EXPERIENCE WITH ALARA AND ALARA PROCEDURES IN A NUCLEAR POWER PLANT

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SUMMARY

The nuclear power plant Borssele is a Siemens two-loop Pressurised Water Reactor having a capacity of 480 MWe and in operation since 1973.

The nuclear power plant Borssele is located in the southwest of the Netherlands, near the Westerschelde River.

In the first nine years of operation the radiation level in the primary system increased, reaching a maximum in 1983. The most important reason for this high radiation level was the cobalt content of the grid assemblies of the fuel elements.

After resolving this problem, the radiation level decreased to a level comparable with that of other nuclear power plants.

In the first few years of operation, the annual collective dose was relatively high, 4,000 - 5,000 mSv, but it decreased to 1,200 - 1,500 mSv, the target being a dose of 1,000 mSv in a year of normal operation. These results have been achieved by taking various measures, among them are the following:

- optimization of the water chemistry,
- restricted testing and maintenance management programme,
- dose control and limitation of the individual day and annual dose,
- implementation of an ALARA group (consisting of people with various disciplines),
- implementation of ALARA procedures:
- justification
- optimization.

In the ALARA procedures, recommendations are given on how to estimate the financial value of the received doses.

GENERAL

The Nuclear Power Station Borssele (KCB) was commissioned in 1973. It is a two-loop Pressurized Water Reactor built by KWU.

Right from the start, much attention had to be given to radiation aspects by the station management. After the higher dose values in the beginning of operation, a falling tendency became visible, especially after 1984.

The nuclear power plant Borssele is an older plant with relatively high radiation levels. The collective dose will therefore be higher than in the case of more recent plants.

By means of a strict regime of dose limitation and application of ALARA, it is now achievable to realize a normal year of operation at about 1,200 mSv. The target is to come down to lower than (<) 1,000 mSv.

RADIATION LEVELS

Radiation and Contamination Levels of the Primary System

The radiation levels of the primary system had risen strongly from 1973 to 1982 (see Figure 1). The increase was so disquieting that drastic measures were considered to keep working possible in the primary system, especially in the steam generators.

The nuclide that determines to a large extent the radiation level in the primary system is ^{60}Co. In 1982 it was established that the high ^{60}Co contamination in the primary system was caused by activation of the Co content of the nickel layer present in the grid assemblies of the fuel elements.

By using grid assemblies with little Co content after 1983, the radiation level of the primary system has strongly dropped since that time. At the moment, the radiation level is again comparable to that of 1977 and a falling tendency can still be perceived.

In addition to changes connected with the fuel elements, measures are also taken regarding operation. Maintaining pH values of the primary coolant between narrowly specified boundaries, together with optimal cleansing, has also contributed to the decrease of the radiation level of the primary system. Also, measures were taken with the intent to make work in strong radiation fields possible.

