OECD Nuclear Energy Agency
International Atomic Energy Agency
ISOE
European Technical Centre

General Distribution

August 2005

ISOE INFORMATION SHEET

WORKERS INTERNAL CONTAMINATION PRACTICES SURVEY

ISOE European Technical Centre - Information Sheet No. 40 (2005)

1. Introduction

Internal contamination management is an important issue, especially during the decommissioning of nuclear plants, as the contamination levels could be much higher than during the operating time. Then it is interesting to think to the necessity to always wear respiratory protective equipments, and more generally to the actions to take to monitor the internal exposures.

This information sheet summarizes the results of an international ISOE request of information concerning the practices regarding the management of workers internal exposure. Seventeen answers from twelve countries (ten European countries, South Africa and the United States – see annex A) have been received.

The document presents:
- The policy of the operators concerning the acceptance or not of the occupational internal exposures;
- The protection measures to limit the internal exposures;
- The control of the contamination levels in the areas and the monitoring of the internal exposures of the workers;
- The policy and the opinion of the operators concerning global optimisation (i.e. optimisation between external and internal dose).

2. Internal dose constraints

Limits fixed by the authorities

In each country, the regulatory body defines dose limits. Most of these limits are general dose limits including both internal and external dose. Thus, the limit for the internal dose is the same that the limit for the total dose. In Switzerland for pregnant women, the internal dose is limited to 1 mSv during the period between knowledge and birth. Nursing mothers are not allowed to work with unsealed sources.

Constraints fixed by the operators

Most of the NPP operators try to reduce internal exposure as low as possible. That is why they often define internal objectives, more restricting than the limits fixed by the regulatory body. Thus, most of the NPP operators do not authorize any internal dose. However, that does not mean that there is no internal dose. In fact a registration limit for internal dose, which is generally the reporting level to the regulator is applied in some nuclear power plants: 0.1 mSv at Loviisa NPP in Finland, 0.5 mSv at Koeberg NPP in South Africa (reporting level to the authority), 1 mSv at Cofrentes NPP in Spain and 1 mSv (tritium intake) at Cernavoda NPP in Romania. In Switzerland the registration limit as well as the reporting limit is 1 mSv.

In France, EDF, the NPP operator, has to impose no risk for internal contamination. The authority does not forbid explicitly internal contamination but it imposes to declare each low internal contamination as a significant event. That is why EDF chose to reduce the internal exposures as low as possible.

Few of the NPP operators have defined a specific constraint for internal dose. At the Sizewell NPP (United Kingdom), it exists a limit of 1 mSv/y. At Cernavoda NPP (Romania), 1 mSv committed dose for tritium intake represents the investigation and removal limit. Concerning the other answers (Ringhals NPP in Sweden, San Onofre NPP in the USA), a TEDE[1]-ALARA evaluation is performed accepting some internal exposure. However, the fact that the internal dose represents a low percentage of the total dose has to be underlined.

Table 1. Internal dose constraints adopted by the NPP operators

Plant	Is an internal dose authorized?	Internal dose limit	Investigation level for internal dose	Regulatory total dose limit
Loviisa (Finland)	No	/	0.1 mSv	100 mSv/5y Max. 50 mSv/y
Sizewell B (UK)	**Yes**	1 mSv/y	/	20 mSv/y
Cofrentes (Spain)	No	/	1 mSv	100 mSv/5y Max. 50 mSv/y
Cernavoda (Romania)	**Yes**	/	1 mSv (tritium intake)	20 mSv/y
Philippsburg (Germany)	No	/	/	20 mSv/y 400 mSv/life
Biblis (Germany)	No	/	/	20 mSv/y 400 mSv/life
Bohunice (Slovakia)	No	/	/	100 mSv/5y Max. 50 mSv/y
Oskarshamn (Sweden)	No	/	/	100 mSv/5y Max. 50 mSv/y
Forsmark (Sweden)	No	/	/	100 mSv/5y Max. 50 mSv/y
Ringhals (Sweden)	**Yes**	0.25 mSv per event	/	100 mSv/5y Max. 50 mSv/y
Barsebäck (Sweden)	**Yes**	/	/	100 mSv/5y Max. 50 mSv/y

