Monitoring of External Workers (Section 20 of German Radiological Protection Ordinance)

Wilfried Roth

Power Generation Group (KWU) of Siemens AG, Dept. UAS3, Erlangen, Germany

Abstract

Employees of external companies performing work within the scope of service, repair and upgrading activities in nuclear facilities must be monitored for possible incorporation of radioactivity in the same way as operating personnel employed full-time by the plants concerned. The practical implementation of regulations governing activity incorporation monitoring in accordance with the Guideline for Physical Radiation Protection Monitoring, and the application of these procedures to external, occupationally exposed workers executing work in nuclear facilities (in particular nuclear power plants), are described. The criteria for determining the radionuclides to be monitored, the monitoring techniques available, and the frequency of measurement performance are presented. To minimize the effort involved, the practical implementation of the monitoring procedure is carried out in close cooperation with the plant operators. The key interfaces and threshold values involved are indicated. The experience and results gained within the course of implementing this monitoring procedure over the past four years are described.

1 Introduction

The employees of the Power Generation Group (KWU) of Siemens AG are mainly involved in performing service, repair and upgrading activities at nuclear power plants. A small proportion of our staff also work in other nuclear fuel cycle installations (fuel assembly fabrication plants, hot-cell facilities, etc.) or at research facilities. This paper will focus mainly on incorporation monitoring with respect to the most frequently occurring activities in nuclear power plants.

2 Nuclides to be monitored and determination of nuclide vector

Incorporation of radionuclides can occur at nuclear power plants as a result of contamination and a resultant inhalation of released aerosols. In addition, inhalation of iodine nuclides and exposure to radioactive noble gases may occur in specific cases. Alpha-emitters arise to only a very limited extent in nuclear power plants in which no major fuel rod damage occurs.

The key radionuclides to be taken into consideration are shown in the following table together with their limit values:

Nuclide	γ - Energy [keV]	Annual Limit for Category A [Bq]
Co-60	**1332**	**4 E 05**
Cs-134	**605**	**4 E 06**
Cs-137	**662**	**6 E 06**
I-131	**365**	**1 E 06**
Alpha-emitters	**-**	**100 – 400**

Co-60 arises from activation of material losses in piping and vessels, while the cesium and iodine isotopes occur as fission products only in the event of fuel rod damage. The same applies to the alpha-emitters. The nuclides occur in the form of oxides, where applicable. Alpha-emitters do not occur alone, as Cs-137 is always released together with alpha-emitters in the event of fuel rod damage. (This serves as an indicator for a possible increase in alpha activity fractions.)

Co-60 is always the dominant nuclide in contamination events in boiling water reactor (BWR) and pressurized water reactor (PWR) nuclear power plants. Fission products and alpha-emitters may also arise subsequent to fuel rod damage. Experience has shown that the alpha-emitter fraction in normal operation is only 1 E - 05 to 1 E - 04 of the total activity. A fraction of approximately 1 E - 03 has been observed in individual cases.

Co-60 and the other aerosols, including alpha-emitters, are incorporated by inhalation, and can initially be found in the lungs of the individuals concerned. Cesium is distributed uniformly throughout the body. Iodine isotopes accumulate in the thyroid gland.

Between 1991 and 1993, we carried out over 2000 incorporation examinations of Siemens employees who had been deployed for work at nuclear power plants using our analysis facilities (lung counters and thyroid monitoring station) at Erlangen, Germany. Measurement examinations were carried out on an annual basis, generally after completion of the refueling outage cycle at the nuclear power plants.

The following results were obtained:

- Co-60 was detected in 22% of analyses
- Cs-137 was detected in 19% of analyses

Other nuclides were detected in only 3% of analyses.

66 % of analyses showed no detectable intake (detection limit: 50 Bq).
33 % of analyses produced results between 50 and 1600 Bq.
Values between 1600 and 6400 Bq were found in only 21 analyses.
Only the nuclides Co-60 and Cs-137 were detected in the latter analyses.

