Clearances at the Mühleberg Nuclear Power Plant and clearance of the buildings and plant area of the Lucens Experimental Nuclear Reactor: Practical experience with HSK Guideline R-13

E. Neukäter[a]; H. Leuenberger[a]; Dr. C. Vuilleumier[b]; Dr. A. von Gunten[a]

[a] BKW FMB Energy Ltd, CH-3203 Mühleberg, Switzerland
[b] National Association for the Support of Industrial Nuclear Technology, CH-3000 Bern

The criteria in HSK Guideline R-13 relating to the clearance procedure allow operators to handle clearances efficiently within a reasonable short time period and also still with a high degree of safety. By the virtue of the commitment by the operator to speedy processing based on the guarantee of prompt assessment and its confidence in operator responsibility, the supervisory authority makes it possible for the operator to meet specific targets. Experience acquired with the clearance of approximately 120 Mg of different materials at the Mühleberg Power Plant and clearance of the radiation protection areas at the former experimental nuclear reactor in Lucens is described and areas for improvement are discussed. Both Guideline R-13 and the clearance procedure, that is based on it, have proved to be very effective overall.

1 Introduction

Under the Swiss Radiation Protection Act [1], operators of nuclear facilities must use a documented clearance procedure for removing inactive materials from a controlled area for the purpose of disposal or reutilization and also for removing certain areas from the controlled area. The Swiss Federal Nuclear Safety Inspectorate (HSK) has described in accordance with the Radiation Protection Ordinance [2] this procedure for its area of supervisory responsibility in its Guideline R-13 entitled “Clearance of inactive materials and areas from controlled areas (clearance guideline)” [3].

This guideline – which came into force on 15 February 2002, after a consultation period in which the facilities discussed comments and suggestions for changes with HSK – contains procedures and criteria for clearance or release of inactive materials and areas from controlled areas, a process that will be referred to in the following simply as clearance. These procedures and criteria are binding for operators of nuclear facilities.

In the present paper, practical implementation of HSK Guideline R-13 is described with reference to the procedure for clearance of materials at the Mühleberg Nuclear Power Plant (KKM). In addition, the paper also discusses the clearance of controlled areas and the clearance of radiation protection areas as a precondition for terminating a nuclear licence, with reference to the procedure used for the Lucens Experimental Nuclear Reactor.

2 Basic information regarding clearance

The Radiation Protection Ordinance defines the essential boundary conditions under which the clearance of materials from controlled areas or the clearance of controlled areas themselves can take place. After the clearance is completed, the materials or areas in question are no longer radioactive substances as defined under the Radiation Protection Ordinance and are no longer subject to that ordinance.

The HSK guideline does not contain any new rules or limit values. It has been conceived as a guide. If followed, it will guarantee a relatively simple and quick assessment or check by the inspection authority, but it lays no claim to absoluteness. If the legal requirements can be satisfied in ways other than are described in the guideline, then that is certainly possible, but the expense for the assessment will be higher due to the individual analysis required and the longer processing time involved. Guideline R-13 is therefore not normative in nature but it does summarize the legal standards and defines procedures that, if followed, will mean that no testing by the authorities will be necessary other than random inspections and checks for compliance with clearance values.

Clearances are generally handled by the operator. Guideline R-13 provides the operator with a tool that permits reliable, real needs-based and feasible processing. This ensures that the procedure will be in compliance with legal regulations and also that materials can be removed promptly from the plant area after clearance.

This is only possible because the following conditions have been provided for carrying out the measurements and steps associated with clearance:
- uniform procedures have been described;
- reliable boundary conditions have been defined based on legal standards;
- as a result, a common understanding exists between the supervisory authorities and nuclear power plants regarding the clearance of materials.

3 Provisions of the Radiation Protection Ordinance and HSK Guideline R-13

3.1 Limits and guideline values

The defined limits and guideline values, together with the permissible averaging criteria, form the basis for selecting the measurement techniques that will be used to carry out measurements proving that radioactivity levels are below clearance limits both as regard to materials to be cleared and structures in which controlled areas are to be eliminated.