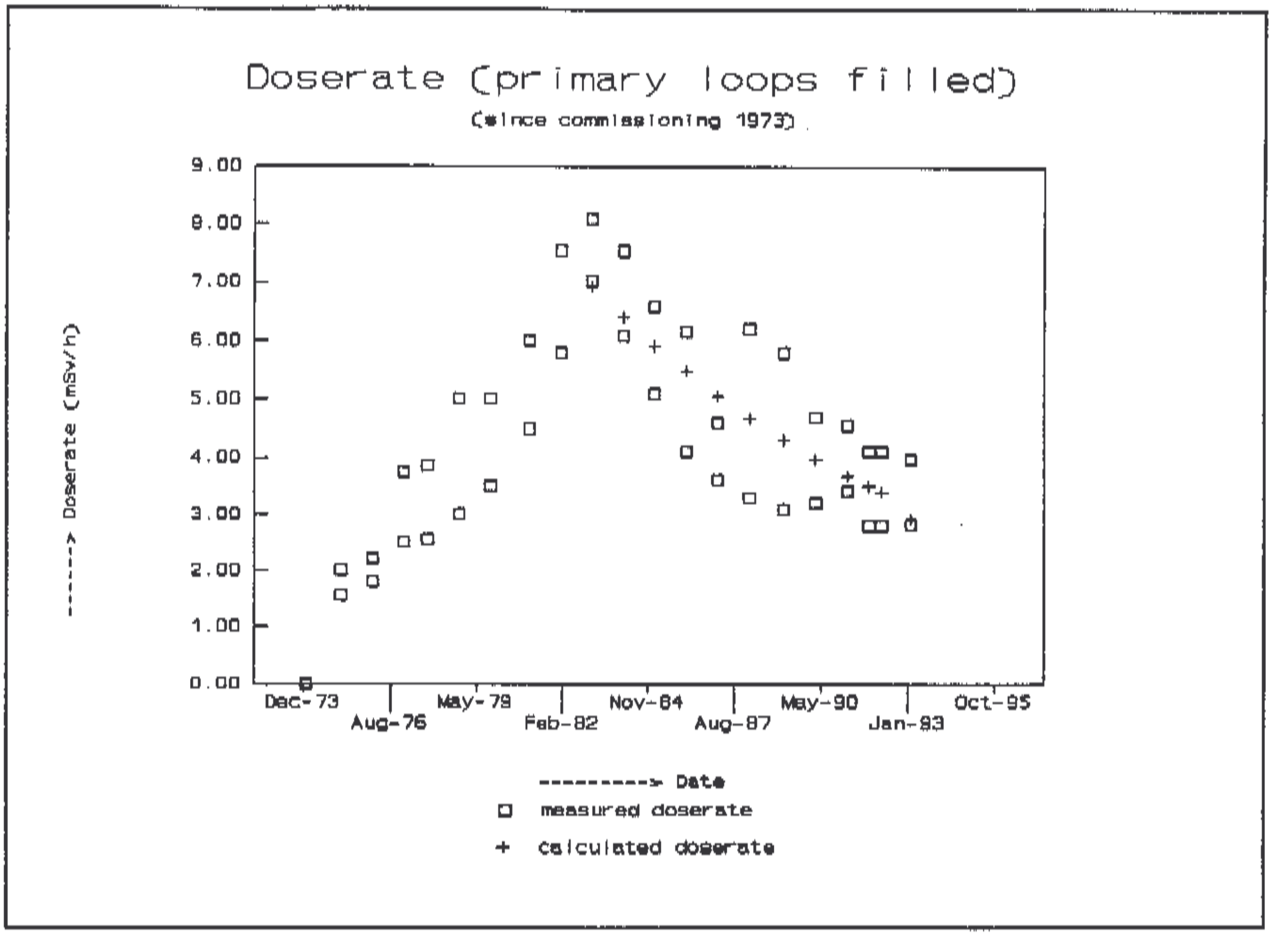
These measures comprise:

- practicing with dummy equipment, for instance, to train to open and close manholes of the steam generators,

- acquiring of advanced equipment for remote control (e.g., a fingerwalker),

- placing protective walls.

figure 1: Dose rate primary loops since 1973



In 1987 an investigation was started into the feasibility of a decontamination of the entire primary system. For this purpose the behaviour of many materials under influence of various decontamination fluids was tested and examined by KEMA (a Dutch laboratory for testing of materials and equipment) and KWU.
However a great uncertainty whether such a decontamination would lead to positive results, together with an uncertainty whether the materials would or would not be affected by the decontamination process, lead KCB to the decision not to pursue such a large decontamination further.
This decision was also influenced by the steadily decreasing radiation levels since 1983.

In 1991 gammaspectrometrical measurements were done of the primary system by means of a mobile HpGe-detector.
The measurements were carried out in the hot leg of loop 1 and the cold leg of loop 2.
A summary of the measured surface contaminations is given in table 1.

Table 1: measured surface contaminations in the hot leg of loop 1 (YA001Z001) and the cold leg of loop 2 (YA002Z011).