Assuming that incorporation occurred 180 days prior to the analysis (i.e. at the mid-point of the monitoring period of 12 months), the correspondence between measured activity and intake is as follows:

- a measured activity level of 6400 Bq Co-60 corresponds to an intake of approximately 60,000 Bq Co-60 (14% of the annual limit),

- a measured activity level of 6400 Bq Cs-137 corresponds to an intake of approximately 40,000 Bq Cs-137 (1% of the annual limit).

These results show that, for incorporation monitoring, Co-60 is the significant nuclide for activated corrosion products, with Cs-137 selected as the significant nuclide for fission products.

3 Incorporation monitoring techniques

The following techniques are available for determining incorporated activity with respect to the aforementioned radionuclides:

- whole-body analysis
- lung/chest region analysis
- excretion analysis
- airborne activity analysis.

Whole-body and lung analyses are suitable for determining gamma-emitters.

Excretion analyses are particularly suited to determining incorporated alpha-emitters.

Airborne activity analyses are only representative given constant room air conditions (which do not apply, given the deployment of the personnel concerned to outage activities at a number of different nuclear power plants). Airborne activity analyses are therefore not used for incorporation monitoring.

Airborne activity analyses at the nuclear power plants act as alarm or action thresholds. Increased airborne activity levels indicate unexpected activity releases, and signal that respiratory equipment should be worn to prevent incorporation.

Where the alpha-emitter fraction lies significantly below 1 E -03, no excretion analyses are necessary to determine activity intake levels, as the dose contribution due to gamma-emitters is predominant.

Incorporation monitoring at nuclear power plants is thus generally carried out via whole-body or lung/chest region analyses, as specified in the Guideline for Physical Radiation Protection Monitoring.

The detection limits of standard whole-body counters and lung counters are 100 Bq for Co-60 and Cs-137 or lower. ‘Quick-counters’ can detect gamma activity from 2000 Bq.

Gamma activity levels in the body of 10,000 Bq are detected by the contamination monitors at the exits from the radiation controlled area.

4. Monitoring frequency

The Guideline for Physical Radiation Protection Monitoring stipulates monitoring intervals of 180 days for gamma-emitters with long effective half-lives. A monitoring interval of 14 days is specified for I-131. No regular monitoring intervals are specified for alpha-emitters, as the period depends on the type of monitoring.

In practice, workers are analyzed for incorporated gamma-emitters before and after deployment at a nuclear power plant. The monitoring interval for gamma-emitters is thus significantly shorter than the 180 days required in accordance with the guideline.

Iodine releases are detected directly at the nuclear power plant, and thyroid analyses to determine iodine incorporation are carried out immediately after detection. With this system, monitoring is carried out in response to specific conditions. The time between incorporation and analysis is thus significantly shorter than the 14 days required in accordance with the guideline.

Incorporation of alpha-emitters can be monitored at nuclear power plants via monitoring of the simultaneously-released radionuclide Cs-137. Additional excretion analyses for alpha-emitters are only required if significantly increased Cs-137 values are determined. These additional analyses are then carried out on a rapid follow-up basis.

5 Practical implementation of the monitoring program

After many years of experience of deploying workers at nuclear power plants, incorporation levels lie well below 10% of the limit values. Higher incorporation levels have been found in only a few cases, and these were detected immediately via room air monitoring and alarm annunciation, or via contamination analysis. In such cases, incorporation analyses were initiated immediately for the individuals concerned.

Regular incorporation monitoring for gamma-emitters is therefore not required at nuclear power plants according to the Guideline for Physical Radiation Protection Monitoring. Regular monitoring for iodine incorporation is also not necessary at nuclear power plants. Monitoring is carried out in response to specific conditions.

It can also be assumed that the incorporation monitoring measures implemented by nuclear power plant operators ensure that intakes in excess of 10% of the limit values are rapidly detected and quantified in every case.

Companies deploying occupationally exposed persons in nuclear power plants which have been handed over to the customer/plant operator still have to verify that globally increased incorporation levels do not occur as a result of repeated intakes at different plants. At least one analysis should therefore be carried out every year (or within twelve months of the last deployment) using an appropriately qualified whole-body or lung counter.

