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Contents

Appendix: Tables, Diagrams and Lists

Introduction and Summary

This report is concerned with the safety of the Swiss nuclear installations in the period of 1994. The surveillance of these installations with regard to nuclear safety, including radiation protection, is among the tasks of the Swiss Federal Nuclear Safety Inspectorate (HSK).

Five nuclear power plants are operational in Switzerland: the three units Beznau I and II and Mühleberg with electrical capacities in the range 300 to 400 MWe, and the two units Gösgen and Leibstadt with capacities between 900 and 1200 MWe. These are light water reactors; at Beznau and Gösgen of the pressurized water reactor type, and at Mühleberg and Leibstadt, of the boiling water type.

Research reactors, (thermal) are operational at the Paul Scherrer Institute (PSI), at the Swiss Federal Institute of Technology Lausanne and at the University of Basel. Further subject to HSK's supervision are all activities at PSI involving nuclear fuel or ionizing radiation, the shut-down experimental reactor of Lucens, the exploration, in Switzerland, of final disposal facilities for radwaste and the interim radwaste storage facilities.

The present report first deals with the nuclear power plants and covers, in individual sections, the aspects of installation safety, radiation protection as well as personnel and organization, and the resulting overall impression from the point of view of HSK (chapters 1 to 4). In chapter 5, the corresponding information is given for the research installations.

Chapter 6, on radwaste disposal, is dedicated to the treatment of waste, waste from reprocessing, interim storage and exploration by the National Cooperative for the Storage of Radioactive Waste (Nagra).

In chapter 7, the status of emergency planning in the nuclear power plants' proximity is reported. Certificates issued for the transport of radioactive materials are dealt with in chapter 8. Finally, chapter 9 goes into some general questions relating to the safety of nuclear installations.

In the reporting period, a total of 13 reportable safety relevant incidents were recorded in the Swiss nuclear power plants. Among these incidents there were 5 scrams at full operating power. There were 3 incidents reported for the research installations. All these events had no harmful effects on the population in the environment. All nuclear installations adhered to the annual limits for the release of radioactivity. The radiation doses to members of the public caused by the Swiss nuclear installations were below the authorized limits in all cases. Compared to the public's mean annual radiation exposure of about 4 mSv (1993 report of the Federal Office of Public Health, BAG), the fraction of the dose, to the most exposed member of the public, originating from radioactive discharges of the nuclear installations, is less than 1 percent.

All in all, the safety of operation of the Swiss nuclear installations, in the period of 1994, is judged as good by HSK.

1. Nuclear Power Plant Beznau

1.1 Operational data and results

The Nuclear Power Plant Beznau (KKB), owned by the Nordostschweizerische Kraftwerke AG (NOK), comprises two nearly identical dual-loop pressurized water reactor units (KKB I and KKB II), each of net capacity 350 MW, that became operational in 1969 and 1971, respectively. Additional data are summarized in the appendix in Table 1. Figure 1a shows the functional diagramme of a pressurized water reactor installation.

Units KKB I and KKB II performed with load factors[1] of 87.8 % and 100.1 %, respectively, with availability factors[2] of 86.8 % and 99.6 %, respectively, whereby the percentage of unproduced energy in unit 1 is due, essentially, to refuelling and the annual revision. The planned outages for refuelling and maintenance lasted 48 days for KKB I. There was no refuelling done in KKB II in the reporting period and therefore there was no yearly revision because the fuel cycle was switched over to a 18 months cycle in 1993.

The thermal energy fed into the regional public heat supply system of the lower Aare valley (REFUNA) amounted to 120.4 GWh for both units in 1994.

Operation of unit KKB I was interrupted by two unplanned outages. A manual shutdown of the reactor was performed after an erroneous control drop signal problem with the feedwater pumps appeared. Three consequentive power reductions took place due to an anomaly on the control rod control, an erroneous protection activation in the REFUNA heating regulation and through the advanced state of the core burn-up. False control rod drop signals, via the newly installed control rod control system, caused several cases of turbine load run-back. These error signals, and their consequences, could be corrected by the supplier of the system only after extended investigations.

The operation of unit KKB II was disrupted through an unplanned outage due to an emergency trip (scram) caused by a transient in the feedwater supply. A power reduction was necessary to maintain conformance with the water protection rules with respect to the river water temperature. Three power reductions occurred due to a transient in the actuator of the generator of a turbine group, repair work on a high pressure pre-heater and an intermediate superheater.

The continued operation of unit KKB II, to 31. December 2004, was authorized on 12. December 1994, by the Federal Council.

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[1] Load factor (in %): Energy produced with respect to the rated power and a 100 % availability

[2] Availability (in %): Time that plant is available for power generation

1.2 Plant installation safety

1.2.1 Particular incidents

No incidents of the A or S class have occurred and no events to be classified higher than 0 on the INES scale (see also chapter 9.7).

For unit KKB I, two incidents were classifiable as "B":

- reactor trip (scram) due to a transient in the control to the feedwater supply to the steam generator. The failure of a melt-fuse lead to an immediate disruption of the steam generator feed. A low steam generator level together with a steam/feedwater mismatch caused an automatic reactor shutdown. After replacing the fuse, the plant was run up again whereby a defect compressed air jet of the hot well control caused the loss of the condensate pump capacity; this lead to another scram.

- Turbine load run-back due to a false control rod drop signal and manual reactor shutdown.
  False signals from the control rod surveillance system caused a turbine load run-back to each 50 MW per turbine. Due to this, a problem concerned with the minimum flow valves on the feedwater pumps appeared; this made a manual shutdown of the reactor necessary. The cause of the erroneous signal could not be localized, however. After the defect control rod drop signal had been temporarily by-passed, the plant could be run up again and connected to the net. The system for indicating the control rod position was examined and watched over in collaboration with the supplier. The control rod surveillance system was checked over particularly, and electronic components were replaced. The full control rod drop surveillance was put into service after this.

- A month later, a multiple turbine load run-back occurred again due to false control rod drop signals. This incident was controlled through the reactor regulation and therefore no reactor scram took place. Due to this, it is not classified. Some time later, a defect was found in the control rod position indicator system. The defect lay in an amplifier which was replaced. Since this, there have been no more problems.

For unit KKB II, a total of three incidents were classified "B":

- Malfunction of a motor operated valve (MOV) during the monthly test.
  During the monthly functional test of the MOV in the safety injection recirculation piping, the valve could not be moved any more. The cause lay in two melted-through fuses in the electrical connections to the valve. After replacement of the fuses, several functional tests could be carried out successfully. The cause of the malfunction could not be found. In order that this malfunction cannot occur again, the total length of cable supplying the electricity to the valves will be exchanged during the outage in 1995.

- Reactor trip after a malfunction in the feedwater regulation.
  A defective electrical power supply component for a feedwater flow measurement channel caused overfill of the steam generator A; this lead to a shutdown of the turbine group and therefore to a scram. The

power supply component was replaced and, after a revision of the feedwater regulation valve at the same time, the plant was put back into service. A general replacement for this type of power supply was started.

- Leakage of a containment spray pump during a test.
  During a monthly test run of a containment spray pump, a heavy leak occurred soon after the start at the locality of a moving ring-seal; this lead to shutdown and immediate repair of the pump. The safety requirements were sufficient since the demands of the technical specification were met.

1.2.2 Work during the yearly outage

As already mentioned, in chapter 1.1, due to the change-over to the 18 month cycle in unit KKB II, there was no refuelling and also no outage revision in the reporting period.

In unit KKB I, the outage time was used for revision, inspection work and for backfitting. The main activities lay by replacement of the original process computer by the new plant information system ANIS, by changes to the control room and by an exceptional eddy current testing of the tubing of both of the replacement steam generators (from the last year) to compare with the earlier tests. Further activities were steam and feedwater piping tests associated with the question of eliminating the possibility of a break in the free space between the metal containment and the reactor building and a total inspection of a reactor main pump. The shaft of the reactor main pump was replaced during the maintenance. This was due to a defect indication; the flywheel was then also replaced because of a shaft-specific conical interference fit. Shaft seals were also replaced, because of advanced wear, and also the thermal barrier because of traces of erosion on the sealing surfaces. The inspection of the pump casing gave no indications for concern.

The inspections of the electrical equipment, in particular the instrumentation and the drives of the motor armatures, took place in the normal framework.

Testing and maintenance of the NANO system was carried out for the first time. These new equipments have performed well until now.

The forseen yearly programme routine tests in unit KKB I could be completed according to plan.

1.2.3 Modifications to the plant

After completing the NANO project, the modifications to the plant in 1994 were less. Except for the already mentioned replacement of the process computer by the ANIS in unit KKB I, the following larger backfittings and modernizations are worth mentioning:

- Improvement of the hydro-electric power plant at Beznau and construction of a switch yard with a view to creating an improved emergency power supply for the two nuclear power plant units.

- Preparations for the replacement of the electrical protection of the two unit's house loads.

- Replacement of motor-driven armatures in unit KKB I within the framework of the requalification programme of safety-relevant electrical equipment in the containment.

1.2.4 Fuel and control rods

Since the activity of the primary circuit water in both units was low during the whole year, it can be assumed that no fuel element defects had occurred.

In unit KKB I 29 fuel elements were replaced during the outage; of these, 24 were new. Of a total of 121 fuel elements, 28 are fitted with a foreign object deflector. The number of uranium/plutonium mixed oxide fuel elements remains unchanged at 40. According to the programme accepted by the HSK, there was no planned control rod inspection in 1994. The behaviour of the control rods gave no suspicion of any damage. Ten transports of depleted fuel elements (each time 7), which were destined for reprocessing, took place in the reporting period.

1.2.5 Radioactive wastes

The quantity of raw radioactive wastes lay at the expected level, according to previous years.

With respect to the conditioning of radioactive wastes, KKB have improved the process for binding the ion-exchange resin in a polystyrol matrix. An improved water removal from the resin has been shown to be not necessary. Based on the improvements done, the revised specification, together with the suitability certificate for final disposal (ELFB) of the NAGRA, was submitted for the purpose of updated release[3].

Five old waste packages of this type, originating from the 1980/1981 period, were inspected in their temporary holding place; the HSK was convinced of their integrity. Within the framework of an information update, the KKB also delivered the specifications for two other types of wastes (pressed mixed wastes and unpressed cemented mixed wastes). This was done also for obtaining an updated acceptance.

Storing of wastes is done routinely in the interim storages of KKB (temporary holding locality and the SAA storage of ZWIBEZ). The application from KKB to keep untreated wastes temporarily in the SAA of the ZWIBEZ was agreed upon but only under certain conditions.

About 20 t of materials (mostly metal) arose through revision and repair work. This could be released for recycling since it was inactive. The exchanged REFUNA-heater was released as being inactive. More severe conditions for the release of inactive materials from controlled zones were applied in accordance to the new ordinance on radiological protection.

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[3] Release based on new tests based on the conditions given in HSK-R-14 from December 1988

1.3 Radiation protection

1.3.1 Protection of the personnel

The following collective doses were determined for KKB in 1994 (1993):

Actions	man-Sv KKB-I	man-Sv KKB-II	man-Sv Total
Planned outage	0.61 (2.31)	0 (0.94)	0.61 (3.25)
Power production	0.16 (0.26)	0.15 (0.25)	0.31 (0.51)
Year's collective dose	0.77 (2.57)	0.15 (1.19)	0.92 (3.76)

Due to the 18 month cycle for unit KKB II in 1994, there was no shutdown. Therefore, the collective dose for the works, including plant transients, was only 0.15 man-Sv.

The collective doses for the outage work in unit KKB I, in 1994, are low thanks in the large part to the installation's lower dose rates. The lower dose rates are due among other things, to the steam generator exchange in 1993. The sum of the year's collective dose of 0.92 man-Sv of both reactor units, is the lowest determined value since the power plants went into operation.

No individual dose exceeding the allowed limit was determined. The highest single dose in 1994 was 12.0 mSv (in 1993: 21.4 mSv). More information is given in the tables 5 to 10 and in the figures 6 to 10.

Dose rates due to recontamination of the new steam generator and the replaced parts of the main coolant pipes in unit KKB I have increased at a slower rate than expected. Accordingly, they were in the region of the steam generator and coolant piping, in average, approximately a factor of 3 less than in the previous years. In the parts of the plant that have not been able to profit from the steam generator exchange, the radiological conditions have remained approximately the same as in the previous year.

To aim for further improvements to the radiological conditions in the working places at unit KKB I, many sources of radiation were again temporarily shielded with approximately 70 t of lead during the scheduled outage. The dose rates could be reduced accordingly, through this, by factors between 2 to 10.

All work-specific collective doses during the shutdown of unit KKB I were lower as a result of the steam generator exchange, and were due mainly to the following measures:

- Detailed planning of the work under consideration of radiological protection
- Good training/preparation of the personnel
- Use of proven machines and tools

- Installation of comprehensive temporary lead shielding
- Permanent surveillance of the work by radiological protection personnel
- Trouble-free flow of the work

1.3.2 Releases to the environment

The releases of radioactive materials to the exhaust air and waste water, and from these, the calculated maximum yearly dose for people in the vicinity are given in Table 4. All releases were of the same order of magnitude as the previous year and were significantly below established limits; for aerosols even below the value of the 0.1 % of the limit.

The releases in 1994 lead to a yearly dosis of 1.5 x 10^{-6} Sv (Adult) and 6 x 10^{-6} Sv (child) for any person of the public, assuming the most unfavourable conditions.

1.3.3 Radiation protection instrumentation

All radiation detection monitors for personnel surveillance and other radiological protection measuring instruments have fulfilled their tasks according to requirements.

The work on optimization of the sample transport on the filter of the movable aerosol monitor could be completed successfully in the reporting period.

1.4 Personnel and organization

1.4.1 Personnel

Four reactor operators and one picket engineer were newly licensed in the reporting year. The total number of licensed personnel is given in Table 2.

The NOK has offered early retirement in order to reduce the number of personnel; 17 workers of the KKB will make use of this in the fiscal year 1994/95 (September 1995). The total personnel was 472 (450.7 full time jobs) at the end of the reporting period (1993: 479 or 455,5 full time jobs). The reduction in personnel occurred in all divisions, whereby it is forseen to replace fully the positions in the areas of plant security and production and partially replace them in the majority of other sections.

The HSK is of the opinion that the high demands placed on the personnel with a corresponding number of well qualified people must be recognized and a reduction of the work force is therefore seen with some reservations.

1.4.2 Organization

Some organizational changes have been implemented in KKB at the start of 1994. The section KBS ("Staff") was renamed as KBD ("Service") and at the same time, the area of activity "Plant security" (KBW) received the new designation KBD-W. Additionally, it receiveo a division internal quality assurance position KBD-Q. The division "NANO" is, with the completion of the project, dissolved as per the end of 1993.

The two areas of activity "Nuclear Safety" (new: Plant Safety) and "Nuclear technology" (new: Reactor) went over on the 1 January 1994 to the newly formed division KBR (Reactor and Safety). These were, at the same time, completed by the special area "Particular tasks".

The concentration of the workforces as a result of the re-organization is welcomed.

1.4.3 Quality assurance (QA)

The production of the QA documentation has progressed further. At the end of 1994, all 11 partial programmes were implemented.

The KKB is the first nuclear power plant in Switzerland to receive the HSK acknowledgement of the partial programme "Transport of radioactive materials".

1.4.4 Emergency exercises

A total emergency exercise, having the name "ERATO", was carried out in the autumn of 1994 in the KKB. Emergency organizations of the canton of Aargau, the Confederation and the land of Baden-Württemberg (Germany) took part. A handling accident with a fuel element transport container, which led to the release of radioactivity, was taken as the accident scenario. For a realistic situation, suitable for the exercise aims, (radioactive release exceeding design limits), a grave disregard concerning the reglementation on fuel handling from the side of KKB had to be assumed.

The aim of the exercise was to test the communication exchange within the plant as well as the transfer of information to external emergency organizations and to the media. Additionally, the new information concept of the Confederation was to be tested.

After some initial information difficulties, in the places of the plant under the exercise concerned with the media, the tasks were completed satisfactorily. However, the communication to and between the external places showed up some difficulties. These have given cause to retest and improve the technical and organizational demands.

1.5 Overall judgement by HSK

The condition of the plant with respect to nuclear safety, radiological protection and plant management of the two units KKB I and II can be classified as good. With respect to radiation protection, the total collective dosis for plant own and also external personnel was the lowest value since the KKB went into service. Besides the low dose rates and a good work plan, the fact that a yearly outage had taken place only in unit KKB I had contributed to this. Also, the release of radioactive materials to the environment lay well below the officially prescribed and allowed limiting values.

The incidents which had occurred had only a minor significance for the nuclear safety.

2. Nuclear Power Plant Mühleberg

2.1 Operational data and results

The nuclear power plant Mühleberg (KKM), which is owned by the Bernische Kraftwerke AG (BKW) is a boiling water reactor of 355 Mwe electrical net capacity. This is the official capacity since 1 January 1994 because an increase in the thermal capacity of a total of 10 % took place in 1993. The KKM started commercial production in 1972. Data are presented in Table 1 in the appendix; Figure 1b shows a functional diagram of a boiling water reactor.

The nuclear power plant Mühleberg reached a load factor of 84.8 % (relative to the new thermal capacity of 1097 MW) and an availability of factor of 90.5 %. The annual revision and refuelling lasted 34 days. A total of 2.3 Gwh of thermal energy was given for the residential heating of the locality "Steinriesel".

The plant experienced an unplanned reactor scram in the reporting period. During power operation, four planned power reductions, for carrying out physical measurements and routine tests, and ten power reductions (due to transients) occurred due to the following causes: loss of function of a feedwater pump, loss of the 6 kV bus D (see paragraph 2.2.1) and two malfunctions each of a recirculation pump. The remaining disturbances, which lead to a power reduction, had their origins in the secondary side. In addition, a power reduction took place due to low demand for electricity by the power distribution net.

2.2 Plant installation safety

2.2.1 Particular incidents

No incidents of the A or S class have taken place; correspondingly, none higher than 0 on the INES scale (see chapter 9.7).

The following two incidents were classified as B:

- Manual reactor trip during plant start-up after the yearly revision. Due to an false signal on the vibration surveillance, there was earlier a trip by the turbogroup A with a break of vacuum. The ractor was, at this point in time, at about 10 % power; the plant had not yet produced any electrical power.

- State of inoperability of an isolation armature in the steam drain circuit. The external isolation valve of the steam drain circuit could not be closed via the remote control during a functional test (carried out every 3 months on the isolation armatures of the primary containment).
  The valve could be only closed manually but then not re-opened. It remains in the closed condition until the next reactor outage.

Worth mentioning is the following unclassified incident:

A short circuit was caused due to an accidental contact on the 6-kV line during the work concerned with the installation of the large television screen of the ERIS in the control room. This caused the drop-out of the block bus D and therefore the of functionloss of a condensate, feedwater and recirculation pump. The behaviour of the plant accorded with the design measures. A scram could be avoided by manually adjusting the feedwater control. Since this manual adjustment occurred on a routine basis, the incident was not classed as B. The events were of a low significance for the nuclear safety.

2.2.2 Work during the yearly outage

The usual activities concerned with revision such as fuel element exchange, inspection routine tests, functionality tests on components and systems, maintenance etc. were all carried out according to plan. The following activities can be seen as the most important:

- Test on the core shroud

  In 1990, cracks were discovered in the central circumferential weld seam No. 11 on the core shroud; consequently, thorough tests were again carried out on this. The circumferential weld seam No.11 was regularly tested using an ultrasonic method; thereby, the crack indications from 1993 could be confirmed within the framework of the measuring precision. The sum of the determined crack lengths is 73 cm; in 1993 they were 65 cm. Due to the existing systematic uncertainties in the crack length determination, this difference must not necessarily be interpreted as a sign of crack growth. The newly determined sum of the crack lengths lie, in every case, well below the critical length. According to the inspection results, for the working period 1994/95, there is not expected to be a crack growth which could endanger the safety. These cracks do not yet present any danger to the core shroud.

  All longitudinal weld seams were inspected using a videocamera from the inside; the lower circumferential weld seam No. 3 was inspected to about 65 % of the circumference from outside. No cracks could be found.

  The upper circumferential weld seam No. 4 was tested from the outside, for the first time, using an ultrasonic method; about 80% of the weld seam circumference was checked. Two separate cracks were discovered on the inside surface; these were confirmed visually via the videocamera. The total crack length was measured as 26.5 cm with a maximum depth of 18 mm at a 31 mm wall thickness. The circumferencial region of the weld seams not accessible for ultrasonic testing, was inspected with the videocamera; additional cracks were not discovered.

  The cracks at the weld seam No. 4 (core upper edge) are smaller and lie approximately 180° displaced relative to the cracks in the weld seam No. 11. A mutual interaction is not possible. A growth of these cracks must be forseen. The crack growth prognosis from General Electric (GE) for the cracks in weld seam No. 11 is conservative for the cracks in weld seam No. 4. Based on experience and analyses to date, these cracks do not endanger the coreshroud in the 1994/95 operation cycle.

- Feedwater nozzles
  All four feedwater nozzles were tested, using an ultrasonic method, on the inner edges and inside bore for fatigue cracks. No relevant indications were found.

- Visual examination inside the reactor pressure vessel (RPV)
  In this outage, the RPV internals were again thoroughly examined visually using a remote controlled underwater videocamera. No anomalies could be found by this examination.

- Feedwater and steam lines
  Two circumferencial weld seams in the feedwater piping in the drywell were examined using ultrasonic and magnetic powder methods according to programme. No changes relative to earlier tests could be detected.
  In the course of improvement work in the steam tunnel, ultrasonic benchmark examinations were carried out on seven weld seams, in the ground condition on the steam lines between the isolation valves and the fixing points. There were no relevant signs found.

- Shutdown, torus cooling and core spray lines
  Some weld seams of these lines were examined using magnetic powder and ultrasonic methods according to programme. No relevant indications were found.

- Replacement of the rest of the pins and rollers made from "Stellite", by low cobalt alloy sliding pieces.

  The remaining 19 "Stellite" pins and rollers were replaced by low cobalt sliding pieces so that a significant cobalt source has been now removed from the reactor core region. In addition, four low cobalt "DURALIFE" control rods were incorporated. With this, a significant cobalt-60 source has been removed from the reactor core region.

2.2.3 Changes to the plant

The following plant changes are worth mentioning:

- ADS-level protection logic and ADS prevention switch (ADS = automatic depressurizing system)
  The installation of the ADS level protection logic and the ADS-prevention switch was already carried out in the 1992 outage. After satisfying the demands of the HSK, the changes could be put into operation in the 1994 outage. These changes will enable better control of design level transients during reactor run-up and run-down as well as anticipated transient without scram (ATWS).

- Barsebäck Phase II

  As a consequence of the incident in the Swedish NPP Barsebäck, the phase II backfitting work in KKM was concerned with motorising the slide valve in the joining piping the cold-condensate tank to the ALPS and attaching check valves. Also, an additional connection for fire extinguisher water was installed. The backfitting campaigns in connection with the incident in NPP Barsebäck are now completed.

- New wide scale detector system

  A new neutron flux measurement system for the start-up and intermediate range, the wide range detector system (WD-System), was incroporated during the revision outage. With this, the existing three SRM and six IRM detectors have been replaced through four wide scale detectors.

- Improving the feedwater and steam lines

  The feedwater and steam lines were qualified for a postulated pipe rupture outside of the containment. For this, the fixing points of the feedwater and steam lines in the steam tunnel of the reactor building and the sliding rails in the drywell were improved. Modifications on four of the eight steam isolation valves were also performed. The remaining four will be modified during the next outage.

- Drywell intermediate cooling water system

  The containment penetrations of the drywell intermediate cooling water system were equipped with additional isolation armatures after the penetrations had themselves been improved within the framework of the seismic requalification.

- Backfitting of the main control room and SUSAN ventilation with an active charcoal filter

  The montage and bringing into commission of this backfitting, for satisfying the demands of the HSK, was largely completed. The systems were provisionally put ready for use. The acceptance by the HSK follows in the spring of 1995.

- Relief valve 02V71A

  The control logic and the drive of the relief valve 02V71A was relocated from SUSAN to the reactor protection system. With this, a pressure reduction with at least one valve from all four divisions is now possible.

2.2.4 Fuel and control rods

Since the activity in the reactor water and exhaust gases was low throughout the year, it can be assumed that no leaks in the fuel elements were present.