1 Total Effective Dose Equivalent

Table 1. Internal dose constraints adopted by the NPP operators

Plant	Is an internal dose authorized?	Internal dose limit	Investigation level for internal dose	Regulatory total dose limit
Koeberg (South Africa)	No	/	0.5 mSv	20 mSv/y
Dukovany-Temelin (Czech Republic)	No	/	/	100 mSv/5y Max. 50 mSv/y
HSK (Swiss authority)	**Yes**	/	1 mSv	20 mSv/y Max. 50 mSv/y if 100 mSv/5y
All EDF plants (France)	No	/	/	20 mSv/y
San Onofre (United States)	**Yes**	/	/	50 mSv/y

3. Actions taken to limit internal exposure

Respiratory Protective Equipments

Most NPP operators have defined values above which specific Respiratory Protective Equipments (RPE) must be used. Most of the time, those values depend on the type of contaminant (airborne, surface contamination, radionuclides…). The definition of this classification is more or less precise depending on the operators. Thus, some of them use only one value from which a RPE is mandatory whatever the radionuclides. Some others, as at Ringhals NPP (Sweden) or Biblis NPP (Germany), a detailed classification with different protection levels are described depending on the type of radionuclide (α or β emitters), the contamination level and/or the type of contamination (airborne, surface contamination).

Table 2. Protection measures adopted by the authorities and the NPP operators to limit internal contamination

Plant	Threshold and specific actions taken to reduce internal exposure
Sizewell B (UK)	British Energy Corporate Standards define an Airborne Activity Area (called a C3 area) as one where the **airborne activity level is greater than 0.1 Derived Air Concentrations (DAC)[2]**. Normally in these areas, personnel wear RPE. The type of RPE depends upon the specific nuclides and type of work to be done together with other practical considerations.
Cofrentes (Spain)	RPE is necessary when **airborne contamination is greater than 0.5 DAC** or when it is expected that internal exposure without RPE will be **higher than 2 DAC.hr in one working day**.
Cernavoda (Romania)	If the dose rate is **lower than 50 μSv/hr** (aerosols in the breathing air), it is **recommended** to wear a specific RPE. If the dose rate is **higher than 50 μSv/hr**, a specific RPE (**half-face mask with filter or with air supply**) is **mandatory**. If the dose rate is **higher than 500 μSv/hr** (aerosols in the breathing air), **a plastic suite with air supply is mandatory**.
Bohunice (Slovakia)	If a **loose surface contamination is higher than 3 Bq/cm^2** or if the **airborne contamination is higher than 40 Bq/m^3,** a **respirator** must be worn. A **breathing equipment** is required if the **concentration in tritium in air is higher than 5 10^4 Bq/m^3**.
Barsebäck (Sweden)	The protective actions are determined case by case. The whole radiological environment must be considered.
Oskarshamn (Sweden)	Actions are taken when **air contamination is higher than 1 DAC** or when the **surface contamination is higher than 4 Bq/cm^2 for γ emitters and 0.4 Bq/cm^2 for α emitters**.

2 DAC (Derived Air Concentration): Concentration (in Bq/m^3) of radioactive material in air which, if it is breathed by a worker 2000 hours in one year, will result in the intake of enough radioactive material to reach the annual committed dose limit.