The limits that are to be used for clearances are defined in Art. 2 (2) of the Radiation Protection Ordinance as follows:
- dose rate at a distance of 10 cm (0.1 μSv/h) and
- absolute (Bq) or specific (Bq/kg) activity (Radiation Protection Ordinance, Appendix 3, Column 9).

Guideline values, according to the definitions given in Art. 4 of the Radiation Protection Ordinance (and in Appendix 1), are values derived from limits. Adherence to the guideline values guarantees compliance with the limits. If the guideline values are exceeded, then measures must be taken to ensure compliance with the limits. The surface contamination values to be adhered to are guideline values.

3.2 Important points from HSK Guideline R-13

The important points from HSK Guideline R-13 for the entire clearance procedure are the following:

1. Individual analyses for clearance purposes are possible. Clearance may occur even if the dose rate criterion is exceeded, provided that compliance with the de Minimis concept, i.e., a value below 10 μSv/a, can be demonstrated.
2. In individual cases, the authorities may approve the mixing of active and inactive wastes with the goal of clearance as non-radioactive waste.
3. Clearance is not handled by HSK but is the responsibility of the operator, based on a qualified procedure and on the documentation resulting from application of this procedure.
4. Clearances for materials from the same process whose total weight exceeds 1 Mg or whose volume exceeds 1 m^3 must be reported to the authorities at least 10 working days before removal.
5. During this period, HSK shall decide, on the basis of submitted documentation, whether it shall carry out an inspection that will include a check of the measured values. An eventual inspection generally occurs within 10 days so that, if HSK confirms that the limits have not been exceeded, the materials can be removed as scheduled by the operator.
6. Smaller amounts, i.e. materials less than 1 Mg in weight or 1 m^3 in volume, may be removed from the facility after clearance without a waiting period and without inspection by the authorities. No individual reports are required.
7. If HSK determines that the limits have been exceeded, the cause must be determined. If the deviation is greater than a factor of two, then the matter must be classified in accordance with the reporting criteria, reported to HSK and explained in a further report.
8. Measurement procedures are defined as well as minimum requirements for quality procedures. This also applies to training of personnel and documentation of test results.

4 Practical application

4.1 Mühleberg Nuclear Power Plant

BKW FMB Energy Ltd has been successfully operating the Mühleberg Nuclear Power Plant (KKM) since 1972. In the course of operation, materials are arising that have a low activity content and may therefore be disposed of as inactive materials in accordance with legal provisions.

Measuring techniques

Tab. 1 lists the measuring devices used at KKM for each limit or guideline value category. The maximum allowable averaging criteria have a significant effect on classification.

Tab. 1 Limits and guideline values, averaging criteria and measuring techniques

Limit or guideline value	Averaging criterion	Measuring technique
Surface contamination for buildings and materials having a suitable surface	100 cm^2	Contamination monitor
		Smear test sampling with evaluation, total β/γ or γ-ray spectrometer reading
		Material sampling (scratch sample), total β/γ or γ-ray spectrometer reading
Activity, absolute or mass-specific	100 kg	Indirect detection through surface contamination measurement
		Total γ measuring system
		Solid material sampling with γ-ray spectrometric evaluation
Dose rate	0.1 μSv/h at distance of 10 cm, single part	Scintillation dose rate measuring device, computational verification

As shown by the averaging criteria, it is not possible to verify that values are below all limits and guideline values using a single measuring technique. A combination of several measuring techniques is normally required, based on evaluation of their respective advantages and disadvantages (see Tab. 2).

Method

A combination of different measuring techniques is used at different times and locations inside and outside the controlled area to verify that the individual limits and guideline values are not exceeded.

The overall procedure is described in a work instruction document that includes an analysis of the advantages and disadvantages of the measuring techniques and defines the measurements to be carried out, their parameters, and any other steps that may need to be taken.