From a total of 240 fuel elements there were 44 replaced by new ones in the 22 fuel cycle (1994/95). All newly loaded fuel elements had a 9x9 fuel rod arrangement.

Additional to the control rods replaced over the last three years, four used-up ones were removed and replaced with new ones during the outage of 1994. These have a low cobalt content. With this, all 57 control rods are from low cobalt materials.

2.2.5 Radioactive wastes

The amount of raw radioactive wastes lay, in the reporting year, in the region expected based on previous years.

The main activity in the aera of conditioning was the creation of a cement volume reduction solidification plant (CVRS) for the conditioning of resins, concentrates and slurries. The corresponding permission to commence installation was delivered by the HSK in April. A modification to the system with regard to the preparation of slurries was accepted in the autumn. The binding process was demonstrated on the occasion of a visit to the reference plant in Forsmark (Sweden). The procedure for qualification of the cement recipes was agreed upon with all instances involved. The active start up of the plant is seen for 1995. At the end of the year, the KKM have supplied a specification for compressible wastes to the NAGRA for judgement and certification as to the suitability for final disposal. The KKM has created in the reporting period, a quality assurance book concerned with the activities for disposal of radioactive wastes.

Conditioned waste packages were routinely stored in the interim storage. The application from KKM, for a tempory storage of half-finished products (pressed drums), was conditionally accepted.

A large amount of inactive materials came from diverse repairs and maintenance work as well as the modifications to the processing building for the installation of the CVRS plant. A total of about 24 tonnes of metals and 42 tonnes of building rubble could be released as inactive. This was even under the severe conditions of the new radiation protection ordinance for the release of inactive materials coming out of controlled zones.

2.3 Radiation protection

2.3.1 Protection of the personnel

In the calender year 1994 (1993), the following collective doses were determined:

Actions	man-Sv
Planned outage	1.14 (1.00)
Power production	0.47 (0.77)
Year's collective dose	1.61 (1.77)

The year's collective dose of 1.61 man-Sv is satisfactorily low and lies far below the HSK guideline of 4.00 man-Sv.

No exceeded dose limits were found in the individual doses. The highest single dose was in 1994 (1993) 15.0 (22.1) mSv. Further information is given in Tables 5-10 and in Figures 6-10.

Compared to the previous year, there has been no significant change in the radiological conditions of the installation. In the drywell, the average dose rate on the recirculation pipes increased by 3 % to 5.1 mSv/h. Numerous sources of radiation in the drywell were temporary shielded during the outage with lead sheets (about 55 tons), in order to improve the radiological conditions there.

The KKM has newly installed permanent fixtures for lead sheet in the plant. This allows for a thicker shielding and a faster montage. The owner estimates that through these temporary shielding measures, a netto saving of the dosis of more than 1.5 man-Sv can be achieved.

The power rating increase of about 10 % has had no visible effects on the radiological conditions.

The deposition of active corrosion products, in particular cobalt-60, leads mostly to doses by external radiation in the case of service personnel. The injection of iron (Fe-III) into the feedwater, as a means to reduce the deposition of activated corrosion products was continued. This was, however, stopped three months before the annual outage due to a defect. The cobalt content in the reactor water has shown a falling tendency over the last three years. Due to simultaneous changes of several parameters with potential effect on the radiological conditions in the drywell, (power increase, replacement of pins and rollers and iron dosing), an assessment of the separate effects of these measures is, at the time, not possible.

Due to the undamaged state of the fuel, the contamination has been very low in the turbine building; this eased the carrying out of work.

The efforts of KKM to shield radioactive sources, removal of radiation causing parts (pins and rollers) and also by influencing the transport of activated corrosion products (iron dosing), to hold the doserates low at the working areas, should make it possible to keep the collective dosis in the NPP at a low level.

2.3.2 Releases to the environment

All releases of radioactive materials to the environment lay significantly below the prescribed limiting values. The releases lay below the level of 0.1 % of the release limit for aerosols and iodine-131 also. The calculated dosis for a member of the population, assuming the most unfavourable assumptions, was approximately 0.7×10^{-6} Sv (adult) and 3×10^{-6} Sv (child) for the total release in the reporting period. When considering also the releases of previous years, the doses were 11×10^{-6} Sv (adult) and 12×10^{-6} Sv (child).

Table 4 gives more detailed informations about the releases and the calculated doses in the vicinity of the plant.

2.3.3 Radiation protection instrumentation

All measuring instruments used for controlling the release of radioactivity to the environment and the level of radioactivity in the plant, the personnel monitors and the individual dosimetry systems have fulfilled their tasks in the reporting period.

2.4 Personnel and organization

2.4.1 Personnel

After successfully completing their examinations, four reactor operators (level B) and a picket engineer were licensed. The total number of licensed personnel is shown in Table 2. The total plant personnel was 282 (in 1993: 274).

2.4.2 Organization

The plant organization remains unchanged.

2.4.3 Quality assurance

The structuring of a quality assurance (QA) system was started in the reporting period in KKM. The QA programme for the transport of radioactive materials was completed and the QA handbook "Radioactive Wastes" was put into operational use.

2.4.4 Emergency exercises

According to the wishes of the nuclear technology and security section of the BEW, the KKM has postponed the planned security emergency exercise until 1995.

2.5 Compliance with mandatory requirements

In addition to the requirements demanding a periodic plant check-over and updating of important plant documents (safety reports, MUSA), the position is as follows:

Creation of a fire protection (mandatory requirement 4.5)
The HSK has demanded from the KKM that it should create a smoke and heat removal device in the reactor building. The KKM has decided to satisfy this demand with the insertion of a by-pass in the exhaust air filter (improving the existing ventilation). Apart from this, the HSK insists on an administrative limit of the transient fire loading in the reactor building.

Measures on the interim storage, adjusting the conditioning process to the state of the technology (mandatory requirement 4.10)

The last open point for satisfying this requirement is the creation of a state of the technology conditioning plant. This is being built and will go into service in 1995.

Measures for reduction of the dose rate due to a power increase (mandatory requirement 4.11)

The remaining pins and rollers made out of "Stellite" have been replaced during the 1994 outage. With this, a significant contribution tc the reduction of the dose rate can be made. The dosing of iron into the feedwater continues. The requirement is satisfied.

2.6 Overall judgement by HSK

The condition of the NPP Mühleberg and its management with respect to nuclear safety and radiation protection can be classified as good. The existing damage to the core shroud will not endanger the safe running of the plant in the current cycle. The safety level of the plant could be again increased via a series of plant modifications. The average dose rate on the recirculation loops increased by about 3 % compared to last year. Dosis reducing measures were again undertaken. The year's collective dosis of the personnel has again sunken relative to the previous year. It lies, together with the releases of radioactive materials to the environment, significantly below the officially prescribed guide and limit values.

3. Nuclear power plant Gösgen

3.1 Operaticnal data and results

The nuclear power plant Gösgen (KKG) is a 3 loop pressurized water reactor of 940 MWe net capacity. Operation started in 1979. Further information is given in Table 1 in the appendix; Figure 1a shows a functional diagram of a pressurized water reactor.

In the operating period 1994, KKG reached a load factor of 93.5 % and an availability factor of 92.5 %. The scheduled outage lasted 27 days. In the reporting period, the installation provided 159.5 GWh of process heat to the heat supply for the nearby carton factory.

The plant operation was not interrupted by any unplanned scrams. Some days after restart, after refuelling, a turbine trip occurred due to a too high sealing oil temperature in a generator. The reactor power was brought back automatically to about 25 %.

3.2 Plant installation safety

3.2.1 Particular incidents

No incidents of classes A or S have occurred; accordingly, also none on the INES-scale higher than 0 (see also chapter 9.7).

Two reportable incidents were registered; one unclassified and one of the class B.

The line 1 of the leak pump back system of the containment was closed to allow an inspection. By going back to the original condition, it was seen that also line 2 had been closed due to a handling error. The time allowed for inoperability was therefore exceeded slightly due to this. The system pumps any possible leakage of the containment penetrations back again into the containment. Since both suction armatures had been closed, the containment function was preserved. The secondary containment function, namely the standby gas treatment system of the secondary containment, remained equally unaffected. Due to these grounds, the incident was regarded as non-classified.

Based on the detection of a slightly increased activity in the primary coolant, it was assumed that fuel element damage was present. This suspicion was confirmed when the fuel element inspection took place. It was found to be a wear damage in the region of the lower spacer. The fuel element concerned was not put back into service. Just before the end of the year, a slight increase in noble gas activity in the primary circuit was again noted.

3.2.2 Work during the yearly outage

All operat ons involved in the revision such as exchange of fuel elements, inspections, routine testing of mechanical and electrical components, functional tests of systems and components, maintenance etc. were carried out as scheduled and planned.

The following important activities are mentioned:

- The reactor pressure vessel (RPV) leak sealing line was replaced as a precaution due to leaks. The new line is placed in the RPV ring gap and is now easier to reach.

- During the revision in 1993, numerous foreign objects, in the form of nails, were found in the steam generator (SG) 3. These came from the time of the construction of KKG. For the revision of 1994, there were equipment and techniques developed for recovery of the nails from the flow distribution plate. For this, additionally, in both SG 1 and 3, there were 28 openings eroded into the SG shell.

  The boiler tubes of both SG were subjected to eddy current testing. Nails could be localized using a newly developed combined probe. In addition, wall thinning could be measured as usual. In the two SG, nails on the flow distribution plate, the tube holding plates and separately on the tube sheet, were found. Of these, 46 were recovered. The SG 2 is not affected by these foreign objects. Two heating tubes were plugged, as a precautionary measure, in SG 3.

- Surface crack testing and ultrasonic testing were also performed on the secondary side of the SG 1 shell. These tests revealed nothing. All three SG were in good condition.

- Due to the discovery of cracks in the weldments of "thin walled" tubes made from stabilized stainless steel in German boiling water reactors, the HSK has demanded a thorough testing programme. Up to now, over 70 circumferential seams of the nuclear auxiliary systems have been tested using an X-ray method. The test results to date have not indicated the presence of cracks.

- A feedwater pump was completely overhauled.

- All calibration, functional and locking tests in the control and instrumentation showed no malfunction; the same was valid for the reactor protection system.

- The capacity tests of the emergency supply of train 1 and the control rod batteries were carried out successfully.

The findings by other usual inspections gave no indication of problems.

3.2.3 Changes to the plant

The following significant changes to the plant have been carried out in the reporting period:

- All three main coolant pumps have received new impellers. They correspond to the "optimised impellers" of the convoy plants in Germany. They are made from forged impellers, optimised shafts with central bolts for fixing the impellers and have an access hole to facilitate in-situ non-destructive testing. The removable part and the shaft bed with the axial positioning plate were also renewed. The pump commissioning measurements showed that the measured values exceeded the design specification with respect to coolant flow rate.

- Safety valves were built into the penetrations for overpressure safety of the water enclosed between two of the containment isolation valves for the case of a loss of coolant accident.

- All magnetic pilot valves on a steam isolation valve were exchanged together with their control blocks. With this, improvements with regard to the magnetic power and position indicator were reached.

- Last year, in connection with measures against severe accidents, the steam generators were each supplied with a valve allowing manual pressure relief to be carried out. In this year, an emergency feed possibility was created. With mobile aggregates, this is possible from out of the emergency feedwater building via the newly installed emergency feed nozzles which have been built into each steam generator.

- To prevent the danger of blockage in the coolers of the emergency diesel generators by debris transport, the high and low temperature coolers of all four diesels were exchanged for those having larger diameter cooling tubes. This work is now complete.

- To improve the situation concerning the debris transport in the Aare river with the first water intake, two separate direct drain channels for the sieve drums were made. A sieve screw conveyor device was installed to remove the debris during normal operation. For extreme cases, such as severe pollution of the river Aare after thunder storms and flood water there now exists the possibility for directly diverting the debris back into the superior water channel; a cantonal permission exists for this.

- Sand transport, above all by high water conditions in the Aare, has been observed for some time in the second water intake construction. On the occasion of the water collection revision, countermeasures were put into action. The sieve conveyor plant was increased in length downwards by a metre, the mesh size and the form of the sieve were changed so that the sieve area could be increased by approximately 50 %. At the same time, the sieve conveyor plant was strengthened. Observations to date confirm the correctness of the measures taken. The screw spindle on the pump intake was replaced by a new construction; this will hinder the take-up of debris. A reserve diesel motor replaced the existing one. The miter gear was completely serviced and the lubricating oil pump was modified to a direct drive one. On the pumps, the casings and suction caps were made from erosion resistant material and the pump shaft bearing was given a new maintenance-free construction.

- The low pressure turbines 2 and 3 were exchanged. Together with the forseen modification of the turbine 1 during the 1995 revision, an efficiency improvement of about 3 % is expected.

3.2.4 Fuel and control rods

From a total of 177 fuel assemblies, 52 were replaced by new ones in the 16th production cycle (1994/95). The fuel rods of the newly loaded fuel assemblies have a cladding, the surface of which has been coated with a corrosion-preventing protective layer.

Again, in collaboration with the fuel supplier, there were various test fuel rods present having cladding tubes of various material compositions and manufacturing history; a comprehensive measurement programme was carried out. In general, a good behaviour was seen.

As in the previous year, all 48 control rods were eddy current tested for cladding damage during the outage; they could all be used again. To examine the behaviour in service of the new control rods with specially coated absorber cladding there were, nevertheless, four control rods replaced by new ones.

3.2.5 Radioactive wastes

The amount of radioactive wastes was similar to that experienced in the previous years.

At the beginning of 1994, the last questions concerned with concentrates in bitumen were cleared up. With this, the updated release for the continued production of this type of waste package could be granted by the HSK. Also, at the start of the reporting period, the KKG has applied for the release of pressed wastes, based on the specification and the accompanying certificate for the suitability for final disposal (ELFB) of the NAGRA. The HSK will process all of the corresponding applications of all nuclear power plants in the spring of 1995. Furthermore, the KKG has updated the documentation of old resin which was embedded in cement and bitumen from trials; the KKG has presented the specification to the NAGRA with the aim of obtaining ELFB. The KKG intends to condition the deposits which have occurred in the waste water collection containers since start up. This is a new type of waste which is subject to release regulations; the specification of these will be dealt with.

The used-up active charcoal out of the pre-filter of the secondary containment gas treatment system was released as inactive. Approximately one tonne was brought away to be burnt in a rubbish processing plant.

3.3 Radiation protection

3.3.1 Protection of the personnel

In the calender year 1994 (1993), the following collective doses were determined in KKG:

Actions	man-Sv
Planned outage	1.30 (0.77)
Power production	0.16 (0.15)
Year's collective dose	1.46 (0.92)

Due to comprehensive work and routine tests in the 1994 outage, the year's collective dose of 1.46 man-Sv is higher than in the previous year. It lies well below the HSK guideline of 4.00 man-Sv and can be classed as low despite the extent of work performed.

No exceeded dose limits were found in the individual doses. The highest single dose was in 1994 (1993) 19.22 (12.7) mSv. Further information is given in Tables 5-10 and Figures 6-10.

Based on many dose rate measurements on the primary circuit, it is seen that a slight rising tendency is present. The KKG is taking part in studies concerned with the possibility of reducing activated corrosion products (in particular cobalt-60) and therefore the reduction of the dose rate on components due to lessened deposition of the activated products in oxide layers. The HSK has encouraged the study of seeing in how far running the plant with increased burnup of the fuel elements has an influence on the dose rates in the plant. The substitution of the impellers of the three main coolant pumps by a cobalt free alloy (instead of Stellite which is a cobalt alloy) in this year's outage will work in the direction of a further reduction of cobalt-containing materials in the primary circuit.

The KKG has used more temporary lead shielding in the 1994 outage. From a total of 20 t of lead, 12 t were used for shielding the working area near to the steam generators. The saved collective dosis lay in the region of 60 man-mSv. The HSK is of the opinion that specific and increased use of temporary shielding is useful and it should be continued.

In the sense of optimizing the radiological protection, the KKG will examine the possible use of an automatic ultrasonic testing for the routine testing of the primary circuit components. This is because of the fact that the dose rates in the working areas are relatively high for this type of examination.

3.3.2 Releases to the environment

All releases of radioactivity were well below the permitted limiting values. Table 4 gives an overview of the releases and, calculated from these, the maximum dose for a single person in the vicinity, assuming the most unfavourable conditions. These are in the order of magnitude of $0.7x10^{-6}$ Sv (adult) and $3x10^{-6}$ Sv (child) in the reporting period.

It should be noted that the releases from KKG for waste water without tritium, aerosoles and iodine, were below 0.1 % of release limits. For noble gases, since no nuclide-specific measurements are available, a conservative mixture of 80 % Xe-133, 10 % Xe-135 and 10 % Kr-88 is taken. Also under these assumptions, there was an insignificant dosis contribution to the release of $< 0.1x10^{-6}$ Sv.

3.3.3 Radiation protection instrumentation

The radiation protection measuring instruments and the personal monitors fulfilled their purposes. During the course of the reporting period, two new systems for evaluating the TLD dosimetry (person and environment dosimeter) were bought and commissioning work for them started.

The final homologization of the system will take place at the start of 1995. Until then, the evaluation of personal and environment dosimeters will continue using the old system.

3.4 Personnel and organization

3.4.1 Personnel

Five reactor operators (level B) were newly licensed in 1994. The total number of licensed personnel is given in Table 2. The total plant personnel was, at the end of the reporting period, 374 people (1993: 371).

3.4.2 Organization

Plant organization remained unchanged.

3.4.3 Quality assurance

The KKG has completed the quality assurance programme for "Transport of radioactive materials". The audit, necessary before the HSK can acknowledge it, has still to be carried out.

3.4.4 Emergency exercises

The security emergency exercise, planned for 1994, was, with the permission of the section "Nuclear technology and security" of the BEW, postponed to 1995.

3.5 Overall judgement by HSK

The condition of the installation and the management of KKG can, with reference to nuclear safety and radiological protection, be classified as good. Both of the incidents which occurred had only a slight significance for safety.

The quantity of radioactivity released to the environment was very small and far below the official limits.

No person accumulated an individual dosis of more than 20 mSv. The year's collective dosis of the personnel lay with 1.46 man-Sv far below the HSK guideline value of 4 man-Sv.

4. Nuclear power plant Leibstadt

4.1 Operational data and results

The nuclear power plant Leibstadt (KKL) is a boiling water installation of 990 MWe net output. Further plant data are given in Table 1 of the appendix; Figure 1b shows a functional diagram of a boiling water reactor.

In its tenth year of operation, the KKL plant performed with a load factor of 80.7 % and an availability of 82.5 %. The yearly outage, which lasted 52 days, caused a non-availability of 14 %. The stretch-out operation and three further shutdowns all had influence on the load factor.

The power production of KKL plant was interrupted in February to remove a water leak on a drain line of the mainsteam isolation valves in the region of the reactor. For this, the flange connection was resealed. Since the radioactivity values in the reactor water rose sharply in May, the KKL decided to shut down the plant to look for fuel element damage. During the shut down, the complete core was checked over and five defect and one possibly defect fuel elements were exchanged. The third shut down, in December, was caused by a transient which led to an reactor trip.

4.2 Plant installation safety

4.2.1 Particular incidents

No incidents of the A or S class have occurred; none also higher than level 0 of the INES (see also chapter 9.7).

The following five incidents were classified "B" as to their safety relevance:

- An increased water leakage was noted in the drywell at the end of December 1993; this became subject to official registration at the end of January 1994. By the already mentioned shutdown of the plant in February, a leaking flange joint was found at one place, where a fitting piece for the sealing test on the inside valves can be used in the drain line for the isolation valves of the main steam lines. The leak could be corrected by resetting the flange joint and changing the seal.

- The periodic functionality test of a diesel generator of the emergency system was interrupted by a protective shut down. By start up of the diesel, the pressure build-up in the oil pressure control of the piston cooling oil followed too slowly; the diesel was shutdown after 15 seconds. The cause was an erroneous fast coupling in the measurement line to the oil pressure switch which retarded the build-up of oil pressure.

- During the monthly functionality test, the groundwater pump, which provides the cooling water, lost its electricity supply and failed due to a defect in the breaker cabinet. Due to this, the diesel was switched off manually. A loose screw, on the joining bars of the switch-contact apparatus of one phase, was found in the breaker of the groundwater pump. The overloading on the two other phases caused the breaker to trip.

- In the 11th working cycle, which began in September, the concentration tendence of selected nuclides in the exhaust gases and in the reactor water indicated fuel element damage again from the 1 December 1994. These concentrations were still far from limiting values and shut down criteria at the end of the year.
- The reactor trip in the middle of December was caused by a low water level in the reactor. Previously, there had been an emergency generator unloading due to a leak in the sealing oil system of the generator. The emergency unloading required a reduction of the reactor power and a rapid closure of the turbine control valve. This lead to a loss of the feedwater pre-heating. The pressure in the feedwater tank was insufficiently kept up by the support steam from out of the live steam lines; this reduced the supply to the feedwater pumps, for a short time, and therefore the level of water in the reactor fell to such an extent until a scram followed.

The first three above-mentioned incidents indicate an insufficiency in quality assurance and control. It remains to be tested whether the newly introduced quality assurance system can prevent the appearance of such inadequacies in the future.

4.2.2 Work during the yearly outage

During the annual shutdown from 17 July to 6 September 1994, the usual operations involved in the revision were performed. These included refuelling, maintenance, recurrent testing of components, plant modifications, inspections and functionality checks of systems and components.

By the maintenance work, tests and inspections, two short-comings on the reactor recirculation system were discovered; these were not significant as far as the plant safety was concerned.

A shaft protection cover, to prevent thermal stress on the recirculation pump A, was exchanged due to cracks on the cover. The worn connections between the spindle and plate on the two pressure valves in the recirculation loops were repaired.

The recurrent non-destructive tests on the mechanical equipment included circumferential and longitudinal weld seams as well as the nozzle welds on the reactor pressure vessel (RPV). With this, the ten yearly testing cycle of the routine tests on the RPV was completed. Additionally, the annual routine testing for this year was concerned with testing on RPV closure head bolts, different RPV internals such as the coreshroud, vessel and piping seams on the emergency core cooling systems, decay heat removal and, on the emergency system, testing of the recirculation system, feedwater and main steam lines and their armatures. The tests gave no grounds for concern. Furthermore, all functionality and leak tests on isolation armatures and penetrations of the containment went satisfactorily. An equally favourable result was reached with tests on the various thermal components (preheater, superheater and control vessels) on the secondary side of the plant.

As a further test for the RPV at the end of the test cycle, a water pressure test at 1.25 times the design pressure has been carried out. The test embodied the connecting piping parts up to the first shut off armature; no unacceptable leaks were seen.

The integral leak rate testing on the containment was done for the second time since the plant commissioning. The leak rate was about half the value allowed.

The wall thickness measurements on piping mostly on the secondary side were continued in the framework of the programme started in 1990 for weak point analysis due to erosion and corrosion via a flowing medium. No unacceptable wall thicknesses were determined. The programme will be continued in next year's outage.

4.2.3 Plant modifications

In the reporting year several plant modifications have been initiated, continued or completed. They serve to increase the nuclear safety and also the operating requirements. The significant changes were:

- Various electro-technical changes have been performed on the emergency system (SEHR). They increase the operational safety and availability of the system and encompass:
  - external electrical supply via the plants house loads
  - improvement of the diesel generator monitoring
  - equipping the SEHR control room with transient warning devices
  - improving the shut off baffles logic by an additional end-position surveillance
  - position surveillance of important armatures.

- The hold-down beams of the 20 jetpumps in the RPV were replaced with better designed ones. This was done on the recommendation of the reactor manufacturer following observations of damage to these parts in a similar American NPP.

- The voltage surveillance of the speed control of the driver turbine was changed to improve the reliability and testability of the reactor emergency feeding system (RCIC). Further, the possibility was made to use a plug-in simulator in the electronics for the testing of the turbine regulation.

- Two changes to the exhaust gas plant were made to increase the reliability. They were concerned with a simplification of the pressure regulation of the steam jet air ejectors, a stationary heating for the jetstream air ejectors and the piping to the hydrogen recombiners through which the ignitability will be supported under low load conditions.

- The KKL has decided to build a new well water supply with a horizontal filter. This decision is based on the fact that the delivery capacity of one of two groundwater supplies of the emergency system (SEHR) has diminished; this has necessitated, since two years, several measures to increase the production of the well in order to satisfy the demanded quantities. The sinking of the vertical shaft, necessary as a first step of the project, will be started at the end of the year.