As an alternative to performing analyses using our own or independent measuring facilities, it is also possible to utilize the analysis facilities at nuclear power plants for incorporation monitoring of external workers.

To enable this, we have entered into agreements with the operators of a number of nuclear power plants, whereby the plants undertake to carry out incorporation monitoring in accordance with the concept applied by the German Technical Association of Large Power Plant Operators (*Verein der Großkraftwerksbetreiber* (VGB)). This concept provides for analyses using quick-counters or lung analysis stations before and after performance of an activity at one of the nuclear power plants concerned.
Provided that the body activity levels detected in the chest region remain below 2000 Bq Co-60 or Cs-137, no further action is taken. If this threshold is exceeded, our health physics officer is informed. In consultation with the power plant health physics officer, an analysis is then arranged at an officially accredited analysis station, and the results are sent to us. It is thus not necessary to carry out our own analyses in this case.

In the event of a Cs-137 activity level in excess of 2000 Bq, additional stool and urine analyses are necessary to determine any simultaneous incorporation of alpha-emitters.

No further analyses by external analysis stations are necessary in the case of workers who have worked within the last twelve months inside the radiation controlled area at one of the nuclear power plants with which an agreement has been concluded regarding application of the VGB incorporation monitoring concept.

Incorporation analyses should be carried out by an officially accredited analysis station at least once every year for workers who have only worked at nuclear power plants which are not covered by the VGB concept, or at

nuclear power plants of different designs (i.e. other than BWRs or PWRs). The analyses should be carried out as soon as possible after the return of the workers concerned from a period of deployment at the power plant.

In the case of workers who have worked at other nuclear installations, such as, for example, fuel assembly fabrication plants or hot-cell facilities, incorporation monitoring should be carried out in accordance with the procedures utilized by the individual plants concerned. If monitoring is not carried out by the operator of the facility (for example airborne activity analysis or excretion analysis), appropriate analyses should be carried out at an accredited analysis station after the return of the workers concerned from the period of deployment.

This monitoring concept was submitted to our competent regulatory Authorities, and has been accepted by them.

6. Experience with practical implementation of the monitoring procedure

Approximately twenty nuclear power plants have so far indicated a readiness to cooperate with respect to incorporation monitoring on the basis of the VGB concept (including two in Switzerland and two in the Netherlands).

The requirement for analyses arranged by us in addition to analyses by plant operators has significantly reduced since the introduction of the VGB concept in 1995, as shown by the table below for our employees located at Erlangen:

Year	**1995**	**1996**	**1997**	**1998**
Number of additional analyses	**451**	**198**	**159**	**85**

The reduction in the number of additional analyses required after 1996 can be attributed to the fact that increasing numbers of nuclear power plants have adopted the concept.

Taking into account the cost of analyses and the non-working periods for the workers concerned, the resulting savings total several hundred thousand deutschmarks.

Only a few cases of intakes in excess of 3% of the annual limit were detected in the analyses. No intakes over 10% of the limit occurred. This confirms the high quality of radiation protection at the nuclear power plants.

References

1) German Radiological Protection Ordinance, Bundesgesetzblatt Part I, No. 34, Bonn, Federal Republic of Germany, 1321 - 1375 (1989)

