria and data assessment, and the issue of underground contamination.

- **The appropriate authority in a country where the release of sites shall be implemented needs to make a decision on the appropriate dose criterion which shall be used.**

There is no unanimous opinion on whether the same criterion should be used for the release of land as for clearance of materials (10 μSv/a) or whether more flexibility should be allowed. Some countries have used dose values up to 250 μSv/a for sites, others prefer 100 μSv/a. A few even go as far as 10 μSv/a. However, while materials can be traded across borders, land cannot. Compliance with 10 μSv/a in all cases might be a waste of effort. There are many types of installations which certainly could meet 250 μSv/a quite easily, while clean-up to a standard of 10 μSv/a would create additional effort which may not be justified by the reduction of potential individual dose. Nevertheless, it might currently be prudent to allow countries a flexible approach until more experience is gained with site releases. A flexible approach offers the possibility of applying the ALARA or optimisation principle and making best use of available resources.

Release levels are usually derived on the basis of radiological models, which in turn consist of scenarios describing a multitude of exposure situations and pathways.

- Site-specific approaches will usually concentrate on a smaller number of exposure pathways and scenarios which are tailored to the conditions of the site. Site-specific models will take account of site-specific parameters, such as the size of the site, the exact nuclide vector, known details of the future use of the site, and meteorological, hydrological and other parameters relating to the site.
- Generic approaches need to accommodate a larger number of different sites, the details of which are not known *a priori* therefore cannot be incorporated into the models. Generic models have to include all pathways and scenarios that might become relevant for any site in the country or in the region for which the derived release/clearance levels shall be valid. Such models may therefore have a tendency to be conservative when compared with site-specific approaches.

The models which have been used in a number of countries usually contain scenarios that cover all exposure pathways. A general overview of such pathways is given in the Figure. The radiological models are used to calculate release levels for a number of radionuclides which are or are deemed to be relevant for the release measurements.

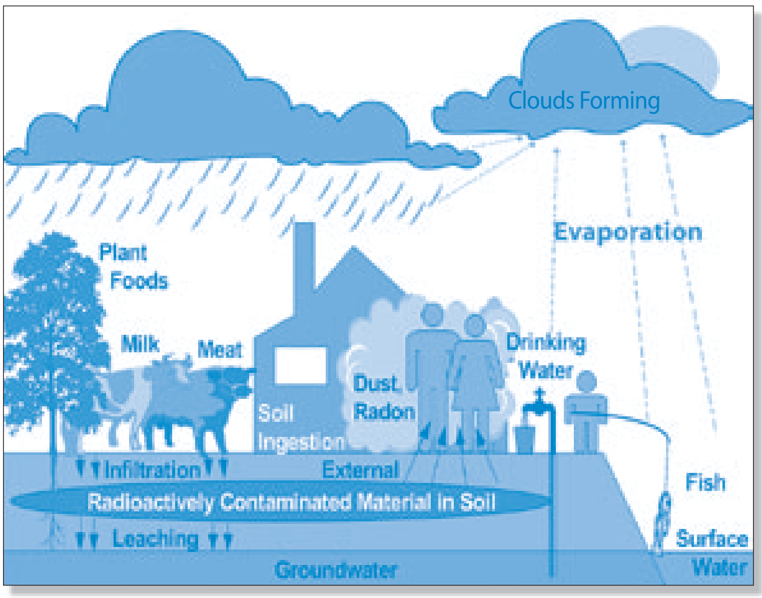
If the site complies with the appropriate release criteria when a reasonable set of possible future uses have been considered, the site should be released for unrestricted use, which is the preferred option. If this is not feasible, the site may still be released after remediation for restricted use. In case of restricted use, the restrictions should be designed and implemented to provide reasonable assurance of compliance with the dose constraint for as long as they are necessary.

Some sites may be released using a phased approach. This means that a substantial part of the site will be released prior to the end of institutional control of the whole site, for example to enable the setting-up of new (non-nuclear) companies there or to reduce the size of the licensed nuclear site. Such a situation may occur when one reactor is decommissioned to green-field at a multi-block nuclear power plant site where the other units remain operational, or at a large nuclear site where some part of the land is not necessary due to changes in the nuclear programme.

