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CONTAMINATION OF STEEL PRODUCED IN THE CZECH REPUBLIC BY COBALT 60

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Introduction

In recent years, the metal recycling industry has become aware of the presence of radionuclides in scrap metal. While the problem has its historical roots dated to the earlier days of radium usage, the use of radioactive materials in industrial devices, accompanied by improper disposal of those devices, has led to many cases where radioactive sources were unintentionally melted down in the course of recycling scrap. The number of reports on the discoveries of the radioactive material in recycled scrap in USA according to [1] has sharply increased in recent years. It is not clear whether this increase is attributable to the increasing surveillance by the metal cycling industry, to the increase in the amount radioactive materials entering the recycling stream, or to the combination of both.

Since the publication by Lubenau and Yusko [1], the attention paid to contamination of the produced steel and the steel scrap has increased dramatically. Many cases of radioactive sources found in steel and steel scrap have been reported recently. A comprehensive report covering probably all known cases of meltings down radioactive sources up to present time was published again by Lubenau and Yusko [2]. Cases of scrap contamination in the US and Canada are mentioned summarised in this paper too. Since the publication of [2], melting down and volatilisation a ^{137}Cs source has occurred in metallurgy facility Acinerox Plant in Algeciras, Spain at the end of May 1998 [3]. Traces of ^{137}Cs in the air aerosol were detected by many stations over Southern and Central Europe. An interesting feature of this incident was that the contamination in the plant was discovered only after the of the increase of ^{137} Cs concentration in the samples of air aerosol had been detected on many locations and after the discussion among scientists about possible source of the contamination had begun.

In the Central and Eastern Europe, there is a possibility of import of the contaminated scrap from countries of the former Soviet Union. The change from totalitarian government to the democratic one in the post-communist countries has brought the change of the legal system, which in many countries has not been finished yet. Legal gaps could be in the radiation protection regulatory system and there's also possibility that in the privatisation process the practice of the recording of the radioactive sources was not perfect. Such cases were also reported in the Czech Republic recently [4].

To gain information about the level of the contamination with radionuclides of the contemporary produced steel, a study covering time period from 1993 to 1996 was launched in the Czech

Republic. A part of the study was published earlier [5]. To compare the present findings with the previous ones, the current level of contamination of steel with ^{60}Co was compared with the results of a study performed with a different primary aim from 1983 - 1985 [6].

Review of the Czech study from the years 1983 - 1985

The aim of the study [6] was to find or produce some steel with negligible content of radionuclides, which would be suitable as a shielding material for the low-background semiconductor gamma spectrometry of samples and whole body counting.

The most important and efficient step was to avoid any contamination of steel with artificial radionuclides and also to choose the steel produced with lowest possible content of the natural radionuclides.

Altogether 31 samples were measured during the years 1983 to 1985 by a very sensitive semiconductor gamma spectrometry, for very long measuring time, in a good low-background shielding. Three samples were made of so called pre-atomic steel without ^{60}Co contamination, 11 samples came from the steel of contemporary production and 17 samples of steel came from intentional experimental melts. In the samples of old steel and the samples from aimed experimental melts, the content of ^{60}Co was not measurable. The presence of ^{60}Co was found in all steel samples of the normal contemporary production. The arithmetic mean value of the ^{60}Co specific activity, was about 0,26 Bq/kg, calculated from logarithmic-normal distribution of measured activities, with median of 0,06 Bq/kg and geometric standard deviation of 7,6. The value found is not fully representative, as the number of samples was small and 9 of them came from the same steel plant. However, as it is the only information about steel contamination in the Czechoslovakia then, we take it as the base for the comparison with the present situation.

Current study - materials and methods

Samples of steel produced in different metallurgy plants were used. The test samples were selected randomly from the production covering from 3 to 4 previous years. For each individual plant, there were selected, if possible, two sorts of produced steel, one with a high and the other with a low scrap addition to the raw metal. Samples from the production were taken on 15th of each month, if possible, or the closest possible production day before or after.

The shape of the test samples varied. The sample was usually cylinder or a prism 8 to 39 mm high. The description of detection efficiency calculation for such a sample is given in [5].