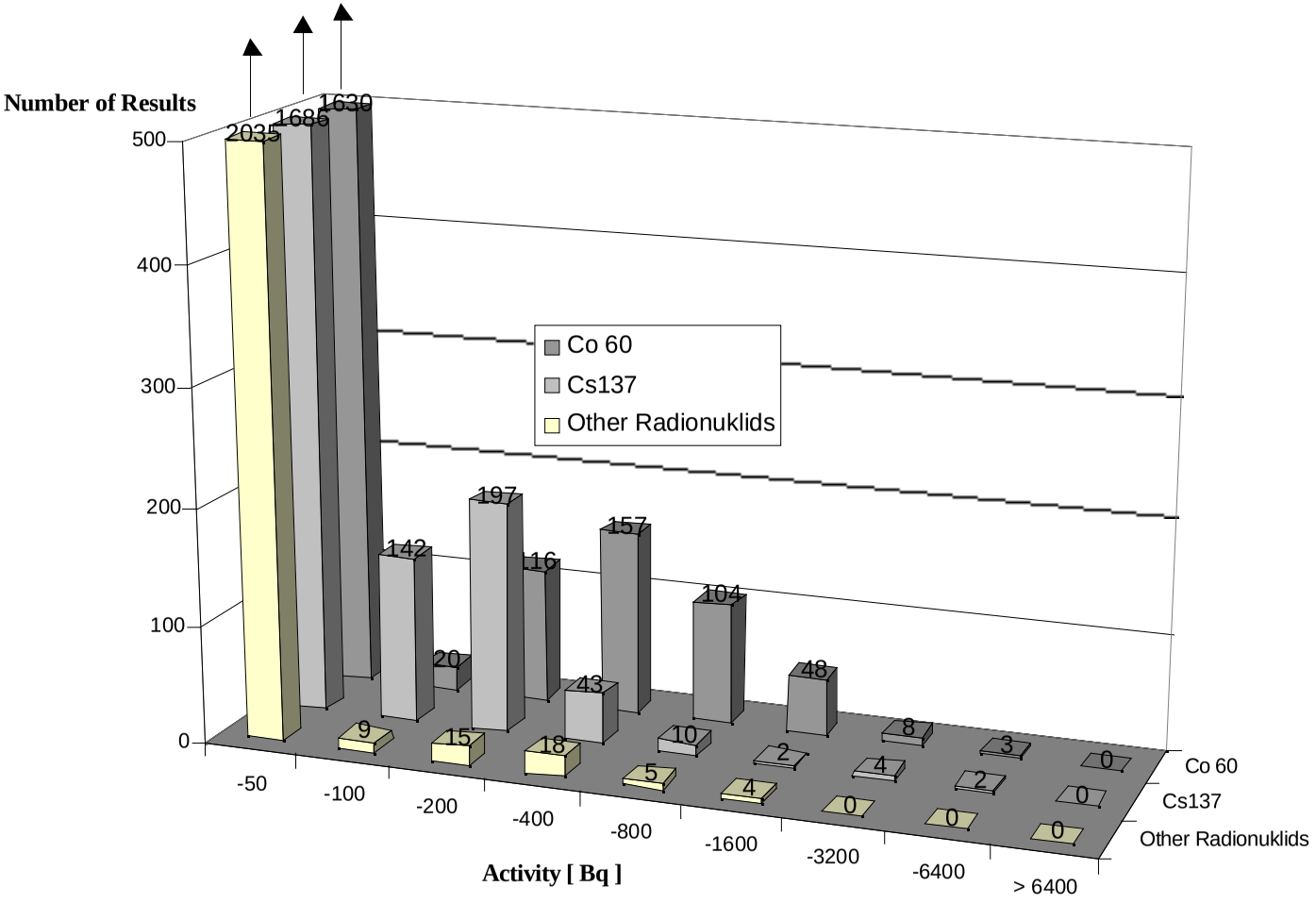
2) Guideline for Physical Radiation Protection Monitoring, Gemeinsames Ministerialblatt (dated 13 March 1997), Vol. 45, No. 7, 285 - 308, Bonn, Federal Republic of Germany (1994)

3) Concept of the VGB „Practical Radiation Protection“ working group on Incorporation Monitoring at German nuclear power plants, dated February 21, 1995

4) K. Henrichs, R. Neuhaus, W. Roth: The monitoring of potential incorporations of occupationally exposed workers in Germany, Kerntechnik 62 (1997) 1

5) Siemens Radiation Protection Guide M44:Durchführung der Inkorporationsüberwachung bei Mitarbeitern, die als beruflich strahlenexponierte Personen in Kernkraftwerken tätig sind(*Performance of Incorporation Monitoring of Personnel Active as Occupationally Exposed Workers in Nuclear Power Plants)*, New edition dated March 9, 1999

Results of the Body - Counter - Measurements



Appendix 2: Scheme for the action procedure for the monitoring of external workers at nuclear power plants in germany