The role of ALARA in management decisions.

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1. Introduction

Many health physicists see ALARA as the main instrument in radiation protection. However, management decisions mostly are based on arguments in which ALARA has no or at most a very limited part. In the execution of management decisions, the ALARA principle is practised much more. The above given statement will be illustrated by two examples from the history of KEMA in Arnhem, the Netherlands.

In the fifties of the past century, KEMA (the research institute of the Netherlands electricity companies) started a nuclear research program. At that time, a variety of power plant concepts has been investigated. At KEMA a suspension test reactor was developed and operated. It was a 1MWth reactor in which a suspension (5 _m spheres) of a mixed oxide (UO_2 / ThO_2) in light water was circulated in a closed loop through a sphere-shaped core vessel.

In the initial phase, the research was focussed on the production of the fission spheres and the management of suspension flows. Inevitably, significant amounts of radioactive waste were produced. At that time, in the Netherlands there were neither regulations nor an organisation for the collection and storage of radioactive waste. Therefore, it was decided to bury the waste at the KEMA premises, which practice was stopped in the early seventies. In the late seventies the waste site got a lot of local and national public and political attention. This resulted in the decision to dig up the waste, which has been performed in 1982. The decision making process as well as the actual execution of the project will be discussed with special attention to the role of the ALARA principle

Immediately after the shut down of the suspension test reactor the nuclear fuel was removed and transported to ORNL in the USA. Directly, the preparation for the decommissioning of the reactor installation itself has been started. The decommissioning of the reactor installation has been finished in 1991. In the recent years the remaining structures, with activated and contaminated construction materials (mainly steel and concrete), has been demolished up to green meadow. So, the decommissioning of the KSTR was performed in two distinct periods with an intermediate period of about 10 years. Evidently, the philosophies and regulations with respect to radiation protection and waste management differed significantly for both periods. Evidently, during both periods also ALARA was practiced differently, as will be illustrated.

In chapter 2 is dealt with the remediation of the waste disposal site (reference 1). The project is described and the role of ALARA in the (management) decision making process as well as in actual execution of the project are discussed. In chapter 3 the same aspects are discussed for the decommissioning of the KSTR (reference 2).

2. Remediation of the KEMA waste disposal site

2.1 History

The nuclear research program at KEMA started in de mid fifties of the last century. In the first decades the program was focussed on the development of a reactor concept in which the nuclear fuel is a suspension of small UO_2/ThO_2 particles in water. In the experimental work in the early days mainly natural uranium and natural thorium was used. At that time in the Netherlands there were no regulations with respect to radioactive waste nor there was an organisation for the collection and disposal of radioactive waste. Nevertheless, it was felt that the radioactive waste should be treated different from the normal laboratory waste. It was decided to bury the waste on the KEMA premises. In totally an amount of 70 m^3 waste was buried in the period from 1957 until 1972. The waste was buried in about 20 different holes with a maximum depth of about 2 m in an area of about 1000 m^2. The area was located nearby a busy street (distance about 20 m) and also very close to a housing estate (distance less than 100 m). Furthermore, it must be remarked that at that time the KEMA premises were accessible for members of the public. It was a playground for children from the neighbourhood and the roads were used as short cut. Even, some employees lived with their families on the KEMA premises.

In the end of the seventies of the last century the site got nation-wide a lot of attention. The attention was caused by a possible relation which was seen between the site and the cancer of a young man. He lived on the KEMA premises during the burying period and said that he had played with waste material from the holes which were not covered yet. This case was subject of a nationwide television program, which caused a lot of commotion. The government started an investigation and early 1980 the results were reported to the parliament. In the report was stated that with respect to radiation risks there was no objection against the burial site, but on the other hand the governmental policy was to remove or modify dump sites which did not fulfil the environmental standards of that time. In view of this policy and considering possible future developments at the KEMA premises, the minister wanted the removal of burial site. The KEMA agreed to remove the site, however with the strict condition that the government would assure that the waste could be removed permanently from the KEMA premises. This condition was not so easy to fulfil by the government. At that time in The Netherlands there was no radioactive waste deposit with enough capacity and up to than, low level and medium level radioactive waste used to be dumped in the Atlantic ocean. The latter activity was strongly criticized by environmental pressure groups. Ultimately, end 1981 KEMA got the assurance that the waste could be removed. In the first half of 1982 digging up of the waste was done and it was subsequently removed with the very last dumping of radioactive waste in the Atlantic ocean by the Netherlands.

2.2 The digging up operation

The position of the dump holes was only roughly known from a drawing made during the burying period by an involved radiation protection technician. The first step was a more accurate localisation of the holes, which was done by means of ground core samples.

Three kinds of waste had to be dealt with:

- the actually buried waste
- soil
- trees and tree trunks

The soil around the holes could be contaminated. But, because the waste mainly contained natural uranium and natural thorium, criteria had to be set for the allowable natural activity in the soil. Therefore, on the Kema premises the natural activity in a lot of ground samples was measured. The highest level found (0,22 _Bq/g) was defined as the level above soil was considered as being radioactively contaminated. This soil was cemented and dumped in 200 l steel drums.

