MEASURING METHODS FOR THE FREE RELEASE OF STEEL AND OTHER MATERIAL FROM NUCLEAR POWER PLANTS AS NON-RADIOACTIVE MATERIAL

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ABSTRACT

To reduce the amount of radioactive waste you have to measure the radioactivity and to compare it with the limits given by the authorities:

- Surface activity with a limit of 0.37 Bq/cm^2.
- Mass-specific activity with a limit of 0.1 Bq/g for unrestricted re-lease and 1 Bq/g for controlled release.

The measurements therefore have to be made in two steps. The surface-activity is a ß-measurement over a 100% of the surface to avoid hot spots and the mass-specific activity is only a spot check gamma-measurement at a place of higher surface-activity within a charge of the same material.

The measurements of the mass-specific activity with a germanium-counter are no problem, because they are spot checked and you can spend much time for the single measurements.

But during the decommissioning of nuclear power plants when thousands of tons of steel must be measured it takes too much time to use normal methods. In this paper is reported about the possibilities to minimize time. Several methods are used for the measurements of the surface activity:

- analogue measurements
- digital measurements with computer evaluation
- total-gamma-measurements

INTRODUCTION

The nuclear power plant KRB-A in Gundremmingen was the first commercial power plant in Germany with an electric power of 250 MW. It was constructed by the GE in cooperation with the German AEG from 1962 till 1966 and started operation in November 1966. After 11 years of operation with best availability of more than 85% it was shut down after an accident in January 1977 and due to the costs of backfitting the owners decided the decommissioning of the plant. The license for decommissioning was given in May 1983 by the authorities and since then many investigations in technics for decommissioning, decontamination and measuring methods for the free release of radioactive material, have taken place. Also our authorities have got a lot of experience in regulating limits for the free release of radioactive material, which results in the recommendations of the German radioprotection commission (SSK) (1).

If you have only a few masses of rebuilt material like during the revision of a plant there is no problem of handling this material as radioactive waste and store it in a final or intermediate storage. But in our plant where several thousand tons of steel, concrete and other material have to be rebuilt, the main aim is to reduce the radioactive waste, because the planned final storage for radioactive waste is not yet available and the available intermediate storage doesn't accept decommissioning waste. This means that we have to try to release the material unrestricted, i.e. the activity is below 0.1 Bq/g, or we have to recycle the material into the nuclear industry, i.e. the activity must be below 1.0 Bq/g. If the activity exceeds 1.0 Bq/g the only possible way is the final storage as radioactive waste.

In Fig. 1 the possibilities of handling material from controlled areas of nuclear power plants are shown . The marked way is preferred by our atomic law (2).

LIMITS FOR FREE RELEASE

First of all you have to look for the limits of free release given by the authorities. There are two values which are to be measured: the surface contamination over a 100% of the surface and the mass-specific activity measured as spot check at a place of maximum surface contamination.

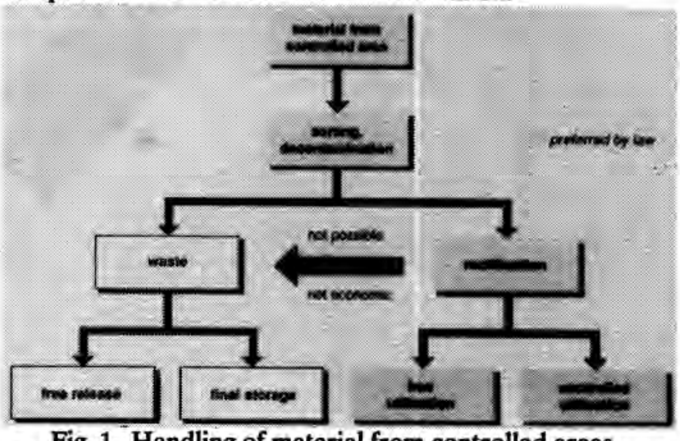

Fig. 1. Handling of material from controlled areas.

In Fig. 2 the limits are listed: You can see that the values for KRB are reduced by 40%. The reason is the following: there are nuclides which can't be measured with normal methods and the recommendation of the radiation protection commission says that we have to measure all nuclides, because the free release values are the sum over all nuclides. For example: if we make a gamma-measurement with a germanium detector we can't see Sr-90 because there is no gamma-radiation or if we measure betas with a gasfilled large surface detector we can't see Ni-63 due to the very low ß-energy. Therefore, in both methods we only measure the so called key-nuclides like

	free release		controlled release (recycling)	
	law	KRB	law	KRB
surface contamination (Bq / cm²)	0,37	0,22	0,37	0,37
mass specific activity (Bq / g)	0,1	0,06	1	0,6

Fig. 2. Limits for free release and recycling.