Measurements were performed by low-background semiconductor gamma spectrometry using detectors with the relative efficiency of 36%, 38% or 55%, the time of measurement of each sample was 7200 s. In the spectra of the test steel samples peaks of ^{60}Co were found only. Therefore, the calibration and the estimations of decision threshold (minimum significant activity – MSA) were focused only on ^{60}Co. To decrease statistical error, the counts under the two ^{60}Co peaks (1.17 MeV and 1.33 MeV) were summed up and evaluated together.

The resulting decision threshold (MSA) for ^{60}Co was about 0,1Bq/kg.

Results and discussion

Results of the measurement are summarised in the tables 1 to 6 and in the graphs of the logarithmic-normal distribution of the mass activity of ^{60}Co on figures 1 to 15. The results are sorted by producing plant, sort of steel, and year of production.

Arithmetic mean value of the mass activity a_m of the individual data sets were calculated from the parameters of the logarithmic-normal distribution, i.e. median and geometric standard deviation (GSD) estimated from the censored cumulative log.-norm. distribution.

According to [6], in the years 1983 to 1985 the average mass activity of ^{60}Co in the steel then, calculated from measurement of 13 samples was about 0,26 Bq/kg. The tables 2 and 3 shows that the mass activity of ^{60}Co in the contemporary steel is still very low and generally makes no problem from both the radiation protection and the commercial use point of view.

However, the cases of lost radioactive sources do occur [2,4] and if the sources were melted down into steel, it could lead in the particular case not only to great economic losses, but also to the not negligible exposure of people. The strict surveillance of the radioactive sources is the most important condition. To avoid such cases the check of the scrap or at least steel produced seems to be the useful method to prevent unnecessary bringing of the radionuclides into the environment.

Acknowledgement

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Fig. 1-15: Cumulative log.-norm. distribution of mass activity of ^{60}Co

Fig. 1: Overall (all steel-plants)

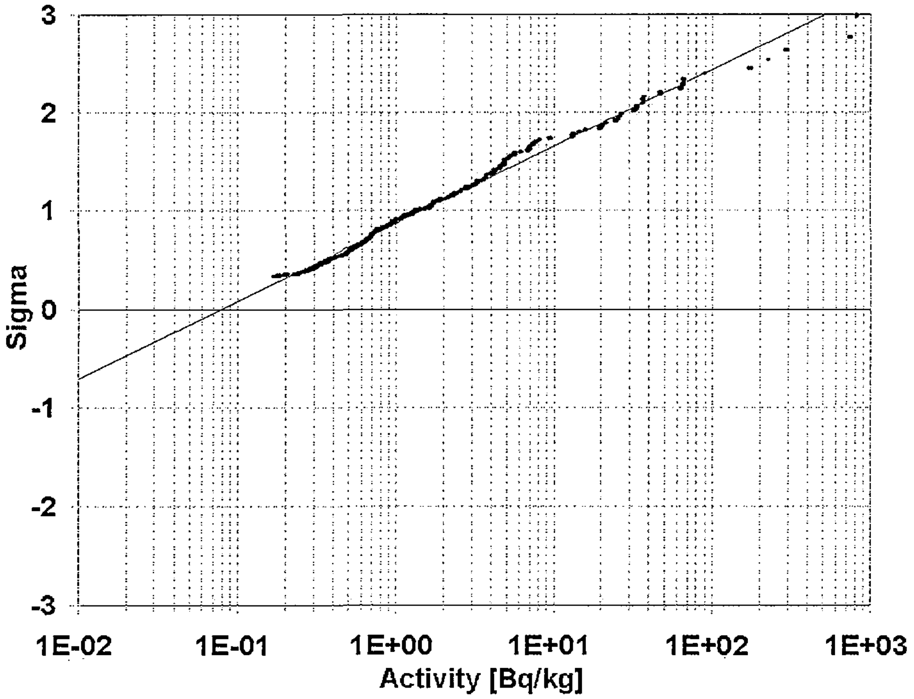

Fig. 2: Year 1993 (all steel-plants)