Table 2. Protection measures adopted by the authorities and the NPP operators to limit internal contamination

Forsmark (Sweden)	HP judges the actions which could be taken when the work is planned. It depends on the type of work and on the classification of the work place (regarding contamination). Mainly, the decision is based upon experience.
Ringhals (Sweden)	It exists a specific classification (cf. **Annex C**) depending on the surface and air contamination. The RPE used depend on this classification. Works in **noble gases** environment may be performed in many cases without RPE. In fact, for these nuclides, a **dose higher than 0.25 mSv is accepted** if it makes the work easier.
Philippsburg (Germany)	The use of RPE depends on the activity concentration C in air and on the working time: - **$C_{aerosol}$ > 10 (during 10 hr) – 100 (during 1 hr) Bq/m^3 => mask with filter** - **C_{iodine} > 10 (during 10 hr) – 100 (during 1 hr) Bq/m^3 => mask with charcoal filter** If the concentrations are **100 higher (1000 Bq/m^3 during 10 hr or 10000 Bq/m^3 during 1 hr) protective clothes with air autonomous breathing equipment** have to be worn for the same working times.
Biblis (Germany)	A system of so-called Maximal Allowable Concentration of air activity (in German **MZK**) has been defined. One MZK was determined for each nuclide (cf. **Annex B**). It is possible to work 10 hr without any RPE if $MZK_{iodine\ and\ aerosol}$ < 1 and $MZK_{noble\ gases}$ < 1. If **1 < MZK < 10**, then it is possible to work **10 hours/MZK without any RPE**. If **MZK > 10** and air is exclusively composed of **aerosol and iodine**: - **Work only with mask if MZK < 100**; - **Work only with compressed air if 100 < MZK < 1000**; - **The permission of the RP manager is necessary if MZK > 1000**. If **MZK > 10** and **noble gases** are in air: - **Work only with compressed air if MZK < 100**. Short inspections are possible without protective equipment with permission of RP manager.
Dukovany-Temelin (Czech Republic)	The use of RPE is considered from a level of **3 Bq/cm^2** gamma/beta contamination or air contamination higher than **30 Bq/m^3**. The use of **full-face mask a** is necessary from an air contamination level of **3 000 Bq/m^3**. A **decontamination** is performed before grinding, cutting… if the **surface contamination is higher than 3 Bq/cm^2**.
Koeberg (South Africa)	The use of RPE is considered **from a level of 0.1 DAC**.
HSK (Swiss authority)	The specific actions taken depend on the type of controlled zone (0, 1, 2, 3 or 4) based on the potential contamination in the area. The potential air concentration is expressed in the multiple of a nuclide specific value CA, where 1 CA during 2000 h leads to 20 mSv. For each zone type, different requirements on protection measures and monitoring have to be used or performed. (e.g. 1 CA: 800 Bq I-131/m3, 200000 Bq H-3/m3, 0.3 Bq Am-241/m3 air contamination < 0.1 CA — zone type 0,1,2 — no protection against inhalation air contamination > 0.1 CA — zone type 3 — simple dust mask air contamination > 10 CA — zone type 4 — respirator mask with forced air or compressed air or special filters
All EDF plants (France)	For mechanical servicing works, the protections depend on the type of work to be done. For cleaning works, the protections depend of the contamination level. Moreover, the cleaning way is chosen to avoid putting the surface contamination in suspension.
San Onofre (USA)	The law imposes to perform systematically an ALARA evaluation to determine whether a RPE is necessary or not [1]. For work in an airborne area or highly contaminated area (**surface contamination greater than 25 Bq/cm^2**) engineering controls are used to mitigate internal contamination: decontamination, ventilation, enclosure tents, vacuums, protective clothing…

Other protective measures

RPE are not the only mean to reduce the risk of internal contamination. At Cofrentes NPP (Spain), a system based upon experience helps to optimise the risks of internal contamination. If the internal dose exceeds 1 mSv over the year, it is considered as an incident, which demands an investigation of the circumstances of the event in order to avoid future recurrences. At Ringhals NPP (Sweden), specific procedures are used depending on the knowledge concerning the contamination levels. When