If retrofitting or modifications are being carried out, then a decision is made in the planning phase regarding which materials are to be disposed of as radioactive material and which materials, after decontamination if necessary, can and will receive clearance for removal as inactive material.

When materials accumulate in the controlled area, initial contamination measurements are taken during decommissioning in conjunction with operational radiation protection, preferably by taking smear test. These measurements determine basically whether the materials qualify for clearance. Additional information is obtained through measurements taken after decontamination in order to check results.

If the results of these measurements are below the limits or guideline values, then the materials are subject to more exact measurements at the boundary of the controlled area. These measurements are generally taken using a total gamma measuring system, surface contamination measurements with contamination monitors, and dose rate measurements using a scintillation measuring device.

Tab. 2 Advantages and disadvantages of various measuring techniques

Measuring technique	Advantage	Disadvantage
Smear test sampling	Quick evaluation possible, even in areas that are not accessible using contamination monitors or dose rate meters	Only activity that can be wiped off, not fixed surface contamination Sampling factor not defined
Contamination monitor	Measurement of total activity; measured area corresponds more or less to averaging area	Surface being measured must correspond to the detector area; self-absorption in the surface and distance must agree with the calibration
Material sampling (scratch test samples, solid material test samples)	Very precise gamma-spectrometric determination of activity; detection both of mass-specific and surface-specific limit or guideline value with one measuring technique	Expensive method as regards sampling and evaluation; time-consuming; representative quality of sample must be guaranteed
Total γ radiation measuring system	Fast measurement of large masses; very precise measurement; reproducible; can detect hidden and hot spot activities; averaging weight corresponds more or less to the measured weights	Detection of the surface-specific guideline value not possible with 100 cm^2 averaging area, not even via rating of the homogeneity of the activity distribution; computational verification of dose rate not fully developed
Dose rate	Fast measurement of single part possible; γ-spectrometric detection of single nuclides possible to a limited extent	Single-part measurement only for dose rate; some contradiction with averaging criteria

When the measured values are below the limits or guidance values, the materials are removed from the controlled area (outward transfer) and undergo further measurements outside (in areas with a low background dose rate) using contamination monitors and dose rate meters. In addition, samples are taken as a function of these measurements and tested further by total β and/or γ-ray spectrometry measurements.

Once the documentation is completed, the materials are cleared in accordance with the boundary conditions defined in Guideline R-13 and prepared for transport. Materials less than 1 Mg in weight or 1 m^3 in volume can be immediately cleared by the operator alone.

If these minimum amounts are exceeded, clearance of the materials must be reported to HSK and the appropriate documentation submitted. HSK may carry out check measurements within 10 working days after being informed about the clearance. If there is no HSK inspection within those 10 days, then the material can be removed from the plant area without any further action.

4.2 Lucens

The National Association for the Support of Industrial Nuclear Technology (NGA) was responsible for the controlled area of the storage building and the monitored area on the plant grounds until the last casks containing radioactive waste from the decommissioning of the Lucens Experimental Nuclear Reactor were removed. Once the casks had been shipped to the interim storage facility operated by Zwischenlager Würenlingen AG (ZWILAG), it was necessary to verify that the activity limits were not exceeded in the controlled area and on the monitored plant grounds so that radiological clearance could take place, followed by an application for release from nuclear regulatory control.

NGA asked KKM to take care of overall radiation protection. This also included the radiological clearance process as it relates both to materials and to elimination of radiation protection areas (controlled and monitored areas).

The standards in Guideline R-13 on material clearances were implemented in a process similar to that used at KKM. Additional provisions had to be defined only for the clearance of controlled areas. An additional consideration was that Guideline R-13 deals only with the controlled area and not with the monitored area of a nuclear facility or with any adjacent areas.