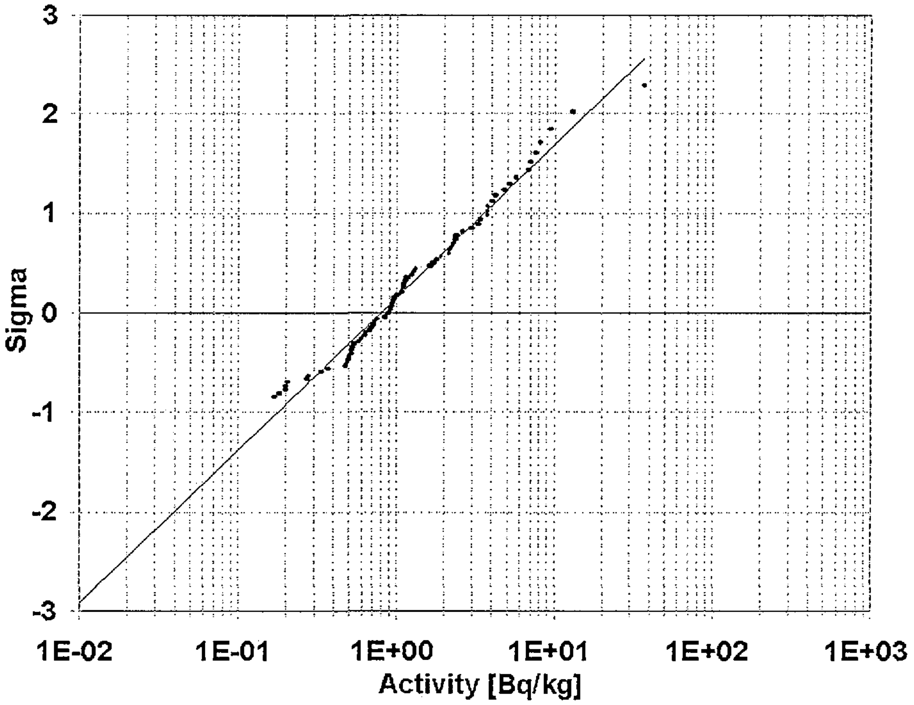

Fig. 1-15: Cumulative log.-norm. distribution of mass activity of ^{60}Co

Fig. 3: Year 1994 (all steel-plants)

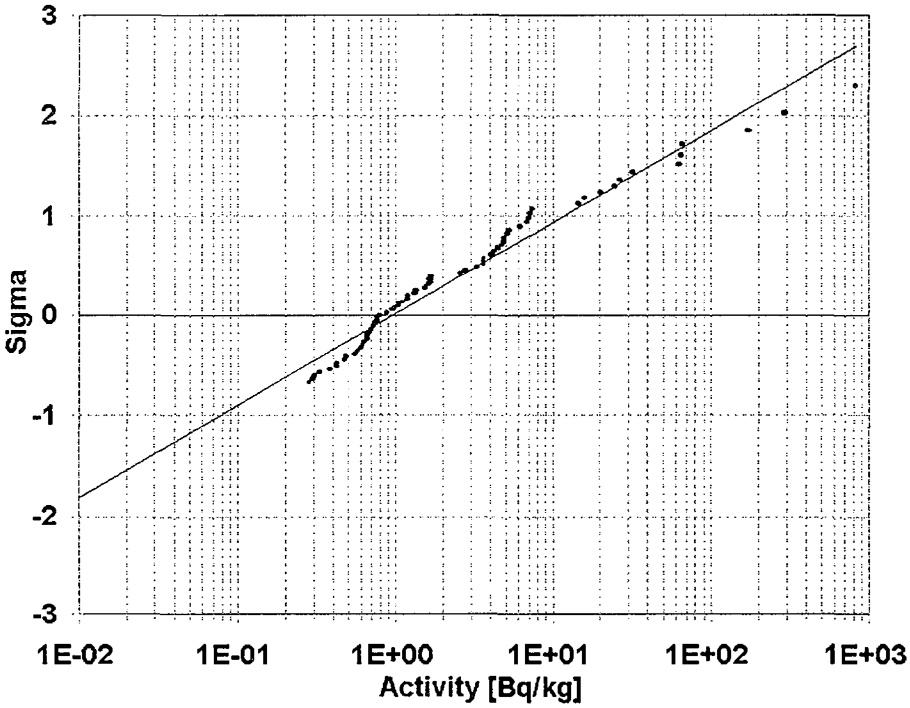

Fig. 4: Year 1995 (all steel-plants)