a system is to be opened that has a potential risk for contamination of any kind breathing protection are used initially. When the system is open the surface contamination is measured. Areas with potential risk of contamination getting airborne will have online sampling (*e.g.* with alarm to warn workers and for HP to take actions). Systems with very high contamination content are ventilated if possible or a tent has to be erected with under pressure to avoid spreading of airborne contamination. Moreover, the most common cause for internal intake of any significance is most likely cross contamination when workers undress in a wrong manner and move contamination to the face area and get an oral intake. Training, workers awareness and HP support are the keywords to avoid this type of internal contamination. The exits from controlled area are manned during shut down. One important task for this guard is to document and informed HP staff of contaminated workers, important information that can reveal a potential internal intake situation and prevent further inconveniences. Further knowledge on the nuclide content in the systems is very important to foresee risks for different kinds of causes to internal intakes.
Finally, all types of risk should be taken into account. This is underlined in the answer of the Sizewell NPP (United Kingdom). For each job, the risk assessment considers all risks, not only radiological risk. Then, internal and external doses are optimised to the 1 mSv internal dose constraint.

Decontamination is another action to reduce the risk of intake. However, only the Czech and San Onofre answers evoke this measure (see Table 2). Additional to these measures the use of glove boxes, hot cells, the fixation of contamination with finish dispenser and covering with plastic film are typical protection measures against incorporation.

Management of the internal contamination by ^{3}H and ^{14}C

In most working nuclear power plant, the risk of contamination by ^{3}H or ^{14}C is negligible. No particular precaution is thus taken. For the others, the precautions concern principally the threshold for using RPE.

Table 3. Measures adopted to limit internal exposure by ^{3}H and ^{14}C

Plant	Tritium	Carbon 14
Sizewell B (United Kingdom)	If the air concentration is higher than 0.1 DAC (except if the internal dose due to tritium intake does not exceed 1 mSv and if the use of RPE increases the external dose), a RPE is worn or measures are taken to reduce airborne activity levels.	
Cofrentes (Spain)	Measure of the tritium airborne concentration. if assuming 1000 hr of exposure per year, the internal dose must not exceed 1 mSv. Tritium exposure is determined case by case by controlling exposure time.	-
Cernavoda (Romania)	Ventilation system, continuous monitoring of the radiological conditions during activities with potential risk of internal contamination, use of RPE… Urine analysis to control the contamination.	-
Philippsburg (Germany)	Urine samples measured for people with high working hours on reactor floor in PWR.	-
Bohunice (Slovakia)	A breathing equipment is required if tritium concentration in air exceeds 5.10^4 Bq/m^3. Urine samples measured.	-
Dukovany-Temelin (Czech Republic)	Urine samples measured (internal contamination by tritium has not yet been detected). Continuous air Tritium monitoring in ventilation systems.	-
HSK (Swiss authority)	Continuous air Tritium monitoring when concentration in air > 50000 Bq H-3/m^3. Urine monitoring.	

4. Internal exposure monitoring

Different types of controls of the occupational internal contamination are performed in the nuclear plants:

- Bioassays: the most frequently used is urine analysis. Most answers indicate that urine analyses are essentially performed to detect internal contamination by tritium. The frequency of the analysis varies from once a year to once a month. If a contamination is suspected, an additional test is performed.
- Whole body counter and quick body counter: these techniques to measure the internal contamination have been systematically named. Generally, permanent workers are subjected to this examination once or twice a year; contract workers are screened at the start and at the end of the contract. Workers are also screened when a contamination is suspected.

Otherwise, it is possible to continuously monitor the air contamination and the air inhaled by the workers. Two means can be used:

- The SAS (Static Air Sampling), in the controlled area, measures the contamination level in the air and can sometimes evaluate the evolution of the contamination in real time. Most of the plants use SAS to measure the contamination in the areas.
- The PAS (Personal Air Sampling), which is worn by the workers, analyses the air breathed and then measures the internal contamination; the problem is that this device have to be worn near the mouth to evaluate at best the inhaled air. This type of device seems to be rarely used in the nuclear power plants.
- PAS is used at San Onofre NPP (United States) to monitor workers internal exposure during system breaches, work in an airborne area and for work that involves welding, cutting, grinding on surfaces with contamination levels greater than 3 Bq/cm2.