Therefore a working procedure was created prior to the shipments in which the complete subject of “clearances” was addressed and regulated. The materials, buildings and other areas of the facility that were scheduled for clearance were described, as well as all measurements and procedures in connection with clearance. The working procedure was submitted to HSK for inspection and approval. The essential boundary conditions for clearance can be described as follows:

- Because of the time frame, local conditions and also the types of materials (including material containing asbestos), prompt processing of the clearances was urgently necessary. HSK responded accordingly in that some of the assessment and checking of KKM measurements was carried out on line so that clearance could be confirmed immediately. Fig. 1 shows an example of a cleared batch of material.

Fig. 1: Cleared batch of material in Lucens

- No open radioactive substances had been handled when casks were stored in the structures being cleared, either in the controlled area or in the rest of the monitored area. For this reason, conservative assumptions were made regarding the nuclide vector, and thresholds were defined that would require extra verification measures if they were exceeded.
- In the controlled areas, measurements were carried out dynamically over the entire floor area whereas a static measurement was carried out at the point with the highest counting rate within a marked grid measuring one square meter. Statistic checks of these measured values were made if the results warranted them. The only measurements taken on the walls were random measurements inside a one-square-meter grid. Fig. 2 shows the grid areas that were used for clearance of the former cooling tower basin where the casks containing radioactive material had been stored.

Fig. 2: Grid areas used in clearing the controlled area at Lucens.

- Outside the controlled area in the rest of the monitored area, measurements were taken on the basis of suspected activity relating to work connected with removal of the casks and also purely randomly or at locations at which an accumulation of radioactivity could be assumed. These also included locations where activity concentrations would have been possible as the result of reactor operation.
- Material samples of the building structures were taken only when the threshold values were exceeded, and verification of the specific limit (Bq/kg) was done on the basis of surface contamination measurements.
- In situ gamma-ray spectrometer measurements would have been carried out only in cases where significant contamination and dose rate values were detected.
- The boundary conditions for assessing smear test samples were defined (as well as the thresholds based on those conditions). Samples were only taken at the points at which geometric conditions made it impossible to carry out direct measurements. Sampling plus gamma-ray spectrometric evaluation was only carried out if time allowed. In case of discrepancies between KKM measurements and those of the regulatory authorities the method for further proceeding was fixed.
- There was no provision for radioactivity measurements outside the plant grounds. They were only carried out in connection with check measurements by the authorities to confirm evidence.

The clearance measurements at Lucens were carried out within the scheduled time period of one week at the end of September and beginning of October 2003. The application for clearance of the two radiation protection areas was also submitted in October 2003. The approval required under Art. 72 of the Radiation Protection Ordinance was granted in November 2003 after check measurements by HSK and final verification measurements.

The removal of nuclear regulatory control, for which clearance of radiation protection areas was a necessary precondition, was ordered by the Swiss Government on 3 December 2004. On the same day, the Federal Department of Environment, Transport, Energy and Communications (DETEC) issued the following media release:

„*Der Bundesrat hat heute das Gesuch der Nationalen Gesellschaft zur Förderung der industriellen Atomtechnik (NGA) um Aufhebung der Aufsicht für die Parzelle 925 in Lucens gutgeheissen.*
(…) Nach dem Abtransport dieser Abfälle ins Zentrale Zwischenlager für radioaktive Abfälle in Würenlingen im September 2003 hat die NGA ein Gesuch um Aufhebung der atomrechtlichen Aufsicht für das erwähnte Grundstück eingereicht. Gestützt auf das Gutachten der HSK kommt der Bundesrat zum Schluss, dass die nötigen Stilllegungsarbeiten vorgenommen wurden und die gemessenen Werte der radioaktiven Strahlung der natürlich vorkommenden radioaktiven Strahlung entsprechen. Er hat daher der Aufhebung der atomrechtlichen Aufsicht zugestimmt."

"*The Federal Council today approved the request of the National Association for the Support of Industrial Nuclear Technology (NGA) to remove lot 925 in Lucens from supervisory control*. (…) After these wastes had been shipped to the Central Interim Storage Facility for Radioactive Wastes in Würenlingen in September 2003, NGA submitted a request for removal of nuclear regulatory control for the property in question. Based on the expert report by HSK, the Federal Council has reached the conclusion that the required decommissioning work has been completed and that the measured values for nuclear radiation are equivalent to the naturally occurring nuclear radiation. It has therefore approved removal of nuclear regulatory control."