Co-60 or Cs-137, which are easy detectable, and in reducing the limits we include all the other nuclides.

MEASURING METHODS FOR FREE RELEASE

Mass-Specific Activity

To evaluate the mass specific activity only one measurement as spot check within a charge of similar material is necessary. Therefore it is possible to spend much time for a gamma specific measurement. For example: you can reach a detection limit of 0.002 Bq/g with a measuring time of about 2 hours.

Although we only measure the mass specific activity by spot check we have a way to survey this value by measuring the surface activity. The connection between mass and surface activity depends on the thickness of the material. As first step we assume that the total activity is on the surface. If the limit of 0.22 Bq/cm^2 is not exceeded we believe that this activity is spread homogeneously over the whole material. This means the specific activity is low if the material is thick and - vice versa - the activity is large if the material is thin. This relation is shown in Fig. 3.

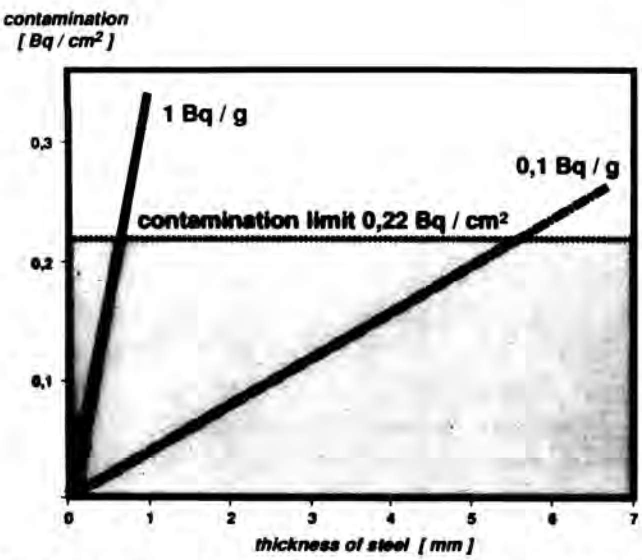

Fig. 3. Interdependence of massactivity and contamination.

Surface Activity

The main problem is the measurement of the surface activity. For the detection of the surface activity with a commercial gasfilled large surface detector you need a lot of time because you have to measure the total surface. In Germany it is required that a 100% of the surface must be free of contamination (3). In a first attempt after the beginning of the decommissioning we needed about one man-year for measuring only 100 tons of steel. If you compare this time with the sum of all other works (cutting, transport and decontamination) of also one man-year you can imagine that the normal measuring methods are too expensive. So, we had to find a new method. In the next chapter the new method is described.

Using a commercial gasfilled large surface counter with analogue electronics containing a circuit with resistor and capacity you have a time constant τ) of normally 10 sec. That means you need 3τ) for each measuring point and you have to wait 3τ) after a measurement in order to avoid pile up effects. So, every point takes one minute which is too much. Reducing the time constant to 5 sec the needle oscillation is too great so that you can't read any value. This is not the way to reduce time.

The idea then was to count the pulses, to multiply them with a calibration factor and to compare the result with a given value. The equipment is shown in Fig. 4. All pulses are lead to a programmable digital pulse counter which gives an alarm (horn signal and red lamp) if the limit is exceeded. If not, a green lamp shows that the next point can be measured.

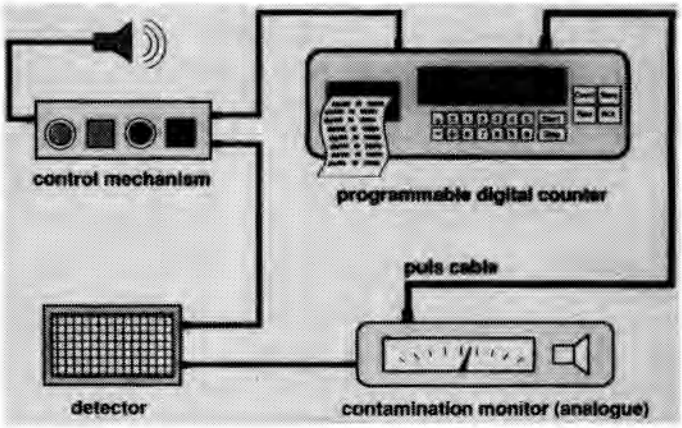

Fig. 4. Equipment for digital measurements.

The principle of the mathematical method is described as example in Fig. 5.

There are two statistical distributions of the underground (UG = 6 counts per second (cps)) and the contamination level of the sample (C = 13 cps) which overlap for some cps. Because the contamination may not exceed 0.22 Bq/cm^2 in case of KRB-A the alarm level (AL) of the equipment is adjusted to a value of e.g. 8 cps. This level cuts the curves into 2 areas A1 and A2 with the following meaning: Area A1 represents the part of the not detected contamination or the possible error. In agreement with the authorities the value may be 2.5 % which corresponds to a statistical safety of 2σ. On the other hand the area A2 represents the part of fictitious contamination. In reality the sample is free of contamination because A2 belongs to the statistical distribution of the underground. As we "detected" a contamination we have to decontaminate it again although it would not be necessary.