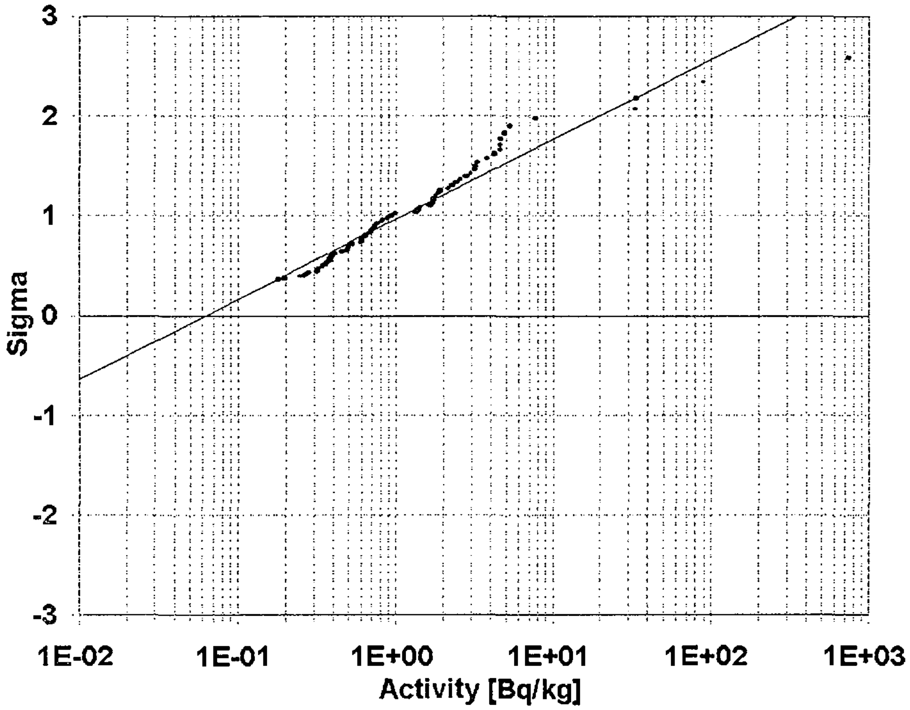

Fig. 1-15: Cumulative log.-norm. distribution of mass activity of ^{60}Co

Fig. 5: Low-alloy steel (steel-plant No.8)