Table 4. Action taken by the NPP operators to measure and monitor internal exposure

Place	Actions to monitor and measure the internal contamination
Loviisa (Finland)	Gamma spectrometry Mobile air sampling Urine analysis for people working at open spent fuel storage pool
Sizewell B (United Kingdom)	Quick Body Monitor (uses plastic scintillation detectors to assess gamma activity in the lung): once a year for permanent workers; at the start and at the end of the contract for contract workers SAS to verify airborne activity levels
Cernavoda (Romania)	Whole Body Counter for gamma emitters: once or twice a year Urine samples for tritium intakes: - Each 28 days for committed dose lower than 0.01 mSv - Each 7 days for committed dose higher than 0.01 mSv - Each day for committed dose higher than 1 mSv
Philippsburg (Germany)	Quick Body Counter: once a year or in case of relevance, Whole Body Counter SAS; portal monitors at RCA exit with additional incorporation detectors
Biblis (Germany)	Quick Body Counter, once a year minimum and if there is an indication, Whole Body Counter SAS or air monitoring at workplaces
Bohunice (Slovakia)	Whole Body Counting: once a year for permanent workers; once a month for personnel working in areas with potential risk of intake; at the start and at the end of the contract for contract workers; if there is a suspicion of internal contamination. Urine analyses for tritium: once a year or when a contamination is suspected SAS for continuous air monitoring
Oskarshamn (Sweden)	Whole Body Counter (1 HpGe detector for the stomach and 1 HpGe for the lung, NaI(Ti) for the thyroid; software: ABACO plus): 10 persons composed a reference group measured 4 times a year; a representative sample of workers in the controlled area taking part in jobs with special risk of contamination
Barsebäck (Sweden)	Whole Body Counting: a reference group of 40 persons is measured 4 times a year; workers with a particular risk of intake of radioactive substances are also controlled (about 100 measurements a year mainly during outages) [2] SAS

Table 4. Action taken by the NPP operators to measure and monitor internal exposure

Place	Actions to monitor and measure the internal contamination
Ringhals (Sweden)	Whole Body Counting: - All personnel with suspected or certified internal intake (based on alarm from exit monitors and HP indicators as increased airborne activity, high unplanned surface contamination, carelessness to use protective equipment in a proper way…); - Control on workers with enhanced risk for internal exposure. A selection of personnel (chosen by the Radiation Protection department) that regularly work in areas with high airborne and/or surface contamination shall be measured at the end of a working operation or each month if it is an extended work. If an internal contamination greater than 0.25 mSv is detected, all the work team members are controlled; - Random sample of 2-3 workers from different work categories (cleaning-up; decontamination, mechanical maintenance…) is controlled once a year; - In each unit 4 workers working in a controlled area are measured 4 times a year; - Control before work starts, at arrival at Ringhals. Urine and/or faeces analysis to calculate dose from internal intake if suspicion of internal contamination by radionuclides that cannot be detected by the counter (as tritium). Samples are taken if the effective dose is larger than 2.5 mSv. SAS
Cofrentes (Spain)	Whole body counting of gamma emitters: once or twice a year for permanent workers; at the start and at the end of the contract for contract workers
Forsmark (Sweden)	Whole Body Counting: - As a general control each person reference group consisting of 30-35 persons (chosen from different categories of workers with potential risk of internal contamination) is measured 6 times a year; - After all types of work where there has been judged risk for internal contamination, at least one person from each work team involved shall be measured. If any internal intake is detected all work team members shall be measured; - At work where there has been judged to be high internal contamination, all workers involved shall be measured before and after the work.
Koeberg (South Africa)	Whole Body Counting: once a year for all radworkers Urine analysis for exposed persons plus a random test of 5 persons monthly SAS for continuous air monitoring
Dukovany-Temelin (Czech Republic)	Whole Body Counter for gamma emitters: - FAST scan (60 seconds, sensitivity for ^{60}Co: 120 Bq/min) for personnel working in controlled areas: before the job and after the job before leaving the NPP; - Whole Body Counting on HPGe detector (600 seconds) for workers who exceed recording level on FAST scan measurement and for a reference group of workers with high risk of internal contamination. Urine analysis for tritium: once a month
HSK (Swiss authority)	Personal monitoring (Contamination and incorporation) when leaving a controlled area; Whole Body Counter once a year; Urine (or stool) analysis monthly if risk exists (H-3 or pure actinides) or an event happened; quick body counter is used to screen contract workers at the start and at the end of the contract. SAS in areas where risk is not negligible: the filter is analysed weekly or once per hour if necessary PAS during job, where risk is not negligible: the filter is analysed daily
All EDF plants (France)	Whole Body Counting: once or twice a year for permanent workers; at the start and at the end of the contract for contract workers. Urine analysis: decided by the physicist when a contamination was detected by the Whole Body Counter
San Onofre (United States)	Passive monitoring upon exit from the Radiologically Controlled Area Whole Body Count at the beginning and the end of a work, if failure to pass passive monitoring, if contamination around nasal and mouth, when required by work plan, trending by Technical Specialists. SAS (but the data are generally not used to determine or monitor internal dose) PAS is used to monitor internal exposure during system breaches, work in an airborne area and for work that involves welding, cutting, grinding on surfaces with contamination levels greater than 3 Bq/cm^2.