➠ **A plan for the release and final radiation survey of the site needs to be developed well before the release measurements.**

When the release of a site becomes imminent, a plan for the release and the final radiation survey needs to be developed. This plan must demonstrate how it will be assured that the site complies with the release criteria. On the basis of the site

Pathways used in the RESRAD (Residual radiation) computer code



characterisation, the plan should identify the radiological contaminants and classify or categorise the impacted areas by their potential or probability for residual radioactivity. The plan also needs to establish the methods and performance criteria used to conduct the survey and to define the number and location of measurements or samples necessary to ensure that the collected data will be sufficient for statistical analysis.

The concept of radionuclide vectors (also called nuclide vectors and "fingerprints") is useful. The activity percentages of the radionuclides which are or might be present on or in the top layer of the site's soil is determined before the release measurement takes place. One of the particular aims of establishing a radionuclide vector is to determine the activity ratios between the radionuclides which are easy to measure, for example cobalt-60 or cæsium-137, and those which are hard to measure, including alpha emitters and pure beta emitters such as strontium-90. The radionuclides which are easy to measure are often referred to as "key nuclides" because the activity of the other nuclides is derived from them.

The subtraction of the background activity is an important issue as soil contains non-negligible amounts of radionuclides of the natural uranium and thorium decay chains as well as potassium-40. In addition, land has been exposed to fall-out which usually may be subtracted as well as it does not originate from the practice which has been carried out on the site.

➠ **Appropriate techniques for release measurements of sites in combination with statistical approaches are available.**

Most direct measurement techniques can be applied in cases where the nuclide vector contains a sufficient amount of gamma- or beta-emitting radionuclides. For areas with a substantial amount of alpha emitters or other radionuclides which are hard to measure, and which cannot be correlated to an easy-to-measure radionuclide, sampling may be the only reasonable approach.

When activity measurements are taken one must define the area to which they relate. A measurement with, for example, a collimated *in situ* gamma spectrometer measures an area of the order of 1 m². Radiological evaluations for site release show that only the knowledge of activity concentrations averaged over much larger areas (100 m² to 10 000 m²) is relevant. This has been demonstrated by several countries which have even introduced such averaging areas in their national legislation (e.g. Germany). These averaging areas match in particular the approach of *in situ* gamma spectrometry combined with statistical approaches.

As it is not desirable to carry out measurements on the entire surface area of the site to be released, there must be statistical criteria to decide which percentage of the area needs to be measured and how reliable the result will be. Such statistical evaluations depend on many factors, such as the measurement technique, the likelihood of contamination and the desired confidence level.

➠ **Underground soil contamination must be taken into consideration in the release of sites.**

Release criteria and survey methods are generally developed for surface residual radioactivity (in the upper 5-15 cm of soil). If significant amounts of residual radioactivity have penetrated the soil deeper than this range, this should be taken into consideration when performing the radiological modelling and when developing the final survey plan.

Conclusions

Releasing the sites of nuclear installations or places where a licensed use of radionuclides has taken place is a mature practice in those countries with a number of advanced or completed decommissioning projects. Appropriate measurement techniques combined with statistical approaches enabling the calculation of the measurement density in accordance with the contamination level of the site are available. Release measurements can be applied swiftly in cases where a substantial amount of gamma-emitting nuclides is present in the radionuclide vector.

A number of countries have carried out site releases successfully by using different dose criteria, ranging from the trivial dose range (~ 10 μSv/a) up to a larger fraction of the individual dose limit of 1 mSv/a (~ 100 to 300 μSv/a). In addition, different models for deriving suitable release criteria have been applied. As a site is immobile, there should be less need for an international harmonisation of release criteria and approaches than, for example, for the clearance of metal scrap and building rubble, which may be transported across borders and for which an international harmonisation is desirable. ■

References

1. NEA (2002), *The Decommissioning and Dismantling of Nuclear Facilities: Status, Approaches, Challenges,* OECD/NEA, Paris.
2. NEA (2006), *Releasing the Sites of Nuclear Installations: A Status Report,* OECD/NEA, Paris.