5 Experience

5.1 Clearances of materials at KKM

After introduction of HSK Guideline R-13 on 15 February 2002, the following amounts of material were cleared without problems from KKM by 30 September 2004 in accordance with the provisions of the guideline:

- Approximately 120 Mg of reportable inactive material in conjunction with 17 clearance notifications. Examples are shown in the figures: a batch of cleared piping (Fig. 3) and a cleared component (Fig. 4). A total of five inspections were carried out. There were no reportable instances of measured values exceeding limits (above a factor of two), and even with inspections the materials were generally shipped from the plant grounds within a short time after clearance, namely within two weeks. The only basis for complaint was a single part weighing 100 g, in which the measured dose rate slightly exceeded the limit.

Fig. 3: Cleared cooling piping at KKM

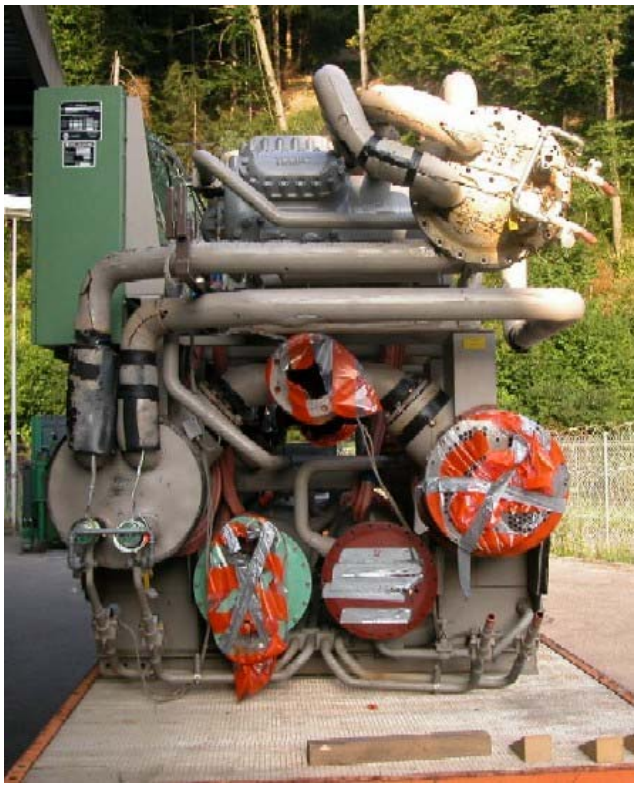

Fig. 4: Cleared refrigerating compressor at KKM

- Approximately 50 Mg of non-reportable small parts classified as small amounts (less that 1 m^3 or 1 Mg, not subject to clearance notification and inspection by HSK) based on the same measuring methods, but on the operator's own responsibility in accordance with a qualified process.
- In addition, approximately 100,000 clearance measurements of tools were carried out.

It should also be noted that there have not been any significant changes in the measuring technology or measuring techniques used or their assessment criteria compared with the period before Guideline R-13 went into force.

Evaluation of whether the materials qualify for clearance was done in the same way in accordance with the same criteria as before, so that acceptance of the personnel entrusted with the measurements was ensured due to this consistency. Tab. 3 shows a summary of the important data on the clearances during the period from 15 February 2002 to 30 September 2004.