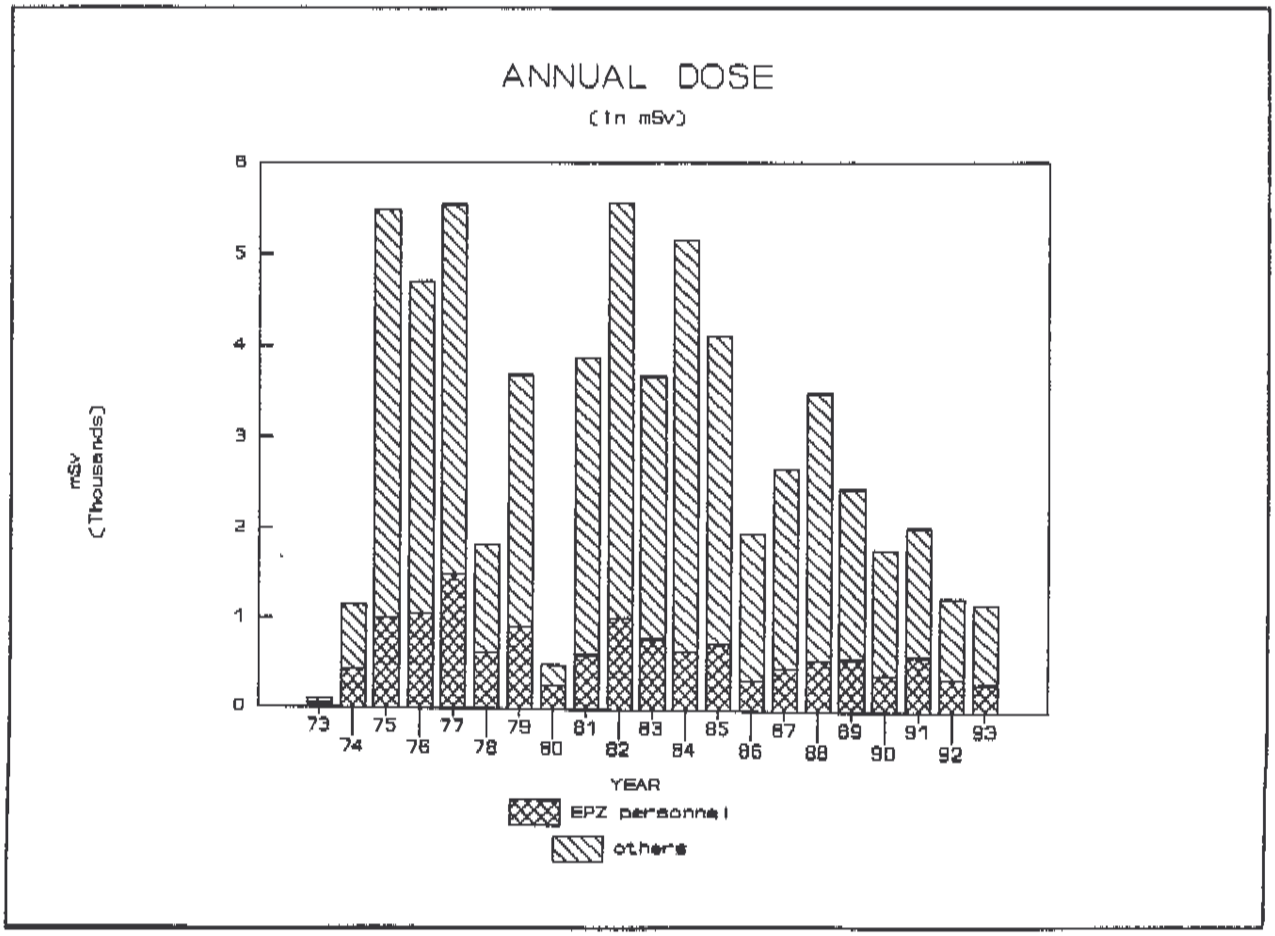
nuclide	surface contaminations			
	YA001Z002		YA002Z011	
	$kBq.cm^{-2}$	%	$kBq.cm^{-2}$	%
^{124}Sb	47	4,9	26	2,0
^{58}Co	135	14,1	108	8,4
^{60}Co	778	81,0	1.152	89,6

From these measurements it can be concluded with some carefulness that in the cold leg the contamination is about 35% higher than in the hot leg.
The above mentioned difference can also be seen from the dose rates at the surface of the pipes which are yearly measured by dose rate measuring devices.