In totally 1344 waste drums of 90 litre were filled with waste. About 1400 m^3 soil had to be removed of which 38 m^3 had an activity above 0,22 _Bq/g and was therefore considered to be contaminated. All trees and tree trunks were controlled and none of them appeared to be contaminated.

2.3 Radiation protection

The basic principles applied were:

- There should be no dispersion of radioactivity in the surrounding environment
- Dose of the workers should be as low as reasonably achievable

To fulfil the first principle, the digging up took place in an closed installation which was kept below atmospheric pressure by means of filtered ventilation. The installation was replaced regularly during the progress of the project by means of rails. In the surroundings the airborne radioactivity was sampled continuously on seven locations. No elevated levels have been found.

The external radiation levels of the waste were expected to be low. Therefore, no protection measures for external radiation were taken, apart from a continuous monitoring of the radiation field. The workers were provided with filmbadges (measures every two weeks) and TLD’s (measured every day). The total collective dose was 0,35 mSv with an individual maximum of 0,05 mSv.

The main concern was to avoid internal contaminations. This was achieved by strong ventilation of the working area and the application of good protective clothing provided with a closed helmet in which continuously filtered air was blown by means of an electric pump on a belt around the waist. Furthermore, the air in the working area was controlled and the workers were controlled by means of total body counting and the analysis of urine samples. No indications of any internal contamination have been found.

The conclusion of the radiation protection program is that a lot of effort and a lot of money has been spent to minimize radiation exposure of the workers and the environment. In fact more ALATA (as low as technically achievable) than ALARA was applied. Anyhow, the ‘social factors’ in the definition of ALARA were leading. Surely this was justified because of the large public attention for the project, specially from the people living very nearby. Furthermore, it had to be considered that most of the workers, especially the diggers, had a total lack of experience with radiological work.

2.4 Information to the public

Very much attention has been given to the information of the public. The following means have been applied:

- three info magazines
- an ‘open day’ for the neighbours

- a weekly bulletin
- an info telephone line
- an information stand at the waste site
- an information video of the total operation

As a result, the project could be done in good harmony with the neighbours, there were no problems with the general public nor pressure groups and up till now there has been no noticeable public attention anymore.

2.5 Discussion

The total costs of the project have been about 5 million Euro (price level 2003). The resulting radiation exposures of the environment as well as the workers were totally insignificant. This was achieved by applying ALATA or ALARA with a leading role for the social aspects.

In the argumentation of the government to insist on the execution of the project as well as in the argumentation of the KEMA management to do so, radiation exposure played no role at all. Nevertheless, the general feeling is in support of the decision taken than to dig up the waste.

3. The decommissioning of the KSTR

3.1 History

The KEMA Suspension Test Reactor (KSTR) was developed, built and successfully operated in the sixties and seventies of the last century (reference 3). It was a 1MWth reactor in which a suspension (5 _m spheres) of mixed UO_2 / ThO_2 in light water was circulated in a closed loop through a sphere-shaped vessel. The thorium was added to the fuel to breed fissionable ^{233}U.

Immediately after the shut down of the reactor, the nuclear fuel has been removed and transported to ORNL (USA). Directly thereafter, the preparation for the decommissioning of the reactor was started. In 1991 this decommissioning has been finished. The reactor compartments were left in tact. These compartments, in which separated subsystems (reactor vessel, heat exchanger, gas purification, etc.) had been located, were separated from each other by one to two meter thick concrete walls with a 8 mm steel lining. The internal contaminated pipe connections between the subsystems, which were embedded in the concrete walls, remained.

After that, the building was used for other radiological work. But, gradually the amount of nuclear work reduced and was stopped totally in the mid nineties. Therefore, it was decided to demolish the remaining building to green meadow. Early 2003 this project has been finished. So, the decommissioning of the KSTR was performed in two distinct periods with an intermediate period of about 10 years. Evidently, the philosophies and regulations with respect to radiation protection and waste management differed significantly for both periods. Subsequently, the approaches of the decommissioning problem in both periods differ significantly as well.

3.2. The decommissioning of the reactor installation

The installation was a complicated structure of 6 interconnected subsystems. The dimensions of the pipes were rather small (diameters ranged 3/6 to 76/84 mm). Due to the fact that the fuel suspension was circulated through the system, the components were contaminated with fission products. Based on measurements, it was estimated that after removal of all the residual suspension from the system, in totally on the internal surfaces the following activities were absorbed: 20-60x10^8 Bq ^{144}Ce; 2-5x10^8 Bq ^{106}Ru; 2-14x10^8 Bq ^{137}Cs; and 2-20x10^8 Bq ^{90}Sr. Besides this contamination, also ^{60}Co was produced by neutron activation. Evidently, the reactor vessel was most activated (8 x 10^8 Bq $\simeq$5 x 10^6Bq/g).In two compartments with the most contaminated and activated components, the dose rates were significant (several mSv/hr) while in the other compartments the dose rates were much lower (<0,1 mSv/hr).