- A new filter type for the condensate cleaning plant was given a trial. Based on the good results, the plant will be supplied with the new filter type in the yearly revision. This will give a higher separation for iron.

- The cooling pipes for the decay heat removal from the fuel element storage pool in the containment were incorporated externally into the two redundances of the decay heat removal system. Apart from a missing armature, caused by a delivery delay, the partial system is complete. The additional electronic devices, necessary for the function of the cooling lines, were installed and tested.

- The construction of a new active workshop has been carried out according to plan; it can be commissioned before the yearly outage of 1995.

- A considerable increase in the electrical power could be achieved, through the replacement of the low pressure turbines, of a better efficiency.

4.2.4 Fuel

In October 1993, due to an increase in the reactor water and exhaust gas activity in the 10th fuel cycle, it was thought that a fuel element damage was present. Quickly rising activity values led, in May 1994, to an approximate ten days non-scheduled shutdown of the plant. Five defect fuel assemblies were found and they were replaced. After this, the cycle could be continued to the end without further indications of damage. The five defect fuel assemblies were thoroughly inspected. In one of them, similar as in other fuel cycles 5 (1988/89), 7 (1990/91) and 9 (1992/93), a large longitudinal crack in the fuel cladding was found. Two more fuel elements had each total circumferential cracks in their cladding. The damage was associated with the wash-out of fuel and the corresponding contamination of the cooling circuit.

The examinations of the defect fuel elements showed that the circumferential cracks arose from a strong local hydridation whereby the primary damage caused by foreign body friction made the water penetration into the cladding possible. The reason for the repeated presence of the longitudinal cracks is not clear.

During the outage for the 11th fuel cycle (1994/95), 112 of the total of 648 fuel elements were exchanged for new ones. All new fuel elements have a 10x10 fuel rod configuration. The average enrichment was increased to 3.75 weight percent of U-235. During the outage, the cooling circuit was searched thoroughly for possible foreign bodies in order to prevent further fuel element damage. Additionally, for the 11th cycle, a special protective method was adopted to avoid fuel cladding loading caused by changes in power.

In the 11th cycle, which began with a defect-free core, there are again, since December 1994 indications of fuel element damage.

4.2.5 Radioactive wastes

The amount of radioactive wastes produced in KKL lay in the bounds of that experienced in previous years.

Based on the certificate for the suitability for final storage (ELFB) received from NAGRA, the KKL applied for the up-dated release of the pressed wastes. In the reporting period, the KKL worked on the documentation with the aim to get an up-dated release for the powdered resin cemented with concentrates. Parallel to this, KKL worked on specifications of other types of wastes: milled ball resin, pure concentrates as well as mixtures of resin, concentrates and sludges. All of these specifications should be presented to NAGRA in the spring 1995 with the aim to obtain the ELFB. The product control on the filling mortar used in the fuel element box disposal action, carried out at PSI, gave largely positive results.

Since two years it has not been possible to fully condition the burnable low active wastes from KKL in the experimental waste burning incinerator installation at PSI. Since a storage of these wastes in the rooms of the installation would lead to an unnecessary irradiation of the personnel, the KKL has put a buffer zone into place for about 2000 barrels of burnable low active wastes. This is situated on the east side of the turbine building, outside of the controlled zone. The HSK has granted permission for this, limited to the end of 1995.

The exchanged and slightly contaminated parts of the low pressure turbine were correctly packed up and brought to a temporary storage place and placed under observation. They should be decontaminated and made reuseable as inactive scrap metal within the next three years.

A total of 4250 litres of old oil could be released as being inactive in the reporting period.

4.3 Radiation protection

4.3.1 Protection of the personnel

The following collective doses were determined for the operation of KKL in the year 1994 (1993):

Actions	man-Sv
Planned outage	1.78 (1.08)
Unplanned outage	0.14
Power production	0.66 (0.57)
Year's collective dose	2.58 (1.65)

The year's collective dose of 2.58 man-Sv lies below the HSK guideline value of 4.00 man-Sv. It is higher than the corresponding values of the previous years (1.65 man-Sv in 1993 and 1.74 man-Sv in 1992). It is also higher than the value which KKL thought would be reached (2.25 man-Sv). The reasons for this are the unplanned but necessary outage due to the fuel element defects and the extent of the work in the drywell (recurrent, routine testing) and in the turbine building (exchange of the low pressure turbines). Relative to the large extent of work done, the collective dosis of 2.58 man-Sv can be classed as low.

No exceeded dose limits were found in the individual doses. The highest single dose was, in 1994 (1993) 18.5 (15.7) mSv. Further information is given in Tables 5 -10 and in Figures 6 -10.

As shown above, fuel element damage appeared during the 10th fuel cycle and this, among other things, led to an increase of the reactor water activity giving rise to an increase in the dose rate in the secondary side of the plant. With a view on the considerable construction work in this part of the plant and, based on data trends, it had to be assumed that the maximum allowed reactor water activity would be reached before the planned shutdown in 1994, the KKL decided to have an unscheduled shutdown in May 1994 to facilitate removal of the damaged fuel elements. With this, the high dose rate in the plant, in particular in the turbine building and high surface contamination on open components and systems which made work difficult, could be avoided.

The fuel element damage led to a release of fuel into the primary circuit and with this, to the possibility that the room air could be contaminated with alpha-emitting nuclides. A new mobile measuring instrument, which has proven itself well, was brought into service to survey the air in critical working areas for alpha-nuclides. Due to these measurements, it could be determined that the air contamination in the working areas always lay below the allowed official guideline one.

Compared to the previous year, the radiological conditions in the drywell have again improved as a result of the practice of zinc dosing into the feedwater since 1990. The average dose rate of the recirculation piping was, in the outage of 1994 (1993), 1.85 mSv/h (2.2 mSv/h). Since comprehensive routine recurring examinations took place in the drywell, the recirculation lines were decontaminated beginning with the suction valve. After the chemical decontamination with the "CORD" method, the average dose rate was reduced to 1.32 mSv/h whereby, in some places, a dose rate reduction factor of 15 was reached. The decontamination had, according to the estimates of the owner, brought a saving of about 1.1 man-Sv. As in the previous year, numerous radiation sources in the drywell were shielded temporarily with about 20 t of lead, in order to improve the radiological situation.

4.3.2 Releases to the environment

KKL releases to the environment remained within the frame of those of previous years. For the most exposed group of people in the vicinity of the plant, the maximum dose of approximately 1.5×10^{-6} Sv (adult) and 7×10^{-6} Sv (child) in the year was calculated assuming worst possible conditions. Detailed information can be taken from Table 4.

The balanced releases of KKL aerosols lay below the 0.1 % release limit.

4.3.3 Radiation protection instrumentation

The radiation protection measurement instruments used for surveillance of releases to the environment and the activity or radiation level in the plant as well as personal monitors and personnel dosimetry system, fulfilled the tasks demanded from them.

The experiences with the new evaluation device for TL dosimetry, in service since 1993, were positive.

Due to the fuel element defects during the 1993/94 fuel cycle, alpha monitors were brought in by KKL for the operational radiation protection. During the reporting period, there were parallel to this, in the Paul Scherrer Institute (PSI) and from the "Institute de radiophysique appliquée" (IRA), in Lausanne, different probes alphaspectrometrically examined for possible dosis contributions from alpha-emitters.

4.4 Personnel and organization

4.4.1 Personnel

In the reporting period there were three reactor operators newly licensed. The total number of licensed people is given in Table 2. The total works personnel was, at the end of the reporting year 1994 (1993) 392 (388).

4.4.2 Organization

There were no changes to the plant's organization.

The KKL is the first nuclear power plant in Switzerland to let its operational safety be examined by an international team of the IAEA (OSART). The overall judgement came out good. In particular, a few "good practices" were found. Recommendations for optimisation in some divisions of the organization are being worked on by KKL.

4.4.3 Quality assurance (QA)

Work on the management of a quality system was continued. At the end of 1994 there were seven of the 23 planned regulations integrated into the system and put into practice. The KKL plans to complete the quality management system by the end of 1995.

The QA-programme "Transport of radioactive materials" is available.

The OSART team (see 4.4.2) has also examined the quality management system and found it to be good. Above all, the manner in which the system was introduced has been praised.

4.4.4 Emergency exercises

A safety full scale security emergency exercise, has been carried out by KKL, under the code name "BLADE", with the participation of the cantonal police of Aargau. The scenario was that a terrorist group had penetrated the installation and had taken hostages. The works personnel showed good and efficient work after the questions concerned with co-ordination and responsibility had been cleared up with the police.

4.5 Overall judgement by HSK

The plant condition and management at KKL, with respect to nuclear safety and radiological protection, can be rated as good. The incidents which did occur had a minimal nuclear safety significance. Only the fuel element damage appears to be a continual companion of the plant operation. This requires corresponding measures such as careful operation and avoidance of foreign bodies for avoiding the contamination of the plant. Also, the use of less sensitive cladding on fuel elements would be advantageous.

The dose rate in the drywell has again decreased compared to the last year. The year's collective dosis remains, happily enough, at a low level despite the long shutdown and further interruptions and particular tasks. No person reached an individual dosis of 20 mSv. The quantity of radioactive materials released to the environment lay far below the official limits allowed.

5. Research installations

5.1 Paul Scherrer Institute (PSI), Villigen/Würenlingen

Due to the complex radiological aspects, the complete PSI with the areas east (Würenlingen) and west (Villigen) will be considered although only six installations, on the east side, are classed as atomic installations in the sense of the Swiss atomic law.

Main points of the HSK supervisory activities were, in the reporting period, the shut down research reactor DIORIT, for which a Federal council permission for decommissioning exists and the closed down research reactor SAPHIR, for which the fuel storage must be consolidated before it is decommissioned. Further, the following installations and things were supervised: the reactor installation PROTEUS, the accelerator installation, the spallation neutron source (being built), the Hot laboratory division, medicinal uses (together with the BAG), and radiopharmacy as well as the radioactive wastes with the Federal interim storage (BZL). The processing and assessing of reportable incidents caused considerable work, similar to that in 1993.

5.1.1 SAPHIR

The 37 year old SAPHIR, a swimming pool type materials test reactor of 10 MW power the most powerful Swiss neutron source for research, is not in use since 17 December 1993. With a view that the spallation source would soon go into service, the Direction of the PSI have decided against a start up of SAPHIR as a neutron source and have put an immediate stop to all backfitting. Five weeks later, on 21 June 1994, there followed the decision, under consideration of the condition to run only one reactor installation at PSI, to also not use SAPHIR as a zero power installation for training. The necessary steps were started for the taking out of service and dismantling of this nuclear installation; this was communicated in a letter on 11 July 1994 to the nuclear inspectorate.

At the time of this decision and up to the end of 1994, there was a considerable amount of fuel stored in SAPHIR. Its surveillance by a greatly reduced staff, has to be maintained. The second half of the year was therefore used for a consolidation of buildings and installations for use in the coming year.

Specific to this installation, a collective dosis of 7.2 man-mSv was shown. In the reporting period, there occurred no registrable events in the nuclear installation SAPHIR.

5.1.2 PROTEUS

The research reactor PROTEUS was used in 1994 for studies on high temperature reactor (HTR) pebble fuel with hexagonal dense and hexagonal cubic arrangements. The reproducibility of the physical measurements of the core were confirmed through repeated loading of a stochastic pebble arrangement. A total of 49 flux hours ($\phi \geq 1 \times 10^9$ $cm^{-2} \cdot s^{-1}$) were reached in 683 working hours. Five core configurations could be loaded and examined using the proven transport and sorting apparatus; the reactor was fully emptied and filled up quite a few times. A new built-in recirculation air conditioner with 5 kW heating power and 11 kW cooling made a 5°C temperature variation possible and with this, the determination of the temperature coefficient at room temperature.

The collective dosis in 1994 was 10 man-mSv. The running of the installation was trouble free and therefore no registrable incidents occurred according to HSK-R-25.

5.1.3 DIORIT

With the decision of the Federal Council on 26 September 1994 to grant the PSI the applied for permission (from 25 August 1992) for a total demolition and disposal of the DIORIT reactor installation (shut down since 1977), this process has reached a further milestone. The expertise of the HSK and the position taken by the KSA have confirmed the suitability of the proposed demolition concept from the point of view of radiation protection.

The dismantling work on the demolition phase 2A, allowed by the HSK, with reduced personnel (on average two people), was continued. Concepts for the construction of an active surface treatment laboratory and a disposal way to demolition phase 2B were developed in the reporting period.

A series of building measures (primarily breaking through of the walls according to the HSK authorization) for realizing the concepts could be met.

The DIORIT building, which contains no nuclear fuel since December 1994, was used by 47 workers of different research groups for bureaus and experiment areas.

The collective dosis of the demolition workers was determined as 2.4 man-mSv in 1994. There were no registrable incidents, according to HSK-R-25, in the nuclear installation DIORIT, in the reporting period.

5.1.4 Hot laboratory

The research themes in the Hot laboratory, and therefore, the given nuclide types and quantities have changed only slightly when compared to the previous year. Above all, contributions were done to the following research themes:

- EDEN (Development, performing and evaluation of post-irradiation examinations), with the main aim on:
  - Fuel rod cladding corrosion
  - Characterization of uranium-plutonium oxide
  - Damage investigation on components from out of the reactor core region of power reactors

  Two damage occurrences could be cleared up in 1994; the examination of the secondary damage on fuel rods of a Swiss boiling water reactor and the explanation of the cause of damage on a defect boiling water reactor control rod blade.

- Disposal:
  This embodies, at the present time, the partial programmes on colloidal chemistry, organic ligands, interaction between nuclides and host rocks and also examinations on cement.

- Preparative actinide chemistry:
  Is mainly concerned with actinide transmutation.

Wastes of different types out of the BAG and PSI areas were processed, as a service in the Hotlab, in the reporting period. The conditioning of core internals from the heavy water moderated research reactor DIORIT took a lot of administrative and technical effort. The newly developed cementing installation for liquid actinide wastes, the so-called FIXBOX was put into service in 1994. According to the HSK, the installation must be worked efficiently to bring the old quantities of liquid plutonium-containing wastes into a safe form as quickly as possible.

The safety report for the Hotlab was reformulated within the frame of planned renewal of all atomic law authorizations for the nuclear installations of the PSI east area. Three building projects (backfitting the respective object's safety, goods lift in the hotcell and building bureaus on top of others) could be started.

The reorganization of the research division, "Nuclear Energy, Safety (F4)" of the PSI, led to a splitting of the earlier Hotlab section into two sections. The new laboratory leader of "Material behaviour" carries the responsibility for the installation; the works group is responsible to him.

The running of the Hotlab went incident-free and no registrable incident occurred. A collective dosis of 64.3 man-mSv and a highest individual dose of 4.7 mSv was noted for the 44 Hotlab workers controlled dosimetrically in 1994.

5.1.5 Radioactive wastes

A lack of personnel at PSI and an underestimation of the extent of work needed on the various PSI waste types are the main reasons for the continued slow progress in the agreed-upon and urgently needed updating of existing, already stored wastes in a variety of packages. The conditioning method of core internals from the DIORIT could be accepted; the specification for this is, however, only provisional. Remaining to be done in this context is still the characterization of the nuclide inventary; based on this, the final specification can be made.

FIXBOX-1B

The experimental production of FIXBOX-1 packages, that are originally liquid, alpha-containing wastes fixed in cement from the Hotcells, with a volume of one liter, could be started in spring 1994. They were, after intensive discussions, on the basis of a provisional generic type release, started for the 350 FIXBOX-1 package. A detailed working regulation for the FIXBOX process was drawn up. A final specification of this type of waste will be drawn up by PSI, after the completion of the currently running leach-out trials and after laying down the final conditioning. The generic type testing agreed upon embodies leach-out trials whereby the first series (leach-out of plutonium, europium and cesium) could be completed at the end of 1994. The experience to date has shown that the binding-up of liquid plutonium containing wastes, using the present manner of work, will continue until the end of 1996. The PSI was therefore requested by the HSK to speed up the process through appropriate measures.

The waste laboratory

Radioactive wastes coming from the whole country of Switzerland are processed in this PSI installation. In the reporting period, 1988 containers of 200 l with mostly burnable contents were conditioned so that a compression of ash and filter remains to 297 containers of 200 l to the long time storage form, could be done.

The waste laboratory was improved and newly instrumented according to the radiological protection requirements for binding up alpha containing plutonium wastes. After preparations, which have taken a long time, the PSI has produced a final specification for the pressed wastes containing plutonium. This was given to NAGRA at the end of 1994 with the aim of obtaining the "ELFB". Prior to the production of further pressings, a suitable expansion device has to be backfitted in order to take up eventual gases released from solvent-containing wastes.

The incineration installation

The incineration installation is connected to the waste laboratory. In two campaigns of incineration of each about 70 days, a total of 54.1 t of radioactive wastes were incinerated. As well as the burnable radioactive wastes coming from the Swiss nuclear power plants and the PSI, there were also radioactive wastes from medicine, industry and research coming from the collecting campaign of the BAG (Swiss Federal Office of Public Health). Due to insufficient declarations concerning these last wastes, there was by the incineration, an exceedance of the release limit of tritium whereby also by a conservative view, this was small and negligible. Despite this, a working group of the PSI was brought into being to work over measures, in particular also by the waste delivery people, to avoid such cases. The corresponding reglementation must be put into practice in time before the collection of 1995.

Wastes arising from out of the use of the proton accelerator

The clarification on the characterization of the types of wastes coming from the use of the accelerator is continuing. The characterization of the nuclide inventory of the accelerator wastes is being followed by a working group in which all concerned are represented. Good progress was made in the reporting period with respect to this. The PSI has a leading position in this region. At the present time, the following packages, with activated or contaminated accelerator wastes, are stored on the West area of PSI: 37 thin-walled containers, 62 thick-walled containers and 7 large containers with a total weight of about 1600 t which find use as shielding.

The Federal interim storage (BZL)

The BZL is in routine use as a temporary storage, according to its terms of reference, since 1992. At the end of 1994, there were stored in this facility: 3117 finally conditioned 200 l containers and 18 PSI West containers (16 t). The necessary authorization for storage at the BZL of standardized waste packages and, on a case to case basis, also for single packages, was given by the HSK. Among these were, in 1994, about 2.5 t of uranium wastes out of which eight waste packages with natural uranium and a package with enriched uranium resulted and were also stored in the BZL. In the reporting period, there were also stored more concrete containers with unconditioned solid wastes from out of the PSI West area. The collection of data in the BZL, concerning the stored waste packages, had made progress in 1994.

Due to newer planning measures, the alpha activity of the plutonium containing pressed wastes per package, relative to the packages, which will be stored in the BZL, will exceed the value assumed in the original safety analysis by a factor of 200 to 500. A completion of this safety analysis, for a release for storage of plutonium containing wastes in the BZL, was carried out in the reporting period. Included in this examination was the radiological consequences of an airplane crash with a destruction of the plutonium containing wastes. The study will be delivered in 1995.

Storage halls A, B, C, collection place (dump) and transfer place

These places are designated for medium term storage of low and medium active waste after conditioning. At the end of 1994 there were stored in these places 1269 containers with 200 l capacity, some of which were in shielding cans. There were also kept there three 16 t and one 60 t PSI West container. In this part of the area there is also a CASTOR-1c-DIORIT which is a container in which the depleted fuel elements of the DIORIT are stored in a dry manner.

Disposal of old material from out of controlled zones

Considerable quantities of inactivated and uncontaminated materials have been produced from out of radiologically protected zones in the year 1994. In the reporting period, the HSK has accepted for release from out of these controlled zones, as inactivated and unconditioned, about 65 t of old material, mostly building rubble for recycling.

Incidents

According to the HSK guideline R-25, one registrable radiological incident of the type A (exceeding a year's release limit out of the incinerator installation) and one technical incident of the type B (BZL) occurred; they will be dealt with in detail under 5.1.10.

Radiation by treatment of radioactive wastes in PSI

Due to the use of the disposal installations at PSI, a collective dose of 52.3 man-mSv was noted in 1994.

5.1.6 Installations for medical use (PET, OPTIS, proton therapy) and radiopharmacy (LRP)

The Swiss Federal Office of Public Health (BAG) and the HSK, as official control channels of the Federation, co-ordinate their surveillance function in this area. The BAG is responsible for the activities concerned with the use of radiation sources on people while the HSK works on the aspects of the operational radiation protection for the PSI staff, persons not directly involved with the installation and also of the environment.

PET

Within the framework of the positron-emission-tomography (PET) programme there were, similar to the previous year, organic (370 times) and inorganic (32 times) tracers used on people. Oxygen-15 preparations were newly allowed for human application and used for the first time in the reporting period.

OPTIS

During the reporting period there were 211 eye melanoma patients treated with protons in the OPTIS installation.

Proton therapy

The building-up of an infrastructure and accelerator device for the new 200 MeV proton therapy installation, which will be used within the framework of the main PSI thema "Treatment of deep tumors with protons", could be brought along so far that a test run (phantom irradiations and treatment of anomal patients) can already be started in the first quarter of 1995.

LRP

After a re-dimensioning of the radiopharmacy laboratory (LRP), only radioisotopes for own research as well as the own on-line usage were made. Correspondingly, only radionuclides with a total activity of about 100 TBq were prepared in the reporting period, whereby products with a total activity of 6.6 TBq found external use. The dominant isotopes were iodine-131 and fluoride-18.

The collective dosis for the personnel of the radiochemical production and the medicinal usage, for 1994, was 41 man-mSv. There were no registrable incidents in 1994.

5.1.7 Accelerator, proton beam directors and experimental areas

The functioning of the injector 1, during about 6000 hours, showed, besides the handling of the standard programme, the first positive experiences with the new heavy ion source and its satisfactory integration into the accelerator. The duration of work of the injector II (72 MeV) was given as 5'800 hours.

A significant milestone of the PSI accelerator installation is the proton beam current of 1mA, from out of the 500 MeV ring cyclotron, which was achieved for the first time on 15 April 1994. The ring cyclotron was in use 5'700 hours in the period being reported on.

The operation of the accelerator installation with its experiments, as before, with very many internal and external research groups involved, caused two incidents worth noting, whereby one case was registrable according to the HSK guideline HSK-R-25. A destructive accident occurred during the start up after the January '94 shut down. The false positioning of a triplet magnet, due to a failure of the machine protection (switch limit set too high), lead to a melt-through of a chamber wall, by actually quite a low beam current (32 µA). Although quite a lot of material damage occurred and extensive damage repair was necessary, there was no immediate danger to persons or the environment. An incident with potentially greater consequences happened on 21 June 1994; an experimenter was locked in an experiment bunker. This will be reported on more closely in 5.1.10.

For members of PSI staff, on the accelerator installation (excepting the LRP and medicinal uses), a collective dosis of 80 man-mSv was noted for 1994. In the same period of time, for over 300 national and foreign experimenters, a collective dosis of 38 man-mSv was noted.

5.1.8 Spallation neutron source project

After the first HSK authorization, in the year 1993, the construction of the projected total installation, in the already existing halls, could continue with only small delays in the reporting period. Therefore, as foreseen, a commencement of service can be reckoned with at the end of 1995. In the fourth quarter of 1994, the HSK has authorized the construction of the cooling water circuits, which was applied for by the PSI. It is worth observing the advances in the non-nuclear trials of the Zircaloy target construction and by the conception and realization of the target bed.

5.1.9 Radiation protection

A total radiation dose of 0.47 man-Sv (1993: 0.52 man-Sv) was accumulated in the whole of the PSI in the reporting year (1994). This is split as 0.26 (PSI-West) and 0.21 (PSI-East) man-Sv. The highest single dosis, that was accumulated by a member of staff of the radiation protection in PSI-West, was 20.1 mSv (1993: 16.2 mSv). As in the previous year, there was no great dosis-intensive work started and the isotope production was reduced further.

For the radiation hygiene department itself, in 1994, there resulted in a collective dosis of 55.1 man-mSv (1993: 25 man-mSv). Further details about dosis values are shown in sections 5.1.1 to 5.1.7 and in Tables 5 to 10 and Figure 7.

The changeover of all stationary and mobile radiation and contamination measuring instruments to the new radiation protection units was continued. The action could be completed for irradiation measurement instruments in the autumn of 1994. The contamination measuring instruments should be modified, at the latest, by the middle of 1995.

The year's release limiting value for tritium was slightly exceeded in the pilot incineration installation at the PSI during the incineration of as non-tritium declared containing wastes from out of a BAG collection. Since the release occurred in the month of March, in which only a slight amount of agricultural products are produced freshly, the dosis coming from the consumption of food through this incident is insignificant.