Tab. 3 Clearances in the period from 15 February 2002, went Guideline R-13 took effect, to 30 September 2004

No.	Clearance date	Material	Weight	Inspection	Result of inspection	Removal date
1/02	26 Mar 02	Metal scrap	3,626	No, ☏ 03 Apr. 02		04 Apr 02
2/02	02 May 02	Metal scrap	3,222	Yes, on 14 May 02	Oral report 14 May, everything OK, inspection report 21 May	15 May 02
		Cleaning fluids	1,296			22 May 02
3/02	16 Jul 02	Metal scrap	3,309	No, ☏ 24 July 02		31 Jul 02
4/02	09 Aug 02	Metal scrap, stone shielding	24,431	Yes, on 20 Aug 02	Orally 20 Aug, everything OK with exception of one 100 g shekel, insp. report 26 Aug	22 Aug 02
5/02	24 Aug 02	Refrigerating compressor	6,200	No, ☏ 30 Aug 02		26 Sep 02
6/02	16 Oct 02	Metal scrap	3,410	No, ☏ 21 Oct 02		22 Oct 02
7/02	29 Oct 02	Refrigerating compressor	2,500	No, ☏ 06 Nov 02		29 Nov 02
8/02	05 Nov 02	Various demolition materials, wood, metal, glass, construction debris	7,563	Yes, on 26 Nov 02	Oral report 26 Nov, everything OK, inspection report 04 Dec	27 Nov 02
9/02	27 Nov 02	Various demolition materials, wood, metal, glass, construction debris	5,518	No, ☏ 05 Dec 02		12 Dec 02
10/02	27 Nov 02	Metal scrap	8,019	No, ☏ 05 Dec 02		12 Dec 02
1/03	21 Jan 03	Metal scrap	3,015	No, ☏ 28 Jan 03		29 Jan 03
2/03	05 Feb 03	Metal scrap	7,242	Yes, on 14 Feb 03	Oral report 14 Feb, everything OK, inspection report 26 Feb	18 Feb 03
3/03	19 Feb 03	Metal scrap	2,875	No, e-mail 27 Feb 03		03 Mar 03
4/03	24 Apr 03	Metal scrap	10,427	No, e-mail 30 Apr 03		05 May 03
5/03	12 Nov 03	Metal scrap	5,128	No, e-mail 18 Nov 03		25 Nov 03
1/04	30 Mar 04	Metal scrap	5,204	Yes, on 30 Apr 04	Oral report 30 Apr, everything OK, inspection report 11 May	30 May 04
2/04	23 Sep 04	Metal scrap	15,428	No, e-mail 29 Sep 04		01 Oct 04

The following features have proved to be especially effective:

- Guideline R-13 makes fast processing of clearances within a short time period possible and also guarantees prompt removal of materials from the plant grounds (no more than two weeks after clearance is reported).
- Because of the clear definition of the supervisory conditions under which HSK assesses the operator's clearances, it has been possible to improve the measurement procedure while maintaining constant quality and thus reducing overall costs.
- The clearance of smaller amounts of material from a given process on the operator's own responsibility but in accordance with a qualified process means that the clearance process can be simplified, since collection and storage are then no longer necessary. The quality of measurements and other steps in the clearance process is just as good as the procedure for larger volumes or weights, even though there is no inspection by HSK.
- The minimum standards for documentation have resulted in a unified system and therefore increased efficiency.

5.2 Clearance of areas at Lucens

Because of the early definition of measurement boundary conditions and the involvement of HSK in the procedure for check measurements, the material clearances went very smoothly. A total of approximately 3.6 Mg of metal and asbestos cement slabs as well as 1 m^3 of construction debris (about 2 Mg) was cleared.

The following procedures proved to be especially effective:

- Measurements for clearance of the controlled area were carried out dynamically over the entire surface based on fast measuring parameters (attenuation τ at 3s). Based on a grid involving one measurement for each square meter, steady-state measurements with statistically higher-value measuring parameters (attenuation τ at 10s, measuring time t at 30s) were then taken at the spots with the highest counting rate. This measurement was marked on site on the building structure, and the counting rates were recorded in a test report.
- By using dynamic measurements, it was possible to scan large areas in a relatively short time and to reliably detect relevant activity levels in comparison with limits and guideline values, because of the selection of the threshold value for further action.
- The scope of the measurements was a function of the contamination risk, so that a significantly lower number of measurements were taken in the monitored area than in the controlled area. They were based on the probability of contamination resulting from activities related to loading and handling or to possible accumulation effects during the period in which the casks were stored. The measurements were carried out under the same parameters as in the controlled area.
- Thanks to the documentation instructions for material clearances, it was possible to document the measurements in the controlled area and in the monitored area so that the documentation was clear and understandable and focused on the essential information.