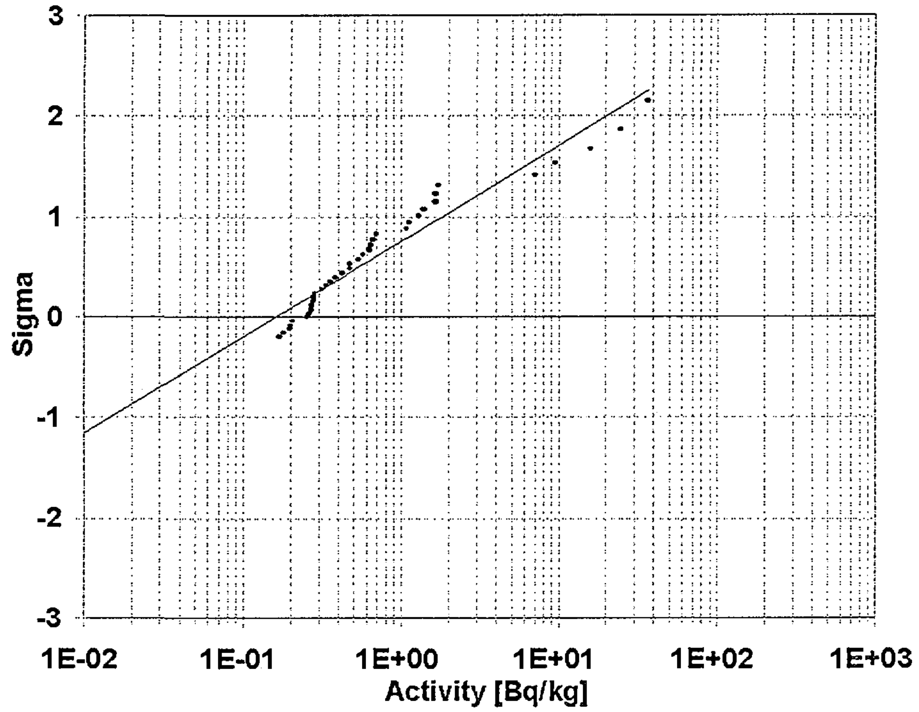

Fig. 6: Mean-alloy steel (steel-plant No.8)

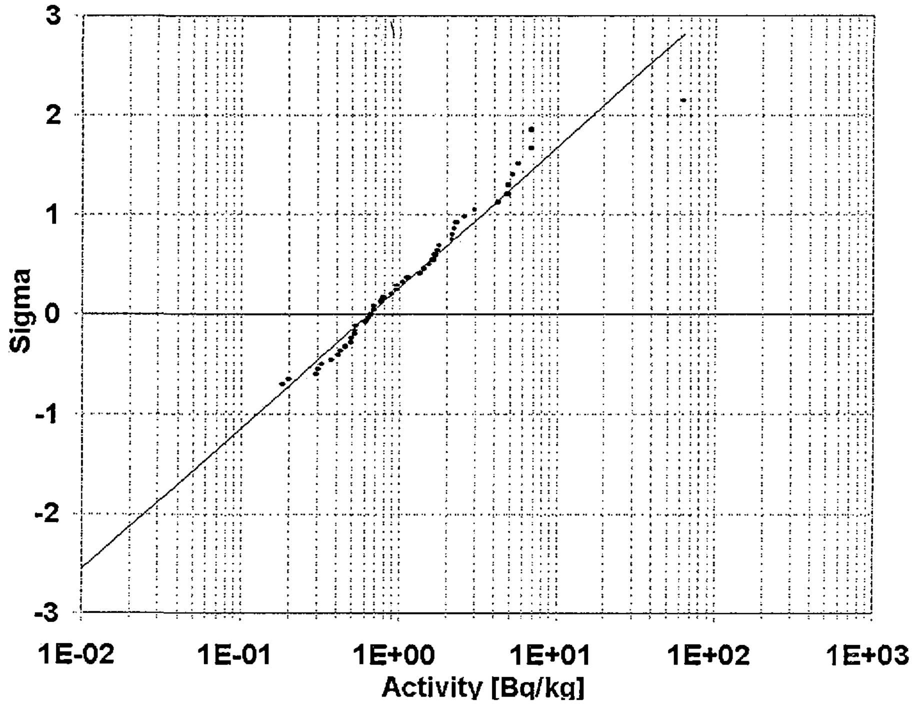

Fig. 1-15: Cumulative log.-norm. distribution of mass activity of ^{60}Co

Fig. 7: Corrosion-proof steel (steel-plant No.8)