DOSES

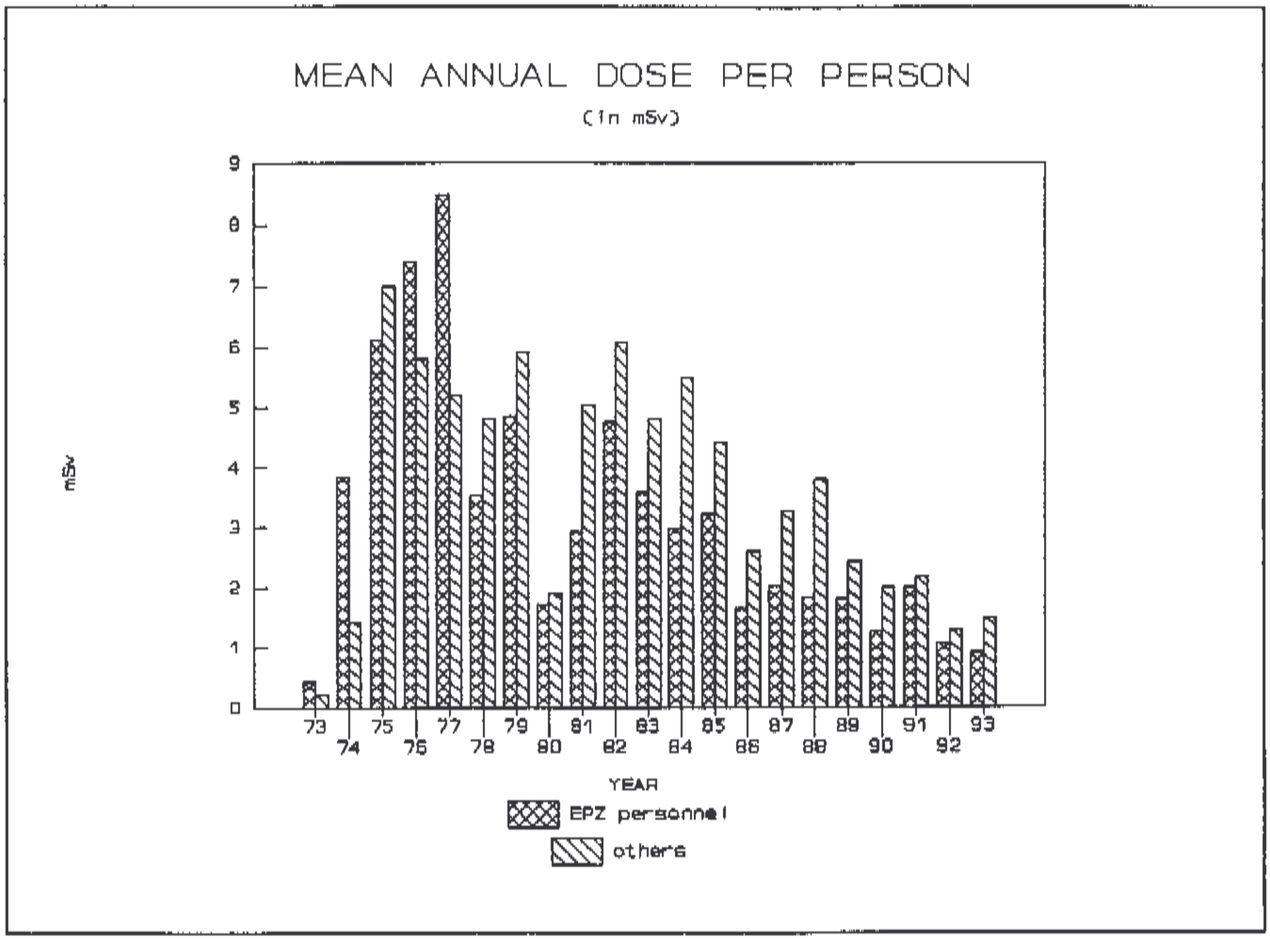
The received collective radiation dose is given below and differs strongly from year to year.
In 1980 the KCB reached the lowest yearly dose (482 mSv) whereas in 1982 the highest yearly dose was registered.