In the most unfavourable case by inhalation, a dosis of 5×10^{-5} Sv will be given due to this incident. For the rest of the nuclides and nuclide groups, the release limit for all release places was not exceeded and gave rise, under the worst conditions assumed, to a dosis of about 3×10^{-6} Sv per year for aerosols from the incinerator installation, respectively 2×10^{-6} Sv per year for noble gases out of the central exhaust air of the PSI West relative to the most exposed person in the locality. It should be noted that the main contributions for the calculation of the dosis from out of the tritium incident and for the remaining year's releases do not come at the same time and that the resulting doses may not be added.

5.1.10 Particular incidents

A registrable incident of the class A and two registrable incidents of the class B, according to HSK-R-25 happened in the reporting period. They are summarized in the following Table.

Paul Scherrer Institute: Incidents 1994			
Date	**Incident**	**Classification HSK**	**INES**
25.03.94	Yearly release limit Exceedance, Tritium VVA	A (radiological)	0
21.06.94	Experimenter locked up	B (technical)	—
30.06.94	Breakdown of exhaust gas measuring instrument in the BZL	B (technical)	—

The exceedance of the yearly release limit for tritium (see under 5.1.9) from out of the pilot incinerator installation, during incineration of inadequately labelled and declared wastes from medicine, industry and research, was classed as an "A" incident. As a consequence of this incident, the burning of all BAG wastes was stopped and further measures were taken to prevent similar such incidents in future. In particular, the separate collection and declarations concerning the wastes in the various industries, medicine and research should be improved.

By the two technical "B" incidents, the causes lay in manipulation errors and construction weaknesses:

The locking-in of an experimenter in the experiment bunker of the accelerator was a result of an inadequately carried out control in the area of the experiment hall. This control is mandatory for the operation. The condition "BLOCKED" was reached in the course of events of the incident; in the rule this would then lead to beam production in the bunker. However, against all regulations, a person was still present in the bunker and this could have meant a significantly increased exposure to radiation. Luckily enough, there was no exposure since no beam production was foreseen and the unlocked beam ports were not opened. In addition to ignoring the very clear working rules in this point, there is recognized a deficiency in the person protection facility whereby a particularly fast change in the condition series of "FREE", "SURVEYED" and "BLOCKED" does not prevent sufficiently that persons can still be in the vicinity of the beam. The incident was put into the classification "B".

As a consequence of a lightening strike, among other things, the control of the exhaust air measurement and the drying installation of the Federal interim storage (BZL) was destroyed. The achieved manual reduction of the fresh air part, due to high humidity, lead to a system-conditional shutdown of the air pumps which serve the isokinetic measurement and balancing of the exhaust air activity. After this, since the alarm was not fail-safe against a control voltage loss, the defect was only discovered in the course of a weekly inspection. The lack of regular tests on the danger warning and alarm systems lead to a categorizing of the incident, which remains without radiological consequences, into the class B of the coresponding HSK-R-25.

The incidents in this reporting period, as well as those earlier, should give a start to the introduction of more effective quality assurance measures so that similar events will be prevented in future.

5.1.11 Personnel and organization

The number of licensed personnel is strongly reduced due to the planned decommissioning of the SAPHIR. The numbers were, at the end of 1994: four reactor chiefs, four shift leaders and one operator. An operator was licensed in the report year. The number of licensed personnel in PROTEUS has not changed at two reactor physicists, two reactor technicians and one operator.

Organizational changes took place in the division "Nuclear Energy, Safety" since the long-planned new structure was implemented. The number of personnel was reduced in the laboratory "Reactor physics and System Engineering" with the SAPHIR and PROTEUS installations. The reorganization of the "Materials and Nuclear Processes" with the Hotlab lead to the "Laboratory for Behaviour of Materials". A planned organizational unit, which will only be concerned with radioactive waste disposal and its practicalities, could not yet be realized.

5.1.12 PSI schools

The Paul Scherrer Institut has two schools on its east area: the reactor school (a technician school recognized by the Swiss Confederation) and the school for radiation protection.

Reactor school

In April 1994, 11 candidates - (three from the nuclear power plant (NPP) Beznau, one from NPP Mühleberg, one from NPP Gösgen, five from NPP Leibstadt and one from PSI) successfully completed the examination on the basic course for a NPP technician TS. They will be trained further by the plants before they apply for the license to be reactor operators.

The fifth course, for NPP technicians, was started in January 1994 in the reactor school. This course will last until April 1995 and is being done by five students from Swiss NPP (three from NPP Beznau and two from NPP Gösgen). Four picket engineer aspirants, from the NPP Leibstadt, started an engineer course in

June 1994; this is running parallel to the course for NPP technicians in the reactor school and will also be completed in April 1995.

The year 1994 was characterized through many retrospective acceptances. In the framework of this process, it was made possible for the participants of earlier reactor school courses to obtain the title of nuclear power plant technician TS. Sixteen reactor operators (three KKB, seven KKG, four KKL and two KKM) made use of this possibility.

School for radiation protection

This teaching centre for the special area of radiation protection, which is used mostly by German speaking Swiss, offers, since many years, officially recognized courses of all levels. In the reporting year there were tought about 3'500 course participants in the special area of radiation protection. In addition to course participants from medical professions, workers from emergency organizations and the radiation protection personnel from industry and trade, there were about 300 persons from the nuclear installations. The last group contained mechanics, works security police, visitor hosts, staff, shift personnel as well as aspirant radiation protection controlers. Additionally, about 100 people from the nuclear installations (nuclear power plants and PSI) visited supplementary courses about general radiation protection themes.

5.1.13 Emergency exercises

The emergency organization (NFO) probe alarm from the 2 February 1994 was announced earlier and immediately carried out after a Swiss national siren test. It had the aim to test the alarm devices in PSI, the audibility of the sirens and the behaviour of the personnel by previously announced alarm step 1. The deficiencies found in the 1993 emergency exercise have been removed.

The emergency exercise "BRIDGE" from the 15 December 1994 had the aim to exercise the collaboration and way of working of all NFO teams during an accident with a release of radioactivity on the bridge across the river Aare. The PSI emergency organization and the personnel of both PSI areas were included in the exercise. The aim was achieved. Compared to earlier emergency exercises, there were confirmed from the side of HSK, considerable improvements. However, there were grounds for complaint concerning the behaviour of a part of the personnel from the PSI West area.

5.1.14 Overall judgement by HSK

The condition of the PSI installations, in the reporting period, was satisfactory. By judging the institute, there were two registrable incidents of the class B and one of the class A. Based on HSK-internal analyses, these occurrences are not related to ageing symptoms but rather, to a significant degree, to human factors. The redimensioning of the nuclear research and the decommissioning of large nuclear installations (SAPHIR) will lead to a lessening of potential dangers but a reduction in the surveillance potential must not follow too quickly. The responsible instances must further make continued efforts to improve the safety culture and maintain it at the level necessary. This is valid, without exception, for all installations with the danger of radiation, radioactive wastes and the emergency preparedness.

5.2 Swiss Federal Institute of Technology Lausanne (EPFL)

From the three divisions of the nuclear installations of the "Institut de Génie Atomique", the "CAROUSEL" serves only as a practice neutron source (moderation and shielding measurements) for third year students. The subcritical 14 MeV neutron source LOTUS plant (run by an accelerator) was used for only 4.92 hours in 1994. The CROCUS zero power reactor was operated for practical lessons (3rd study year EPFL and 4th year of the engineers school in Geneva for 642.1 hours in 1994. The thermal energy was 218 Wh. The detailed yearly control of all rods showed again that no more swelling had occurred since rods with new cladding were used.

The operation of the plant was trouble-free and no reportable incidents, according to HSK guideline R-25, occurred. The accumulated year's dose for 11 employees of the Institute who work on the installation was 0.5 man-mSv. The releases in 1994 over the air and waste water ways, inclusive of tritium, were insignificant.

5.3 University of Basel

The small swimming pool reactor (type AGN-211-P), situated in the basement of the physics institute of the university of Basel, was used mainly for teaching purposes in 1994. After the SAPHIR decommissioning decision of the PSI, there are at the time, only two small installations available for training. The reactor schools of the PSI and the higher technical college of Brugg-Windisch therefore transferred their reactor practicals to Basel. The zero power reactor was therefore somewhat more in use than in the previous year, namely 90.3 hours (1 kW normalized hours). The permitted weekly limit was used up to a maximum of 26% only.

The collective dosis of the five persons classed as reactor personnel was determined at 0.4 man-mSv in 1994 and is insignificant. The operation of the Basel nuclear installation was free from abnormal occurrences and it was without reportable events, according to HSK-R-25 guideline.

5.4 Experimental reactor at Lucens (VAKL)

The Swiss Federal Council has authorized a project, for the decommissioning of the experimental nuclear power plant at Lucens (VAKL), on the 10 September 1990. Following this, the national society for promoting industrial nuclear technology (NGA), which is the sole owner at the moment, of the location, has given the task of carrying out the decommissioning project to an engineer bureau and a business consortium. The authorized work, (filling of 2 of the 3 caves, draining system of the caves to remove water, building the water drain pipe to the river Broye), which started in June 1991, was finished in January 1993. The work to be completed embodied in particular, the injection of mortar for filling up the shrinkage and temperature difference cracks and the last cavities. A programme for observing the decommissioned installation was worked on by the people designated by the NGA; it was controled by the HSK. It lasted from February 1993 to February 1994. The observations were made particularly on the quantities and the chemical and radiological characteristics of the drainage water. The observations should give the NGA and the HSK the necessary documents in order to see whether the conditions and official demands in the Swiss Federal Council decisions from the 10 September 1990 are satisfied. Some observations, which were made towards the end of the observation period with highly sensitive measuring instruments, required additional investigations which took place in spring and autumn 1994. This was to clear up further aspects and to support the conclusions more solidly. Based on the measurement results obtained within the framework of the observation period, it was concluded that all conditions and official demands for a release of the installation from the point of view of the HSK, were met. Based on the one hand on the measurements and observations and on the other hand on the conclusions from the reports of the NGA about the observation periods and their extensions, the HSK came to the decision that the main part of the VAKL location is not more a nuclear installation, in the sense of the 1959 atomic law. The final version of the HSK position on this was nearly finished at the end of 1994 and should be transmitted to the Federal Council at the start of 1995 in order that the Council can confirm acceptance of the release status.

As a result of the filling-up of the caves with cement in 1991, the earlier controled zones of the underground buildings are closed and do no more exist today. Externally to these constructions, there is only the storage place, which has the containers which contain components of the experimental reactor, which is a controled zone. This will be kept as such until the containers can be brought to a suitable temporary or final storage. Therefore, this specific place remains a nuclear installation in the sense of the atomic law and requires control of the Federation until its formal release after the above-mentioned containers are removed.

No radiological or safety technical incidents were noted. There is now one person in the surveillance group who is exposed to radiation in the course of work. The person received a total body dose of 0.82 mSv due primarily to the periodic control of the waste container. The water from the earlier VAKL works which has been let into the river Broye has contained no man-made nuclides in 1994, using standard measurements.

Although the location of the VAKL is under the jurisdiction of the atomic law and at the time, is the formal property of the NGA, the future owner, the canton of Vaud/Waadt, could already have it at its disposal since May 1992; it stores cultural artifacts there. The container storage place is, at the moment excepted from this, and there may be no actions taken for the definitive decommissioning. The canton of Vaud/Waadt is awaiting the release of the installation from the atomic law in order to build a protective room into the usable caves for cultural artifacts.

6. Radwaste Disposal

6.1. Wastes from reprocessing

The assessment by COGEMA, for the reprocessing of wastes in relation with the preliminary application of the nuclear power plant owners to re-import these wastes, could be completed in May. The specification of all wastes, so arising, have therefore been judged. It now goes to follow and control the compliance of the effective import conditions.

Until now, there has been no fuel elements reprocessed from British Nuclear Fuels Limited (BNFL), arising from the Swiss nuclear power plants. Correspondingly, there is not expected any returns to Switzerland of wastes from BNFL before 1999. At COGEMA there has been processed over 200 t of fuel from KKB and KKG. The KKB and KKG have received notice from COGEMA that, according to contract, they are obliged to take back vitrified high active wastes (HAA) within three years. An effective delivery of returned HAA can, however, only take place when the necessary interim storage is ready for use in Switzerland.

6.2 Interim storage

The conditioning and interim storage of the radwastes from the nuclear installations and PSI are reported in the corresponding sections. A summary of the amount of wastes is given in Table 11.

The HSK expertise on the application of the ZWILAG for a permission to build and operate a central interim storage (ZZL) for radioactive wastes in Würenlingen could not be completed in the reporting period. The ZWILAG company has made a revised version of the safety report. The finalization of the expertise is foreseen in the first half year of 1995.

A co-ordination commission will make possible the mutual orientation of the involved instances from the Federation, canton and community, about the result of the permission granting process.

6.3 Low and medium active waste (SMA) final repository Wellenberg

Following the choice of Wellenberg as the locality for the SMA final repository, the co-operative for nuclear disposal Wellenberg (GNW) was founded by the nuclear power plant owners. At the end of June, the GNW handed in an application for a general permission for the SMA. The HSK, together with external experts, has, in the summer, taken up the expertise of the project. The expertise should be delivered in the first half year of 1995.

The voting population of Wolfenschiessen, the SMA locality, were orientated about the project at the end of May with the participation of the HSK. The government council of the canton of Nidwalden has set up a working group which has the job to advise it about the project.

Parallel to the general processing of the permission for the final repository at Wellenberg, the NAGRA has, in August, started with already authorized tests. This second exploration phase should bring additional basic information and, in particular, the planning and optimum line directions of the test tunnels. The main object of this enquiry is an additional deep bore hole (SB4a) that will have a vertical and a 45° angled branch. The depth of the first vertical branch was, at the end of 1994, 295 m. Further, in Secklisbachtal, there were started a few short drillings in order to find out the limit of the host rock. Complementary piezometer bore holes were sunk in the valley plain of the Engelberg river Aa.

There were four meetings of the supervisory commission of Wellenberg in the reporting year. The supervisory commission gave, in their fourth short report, a retrospective view on the first phase of the examinations. After giving up their corresponding final reports, the supervisory commissions of the three other trial localities, (Bois de la Glaive, Oberbauenstock and Piz Pian Grand), were dissolved.

6.4 Preparatory activities for a HAA/LMA final storage

With a view to the final disposal of high active (HAA) and long-lived medium active (LMA) wastes, all instances concerned (BEW, HSK, KNE, KSA and NAGRA), judged in February, the case of the sediment option. On this occasion, the suggestion from the NAGRA about concentrating on checking out the potential of the host rock, opalinus clay, in the wine growing area of Zürich, was supported. In November, the NAGRA applied for carrying out corresponding test borings in Benken.

Parallel to the sediment examinations, the NAGRA proceeded further with the "Kristallin" programme. A synthesis of the knowledge arising from out of the "Kristallin" examinations, which had been done between 1981 and 1983, was made. Based on this, an updated safety analysis was carried out. With a view to the still unavailable locality evidence, the NAGRA has sent in requests to do further "Kristallin" investigations in Leuggern or Böttstein.

The long-time observations in the deep bore holes in the north of Switzerland continue. The yearly meeting between the corresponding supervisory commissions took place in June. Summarizing reports of the supervisory commision, concerning the bore holes in both Riniken and Leuggem, could be approved in the first half of the year.

A further three year trial period could be started in the laboratory in the rocks of the Grimsel Pass. At this facility, diverse trials for developing and testing methods for locality investigations and locality assessment, have taken place since ten years. Questions concerning bore hole closure, two-phase hydrodynamics and nuclide transport are examined here with international participation.

7. Emergency planning for the vicinity of the nuclear power plants

None of the emergency organizations, apart from emergency exercises, were needed in 1994.

7.1 Alarm systems

The alarm systems in the zones 1 and 2 of the Swiss nuclear power stations are operational. The functionality of the sirens was tested in the annual nationwide sirentest and alarm propagation plans.

The mobilization system, using telephone (SMT) in the zones 1 of the nuclear power plants, is tested once annually at the local community level and the necessary changes implemented.

7.2 Emergency preparedness of the cantons

The level of emergency preparedness of the cantons was further improved. In the canton Baselland the broschure for the population has been published. While on one side the civil defense laws see, on the 1 January 1995, a new significance of the siren signals "GENERAL ALARM" and "RADIATION ALARM NPP" and on the other side the emergency concept of the Federation is being revised, the cantonal concept must be brought into line with this after completion. Discussions with the cantons concerned relative to this, took place at the end of the reporting period. They will continue in the spring of 1995.

Examinations concerning the protection of patients and the hospitals in the canton Aargau (near to NPP) could be finished.

7.3 Training in emergency protection

In 1994, there were the following courses and lectures held:

- Each a one day training course for the community staff leaders of the cantons Baselland, Solothurn and Zug
- Different lectures and collaboration with training at institutions of the Federation and cantons (BZS, GFS, communities of Wohlen and Zollikofen).

8. Transport of Radioactive Wastes

8.1 Training and information

Course for radiation protection supervisors responsible for dispatch and transport of radioactive materials.

The course took place, for the fourth time, in October 1994. It was aimed at persons responsible for the dispatch of radioactive materials in their organizations. The course, which lasts five days, is being offered at least once per year in the German and French languages.

Information exchange between federal offices of the administration

The sixth information exchange between those federal offices which have something to do with the transport of radioactive materials took place on the 9 November 1994 in Luzern.

8.2 Transport certificates and inspections

The Swiss regulations for the transport of radioactive materials rely, in part, on the international legislation governing the transport of hazardous goods. Except for inland navigation, which is foreseen for 1995, all modes of transport lie under the binding IAEA recommendations of 1985 for the safe transport of radioactive materials.

The main responsibility for keeping to the transport regulations and radiological safety lies with the expeditor. In certain cases, namely with transports of nuclear fuel or other radioactive materials with higher activity, the regulations require that the expeditor obtains, in advance, a permit or certificate from the authorities in charge. Depending on the case in hand, the permits or certificates cover the objects to be transported or details on the transport itself.

The Swiss authority in charge of issuing the certificates, as mentioned above, is HSK, independently whether it concerns the transport of radioactive materials from nuclear power plants or from other installations or establishments. Concerning permits for radioactive items, HSK bases its decision mainly on documents issued by the corresponding authorities of the country of origin. In all cases, HSK controls them in advance for compliance with the regulations.

In 1994, the HSK had to assess 48 applications concerned with shipment of packages or expedited goods. In 35 cases the accompanying documentation was complete. In 13 cases the HSK issued certificates as follows:

- 2 package approvals type AF
- 4 package approvals type B (U)
- 3 package approvals type B(U)F

- 2 shipment approvals for spent fuel elements
- 2 special arrangements concerning the transport of a large cobalt-60 source.

8.3 Quality assurance (QS) of the transport of radioactive materials

Concerning the transport of radioactive materials, the corresponding regulations must be respected for the safety of the transport workers and population.

Quality assurance programs are intended to ensure compliance with the regulations. Quality assurance embodies plans and measures for compliance of designers and manufacturers of packages, the sender and carrier and the relevant authority in charge.

The legally required quality assurance programmes of the Swiss nuclear installations have been put into force during 1994. For one nuclear power plant, the KKB, the QS transport programme has been henceforth recognized, based on an audit which has been carried out. For the other four nuclear installations (KKM, KKG, KKL and PSI) there have been fixed audit dates arranged for the first quarter of 1995.

9. General matters concerning safety and radiation protection

9.1 Official guidelines

The valid Swiss guidelines for the end of the reporting period are listed in Table 12 of this report. They were drawn up by HSK, partly in collaboration with the KSA and other federal offices. The following guideline was put into force in 1994:

HSK-R-031/d Supervisory process by the construction of nuclear power plants, E1 classified electrical equipments

Guidelines explain how the safety authorities want to consolidate their lawful duties in various areas. They should provide clear legal assurance in that they show after which criteria the authorities intend to judge applications and carry out their supervision.

Design guidelines such as HSK-R-101 for example, apply, as a matter of principle, to new light water nuclear power reactors yet to be built. In the assessment of existing installations, these guidelines are also being consulted to identify deviations. Following these guidelines eases demonstration of plant safety, whereas deviations have to be judged on a case-by-case basis.

9.2 Measures against severe accidents

The safety measures in the Swiss nuclear power plants are based on the use of the concept of "defense in depth", whereafter several layers of safety are foreseen for the avoidance of incidents and control of the consequences of the abnormal occurrences.

On the first safety level, measures against the start of abnormal occurrences are taken. To these belong, among other things, the special design and layout of systems and components, the care with servicing with comprehensive non-destructive testing and how the running of the plant is done to avoid abnormal occurrences. This includes the comprehensive quality assurance measures as well.

On the second safety level, measures are met which restrict the development and spread of technical abnormal occurrences, which can never be excluded, into actual incidents. To these measures belong, among other things, limiting devices e.g. for reducing the power of the reactor, the use of fail-safe principles by the design of important components (by the occurrence of a deficiency in a component, a safe system condition remains), as well as the presence of redundant systems and active components through which, by failure of a system or component, the safety function is satisfied further.

On the third safety level, measures are met which can control and limit the consequences for personnel and environment to within allowable limiting values in the case of a failure of the first two mentioned safety levels. To this aim serve special safety systems such as the reactor protection system, the emergency core cooling and decay heat removal systems and the ultimate systems and the containment systems which are designed to control automatically even very unlikely design basis accidents. This means the assurance of the shutdown, cooling of the fuel and the containment of radioactive materials.

In addition to this protection concept, the HSK has, at the end of 1986, made a catalogue of technical measures to be taken for reducing the consequences of postulated beyond design basis accidents. Important parts of this catalogue are the installation of a system for filtered containment pressure relief and the creation of reasonable radiological conditions for the service personnel in the control room and in the emergency control room of the nuclear power plant so that plant internal emergency measures may be carried out in the case of a severe accident.

The system for the filtered pressure relief of the containment (so-called Filtered Containment Venting System) creates a protection for the containment in the case of a core meltdown accident with continual containment pressure build-up. Through the filtered pressure release, the containment pressure is lowered before a containment failure occurs. In addition, the release of aerosol radioactivity to the environment is significantly reduced so that enough time is available for the protection of the population in the vicinity, using the emergency planning facilities. All Swiss nuclear power plants now possess a system of filtered containment venting.

For the creation of reasonable radiological conditions for the service personnel in the case of a severe accident, a special air conditioning system with overpressure, is foreseen in the working places of the personnel (control room and emergency control room) which possesses a qualified filter. Only the NPP Leibstadt still has to backfit with this system; the other NPP already have it.

In the HSK 1986 catalogue of measures to be taken, there were also demands for more profound examinations into the progression of severe accidents. Important parts of these examinations are the working out of plant-specific risk studies (probabilistic safety analysis-PSA), which encompasses level 1 (determination of the core meltdown probability), level 2 (determination of source terms and release frequency) and the shutdown phase. The risk studies for KKM, KKB and KKG are available, the one for KKL is in progress. With this, all the Swiss NPP will have at their disposal a plant-specific risk study.

9.3 Monitoring network in the nuclear power plant's vicinity and plant parameter transmission (MADUK-ANPA)

A press conference took place at the HSK to inform the public about the existence and aim of the MADUK-ANPA-system (Emergency Response Data System) after it was officially taken into service; this happened in March of the reporting period.

Before this, a test on the complete system was carried out. On the one side also the ANPA data transfer from out of the NPP's could be switched in, and on the other side, the user of the system could intensively access the data. This test showed, on the one hand, the operational availability of MADUK-ANPA but, on the other hand, some problems were identified and these must be removed within the two year non-stop running guarantee. The work concerned with the accessing of weather data from the computer of the Swiss Meteorological Institute in Zürich could not be completed in the reporting year. On the side of HSK, the preparations have, however, been met.

From the working experiences gained in the year, it can be concluded that the availability of data is very good. The communication problems between measurement devices and the central data management at the HSK could be neutralized by the local memory existing on the devices at the locality.

9.4 Collaboration with other countries

The German-Swiss commission for the safety of nuclear installations (DSK) has visited the NPP Beznau before its annual meeting. It has accepted the following report:

Report concerning the nuclear safety and radiation protection
of the nuclear power plant Beznau II (DSK 94/2, October1994).

The DSK is also occupied, among other things, with the central interim storage at Würenlingen, improvement of the special telephone line of the emergency organizations of both countries as well as the radioactivity in the environment each side of the border.