5.3 Areas for improvement

As with an earlier evaluation of initial experience with HSK Guideline R-13 [4], the following issues were raised as areas for improvement in connection with the processing of clearances. However, these points have their roots not only in HSK Guideline R-13 but also to some degree in the Radiation Protection Ordinance:

- The surface-specific averaging criterion often causes problems when total gamma measuring technology is used because of large weights or surface areas. Detection over an area of 100 cm^2 (corresponding to a resolution of 300 Bq for Co-60, for example) is practically impossible in larger installations. Even with a homogeneous activity distribution and larger allowable averaging surfaces such as 1 m^2, detection is still complicated.
- Averaging over 100 cm^2 should be reconsidered, especially where clearance of controlled areas is concerned. A more advanced measuring technique such as in-situ γ-ray spectrometry is basically excluded by this restrictive criterion or made less effective by requiring it to be combined with other measuring techniques.
- Another issue that should be reconsidered is the extent to which the method that will be used for disposing of the materials should affect the analysis of limits or guidance values or the averaging criteria. If there is to be no manual handling of the cleared materials, for example, then it would not be necessary to provide evidence relating to the surface-specific guidance value.
- When the mass-specific averaging criterion is used, the interpretation of the concept “single part” sometimes causes problems, especially when providing evidence for the dose rate criterion. Averaging over a maximum of 100 kg is permitted. Often, however, there are several single parts in a batch, especially with scrap measurements. If, in such cases, measurement based on the averaging criterion is used to prove that values do not exceed the mass-specific limit, then proof is required that the dose rate limit is not exceeded in any single scrapped part, which is consequently very time-consuming and does not take into account the radiological relevance of this process given the eventual disposal method.
- The reporting criterion that applies when values higher than a given limit or guidance value are detected through HSK check measurements and the requirement that this then must be classified as a reportable event results in a restrictive clearance process and therefore entails additional cost.

6 Final comments

HSK Guideline R-13 has been implemented in the form of internal procedures established by operators of nuclear facilities, and this process has been accomplished without major problems. Our experience has shown that a few points in the guideline and in the Radiation Protection Ordinance need to be reconsidered and perhaps revised so that the practical clearance process can be further improved.

Guideline R-13 is a well-functioning tool for carrying out the measurements and steps associated with the clearance process:

- by stating the legal requirements clearly, it establishes reliable boundary conditions and procedures for clearance and removal of materials from the plant grounds;
- there is a common understanding between the supervisory authorities and nuclear power plants regarding the clearance of materials.

An especially positive result is that by trusting in the operators' willingness to take responsibility and in their sense of responsibility the supervisory authoritiy has created a work climate in which clearances can be handled in a short time period, in accordance with objectives, and in an atmosphere of mutual respect, while at the same time maintaining a high standard of safety.

From the perspective of KKM, both Guideline R-13 and the clearance procedures based on it have proved on the whole to be very effective in Switzerland.

Literature

[1] Strahlenschutzgesetz (StSG) [Radiation Protection Act] of 22 March 1991 (SR 814.50).

[2] Strahlenschutzverordnung (StSV) [Radiation Protection Ordinance] of 22 June 1994 (SR 814.501).

[3] HSK Richtlinie R-13 "Inaktivfreigabe von Materialien und Bereichen aus kontrollierten Zonen (Freimessrichtlinie)" [HSK Guideline R-13, "Clearance of inactive materials and areas from controlled areas (clearance guideline)"] dated 5 February 2002.

[4] "Die R-13 in der Praxis" ["Practical Application of R-13"], paper by R. Schuh and E. Neukäter (both KKM) and by F. Cartier (HSK) delivered at the 2003 TüV Nord Clearance Symposium in Hamburg, Germany.