Figure 2: Annual dose



It is of course clear that the amount of work in the installation and the prevailing radiation levels influence directly the collective dose. The dose received during the outage periods amounts as an average over the last 10 years to 80% of the yearly dose.
From the figures it can be seen that in general 80% of the yearly dose is received by contractors (non KCB personnel).
But it cannot be concluded for that matter that the mean individual dose received by others than plant personnel must therefore be higher.
The mean individual yearly dose is given in figure 3.

Figure 3: Mean annual dose per person



From this figure can be derived that over the last years the mean individual yearly dose for KCB personnel is about 2 mSv and for other personnel 2-4 mSv. It should be mentioned that the given dose for outside personnel is only the dose received in Borssele.
The maintenance department and the radwaste department have the highes mean individual yearly dose.

The KCB uses besides the regulatory dose limits the following self-imposed dose limits; these limits are laid down in procedures and are valid for a radiological worker catagory A:

- daily dose : max. 1 mSv
- with permission of the radiation protection department : max. 4 mSv
- in specific situations : max. 10 mSv
- yearly dose (calender year) : max. 15 mSv.

Besides the above mentioned limits KCB has the objective to limit the dose which a radiological worker catagory A receives as an average during a number of years to maximally 10 mSv per year.
As far as the collective yearly dose is concerned the goal is to receive less than 1000 mSv during a normal year of operation.

RELEASES OF RADIOACTIVITY

The discharge of gaseous and liquid radioactive substances has always been far below the licensed limits. For noble gases and I-131 it is given in figures 4 and 5.