The "Commission Franco-Suisse de Sûreté des Installations Nucléaires" also exchanges information about the newest developments, experiences and incidents in their annual meeting. Particular themes were the Super Phénix, the use of mixed oxide (MOX) fuel, the general tendency towards high burn-ups, the uses of INES for the evaluation of incidents and the latest developments in the area of radioactive waste disposal. The NAGRA laboratory in the rocks at Grimsel was visited.

The regular exchange of experience with the nuclear regulatory commission (NRC) of the United States of America was continued with three meetings in Switzerland and one in the USA. Themes were questions of the NPP safety (among other things digital electronics, high burn-up fuel elements) as well as research projects in both lands. The chairman of the NRC visited the NPP Beznau.

Contact took place, within the framework of the collaboration with safety authorities of middle and east European states, with delegations from the Czech Republic, Slovakia, Ukraine and Russia. A probabilistic safety analysis for the NPP Novovoronesch 5 was started together with the Russians.

9.5 Safety research

The HSK, as the Swiss Federal Nuclear Inspectorate, has to judge the safety of the Swiss nuclear installations according to the actual state of science and technology. To this aim, the HSK supports, among other things, different projects on important areas of regulatory safety research.

The research activities were split into three different areas:

- Research projects at the Paul Scherrer Institute (PSI) and at the Swiss Federal Institutes of Technology
- Individual projects by national and foreign engineering companies
- Participation in various international projects

Simulation Model for transient analysis in Switzerland (STARS II); PSI - Villigen

The transference of the necessary data of all the Swiss NPP to read in data for simulation models was continued in phase II of this project.

Stress corrosion cracking of steels for reactor components in hot water; PSI - Villigen

More long-term trials could be successfully carried out using the new hot water loop with an autoclave fitted with an integral tensile machine. At the same time, the older loop was improved from the point of control and measurement techniques. The test series were carried out with a water chemistry which lay just outside the recommended values for dissolved oxygen and conductivity for boiling water reactors.

Stress corrosion cracking of reactor pressure vessel steels; ETH - Zürich

Measurement results and specimens from out of the hot water loops were examined and analysed in the past research year.

LWR Contamination control; PSI - Villigen

The following work was done in the last year:

- Modification of the pilot loop to investigate the influence of temperature gradie ts on the radioactive and inactive deposition on Zircaloy cladding material

- Investigation in "Couette" autoclaves of the deposition of activity under controled flow conditions. It appears that the build-up of the oxide layer and the activity do not occur at the same time. The build-up of activity (dissolved cobalt-58) is independent of the flow speed.

- Recontamination trials on specimens having different surface treatments. The present knowledge shows that the prior surface treatment has a large influence on the build-up of activity. A protective oxide layer lessens the recontamination.

Determination of the re-entrainment from out of the sump of the containment after a core melt-down accident during leaking or controlled depressurization of the containment; ETH Zürich

In the spring of the reporting period, the planned experimental installation, in pilot dimensions, could be constructed and taken into commission according to plan. After some trials, to optimise the measurement and analysis techniques, the first series of measurements, with dissolved impurities (sodium sulphate), could be carried out.

Hydrogen ignition; PSI - Villigen

In addition to the gas mixtures with hydrogen-steam-CO_2-air, the influence of carbon monoxide in the ignition behaviour was also examined. Such gas mixtures could appear in the containment after a severe core meltdown accident. The lower ignition limit dropped from 6.5 vol.% to 5 vol.% of oxygen with the addition of carbon monoxide.

The project will be completed, at the start of 1995, with a final report. The results of the experiments will be considered in eventual measures in the analyses of severe core meltdown accidents.

Aeroradiometric measurements in the vicinity of the Swiss nuclear installations; ETH - Zürich

A radiometric map of Switzerland, concerning the dose rate on the ground, will be made after the complete assessment and publication of the results.

With a view to the use of aeroradiometry in emergencies, the permission granting process to build the measurement system into a Super Puma helicopter of the Swiss army, was started. Training and tests were performed with the surveillance measuring system.

The programme system RADAU for the determination of the dose rate through atmospherical dispersion of damaging radioactive substances in complex regions; PSI - Villigen

The evaluated American simulation code ADPIC (Version 1992) was replaced by the advanced version with radioactive decay chains. The new Mathew/ADPIC Code-system could be implemented into the HSK and PSI working stations according to plan in the last year. The acceptance tests are in preparation.

Collaboration between the HSK and PSI concerning dosimetry; PSI - Villigen

The basic aim of this project was to perform development work, with suitable studies, as well as measurement campaigns for an improvement on the dosimetry; the aims have now been increased due to the new radiation protection ordinance.

Radioanalysis; PSI - Villigen

The new dosimetry process for including the actinides (strontium 90) and alpha-emitters has been refined. Measurements on earth and grass probes have been carried out and they have brought the evidence for its use as a surveillance method.

Behaviour of radionuclides from NPP in the rivers Aare and Rhein; EAWAG - Dübendorf

The main interest was in the measurement of cobalt-60, the distribution of radionuclides and balancing in the lake of Biel as well as the radionuclide behaviour below the NPP KKB. It has been shown that up to 50 % of the radiocobalt was complexed anionically in the Aarewater and therefore exhibits a weak adsorption behaviour on to particles. Based on the very slow adsorption kinetics, there could be no exceptional cobalt-60 enrichment in the water and sediments down stream the NPP.

The knowledge about the transport behaviour of radionuclides out of the waste water of the NPP is an important contribution for the surveillance and possible measures to be taken in the case of irregularities.

Radioecology; PSI - Villigen

The following three partial projects were worked on in the last research year:

- Installation of the calculation model CHECOSYS which is applied by NAZ. Test calculations for the release path grass-milk using Chernobyl measurements.
- Take-up of cesium-134 by the roots of fir tree seedings.
- Determination of the point in time where deposition can lead to the highest contamination of wheat seeds.

Calculation of the kinetic parameter of light water reactors using the example of NPP Beznau; ETH Lausanne

The newly developed mathematical method allows to find the reactor kinetic parameter with standard codes for stationary reactor conditions.

The project was completed successfully with a dissertation (EPFL 1230, [1994]) in which it was shown also that the mathematical procedure, for example in the reactor at Beznau, can be used.

Research work on the area of the fast breeder reactor; PSI - Villigen

The research work has the aim to increase the understanding for the various safety problems on the Super Phoenix installation. The work is done in connection with other European partners and is supported by the insights of the French expertise.

Reactor pressure vessel mode of failure by a core meltdown: CORVIS; PSI - Villigen

The CORVIS project examines the meltthrough of the pressure vessel of light water reactors during a severe core meltdown accident. For this, large technical experiments on reactor pressure vessel models are carried out using an iron-aluminium oxide melt as a substitute of a molten core. These experiments should, above all, serve to improve and validate the calculation models.

Evaluation of fuel-coolant interaction energetics; Energy Research - Rockville (USA)

The analytical examination on the effect of high energy fuel-coolant interactions on the containment during core meltdown accidents is in the forefront here. It could be confirmed that, in the case of a steam explosion, inside or outside the reactor pressure vessel, the failure probability of the containment of Beznau and Leibstadt was insignificantly small.

These analyses are a significant contribution to critical discussions about the safety of the Swiss nuclear installations during core meltdown accidents.

Earthquake resistance capacity or Shear walls in nuclear power stations; Basler and Hofmann - Zürich

Switzerland takes part in this OECD research project. The basic data is provided by the vibrating table experiments carried out on model walls in Japan.

The aim of the Swiss contribution is to evaluate and use the knowledge from the experiments and the related model calculations from the point of view of the Swiss design practice.

Control of the spectrometry and the neutronic dosimetry in complex fields of radiation; CERN - Geneva

Different measurement campaigns could be carried out in the last project year. Several new systems for high energy neutrons were tested and tried for their suitability for field measurements.

The surveillance of nuclear energy and research installations should be carried out with the best possible methods and procedures. This project is an important contributuion for expanded surveillance concepts.

OECD Halden reactor project; Halden (Norway)

Switzerland (HSK and NPP) is a member of the OECD Halden project since 1991. It has two main themes; Fuel and Materials (F+M) as well as man-machine interactions (MMI).

The F+M examines the behaviour of nuclear fuel rods by high burnup and structural materials, near to the active core, under irradiation. The aim is to explain the damage mechanism and to increase the life. These themes are of actual interest for the Swiss NPP:

MMI has three partial areas:

a) Test methods for the safety relevant computer programs (software);

b) Control room design to increase the safety and availability;

c) Calculation systems to support operators.

The MMI results are fundamentally important for the backfitting of the electronics in existing nuclear installations.

Halden serves also for further training of nuclear technologists. Three high school graduates from Switzerland worked in Halden in 1994. From earlier delegated people, one is working at the HSK and one is working in a NPP today. A Swiss representative was leading the Halden programme group in 1994.

Participation on severe accident research of the NRC, Washington (USA)

Switzerland is involved financially and also gives its own contributions to the work of the "Co-operative Severe Accident Research Programme" (CSARP) of the American safety authority, the NRC. A part of this research programme is the development of the computer code MELCOR which is used in the risk studies of the Swiss NPP.

9.6 Incidents in foreign nuclear installations having impact on the Swiss installations

From the incidents reported in 1994 by the foreign nuclear installations, there was practically none of significance for the Swiss installations which would have necessitated immediate measures. Nevertheless, some incidents are mentioned, in what follows, that could have, in the long term, an influence on the Swiss installations.

In the previous years, of all the incidents mentioned (see last year's report), that concerned with the blockage of the sump suction strainer, can be regarded as being dealt with after the applied modifications (Phase II).

The other two incidents (cracks in the reactor pressure vessel penetrations and cracks in the austenitic piping) are also mentioned this time since they have lead to an expanded periodic testing programme.

9.6.1 Incidents in previous years

a) Cracks in penetrations of the reactor pressure vessel

Based on the cracks discovered in 1991 in the French PWR installation Bugey 3, there was testing carried out in the almost identically built blocks of KKB I and KKB II as well as the penetrations in the bottom of the boiling water reactor pressure vessel lower plenums of the KKL and KKM. Only in unit KKB I were two very small cracks indicated. The tests during the shut down in 1994 embodied a reduced programme because KKB had already tested the penetrations and other plants had performed partial tests (without finding anything). A new test method was qualified. More comprehensive tests are forseen for the years 1995/96.

b) Cracks in austenitic pipeing

Cracks in the weld seams of the austenitic pipeing of the German boiling water reactor "Brunsbüttel" have been found in 1992. A manufacturing error was, with high probability, assumed to be the primary cause. There are, however, examinations in progress over the possibility of the cause being dependent on the titanium stabilized material and from conditions in the coolant loop of boiling water reactors. Corresponding crack examinations were carried out during the 1994 outage of KKG and KKL. No indications of cracking were found. The testing will be continued in the next years.

9.6.2 Cracks in the core shroud of boiling water reactors

The core shroud is situated inside the reactor pressure vessel and serves as a flow director of the water as well as a supporting structure for the reactor core. The core shroud is practically under no stress during normal working conditions; the maximum loading stresses would develop during earthquakes and a loss of coolant incident. Such cracks have been discovered in KKM since 1990, and they have been also mentioned in the annual report of that year. Further details about this year's examinations are given in chapter 2.2.2. Cracks, that have mostly the same cause, in other plants of a similar reactor type (about 10 in the USA, Japan and Germany) have been announced. Repairs to the core shroud have been carried out in the USA and Japan.

9.6.3 Defects in the hold down beams for the jet pumps in boiling water reactors

Through-cracks on the hold down beams for the jet pumps have been discovered during an inspection of the American plant Grand Gulf as well as the Japanese plant Fukushima-Daini 3. Although the defect can cause no grave effects, the KKL has decided to premptively replace the components concerned.

9.7 Evaluation of incidents in the Swiss nuclear installations

The owners of the Swiss nuclear power plants are obliged to report to the HSK incidents which occur, according to the following classification (see Table 3):

Class B

Incidents of slight safety relevance. They are registered and evaluated to allow for an early detection of potential weaknesses.

Class A

Safety relevant incidents, bearing no or only small radiological impact on the environment.

Class S

Incidents which represent a threat to the plant, personnel or environment.

Instructions for and examples of incidents subject to registration are given in guidelines HSK-R-15 and HSK-R-25. The reporting thresholds have been set low in order to allow the supervisory authority to be informed in detail of occurrences in the installations. The HSK can set its classification limits either higher or lower than the ones proposed by the owner.

Not only in Switzerland, but also in other countries, the reports about incidents in nuclear installations are taken up by the public with increasing interest. An evaluation of these incidents is, for outsiders, difficult. Facing up to this problem, the International Atomic Energy Agency (IAEA) has introduced the International Nuclear Event Scale (INES), a severity scale for nuclear power plant incidents. This is intended to express the safety relevance of events in a number, similar to the way in which earthquake magnitude or severity is treated. This scale does not replace the obligation to notify the authorities, but rather complements it. Switzerland has adopted IAEA's INES scale (see Table 13). A comparison with this scale shows that the lowest notification class B generally, in general, corresponds to the INES scale 0; i.e. to events of no safety relevance. It is regarded as not appropriate, to make a comparison of the safety between different countries based on the INES or number of classified incidents.

APPENDIX

Table 1a: Basic characteristics of the Swiss nuclear power plants

	KKB I+II Beznau	**KKM Mühleberg**	**KKG Gösgen**	**KKL Leibstadt**
Thermal capacity	2x1130 MW	1097 MW	3002 MW	3138 MW
Electrical capacity	2x 364 MW	372 MW	990 MW	1045 MW
Net electrical capacity	2x 350 MW	355 MW	940 MW	990 MW
Reactor type	PWR	BWR	PWR	BWR
Reactor supplier	Westinghouse	GE	KWU	GE
Turbine supplier	BBC	BBC	KWU	BBC
Generator rating	4x228 MVA	2x190 MVA	1140 MVA	1180 MVA
Cooling	river water	river water	cooling tower	cooling tower
Start of commercial operation	1969/1971	1972	1979	1984

Table 1b: 1994 performance of the Swiss nuclear power plants

	KKB I/II	**KKM**	**KKG**	**KKL**
Thermal energy produced (GWh)	8'459/9'655	8'137,3	24'283,4	21'964,2
Net electrical energy supplied (GWh)	2'685/3'063	2'643,1	7'600,5	6'988,2
Thermal energy supplied (GWh)	114,7/5,7	2,3	159,5	0
Availability factor (%)	86,8/99,6	90,5	92,5	82,5
Non-availability due to annual revision (%)	13,5/0	9,0	7,5	14,0
Load factor (%)	87,8/100,1	84,77	93,5	80,7
Number of unplanned scrams	2/1	1	0	1
Other unplanned shutdowns	0/0	0	0	2
Load reductions due to faults or failures (>10%P_N)	3/3	10	1	0

Tabelle 2: Numbers for the licensed personnel of the Swiss nuclear power plants as of end 1994.
In parentheses: 1993 values.

Job title	KKB I+II	KKM	KKG	KKL
B operator	23 (22)	14 (10)	9 (6)	12 (9)
A operator	17 (16)	7 (7)	18 (16)	8 (8)
Shift supervisor and deputy	22 (21)	10 (11)	17 (17)	17 (17)
Emergency & operating engineers	9 (8)	8 (7)	12 (11)	10 (10)
Radiation protection supervisor	6 (6)	8 (8)	5 (5)	10 (10)
Radiation protection chief supervisor	6 (6)	3 (3)	4 (4)	5 (5)

Tabelle 3: Reports of plant operators on particular incidents in 1994 according to HSK guidelines R-15[1] and R-25
In parentheses: 1993 values.

	Number of reports on						
	technical incidents			radiological incidents			
Plant	class S[2]	class A[3]	class B[4]	class S[2]	class A[3]	class B[4]	INES[5] level
KKB I	0 (0)	0 (0)	2 (1)	0 (0)	0 (0)	0 (0)	-
KKB II	0 (0)	0 (0)	3 (3)	0 (0)	0 (0)	0 (0)	-
KKM	0 (0)	0 (0)	2 (4)	0 (0)	0 (0)	0 (0)	-
KKG	0 (0)	0 (0)	1 (2)	0 (0)	0 (0)	0 (0)	-
KKL	0 (0)	0 (0)	5 (3)	0 (0)	0 (0)	0 (0)	-
PSI	0 (0)	0 (0)	2 (5)	0 (0)	1 (0)	0 (3)	-
EPFL	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	-
UNI BS	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	-
Lucens	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	-

1) Not included are faults with plant components discovered and cleared during the regular outages (cf. text).
2) Incidents representing a threat to the plant, ist personnel or environment.
3) Safety-relevant incidents with no or only minor off-site radiological impact.
4) Incidents of slight safety relevance. They are being registered and analyzed to allow for an early detection of possible weakness.
5) Event classification according to INES scale (levels 1 to 7).

Table 4: Radioactive material released to the environment in 1994 with resulting individual doses. (See footnotes at the end of the tables).

Plant	Medium	Type of discharges	Emission limits (EL) (according to reg.)[1] Bq/year	Actual emissions[2]; (±50%) Bq/year	Calculated effective equivalent doses[3] Adult Sv/year	Child Sv/year
KKB 1+ KKB 2	Waste water (31000 m^3)	Nuclide mixture (without tritium)[4]	3,7E+11	3,0E+09	<1E-07	<1E-07
		Tritium	7,4E+13	1,1E+13		
	Exhaust air	Noble gases[4]	1,1E+15	2,8E+13	2,6E-07	2,6E-07
		Aerosols[5] (without I-131, half life >8 days)	5,6E+09	<0,1% EL	<1E-07	<1E-07
		Iodine-131[4]	3,7E+09 (I-131 only)	2,7E+07	<1E-07	<1E-07
		Carbon-14[6]	–	4,0E+10	1,1E-06	5,3E-06
KKM	Waste water (6545 m^3)	Nuclide mixture (without tritium)[4]	3,7E+11	1,9E+09	2,0E-07	<1E-07
		Tritium	1,9E+13	2,0E+11		
	Exhaust air	Noble gases[4]	2,0E+15	2,7E+12	<1E-07	<1E-07
		Aerosols[5] (without I-131, half life >8 days)	1,9E+10	<0,1% EL	9,7E-06	8,4E-06
		Iodine-131	1,9E+10	<0,1% EL	<1E-07	<1E-07
		Carbon-14[6]	–	2,0E+11	6,8E-07	3,2E-06
KKG	Waste water (8431 m^3)	Nuclide mixture (without tritium)[4]	1,9E+11	<0,1% EL	<1E-07	<1E-07
		Tritium	7,4E+13	1,1E+13		
	Exhaust air	Noble gases[4]	1,1E+15	<9,5E+12 (<3,8E+12)	<1E-07	<1E-07
		Aerosols[5] (without I-131, half life >8 days)	9,3E+09	<0,1% EL	<1E-07	<1E-07
		Iodine-131	7,4E+09	<0,1% EL	<1E-07	<1E-07
		Carbon-14[6]	–	1,0E+11	6,8E-07	3,2E-06
KKL	Waste water (20093 m^3)	Nuclide mixture (without tritium)[4]	3,7E+11	5,3E+08	<1E-07	<1E-07
		Tritium	1,9E+13	5,7E+11		
	Exhaust air	Noble gases[4]	2,2E+15	7,4E+13	<1E-07	<1E-07
		Aerosols[5] (without I-131, half life >8 days)	1,9E+10	<0,1% EL	<1E-07	<1E-07
		Iodine-131	1,9E+10	2,4E+09	1,5E-07	9,7E-07
		Carbon-14[6]	–	2,4E+11	1,3E-06	6,0E-06

Table 4 (cont.): For the release of tritium from the incineration plant of the PSI-East, see text.

Installation	Medium	Type of discharges	Emission limits (EL)[1] Bq/year			Actual emissions[2], (±50%) Bq/year			Calculated effective [cut off] Adult Sv/year		
PSI-EAST	Waste water (11228m³)	Nuclide mixture (without tritium)[4]	2,0E+11			<0,1% EL			<1E-07		
		Tritium	2,0E+13			2,4E+10					
			Main stack	**Incinerator**	**Rest East**	**Main stack**	**Incinerator**	**Rest East**	**Main stack**	**Incinerator**	**Rest Ea**
	Exhaust air	Noble gases/gases (Ar-41-equ.)[4]	--	4,0E+12	5,0E+11	1,3E+09	--	--	<1E-07	--	–
		β/γ-Aerosols[5] (without Iodine, half live >8 days)	1,0E+10	1,0E+09	1,0E+08	<0,1% EL	1.5E+08	--			
		β/γ-Aerosols[5] (8 hrs.<half life<8 days)	--	--	--	8.6E+07	--	--	<1E-07	1,8E-06	--
		α-Aerosols	3,0E+08	5,0E+07	2,0E+06	--	7.9E+05	--			
		Iodine (I-131-equ.)[4]	3,0E+10	2,0E+09	2,0E+08	1,3E+09	3,5E+07	--	<1E-07	<1E-07	--
		Tritium (tritiated water)	--	4,0E+12	2,0E+12	1,8E+11	5,1E+12	1,8E+11	<1E-07	4,9E-06[7]	<1E-07
PSI-WEST	Waste water (92 m³)	Nuclide mixture (without tritium)[4]	--			3,1E+05			<1E-07		
		Tritium	--			3,6E+09					
			Main stack	**Double stack**	**Rest West**	**Main stack**	**Double stack**	**Rest West**	**Main stack**	**Double stack**	**Rest W**
	Exhaust air	Noble gases/gases (Ar-41-equ.)[4]	2,0E+14	5,0E+12	2,0E+12	4,0E+13	2,2E+10	4,1E+10	1,8E-06	<1E-07	<1E-07
		β/γ-Aerosols[5] (w/o Iodine&Be-7, $T_{1/2}$ >8 days)	2,0E+08	5,0E+07	2,0E+08	5,6E+05	<0,1% AL	<0,1% AL			
		β/γ-Aerosols[5] (8 hrs.<half life<8 days)	1,0E+11	--	--	2,4E+09	4,2E+04	2,4E+07	<1E-07	<1E-07	<1E-0
		α-Aerosols	--	--	--	--	--	--			
		Iodine (I-131-equ.)[4]	5,0E+09	--	1,0E+08	3,1E+08	--	--	<1E-07	--	–
		Tritium (tritiated water)	6,0E+13	--	2,0E+12	1,4E+11	--	5,5E+10	<1E-07	--	1,0E-0

Footnotes to Table 4

1) **Release limits** according to the operating licence effective for the respective nuclear installation. The release limits have been laid down to keep off-site exposure of the critical population group in the vicinity below 0.2 mSv/year. For some classes of substances and release locations at PSI, no rigidly laid-down yearly release limit is given, since even if the short-time release limits are constantly fully utilized the dose remains insignificantly small.

2) The **measurement of the releases** is carried out according to the requests of the "Reglementation on the release of radioactive materials from the nuclear power plant ... and on the surveillance of the environment", the "Reglementation for the release of radioactive substances and the surveillance in the vicinity of the Paul-Scherrer Institute (PSI)" and according to directions from HSK. The accuracy of the measurements is about +/-50%. Releases below 0.1% of the yearly elease limits are regarded by HSK as not relevant and are reported as "<0.1% EL" (emission limit).
When no nuclide-specific measurements are available, a standard nuclide mixture is assumed for the calculation of the dose and for eventual equivalence conversions. For KKB, a mixture of 50% Co-60 and 50% Cs-137 is assumed for the aerosols. For KKG, a total β-measurement is performed for the noble gases (see values in the brackets). Therefore, for the calculations (release-equivalent as well as dose) a mixture of 80% Xe-133, 10% Xe-135 and 10% Kr-88 is assumed and applied.

3) **Calculated effective equivalent doses** for persons living at the critical point under the additional assumption that these persons only eat food which is grown at this point and drink water from the river directly below the plant or PSI (mean water-carriage of the river Aare at Mühleberg is $3.8 \cdot 10^{9}$ m^3/year, at Gösgen $9.0 \cdot 10^{9}$ m^3/year, at Würenlingen (PSI) and at Beznau $1.8 \cdot 10^{10}$ m^3/year and of the river Rhein at Leibstadt $3.3 \cdot 10^{10}$ m^3/year).
Doses smaller than 10^{-7} Sv which is equivalent to the dose accumulated through natural radioactivity in about one hour are not reported.
For the **external irradiation**, a shielding effect due to the population staying indoors for part of the time is taken into consideration when calculating the dose. A shielding facor of 0.2 was used for houses and 40 hours per week were asssumed for time spent outdoors.
For the calculation of the **aerosol** contribution , a homogenous release throughout the year was assumed. The dose contribution of the long-lived nuclides due to aerosol deposits on the soil and subsequent irradiation from the soil and incorporation via food, was also taken into account.
In the case of **Iodine**, the ingestion via vegetables and meat was taken into account additionally to the ingestion via milk. This results, in contrast to a purely milk ingestion, in an increas of the dose by a factor of 1.5 for children and a factor of 3 for adults.