In practice we have two possibilities:

1. Our measured value is lower than AL: This means the sample is free of contamination, the next point can be measured.

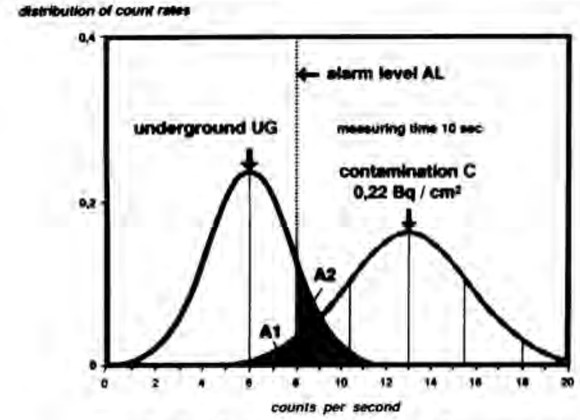

Fig. 5. Statistical distribution of count rates.

2. Our measured value is higher than AL: This means the area of fictitious contamination is marked and after finishing the measurements this part has to be decontaminated once more. After one or two attempts to decontaminate this marked area the sample is given into the waste.

At this point we have saved about 80% of time compared with the normal analogue measuring method. But this is not all. As you have stated the second point means more work and more costs. Therefore, our task is to avoid this unnecessary work by minimizing the area A2. This method is shown in Fig. 6.

In the upper part the measuring time is for example 5 sec. You have the same distribution of count rates as in Fig. 5. There are two possibilities now:

1. the measured value is lower than the alarm level: then we have no contamination, the next point can be measured.
2. the measured value exceeds the alarm level: then the measuring time is extended to 10 sec and we get better statistics. In this case the alarm level will now be 9.5 cps. The area A1 is the same as before with the same error, but A2 - the rate of fictitious contamination - is almost at zero.

Experience shows that an extension to 15 or more seconds is not needed. The mean value of measuring time is 6 sec so that we save a factor of 10 compared with the analogue measurements.

Having large sample surfaces it is possible to mount three counters on a steel sheet and to measure three areas at the same time, so that we save additional time.

Total Gamma Measurements

In many cases it is not possible to measure with the described methods because there is either no defined surface like insulating material, or the samples are too small like screws and bolts or they have a unfavorable geometry like valves. Then we have two other possibilities:

1. we measure the total gamma-activity with a plastic-scintillation-counter or
2. in case of steel we melt the material, take a sample from the molten metal and measure the gamma-specific activity.

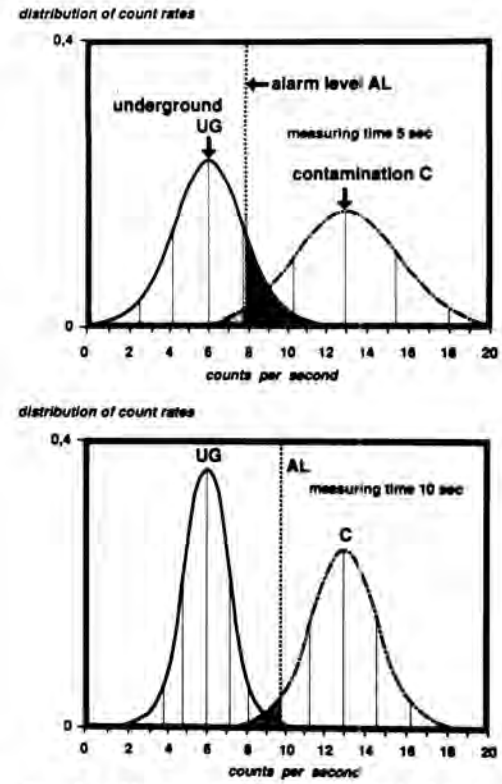

Fig. 6. Minimization of the statistical error.

Both methods are at our disposal in Germany and are used in agreement with our authorities (4).

CONCLUSION

In our plant we have great success with the free release of different material from the controlled area. So we were able, after rebuilding of 3400 tons of steel, to release about 48% without any restriction, 50% were for reutilization in the nuclear industry e.g. for shieldings, and only 2% were waste stored in the reactor building. For concrete, insulation material and other we were able to release from 660 tons about 91% unrestricted and only 9% were given into the waste. The measurement equipment is commercial standard but the computer code for evaluation of the limits is developed in our house. I don't know whether this code is available on the market.

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