Figure 4: Release of noble gases through ventilation stack

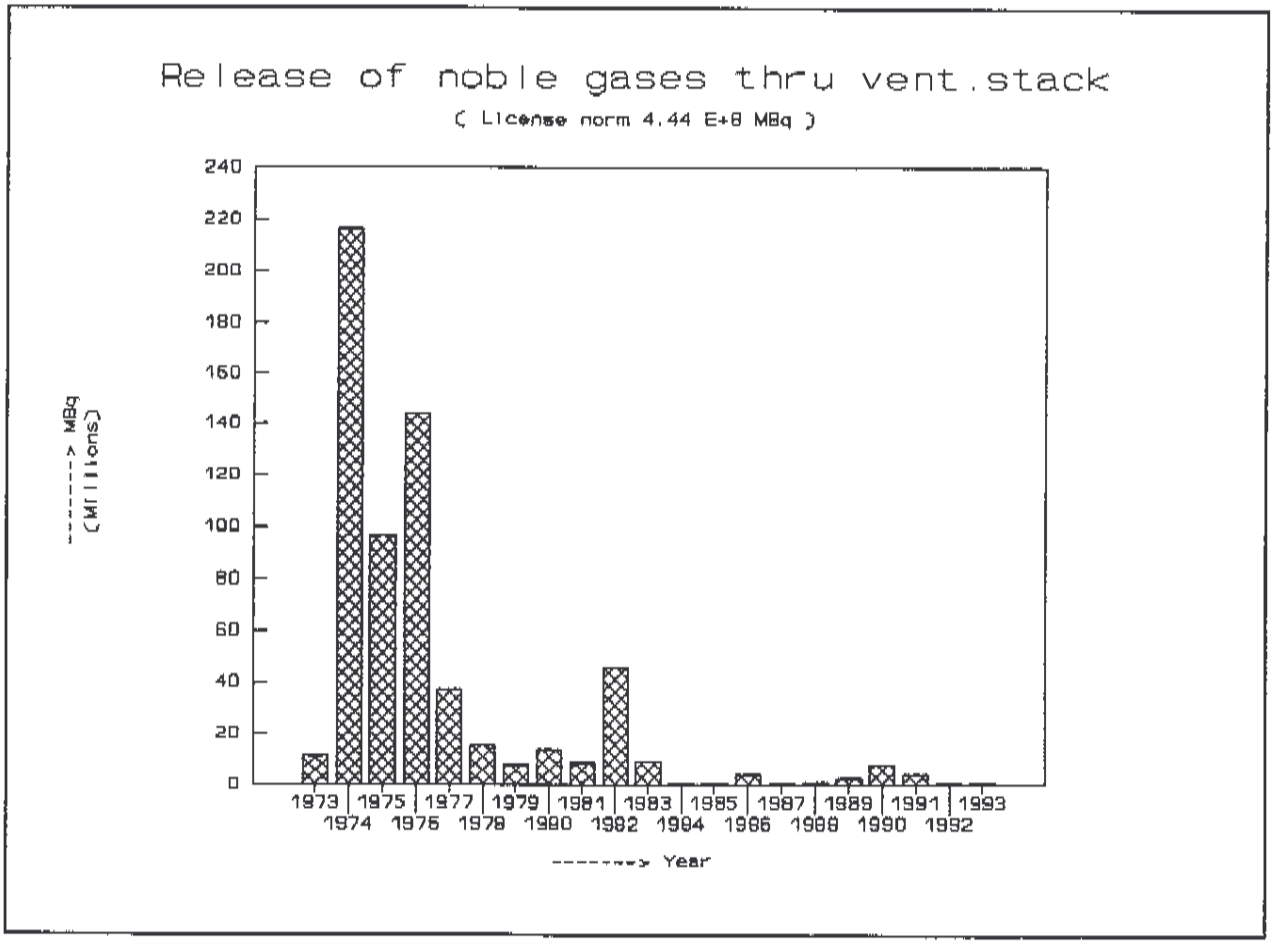
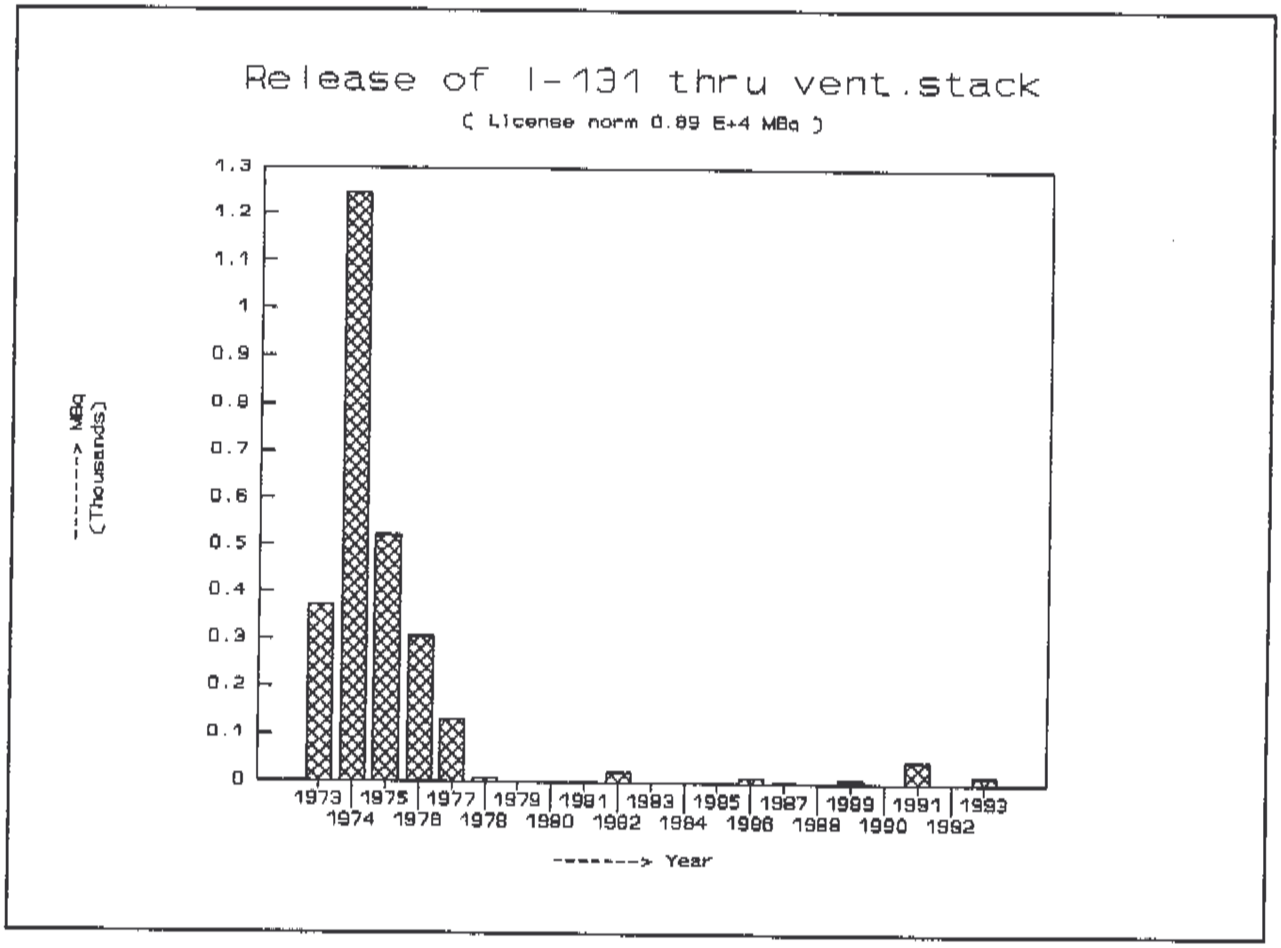