In the eighties of the last century, there was only very limited experience with the decommissioning of nuclear systems. At that time, the electricity companies in the Netherlands were convinced that nuclear power had to be applied in the future. Therefore, the decision was taken to consider the dismantling of the installation as a research and demonstration project, in spite of the fact that the KSTR itself as well as the decommission aspects had no similarities with normal light water reactors al all.

The demonstration and research character of the project did implement:

- a thorough supervision by an internal committee and an external committee with 5 governmental officials
- intensive radiation protection measures with much attention to ALARA and a challenging target for the cumulative dose (200 mSv)
- The development or modification of a variety of segmentation techniques for remote handling.

The total project took more than 10 years in which 100 menyear manpower was spent. The total costs were 10 million Euro (2003 price level) of which 90% were personnel costs. The cumulative dose was 115 mSv, being well below the target (200 mSv). It was concluded than, that the low cumulative dose was the result of a strict application of ALARA. However, ALARA implies a consideration of the financial costs corresponding to achievable dose reductions. Now, it must be concluded that the driving force has not been ALARA but the will to demonstrate that the decommissioning of a nuclear installation can be done with a low cumulative dose.

3.3 Demolition of the building to green meadow

At the end of the last century, all nuclear activities at KEMA were stopped. So, there was no need anymore for the remaining facilities of the KSTR. Furthermore, it became a policy of KEMA to develop the premises as a business park with accommodations for other (high tech) companies. Some candidate companies were somewhat reluctant because of the presence of the ‘reactor facilities’. Therefore, it was decided to demolish the reactor building to green meadow. The electricity companies in the Netherlands were not interested in the project nor they were prepared to support it financially. So, the job had to be done as quick as possible and as economically as possible. Of course, all legal regulation should be obeyed.

All infrastructures (ventilation system, water cleaning and release system, etc) were still in tact and most probably internally contaminated. The steel in the wall (lining and reinforcement steel) of the reactor vessel-containment was activated. In the walls between the containments significantly contaminated pipes (former interconnections between the subsystems) were embedded in the very high quality concrete over long distances (up to ten meters). Furthermore, on several locations on walls and floors significant contaminations, immobilized by a coating, were present. The radiation dose rates were generally low.

The project was done as efficient as possible. To advice the KEMA management there was only a small advisory committee. Working procedures and periodical reports were send to the governmental authorities. The goal was to prepare as much material as possible for reuse or unrestricted release, based on strict cost benefit considerations and the recent European (reference 4) and Netherlands regulations (reference 5). No dose targets were set, but ALARA was embedded in the working procedures. The working procedures were made in cooperation with the workers. Only on the market available demolition techniques were used. Much demolition work was done manually. For radiation protection standard means were applied. Weekly, a progress meeting took place in which working procedures were discussed with special attention to the radiation aspects. When needed working procedures were added or modified. In this way, ALARA was embedded in the working procedures as a result of an effort of the total team.

The project took a period of 4 years. The total costs were about 3 million (2003) Euros. About 1650 tons of material has been removed (0,5 % radioactive waste; 0,5 % conventional waste; 99 % for reuse purposes). About 20 tons lightly activated scrap (^{60}Co levels between 0,01 and 1 Bq/g) has been deposited on a conventional waste dump site. In fact, the scrap below 1 Bq/g is no radioactive waste. But, it is not accepted by the recycling industry (it is detected by the entrance monitors). About 20 tons of crap with more than 1 Bq per gram ^{60}Co will be remelted and temporarily stored until the level of 1 Bq per gram is reached. The total collective dose was 2,5 mSv. No internal contaminations occurred. After an intensive radiological survey, using smear tests, _-spectrometry and surface contamination monitoring, the building could be released for final demolition.

3.4 Discussion

The decommissioning of the KSTR has been completed in two periods with a significant intermediate time interval. In the decisions of the management to perform the projects in both cases ALARA was not involved. On the other hand, the interpretation and actual application of ALARA were strongly affected by the argumentation underlying the management decisions.

The management goal of the first project (the demolition of the reactor installation) was to demonstrate that a nuclear installation can be demolished with reasonable doses for the workers. ALARA was allowed to cost some money, which makes the application tend to ALATA.

The management goal of the second (green meadow) project was to remove as economically as possible the last ‘nuclear residue’ from the premises in order to stimulate the development of it as an open business park. The financial constraints forced the real application of ALARA, with a thorough balancing of achievable dose reductions against the financial costs.

4. Conclusions

In management decision processes ALARA mostly is not involved. This because of the fact that in those decisions many aspects have to be taken into account which are hard to quantify, such as future economic and political developments, public relations etc.

The application of ALARA in the execution of projects is strongly influenced by the argument of the management to execute the project. In case the management support is strong, resulting in a ‘sufficient’ financial budget, the application of ALARA easily tends to ALATA. Strict financial constraints forces to the real application of ALARA, involving the balancing of dose reduction against corresponding financial costs.

In case a project is subject to strong public and/or political concern, the application of ALARA also tends to ALATA or it can be said that the social factors become leading.

5. References

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