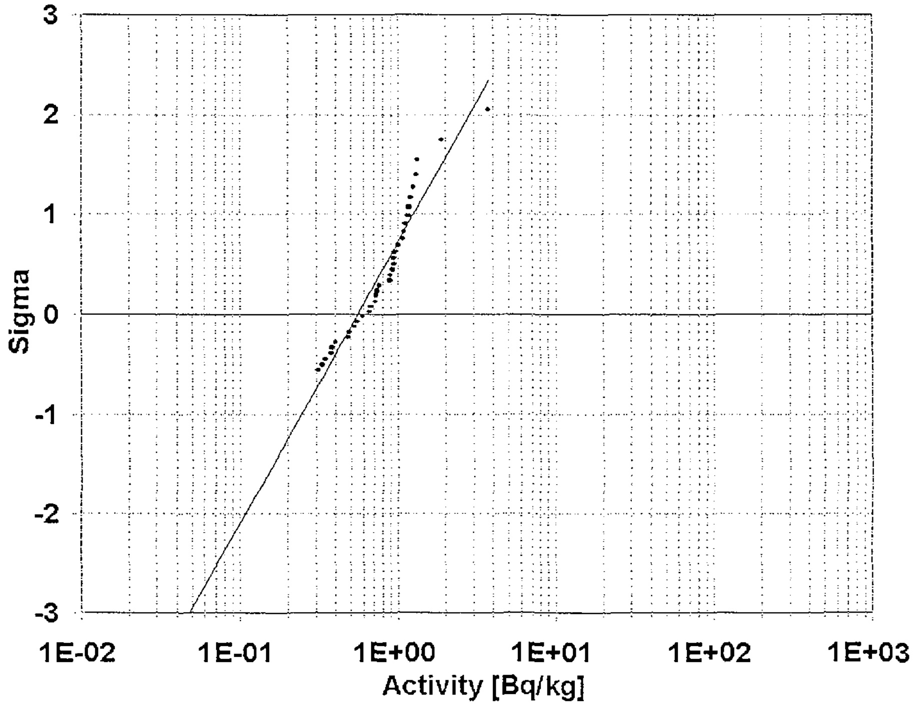

Fig. 8: High-speed steel (steel-plant No.8)

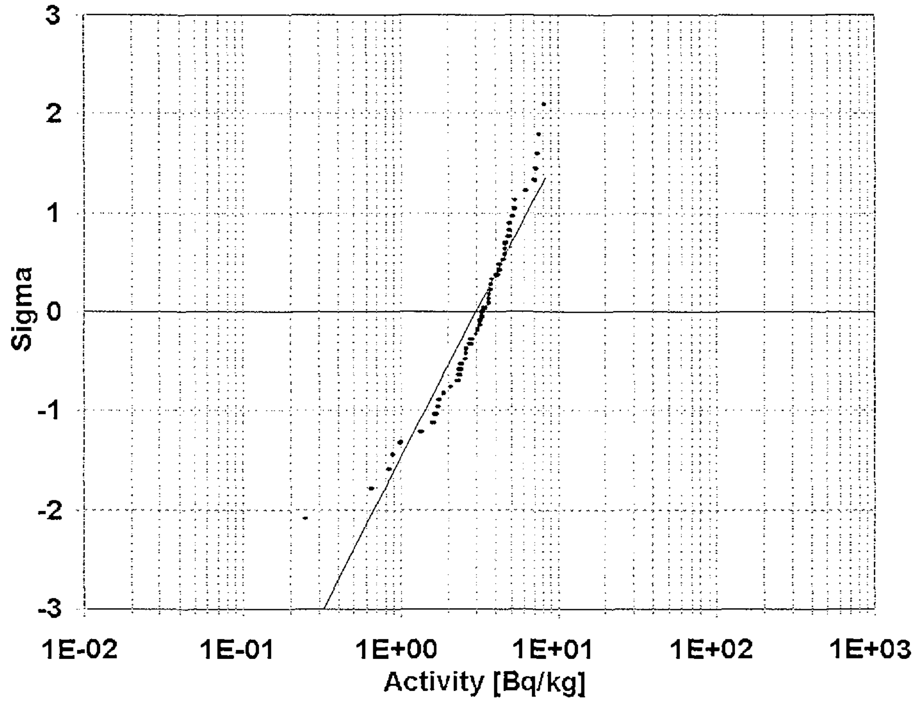

Fig. 1-15: Cumulative log.-norm. distribution of mass activity of ^{60}Co

Fig. 9: Year 1993 (steel-plant No.8)