5. Global dose optimisation

As an internal exposure is not often accepted (by the legislation, the operator and sometimes the personnel), a global dose optimisation (optimisation between internal and external dose) is not often performed. However, among the answers to the request, a majority indicates that allowing some internal dose could reduce in some cases (as in areas with high external dose rates or in areas contaminated by noble gases) the total dose.

In some plants, the global optimisation is performed. Thus, at Oskarshamn NPP in Sweden, this optimisation is performed when the area is contaminated by noble gases. At Sizewell B NPP in the United Kingdom, the global optimisation is a part of the risk assessment process. In the USA, the law imposes to perform a global optimisation [1]. Thus at San Onofre NPP (USA), a TEDE-ALARA evaluation is systematically performed to determine whether to use a respiratory protection or not.

As an example, if an area has an airborne particulate level of 10 DAC, a radiation level of 1 mSv/hr and the planned work would take 60 minutes, the TEDE-ALARA evaluation will be done as follows:

- If a respiratory protection is not used

  10 DAC induce an internal dose of 500 mSv/y[3] or 250 μSv/hr

  1 hr x 1 mSv/hr = 1 mSv as external dose

  => the total dose is 1.25 mSv
- If a respirator is used

  If it is assumed that the respirator is 99.99% effective for particulate material, therefore, the internal dose is 0 mSv.

  A time penalty for reduced efficiency of 15% is applied when a respirator is worn because it is more difficult to see, communicate and move wearing a respirator. Thus the working time would be 69 min instead of 60 min.

  1.15 hr x 1 mSv/hr = 1.15 mSv as external dose

  => the total dose is 1.15 mSv

The above evaluation supports the use of a respirator because the total dose is 0.1 mSv lower.

If the above airborne level were only 1 DAC, the TEDE ALARA evaluation would show a dose of 1.025 mSv without a respirator and 1.15 mSv with a respirator. In that case, the evaluation supports doing the work without a respirator.

6. Conclusion

The internal exposure is a problem relatively marginal in the operating nuclear power plants which answered to the questionnaire. Thus, the question of the internal contamination by ^{3}H and ^{14}C, which is important for the dismantling of the plants, is often not relevant in the operating nuclear power plants.

Mainly, the objective is to reduce the occupational internal dose to zero even if it increases the external dose then the total dose. To achieve this, each plant defines contamination criteria for wearing respiratory protective equipments. Moreover, the workers are controlled regularly to detect an internal contamination (control once or twice a year even more if a contamination is suspected). However, a question could be asked to know if the frequency of the controls is suitable for contaminants for which the biological half-life is short (12 days for tritium, 40 days for ^{14}C).
The cost of the whole body counting and of the bioassays is an important parameter for the management of the internal exposures. An optimisation between the means of protection and control and the avoided doses seems to be essential. For the dismantling works, the optimisation has to be performed case by case depending on the type of contaminants.