4) *Declarations in* ***release equivalents:***
Waste water: releases in Bq/year normalized to a C_w-value of 10^{-4} Ci/m^3 = $3.7 \cdot 10^{6}$ Bq/m^3 according to the "Swiss ordonnance on radiation protection (SSVO, 1976, The new ordonnance (StSV) was not yet in force during 1994)".
Noble gases: C_a = 3.7E+05 Bq/m^3 equivalent for the nuclear power plants and Argon-41 equivalent for the PSI calculated by a weighted summation of the releases of all nuclides during the year.
Iodine (for PSI and KKB):Iodine-131 equivalent calculated by a weighted summation of the releases of all iodine nuclides reaching the weighting factor by the ratio between the ingestion-dose factor of the appropriate nuclide and the ingestion dose factor of iodine-131.

5) The contribution to the dose from aerosols with a half-life less than 8 days is negligible for the nuclear power plants. In the case of PSI-West, extremely short-lived aerosols possibly may play a role for inhalation and immersion as well as in a smaller extend for the irradioation from the soil. Thereby, under very conservative assumptions, a contribution of about 50% of the aerosol dose due to long-lived aerosols may be estimated.

In the case of KKM, the main contibution to the dose stems from soil-deposited aerosols which were unintentionally released in 1986. The dose contribution through aerosol releases in the reporting year is small compared to this and lies within the order of magnitude of other Swiss nuclear power plants.

6) The reported releases of C-14 are, with the exception of KKL, where the C-14 releases are measured, based on estimates of HSK founded on temporary measurements in the power plants in earlier years.

7) Calculated dose due to an incident in the incineration installation on 24/25 March 1994. The tritium releases during the rest of the year are negligible compared to this. It should be noticed that the locations of the maximum dose contribution in the environment for the short-term release during the incident and the long-term release of the entire year usually are not equal. Therefore, it is not possible to simply add this dose to the doses resulting from the other releases of the incineration installation.

Table 5a: Whole-body doses from external irradiation in 1994. Number of persons and average annual dose (E = plant internal, F = external personnel; TL dosimeters used in all plants)

Dose distribution (mSv)	KKB I+II			KKG			KKL			KKM			Total NPP		
	E	F	E+F	E	F	E+F	E	F	E+F	E	F	E+F	E	F*)	E+F*) **)
0.00 - 1.00	232	441	673	194	333	527	216	949	1165	140	634	774	782	2015	2767
1.01 - 2.00	50	44	94	23	45	68	26	142	168	31	86	117	130	279	409
2.01 - 5.00	59	53	112	36	67	103	64	160	224	69	115	184	228	371	599
5.01 - 10.00	24	10	34	31	58	89	25	76	101	24	42	66	104	196	300
10.01 - 15.00	3		3	10	7	17	6	33	39	10	12	22	29	49	78
15.01 - 20.00				2	1	3	2	9	11				4	12	16
20.01 - 25.00														1	1
25.01 - 30.00														3	3
30.01 - 35.00															
35.01 - 40.00															
40.01 - 45.00															
45.01 - 50.00															
over 50.00															
Total persons	368	548	916	296	511	807	339	1369	1708	274	889	1163	1277	2926	4173
Average per person (mSv)	1.44	0.71	1.00	2.03	1.68	1.80	1.68	1.47	1.51	2.17	1.14	1.38	1.80	1.46	1.57

Table 5b: Whole-body doses from external irradiation in 1994. Number of persons and average annual dose (E = plant internal, F = external personnel; TL dosimeters used in all plants)

Dose distribution (mSv)	PSI	EPFL (+)	LUCENS	Basel Univers.	Total Research	Total NPP E**)+F*)	Total NPP + Research ***)
0.00 - 1.00	1020	11	1	5	1037	2767	3747
1.01 - 2.00	46				46	409	454
2.01 - 5.00	47				47	599	646
5.01 - 10.00	14				14	300	314
10.01 - 15.00	1				1	78	79
15.01 - 20.00						16	16
20.01 - 25.00	1				1	1	2
25.01 - 30.00						3	3
30.01 - 35.00							
35.01 - 40.00							
40.01 - 45.00							
45.01 - 50.00							
over 50.00							
Total persons	1129	11	1	5	1146	4173	5261
Average per person (mSv)	0.42	0.05	0.82	0.08	0.41	1.57	1.33

(+) no detectable dose for other personnel

*) external personnel with a radiation dose from several nuclear power plants appears only once in these columns, with the sum of the doses from all the plants (391 persons).

**) internal personnel with a radiation dose from several nuclear power plants appears only once in these columns, with the sum of the doses from all the plants (30 persons)

***) PSI personnel with a radiation dose from several nuclear power plants, or NPP personnel with a radiation dose received at PSI, appear only once in these columns, with the sum of the doses from all the installations (58 persons)

Table 6a: Whole-body doses from external irradiation in 1994. Annual collective doses in pers.-mSv (E = plant internal personnel, F = external personnel)

Dose distribution (mSv)	KKB I + II			KKG			KKL			KKM			Total NPP		
	E	F	E+F	E	F	E+F	E	F	E+F	E	F	E+F	E	F*)	E+F*) **) +)
0.00 - 1.00	58.50	84.10	142.60	58.00	50.00	108.00	46.62	209.78	256.40	28.79	102.48	131.27	191.91	404.65	592.84
1.01 - 2.00	73.10	67.00	140.10	33.00	68.00	101.00	36.96	199.29	236.25	44.15	126.64	170.79	187.21	405.30	592.51
2.01 - 5.00	189.50	173.40	362.90	124.00	238.00	362.00	218.20	515.08	733.28	241.99	361.36	603.35	773.69	1220.16	1993.85
5.01 - 10.00	172.70	63.30	236.00	226.00	395.00	621.00	163.23	531.62	694.85	165.57	284.80	450.37	727.50	1348.87	2076.37
10.01 - 15.00	34.90		34.90	123.00	89.00	212.00	70.61	405.12	475.73	115.11	138.22	253.33	343.62	588.88	932.50
15.01 - 20.00				36.00	16.00	52.00	32.47	147.61	180.08				68.47	193.19	261.66
20.01 - 25.00														23.64	23.64
25.01 - 30.00														81.11	81.11
30.01 - 35.00															
35.01 - 40.00															
40.01 - 45.00															
45.01 - 50.00															
over 50.00															
Tot.(pers.-mSv)	528.70	387.80	916.50	600.00	856.00	1456.00	568.09	2008.50	2576.59	595.61	1013.50	1609.11	2292.40	4265.80	6554.48
Highest individual dose (mSv)	12.00	9.90	12.00	19.22	16.34	19.22	17.21	18.51	18.51	14.99	14.74	14.99	19.22	29.10	29.10

Table 6b: Whole-body doses from external irradiation in 1994. Annual collective doses in pers.-mSv (E = plant internal personnel, F = external personnel)

Dose distribution (mSv)	PSI	EPFL	LUCENS	Basel Univers.	Total research	Total NPP E+F*) **)	Total NPP + research *) **) ***)+)
0.00 - 1.00	132.60	0.50	0.82	0.40	134.32	592.84	718.03
1.01 - 2.00	67.10				67.10	592.51	658.55
2.01 - 5.00	143.90				143.90	1993.85	2137.75
5.01 - 10.00	93.30				93.30	2076.37	2169.67
10.01 - 15.00	12.10				12.10	932.50	944.60
15.01 - 20.00						261.66	261.66
20.01 - 25.00	20.10				20.10	23.64	43.74
25.01 - 30.00						81.11	81.11
30.01 - 35.00							
35.01 - 40.00							
40.01 - 45.00							
45.01 - 50.00							
over 50.00							
Tot.(pers.-mSv)	469.10	0.50	0.82	0.40	470.82	6554.48	7015.11
Highest individual dose (mSv)	20.10	0.20	0.82	0.40	20.10	29.10	29.10

+) due to rounding errors, some vertical and horizontal sums do not add up exactly

*) External personnel with a radiation dose from several nuclear power plants appears only once in these columns, with the sum of the doses from all the plants (391 persons).

**) Internal personnel with a radiation dose from several nuclear power plants appears only once in these columns, with the sum of the doses from all the plants (30 persons). Since the listed doses to the internal personnel may contain contributions from activities at other installations (as external personel there), 3.79 mSv have been subtracted from the values in this column.

***) PSI personnel with a radiation dose from several nuclear power plants, or NPP personnel with a radiation dose received at PSI, appear only once in these columns, with the sum of the doses from all the installations (58 persons). Since the listed doses to the internal personnel may contain contributions from activities at other installations (as external personel there), 10.19 mSv have been subtracted from the values given in this column.

Table 7: Whole-body doses from external irradiation in 1994. Number of persons grouped according to age and sex. *) All NPP and PSI personnel, internal and external, considered (M = male, F = female)

Dose distrib (mSv)	16-18 years M	16-18 years F	19-20 years M	19-20 years F	21-30 years M	21-30 years F	31-40 years M	31-40 years F	41-50 years M	41-50 years F	51-60 years M	51-60 years F	61-70 years M	61-70 years F	71-80 years M	71-80 years F	Total +)
0.00 - 1.00	18	1	35		828	46	959	33	927	34	659	27	156	4	1		3730
1.01 - 2.00	1		3		105	4	139		131	3	57		11				454
2.01 - 5.00			3		166	3	216	1	162	2	80	1	12				646
5.01 - 10.00					86		112		83		32		1				314
10.01 - 15.00					16		29		21		13						79
15.01 - 20.00					3		3		7		2		1				16
20.01 - 25.00									1		1						2
25.01 - 30.00							3										3
30.01 - 35.00																	
35.01 - 40.00																	
40.01 - 45.00																	
45.01 - 50.00																	
over 50.00																	
Total persons	19	1	41	2	1204	53	1461	34	1332	39	844	28	181	4	1	0	5244
Average per person (mSv)	0.1	0.0	0.4	0.0	1.4	0.4	1.6	0.2	1.4	0.4	1.1	0.2	0.5	0.2	0.0	0.0	1.3
Collect. dose (pers.-mSv)	2.6	0.0	18.2	0.0	1706.0	21.2	2370.7	6.1	1860.9	16.1	906.2	6.9	98.0	0.6	0.0	0.0	7013.4

*) External, internal and PSI personnel with a radiation dose contribution from several nuclear power plants appear only once in these columns, with the sum of the doses from all the plants. (479 persons) (- 13.91 mSv)

+) due to rounding errors, some vertical and horizontal sums do not add up exactly

Table 8: Hand doses from external irradiation in 1994: Number of persons (E = plant internal, F = external

Dose distribution (mSv)	KKB I+II E	KKB I+II F	KKB I+II E+F	KKG E	KKG F	KKG E+F	KKL E	KKL F	KKL E+F	KKM E	KKM F	KKM E+F	NPP total E	NPP total F*)	NPP total E+F*)	PSI	NPP tot. and PSI E+F*)
0.00 - 15.00	11	4	15	2	17	19	1	17	18	10	8	18	24	46	70	138	208
15.01 - 30.00				1	6	7				1		1	2	6	8	5	13
30.01 - 75.00				5	5	10	1		1	1		1	7	5	12	4	16
75.01 - 150.00				1	2	3							1	2	3		3
150.01 - 225.00				1		1							1		1		1
225.01 - 300.00				1		1							1		1		1
300.01 - 375.00																	
375.01 - 450.00																	
450.01 - 525.00																	
525.01 - 600.00																	
600.01 - 675.00																	
675.01 - 750.00																	
over 750.00																	
Total persons	11	4	15	11	30	41	2	17	19	12	8	20	36	59	95	147	242

*) External personnel with radiation dose contribution from several nuclear power plants appears only once in these columns

Table 9: Incorporation 1994: Number of persons **)
(E = plant internal, F = external personnel)

Percent i ***)	KKB I+II E	KKB I+II F	KKB I+II E+F	KKG E	KKG F	KKG E+F	KKL E	KKL F	KKL E+F	KKM E	KKM F	KKM E+F	Total NPP E	Total NPP F*)	Total NPP E+F*)	PSI	Total NPP+PSI E+F*)
0 - 2	110	165	275	296	511	807	348	1324	1672	256	889	1145	1010	2889	3899	487	4386
2 - 4																	
4 - 10																	
10 - 20																	
20 - 30																	
30 - 40																	
40 - 50																	
50 - 60																	
60 - 70																	
70 - 80																	
80 - 90																	
90 - 100																	
over 100																	
Total Pers.	110	165	275	296	511	807	348 +)	1324	1672	256	889	1145	1010	2889	3899	487	4386
Nuclides with i>2%																	
Med. exam.	458 +)		458	296		296	322		322	262	54	316	1338	54	1392	690	2082

*) External personnel with a radiation dose constribution from several nuclear power plants appears only once
**) of multiple checks of the same person during one calendar year, only one check has been entered
***) percent i is the annual incorporation expressed as a fraction (in percent) of the highest value permissible under SSVO, annex 7 (Radiation Protection Regulation)
+) Including people non- professionally exposed to radiation

Table 10a: Number of persons (plant internal personnel)*) with life doses, accumulated at work, falling, at the end of 1994, into the following dose ranges

Dose distribution (mSv)	KKB I + II	KKG	KKL	KKM	Plants Total	PSI	NPP and PSI
0.00 - 50.00	159	235	297	160	851	1037	1888
50.01 - 100.00	50	30	27	22	129	49	178
100.01 - 150.00	37	11	11	27	86	20	106
150.01 - 200.00	29	14	2	24	69	15	84
200.01 - 250.00	32	5		18	55	6	61
250.01 - 300.00	20		2	6	28	1	29
300.01 - 350.00	16	1		3	20	1	21
350.01 - 400.00	7			4	11		11
400.01 - 450.00	9			4	13		13
450.01 - 500.00	4			6	10		10
500.01 - 550.00	3				3		3
550.01 - 600.00	1				1		1
over 600.00	1				1		1
Total persons	368	296	339	274	1277	1129	2406

*) including persons leaving the covered group in the course of the calendar year

Table 10b: Number of persons (total NPP and PSI, internal personnel) in categories of age, with life doses, accumulated at work, falling, at the end of 1994, into the following dose ranges >200 mSv *):

Dose distribution (mSv)	21 - 30 years	31 - 40 years	41 - 50 years	51 - 60 years	61 - 70 years	> 70 years	Total
200.01 - 250.00		2	21	30	8		61
250.01 - 300.00		1	11	10	7		29
300.01 - 350.00		1	7	12	1		21
350.01 - 400.00			2	7	2		11
400.01 - 450.00			4	6	3		13
450.01 - 500.00			6	4			10
500.01 - 550.00			2	1			3
550.01 - 600.00				1			1
over 600.00				1			1
Total persons		4	53	72	21		150

*) including persons leaving the covered group in the course of the calendar year

Table 11: Radioactive wastes in the nuclear power plants:
Position, in m^3, at the end of 1994

	KKB	KKM	KKG	KKL	Total
unconditioned	179	595	84	340	1353
conditioned	833	180	168	916	2083
Total	**1012**	**775**	**252**	**1256**	**3436**

The raw wastes produced will be brought into a form suitable for final storage (conditioning) during campaigns. The ion-exchange resin is not yet conditioned in KKM (see under section 2.2.5).

Table 12: List of the Swiss guidelines and recommendations

Guideline	Title of Guideline	Sate of current issue
HSK- R-004/d	Aufsichtsverfahren beim Bau von Kernkraftwerken, Projektierung von Bauwerken	December 1990
R-005/d	Aufsichtsverfahren beim Bau von Kernkraftwerken; mechanische Ausrüstungen	October 1990
R-006/d	Sicherheitstechnische Klassierung, Klassengrenzen und Bauvorschriften für Ausrüstungen in Kernkraftwerken mit Leichtwasserreaktoren	May 1985
R-007/d	Richtlinien für die Strahlenschutzzone in Kernanlagen	July 1977
R-007/f	Directives concernant la zone de radioprotection dans les installations nucléaires	July 1977
R-008/d	Sicherheit der Bauwerke für Kernanlagen, Prüfverfahren des Bundes für die Bauausführung	May 1976
R-011/d	Ziele für den Schutz von Personen vor ionisierender Strahlung im Bereich von Kernkraftwerken	May 1980
R-011/f	Objectifs de la protection des personnes contre les radiations ionisantes dans la zone d'influence des centrales nucléaires	July 1978
R-012/d	Erfassung der Dosen des beruflich strahlenexponierten Personals von Kernanlagen	December 1979
R-014/d	Konditionierung und Zwischenlagerung radioaktiver Abfälle	December 1988
R-014/e	Conditioning and Interim Storage of Radioactive Waste	December 1988
R-015/d	Richtlinie zur Berichterstattung über den Betrieb von Kernkraftwerken	August 1987
R-016/d	Seismische Anlageninstrumentierung	February 1980
R-017/d	Organisation und Personal von Kernkraftwerken	August 1986
R-019/d	Planung und Ausführung der Sirenennetze in der Zone 2 für das Alarmsystem in der Umgebung der Kernkraftwerke	October 1979
R-019/f	La planification et la réalisation du réseau des sirènes dans la zone 2 pour le système d'alarme aux environs des centrales nucléaires	October 1979
R-020/d	Technische Richtlinien für die Alarmsirenen des Alarmsystems in der Umgebung der Kernkraftwerke	October 1979
R-021/d	Schutzziele für die Endlagerung radioaktiver Abfälle	November 1993
R-021/e	Protection Objectives for the Disposal of Radioactive Waste	November 1993
R-021/f	Objectifs de protection pour le stockage final des déchets radioactifs	November 1993
R-023/d	Revisionen, Prüfungen, Ersatz, Reparaturen und Änderungen an elektrischen Ausrüstungen in Kernanlagen	December 1993

Guideline	Title of Guideline	Date of current issue
HSK- R-025/d	Berichterstattung der Kernanlagen des Bundes, der Kantone, des PSI sowie des stillgelegten Versuchsatomkraftwerks Lucens	May 1990
R-025/f	Notification relative aux installations nucléaires de la Confédération et des Cantons, à l'Institut Paul Scherrer ainsi qu'à la centrale nucléaire expérimentale désaffectée de Lucens.	April 1989
R-027/d	Auswahl, Ausbildung und Prüfung des lizenzpflichtigen Betriebspersonals von Kernkraftwerken	May 1992
R-030/d	Aufsichtsverfahren beim Bau und Betrieb von Kernanlagen	July 1992
R-031/d	Aufsichtsverfahren beim Bau von Kernkraftwerken, E1 klassierte elektrische Ausrüstungen	January 1994
R-032/d	Richtlinie für die meteorologischen Messungen an Standorten von Kernanlagen	September 1993
R-035/d	Aufsichtsverfahren beim Bau von Kernkraftwerken, Systemtechnik	December 1993
R-037/d	Anerkennung von Kursen für Strahlenschutz-Kontrolleure und -Chefkontrolleure; Prüfungsordnung	May 1990
R-038/d	Interpretation des Begriffs "abgeleiteter Richtwert für Oberflächenkontamination"	July 1987
R-039/d	Erfassung der Strahlenquellen und Werkstoffprüfer im Kernanlagenareal	January 1990
R-040/d	Gefilterte Druckentlastung für den Sicherheitsbehälter von Leichtwasserreaktoren, Anforderungen für die Auslegung	March 1993
R-042/d	Zuständigkeiten für die Entscheide über besondere Massnahmen bei einem schweren Unfall in einer Kernanlage	February 1993
R-042/e	Responsibility for decisions to implement certain measures to mitigate the consequences of a severe accident at a Nuclear Power Plant	March 1993
R-100/d	Anlagezustände eines Kernkraftwerks	June 1987
R-101/d	Auslegungskriterien für Sicherheitssysteme von Kernkraftwerken mit Leichtwasser-Reaktoren	May 1987
R-101/e	Design Criteria for Safety Systems of Nuclear Power Plants with Light Water Reactors	May 1987
R-102/d	Auslegungskriterien für den Schutz von sicherheitsrelevanten Ausrüstungen in Kernkraftwerken gegen die Folgen von Flugzeugabsturz	December 1986
R-102/e	Design Criteria for the Protection of Safety Equipment in NPP against the Consequences of Airplane Crash	December 1986
R-103/d	Anlageinterne Massnahmen gegen die Folgen schwerer Unfälle	November 1989

Recommen datons	Title of recommendation	Date of current issue
HSK- E-003/d	Empfehlungen für die Planung und Durchführung von Notfallübungen in den schweizerischen Kernkraftwerken	May 1990
E-003/e	Recommendations for the Planning and Execution of Emergency Exercises in Swiss Nuclear Power Plants	October 1991
E-004/d	Steuerstellen und Notfallräume von Kernkraftwerken: Anforderungen betreffend Ausführung und Ausrüstung für Accident Management	December 1989

Table 13: International Nuclear Event Scale (INES) for nuclear installations

A new international scale for the expression of incident severity in nuclear installations is internationally in tentative use since early 1990. Based on their relevance to plant safety, it distinguishes the following seven levels of incidents:

Level	Descriptor	Criteria	Examples
7	Major accident	External release of a large fraction of the reactor core inventory typically involving a mixture of short- and long-lived fission products (in quantities radiologically equivalent to more than tens of thousands of terabecquerels of iodine-131). Possibility of acute health effects. Delayed health effects over a wide area, possibly involving more than one country. Long term environmental consequences.	Chernobyl, USSR, (1986)
6	Serious accident	External release of fission products (in quantities radiologically equivalent to the order of thousands to tens of thousands of terabecquerels of iodine-131) Full implementation of local emergency plans probably needed to limit serious health effects.	
5	Accident with off-site risks	External release of fission products (in quantities radiologically equivalent to the order of hundreds to thousands of terabecquerels of iodine-131). Partial implementation of emergency plans (e.g. local sheltering and/or evacuation) required in some cases to lessen the likelihood of health effects. Severe damage to a large fraction of the core and major plant contamination.	Windscale, UK (1957) Three Mile Island, USA, (1979)
4	Accident without significant off-site risks	External release of radioactivity resulting in a dose to the most exposed individual off-site of the order of a few millisieverts. Need for off-site protective actions generally unlikely except possibly for local food control. Some damage to reactor core as a result of mechanical effects and/or melting. Worker doses likely to have acute fatal consequences.	Saint Laurent, France, (1980)

table continued on next page

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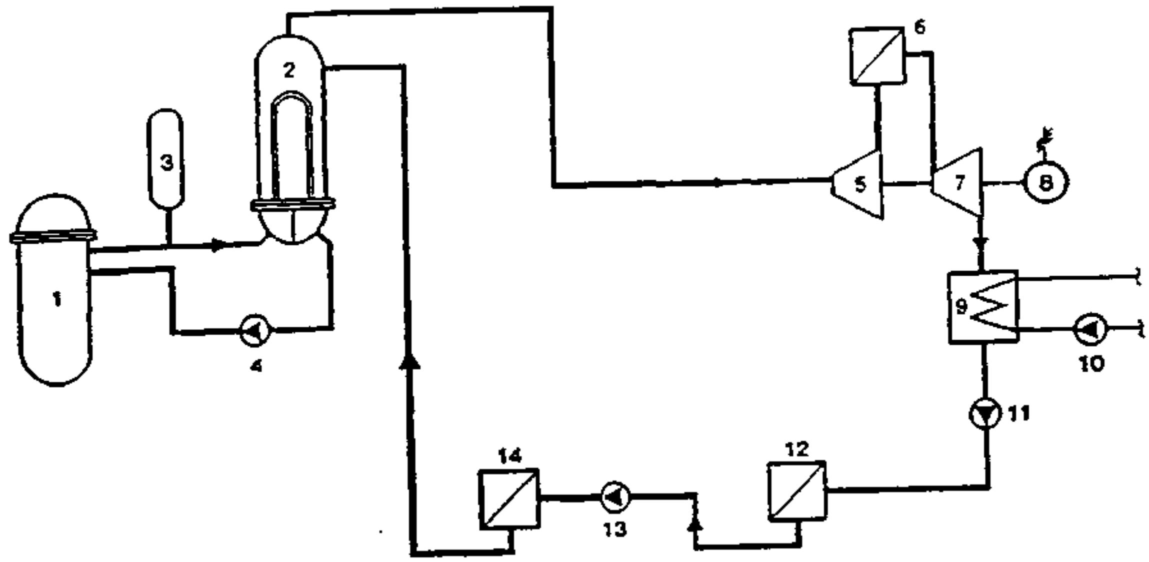
Level	Descriptor	Criteria	Examples
3	Serious incident	External release of radioactivity above authorised limits, resulting in a dose to the most exposed individual off-site of the order of tenths of a millisievert. High radiation levels and/or contamination on-site as a result of workers likely to lead to acute health effects. Incidents in which a further failure of safety systems could lead to accident conditions, or a situation in which safety systems would be unable to prevent an accident if certain initiators were to occur.	 Vandellos, Spain (1989)
2	Incident	Incidents with major failure of safety provisions, but still leaving sufficient safety margins to cope with additional faults. Radiological incident with members of the personnel receiving doses in excess of the annual limit Significant contamination of the installation which was not to be expected on the design basis.	Sosnowy Bor, Russia (1992)
1	Anomaly	Functional or operational anomalies which do not pose a risk but which indicate a lack of safety provisions. This may be due to equipment failure, human error or procedural inadequacies.	
0	No safety significance	Situations where operational limits and conditions are note exceeded and which are properly managed in accordance with adequate procedeures belong here. Examples: Individual failure in a redundant system. Single operational mistake without consequences. Faults (no multiple simultaneous failure) detected in periodic inspections or tests. Automatic reactor scram with normal plant behaviour. Reaching of limiting operation conditions, while adhering to the proper regulations.	