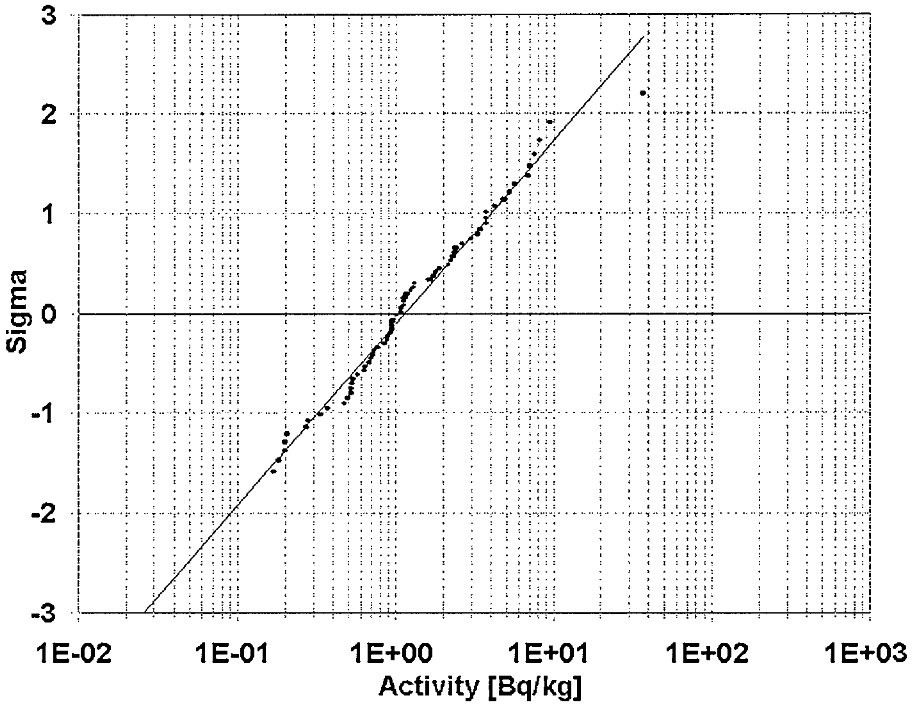

Fig. 10: Year 1994 (steel-plant No.8)

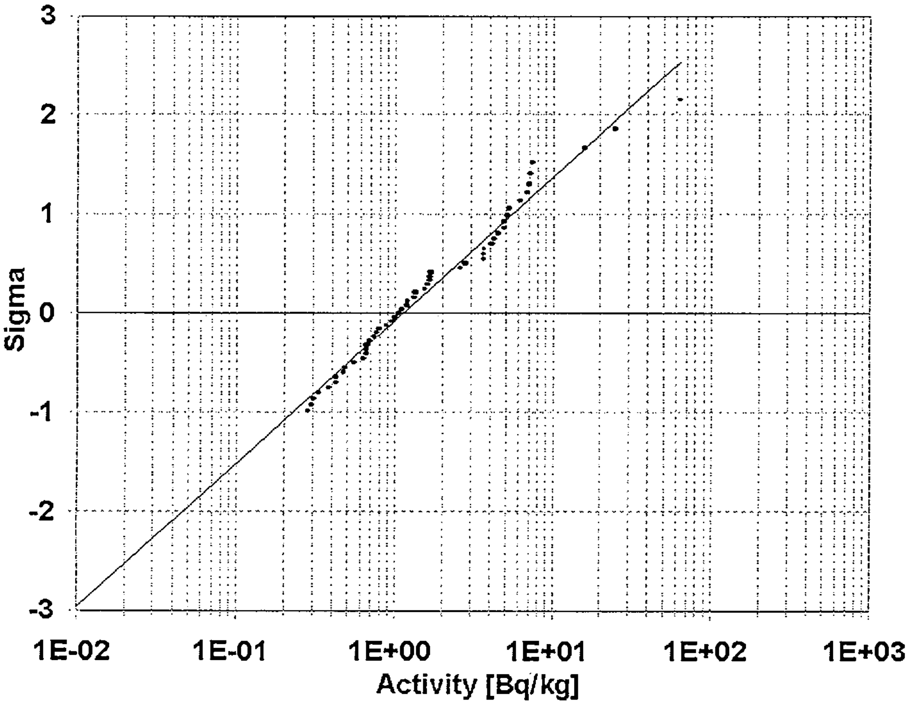

Fig. 1-15: Cumulative log.-norm. distribution of mass activity of ^{60}Co

Fig. 11: Year 1995 (steel-plant No.8)