3 If the annual dose limit is considered to be 50 mSv

The majority of the answers to the request indicates that, in some case, an optimisation between external exposure and internal contamination could reduce the total dose.

References

[1] **Standards for protection against radiation: Respiratory Protection and Controls to restrict Internal Exposure in restricted Areas**, NRC's regulation 10 CFR Part 20, Subpart H

[2] **Regulation on Radiation Protection of Workers Exposed to Ionising Radiation at Nuclear Plants**, SSI FS 2000:10, October 1st, 2000, §21

ANNEX A. QUESTIONNAIRE AND ANSWERS

A1. Questionnaire

1) On the basis of a preliminary global risks analysis (external exposure, classical security risk, etc) do you authorize some predicted internal exposures as usual practice for workers?
   - Yes
   Is that described by a procedure? Reference:
   (please go to question 3)
   - No (please go to question 2)

2) Who imposes « zero risk » for internal exposure?
   - Regulatory body; reference:
   - NPP utility

3) Is a general dose constraint (non-zero) determined for occupational internal exposure for workers?
   - Yes
   - No

   For some specific works, is a site dose constraint sometimes determined?
   - Yes
   Please precise which type of works:
   - No

4) What are the values of these dose constraints?
   Annual dose constraint (for the whole site):
   Job dose constraint (for specific works):

5) Who determined these dose constraints?
   - Regulatory body; reference:
   - NPP utility
   - Other body
     Please specify:

6) How are these dose constraints determined? Please justify the values of the constraints.

7) Are there other specific requirements (for example, air or surface contamination levels)?
   - Yes (please go to question 8)
   - No (please go to question 9)

8) From which values are specific protective equipments (such as full-face mask with filter, protective clothing with air autonomous breathing equipment, etc) or actions (such as depressurization of the building, decontamination, increased control, etc) imposed?

9) Specifically, what is done to manage ^{3}H and ^{14}C internal contamination?

10) How are internal doses monitored and controlled?
   - Bioassays
     Which ones?
     Frequency?
   - SAS (Static Air Sampling)
   - PAS (Personal Air Sampling)
   - Something else
   Please specify:

11) Which measures do you take to control the risk of internal exposure? For example, did you perform a global optimisation (internal dose + external dose)?

12) From your point of view, does allowing an internal dose reduce the total dose (internal + external)?
   - Yes
   - No; reference:

A2. Answers

Seventeen answers from twelve countries have been received (Czech Republic, Finland, France Germany, Romania, Slovakia, South Africa, Spain, Sweden, Switzerland, the United Kingdom, the USA).

Among the answers, one summarizes the practices of the operator in all its nuclear power plants (EDF, France), one concerns the practices of the operators in their country (the Czech Republic) and finally, one answer was received from the authority (Switzerland).

The list of the persons, who answered, is displayed below.

1. Mrs S. Katajala (Loviisa NPP, Finland)
2. Mr. G. Renn (Sizewell B NPP, United Kingdom)
3. Mr. E. Sollet Sañudo (Cofrentes NPP, Spain)
4. Mr. R. Warnock (San Onofre NPP, USA)
5. Mr. P. Jung (Philippsburg NPP, Germany)
6. Mr. C. Solstrand (Oskarshamn NPP, Sweden)
7. Mrs. C. Chitu (Cernavoda NPP, Romania)
8. Mr. S. Hennigor (Forsmark NPP, Sweden)
9. Mr. L. Dobis (Bohunice NPP, Slovakia)
10. Mr. J. Koc (ISOE national coordinator: Dukovany and Temelin NPP, the Czech Republic)
11. Mr. T. Karsten (Koeberg NPP, South Africa)
12. Mr. T. Svedberg (Ringhals NPP, Sweden)
13. Mr. H-J. Wacker (Biblis NPP, Germany)
14. Mr. C-G. Lindvall (Barsebäck NPP, Sweden)
15. Mr. S-G. Jahn (HSK, Switzerland)
16. Mr. J-F. Labouglie (Cattenom NPP, France)
17. Mrs. K.A. Gallion (San Onofre NPP, USA)