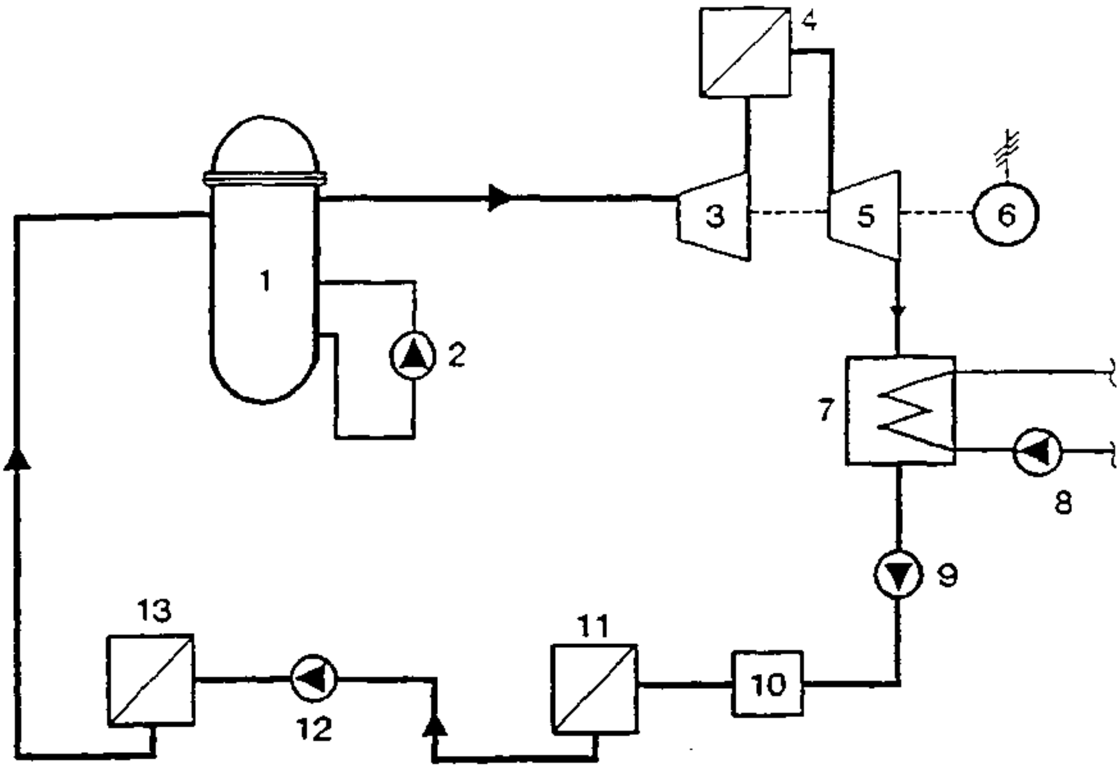
Figure 1a: Function diagram of a pressurited water reactor



Legende

1 Reactor
2 Steam Generator
3 Pressurizer
4 Reactor coolant pump
5 High-pressure turbine
6 Water separator and reheater
7 Low-pressure turbine
8 Generator
9 Condenser
10 Cooling water pump from river or cooling tower
11 Condensate pump
12 Low-pressure feedheater
13 Feedwater pump
14 High-pressure feedheater

Figure 1b: Function diagram of a boiling water reactor



Legende

1 Reactor
2 Recirculating pump
3 High-pressure turbine
4 Water separator and reheater
5 Low-pressure turbine
6 Generator
7 Condenser
8 Cooling water pump from river or cooling tower
9 Condensate pump
10 Condensate polishing system
11 Low-pressure feedheater
12 Feedwater pump
13 High-pressure feedheater

Figure 2: Availability factors and load factors 1985 - 1994 (in %)

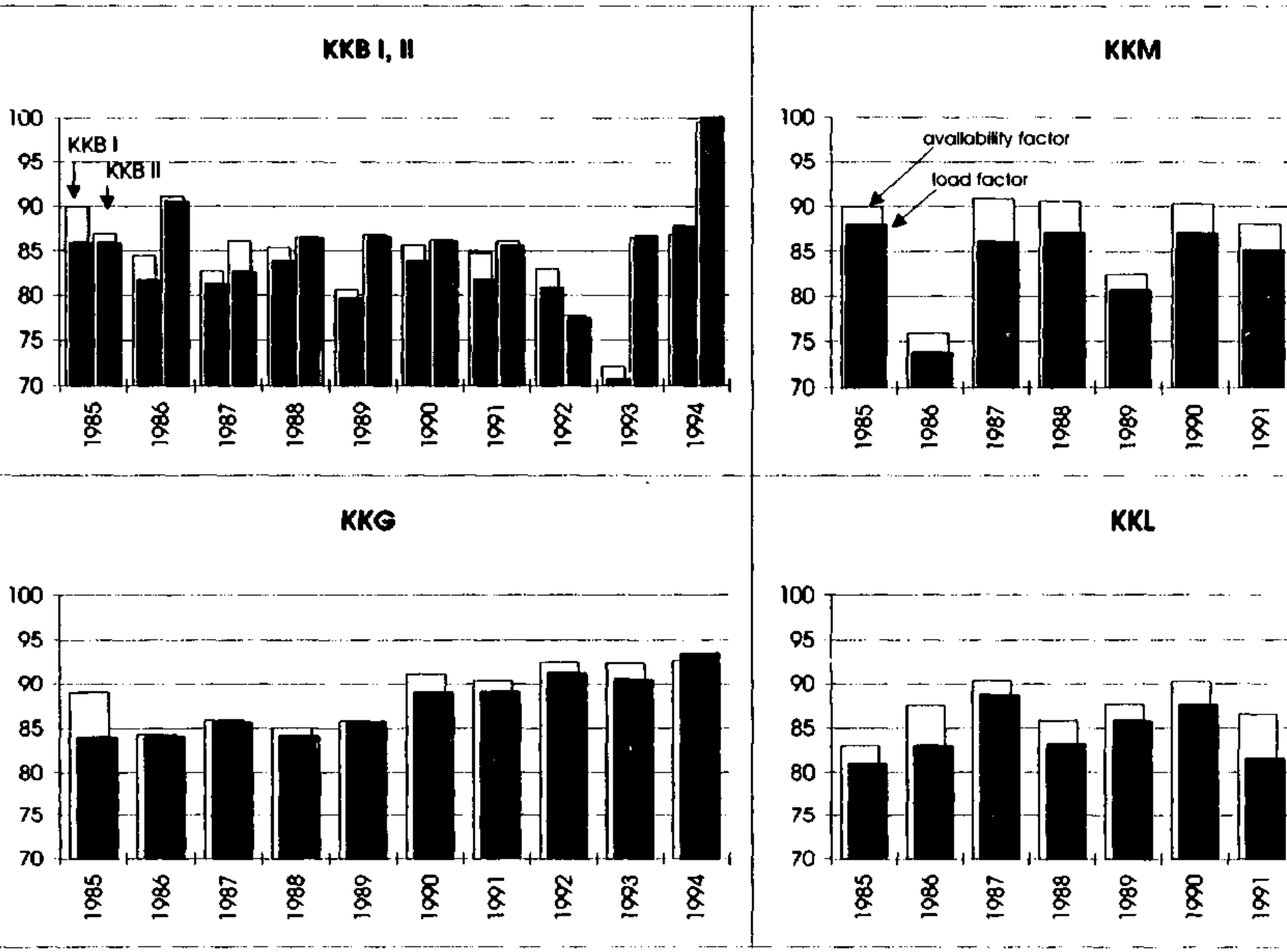


Figure 3: Classified incidents, subject to registration, 1985 - 1994

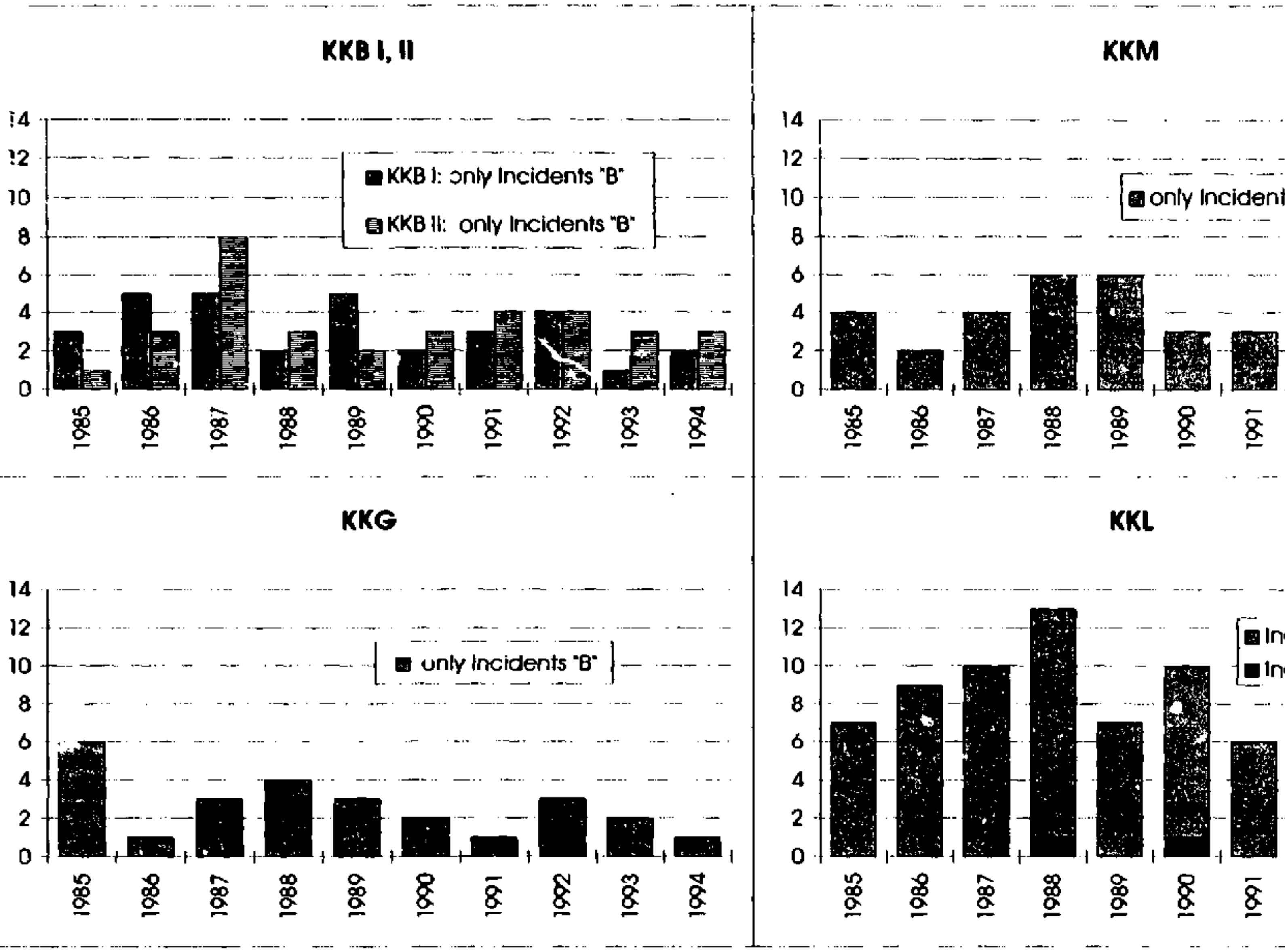


Figure 4: Reactor scrams (unplanned) 1985 - 1994

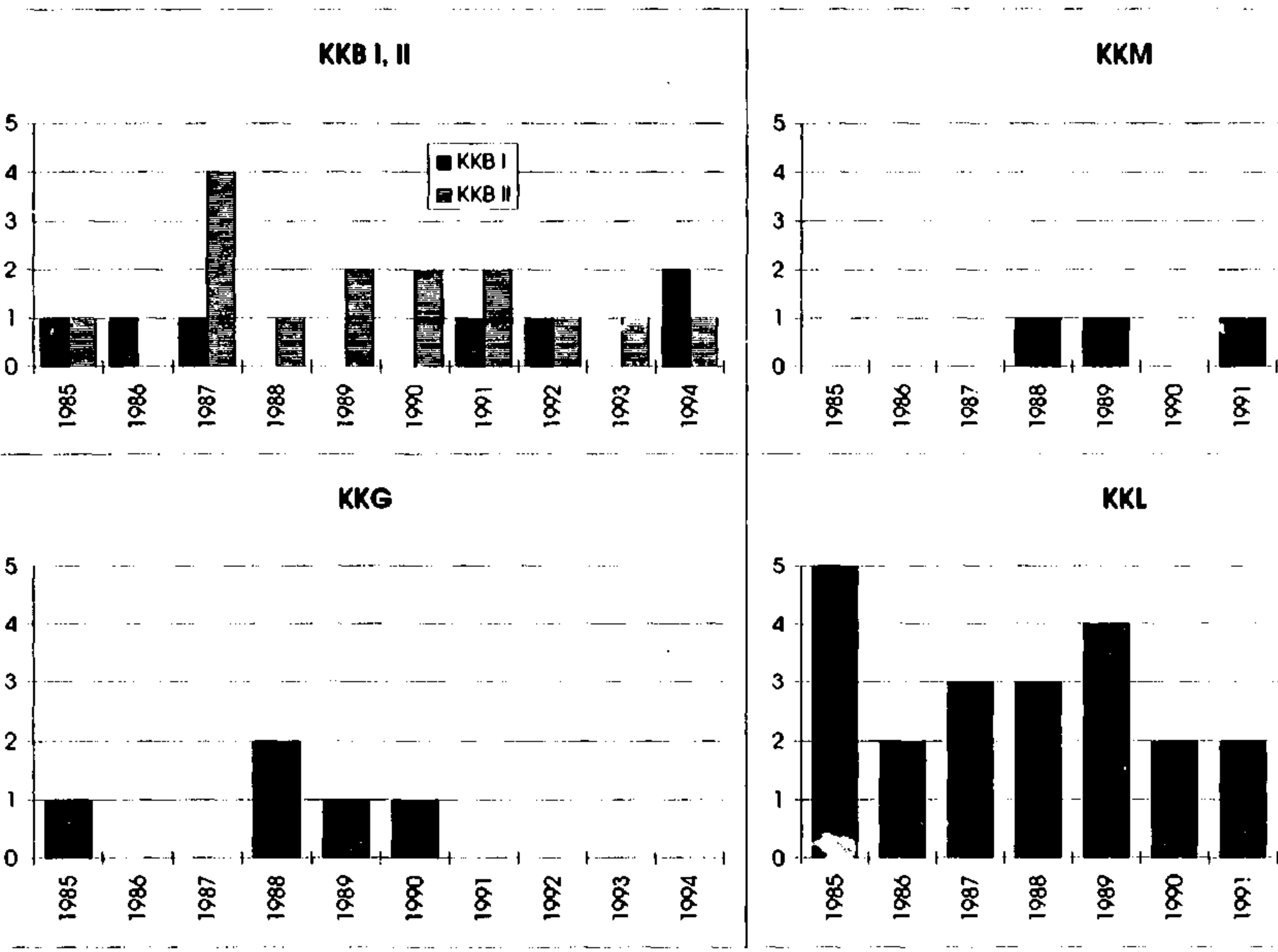
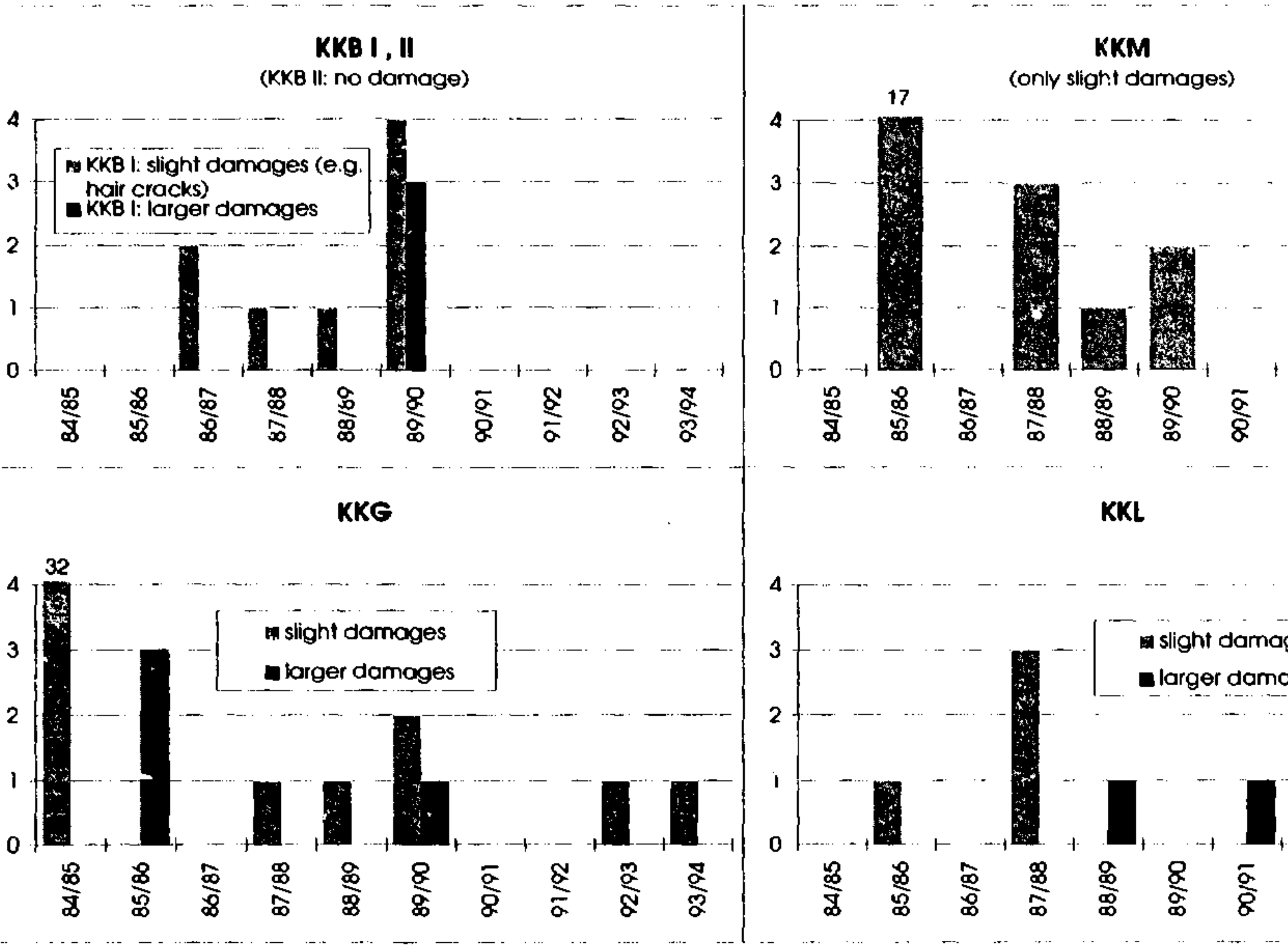
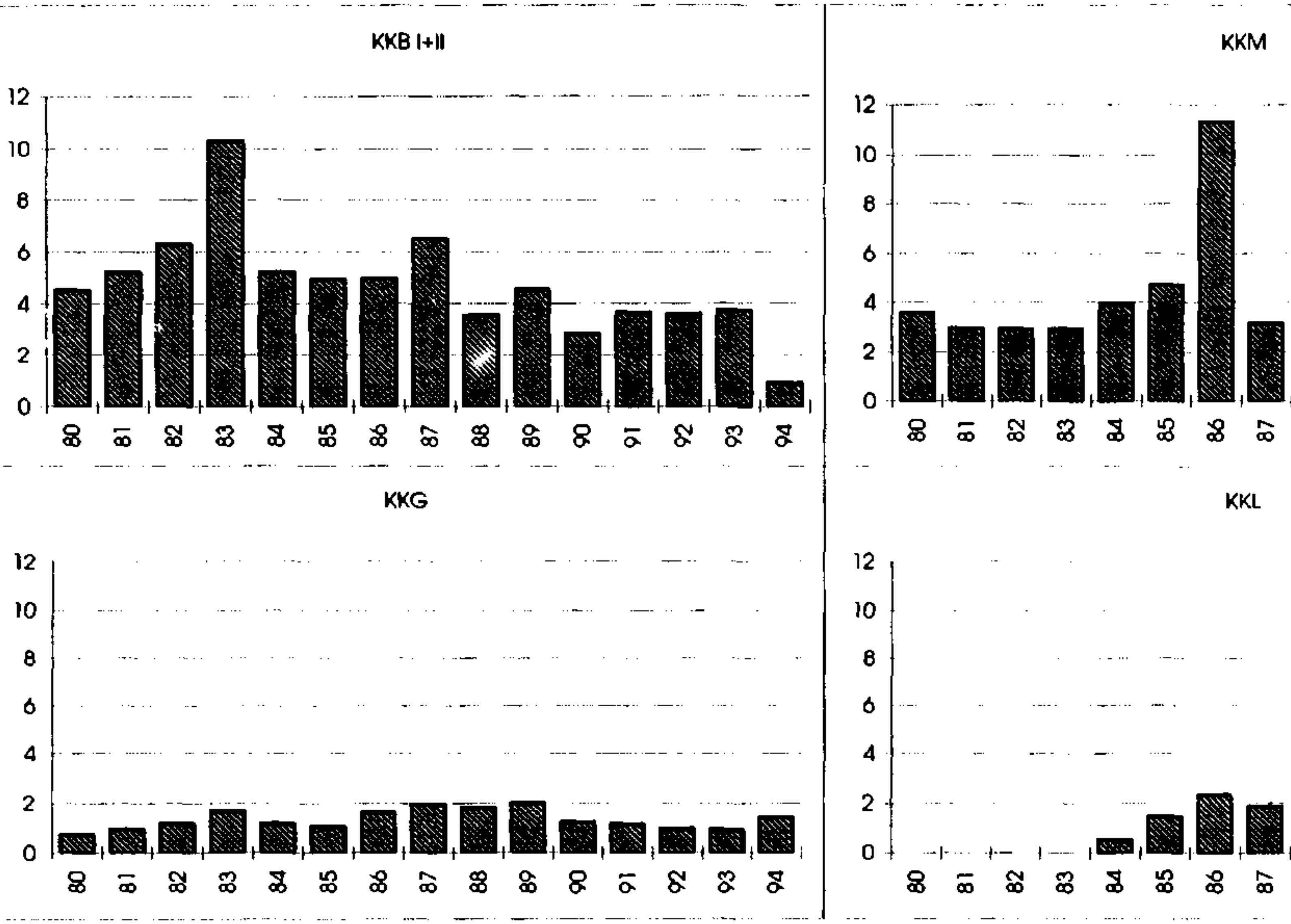