Figure 5: Release of I-131 through ventilation stack



During the first years the release of noble gases and ^{131}I (Iodine) were substantially higher than during the last years.
These higher releases were caused directly by defective fuel elements.

ALARA

In 1977 ICRP 26 came into force, herein the basic principles, justification, optimization and limitation regarding working with radioactivity were clearly established.
At the nuclear power plant Borssele the ALARA principle, also a result of the adoption of ICRP 26, has been put into practice since many years. In 1988 an ALARA committee had been set up. The object of this committee is to advise the management about measures which have to be taken to lower the dose on the basis of the ALARA principle.
The members of the ALARA committee have their own specific expertise and also the most important and involved departments are represented by them.
For a couple of years ALARA procedures are used. In these it is described how one should act to ensure that ALARA is sufficiently applied.
At the moment two ALARA procedures have been developed, one procedure in connection with modification of the installation and one procedure in relation to maintenance.

The following subjects are treated in these procedures:

- justification of the work,
- assessment of alternative solutions,
- influence on the dose
- selection of the optimal solution from the ALARA point of view,
- drawing up an ALARA report.

The implementation of these procedures (within the QA, quality assurance, regime) is laborious and takes a lot of time.

In these procedures a guideline is also given on how to express radiation dose in terms of a financial value. At KCB, a value of 1 million Dutch florin per Sievert is used.

Author Biography

Co Abrahamse is Head of the Department Nuclear Control and is the Health Physicist of the Nuclear Power Plant Borssele. Previously, he was Leader of the Department Radiation Protection, Chemistry, Radioactive Waste and Reactorphysics. He has studied chemistry and is a registered Health Physicist.

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