ANNEX B. VALUES OF THE MAXIMAL ALLOWABLE CONCENTRATION OF AIR ACTIVITY (MZK) AT BIBLIS NPP (GERMANY)

Table B1. Values of 1 MZK for some radionuclides

Nuclide	Activity (Bq/m^3)	Nuclide	Activity (Bq/m^3)
^{110m}Ag	40	^{132}I	8300
^{58}Co	370	^{54}Mn	830
^{60}Co	16	^{95}Nb	830
^{51}Cr	12000	^{88}Rb	41000
^{134}Cs	160	^{124}Sb	160
^{137}Cs	250	^{125}Sb	290
^{138}Cs	37000	^{132}Te	250
^{131}I	40	^{95}Zr	120

If the nuclide is unknown, 1 MZK = 16 Bq/m^3 (value for ^{60}Co)
For noble gases, 1 MZK = 200 kBq/m^3

ANNEX C. VALUES OF CONTAMINATION FOR THE CLASSIFICATION OF THE DIFFERENT ZONES AT RINGHALS NPP (SWEDEN)

Table C1. Surface contamination in β and γ emitters

Contamination kBq/m2		**40**	**1000**	**4000**	**10000**
Surface classification	**BLUE**	**YELLOW**		**RED**	
Minimum extra protection		Yellow shoe covers	Yellow + red shoe covers Gloves	Yellow + red shoe covers Gloves Head cover Extra coverall	Air supply Air tight plastic suit
Respiratory protection			Half face mask + P3 filter	Full face mask + P3 filter	Air supply Air tight plastic suit
Respiratory protection, iodine			Full face mask with iodine filter**	Full face mask with iodine filter**	Air supply Plastic suit
Requirement for classification of air contamination due to surface contamination	BLUE	At least BLUE	YELLOW*		RED

* Yellow is used until air contamination samples have been evaluated, thereafter classification and issuing of protective equipment can be decided

** Valid at > 1 m^2 exposed surface

Table C2. Surface contamination in α emitters

Contamination kBq/m2		**4**	**100**	**400**	**1000**
Surface classification	**BLUE**	**YELLOW**	**RED**		
Minimum extra protection		Yellow shoe covers Gloves Head cover Extra coverall	Yellow + red shoe covers Gloves Head cover Extra coverall	Yellow + red shoe covers Gloves Head cover Extra coverall	Air supply Air tight plastic suit
Respiratory protection			Half face mask + P3 filter	Full face mask + P3 filter	
Requirement for classification of air contamination due to surface contamination	BLUE	At least BLUE	YELLOW*		RED

* Yellow is used until air contamination samples have been evaluated, thereafter classification and issuing of protective equipment can be decided.

Table C3. Airborne contamination

	DAC*		**1**	**5**	**30**	**40**	**1000**
	Air classification	**BLUE**	**YELLOW**			**RED**	
Air contamination Particles	Minimum extra protection		Half face mask + P3 filter		Full face mask + P3 filter	Full face mask + P3 filter Yellow shoe covers Gloves Head cover Extra coverall	Air supply Air tight plastic suit
	Requirement for classification of surface contamination due to air contamination	At least BLUE				At least YELLOW	RED
Air contamination Iodine	Minimum extra protection		Full face mask with iodine filter			Full face mask + Iodine filter Yellow shoe covers Gloves Headcover Extra coverall	Air supply Air tight plastic suit
	Requirement for classification of surface contamination due to air contamination	At least BLUE				At least YELLOW	RED
Air contamination Noble gases*	Minimum extra protection				Extra coverall Head-cover	Head cover Extra Air supply Air tight plastic suit**	Air supply Air tight plastic suit**
	Requirement for classification of surface contamination due to air contamination	At least BLUE				At least YELLOW	RED

* Work 2000 hours in 1 DAC is equivalent to 20 mSv

** Dose estimation for dose from external and internal irradiation should be done before air supply is chosen. If air supply is not used inform the dosimetry department about the DAC-value and used working time.