Figure 5: Fuel rod defects (number of rods) 1984 - 1994

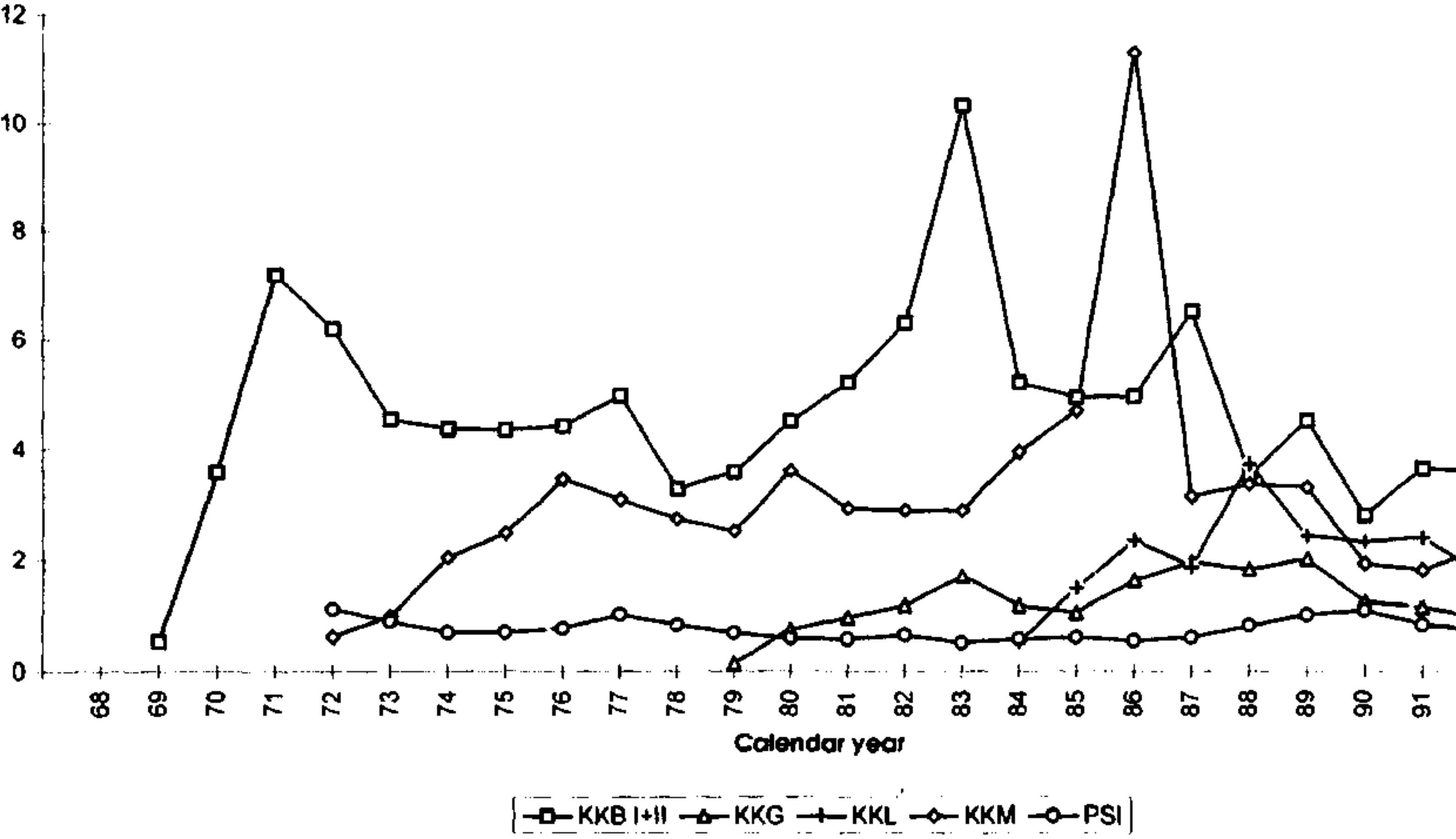


Figur 6: Annual collective doses (pers.-Sv / a) in the nuclear power plants 1980 - 1994



Comment: KKB I+II - 1994 shutdown only in Block I

Fig. 7: Annual collective doses (pers.-Sv/a) in Swiss nuclear installations, from 1969 to 1994 (plant internal and external personnel)



Comment: KKB I+II - 1994 shutdown only in Block I

Fig. 8: Number of persons with an individual annual whole body dose over 20 mSv in the nuclear powe

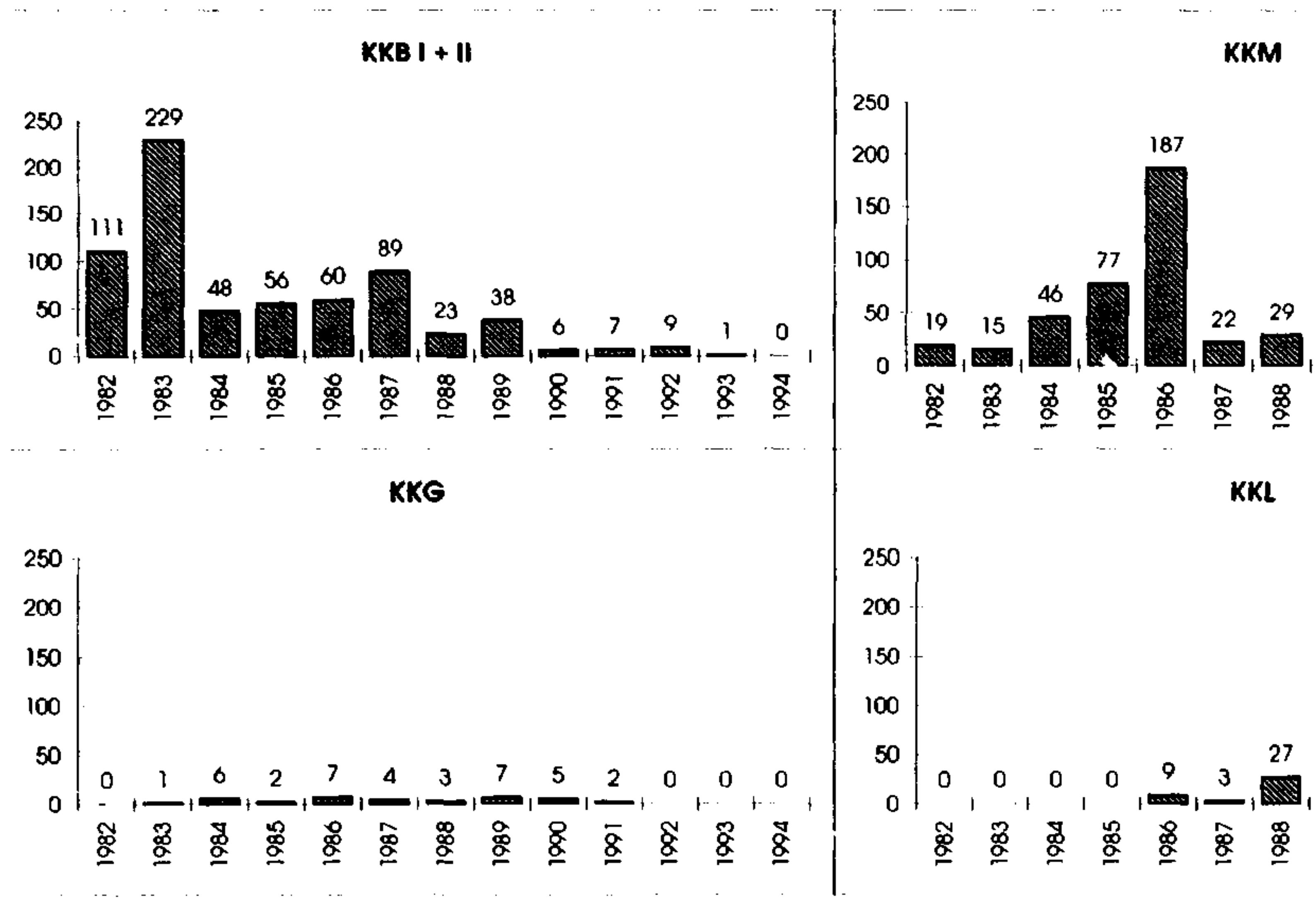


Fig. 9: Average annual individual dose (mSv) of the internal and external personnel of the nuclear powe

Left bar - own personnel Right bar - external personnel

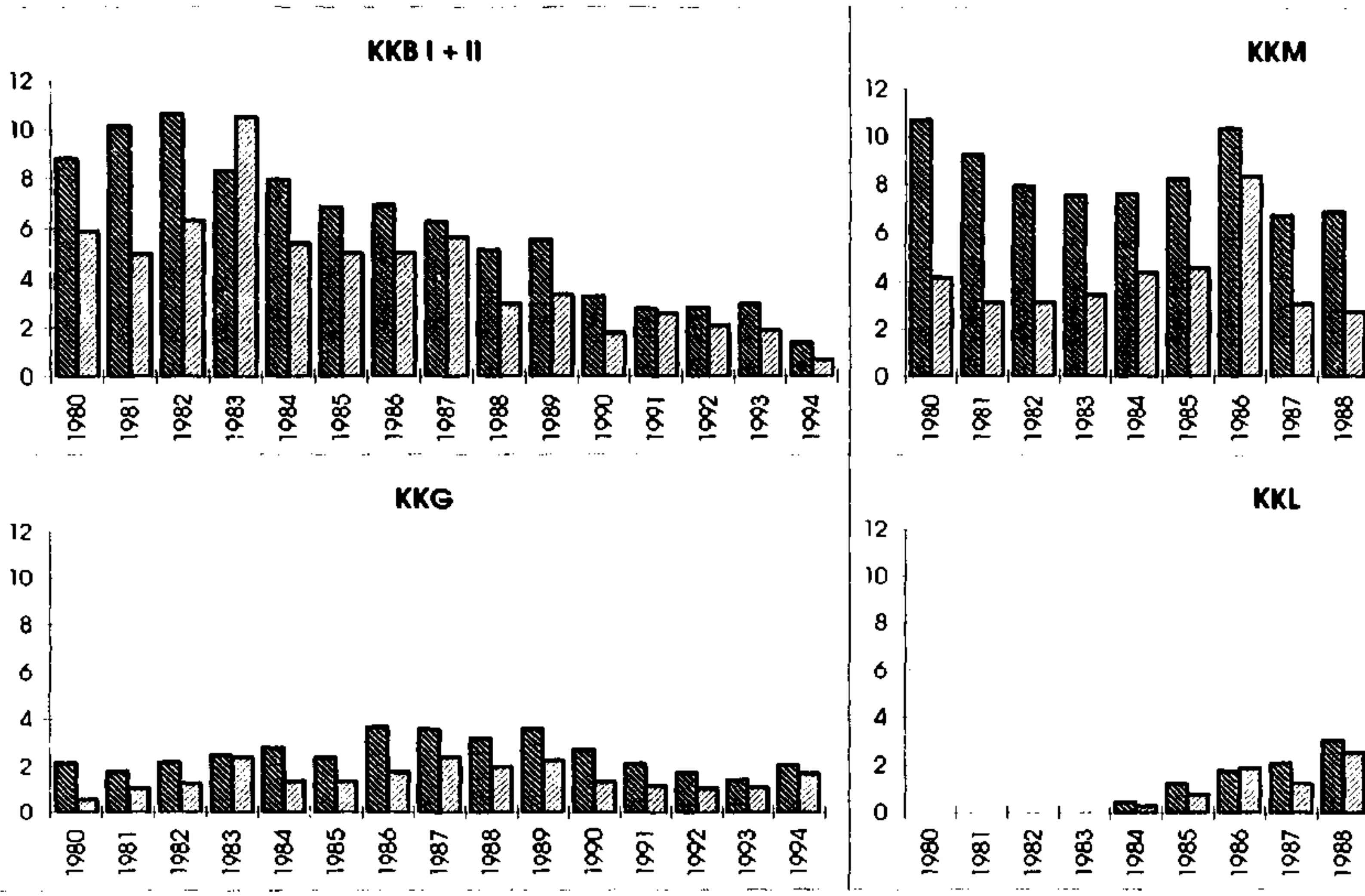


Fig. 10: Number of persons (internal personnel) of the nuclear power plants, who at the end of the year have accumulated integrated doses (life dose) of more than 200 mSv from 1980 - 1994

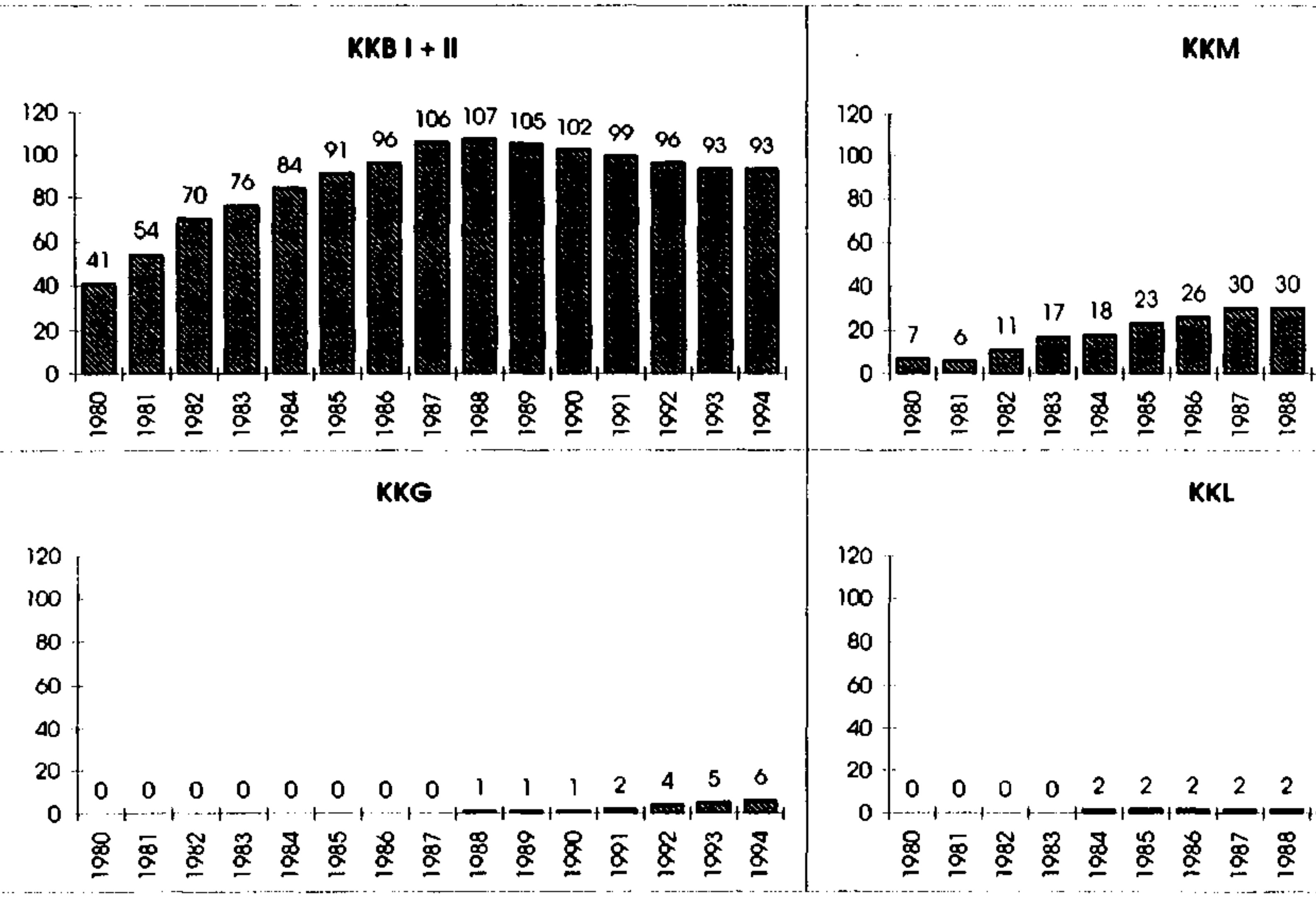
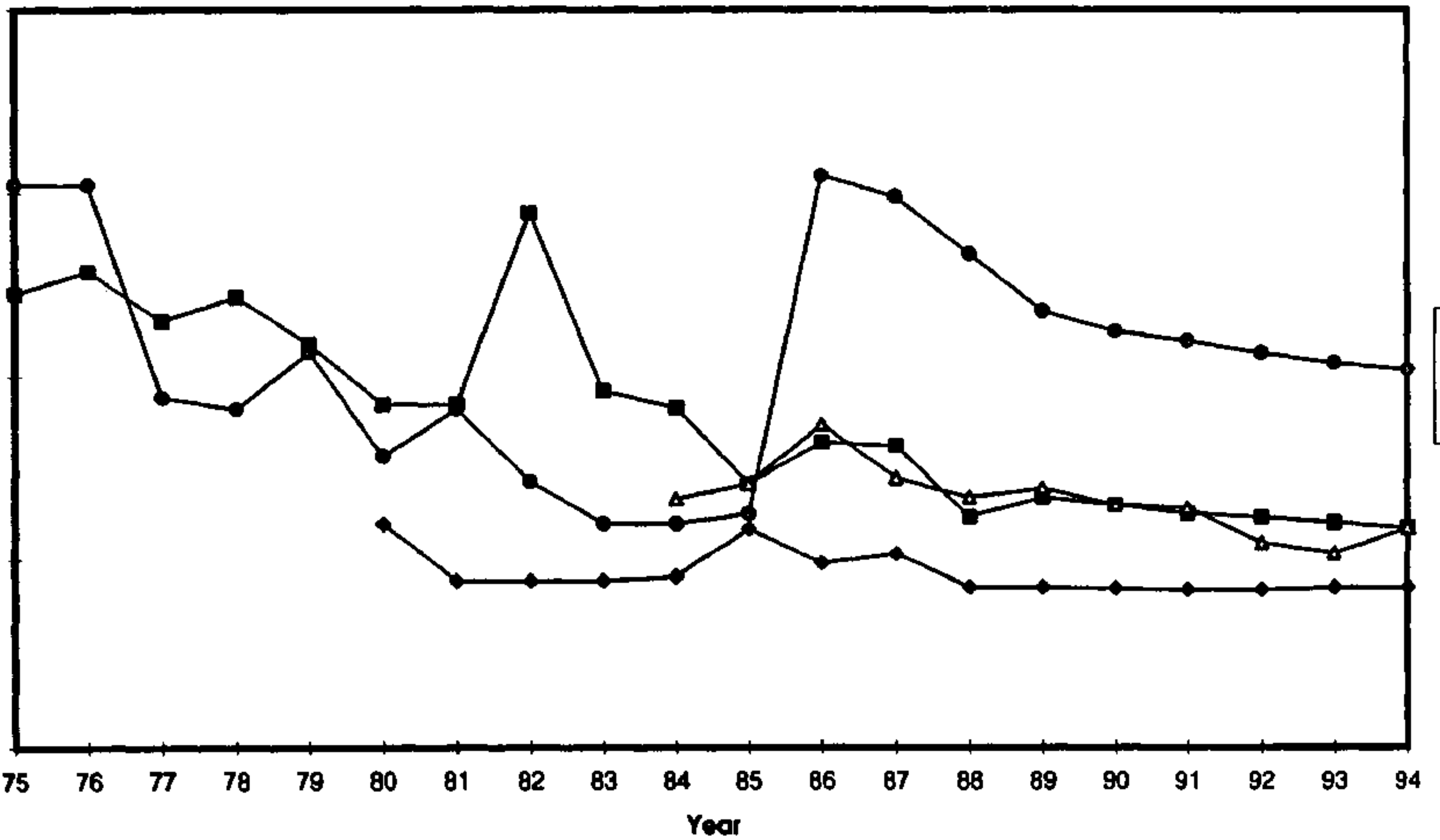


Figure 11: Calculated dose for the most concerned person (adult) in the vicinity of the nuclear power plants



List of abbreviations used

ADS	Automatic depressurization system
ALPS	Alternate Low Pressure Spray
ANIS	Plant information system
ANPA	Emergency Response Data System, (automatic) transmission from NPP to HSK
ATWS	Anticipated Transient without Scram
BAG	Swiss Federal Office of Public Health
BEW	Swiss Federal Office of Energy
BKW	Bernische Kraftwerke AG
BNFL	British Nuclear Fuels Ltd
Bq	Bequerel = activity unit (1 Bq = $2,7.10^{-11}$ Ci)
BZL	Swiss Federal interim storage facility
BZS	Swiss Federal Office for civil defence
COGEMA	Compagnie Générale des Matières Nucléaires, La Hague
CVRS	Cement Volume Reduction and Solidification
DSK	German-Swiss Nuclear Safety Commission
DWR	Pressurized water reactor
ELFB	Certificate for suitability for final storage
EPFL	Swiss Federal Institute of Technology of Lausanne
ERIS	Emergency Response Information System
GE	General Electric Company
GFS	Staff of the local council
GNW	Co-operative for Nuclear Disposal Wellenberg
GWh	Gigawatthours = 10^9 Watthours
HAA	High-level waste
HSK	Swiss Federal Nuclear Safety Inspectorate
HTR	High-temperature reactor
IAEA	International Atomic Energy Agency
INES	International Nuclear Event Scale
IRA	Institut de radiophysique appliquée, Lausanne
IRM	Intermediate Range Monitor
JAL	Year's release limit
KAKO	Cold condensate tank
KAL	Short-time release limit
KKB	Nuclear Power Plant Beznau
KKG	Nuclear Power Plant Gösgen
KKL	Nuclear Power Plant Leibstadt
KKM	Nuclear Power Plant Mühleberg
KNE	Commission for Nuclear Waste Disposal
Kr	Krypton
KSA	Swiss Federal Commission for Safety in Nuclear Installations
KUeR	Swiss Federal Commission for Radioactivity Surveillance
LMA	Long-lived medium-level waste
LRP	Laboratory for radiopharmacy
LWR	Light water reactor
MADUK	Monitoring network for the automatic dose rate measurement in the NPPs' vicinity
man-Sv	Man-Sievert = collective dose unit (1man-Sv = 100 man-rem)
man-mSv	1/1000 of 1 man-Sievert
MGy	Mega-Gray = 10^6 Gray (1 Gray = 100 rad)
MOX	Mixed oxide (uranium-plutonium)
MUSA	Mühleberg safety (probilistic) analysis
mSv	Milli-Sievert = 10^{-3} Sievert
MWe	Megawatt electrical power
MWth	Megawatt thermal power
µSv	Mikro-Sievert = 10^{-6} Sievert
NADAM	Network for automatic dose alarm and monitoring
Nagra	National Cooperative for the Storage of Radioactive Waste
NANO	Emergency standby system and improved power supply at KKB
NAZ	National emergency operation center
NFO	Emergency organization
NGA	National Society for promoting atomic technology
NOK	Nordostschweizerische Kraftwerke AG
NPP	Nuclear Power Plant
NRC	Nuclear Regulatory Commission (USA)

OECD	Organisation of Economic Cooperation and Development
OSART	Operational Safety Review Team (IAEA)
OPTIS	Opthalmic proton therapy device
PET	Positron emission tomography
PSA	Probabilistic Safety Analysis
PSI	Paul Scherrer Institute, Würenlingen and Villigen (East and West)
QS/QA	Quality assurance
RCIC	Reactor Core Isolation Cooling (System) (KKL)
REFUNA	Regional heat supply system of the lower Aare valley
RDB	Reactor pressure vessel
SAA	Low-level waste
SEHR	Special Emergency Heat Removal System (KKL)
SMA	Low and Medium Active Wastes
SMT	Mobilisation system by telephone
SRM	Source Range Monitor
SSVO	Radiological protection requirement
SUSAN	Special independent system for decay heat removal (KKM)
Sv	Sievert = equivalent dose unit (1Sv = 100 rem)
SVP	Flow distribution plate (steam generator)
SWR	Boiling Water Reactor
TBq	Terabequerel (1TBq = 10^{+12} Bq)
TLD	Thermal-luminescent dosemeter
VAKL	Experimental nuclear power plant, Lucens
VVA	Experimental incineration installation (PSI)
Xe	Xenon
ZWIBEZ	Interim radwaste storage facility, KKB
ZWILAG	Interim Storage Facility Würenlingen
ZZL	Central interim storage facility, Würenlingen