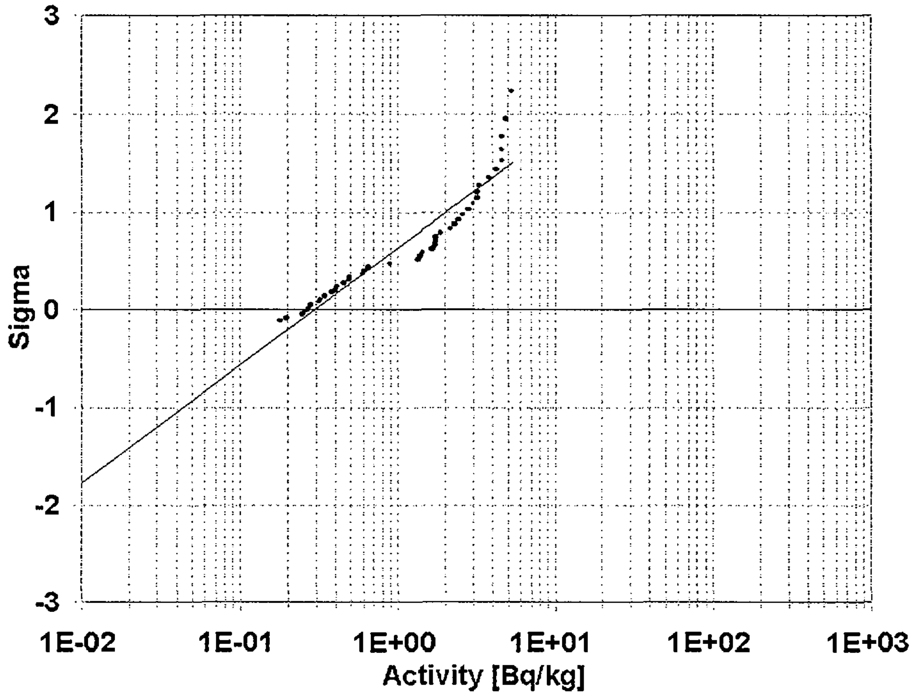

Fig. 12: Year 1996 (steel-plant No.8)

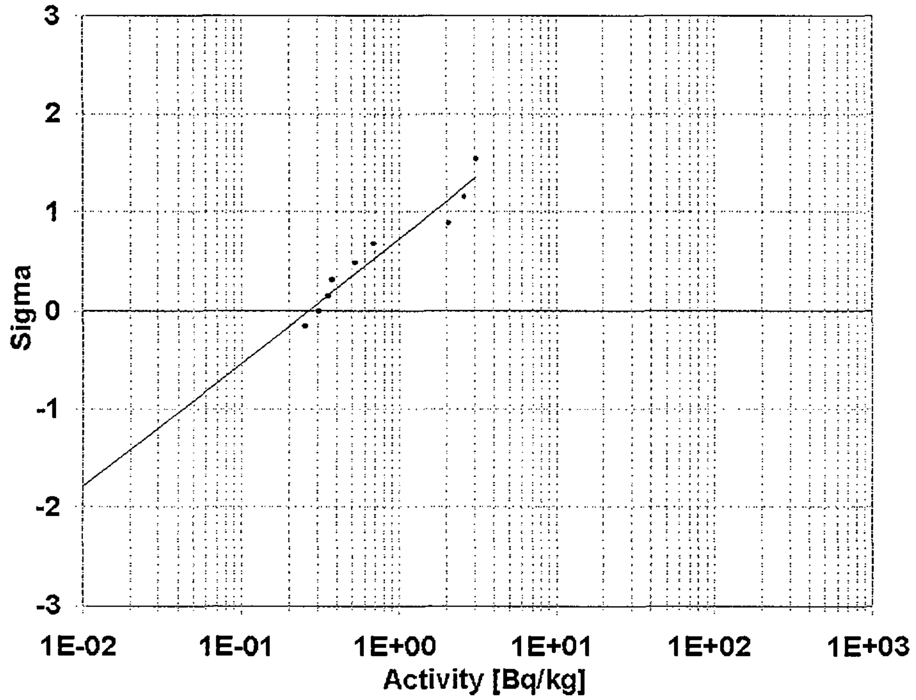

Fig. 1-15: Cumulative log.-norm. distribution of mass activity of ^{60}Co

Fig. 13: Overall (steel-plant No.8)

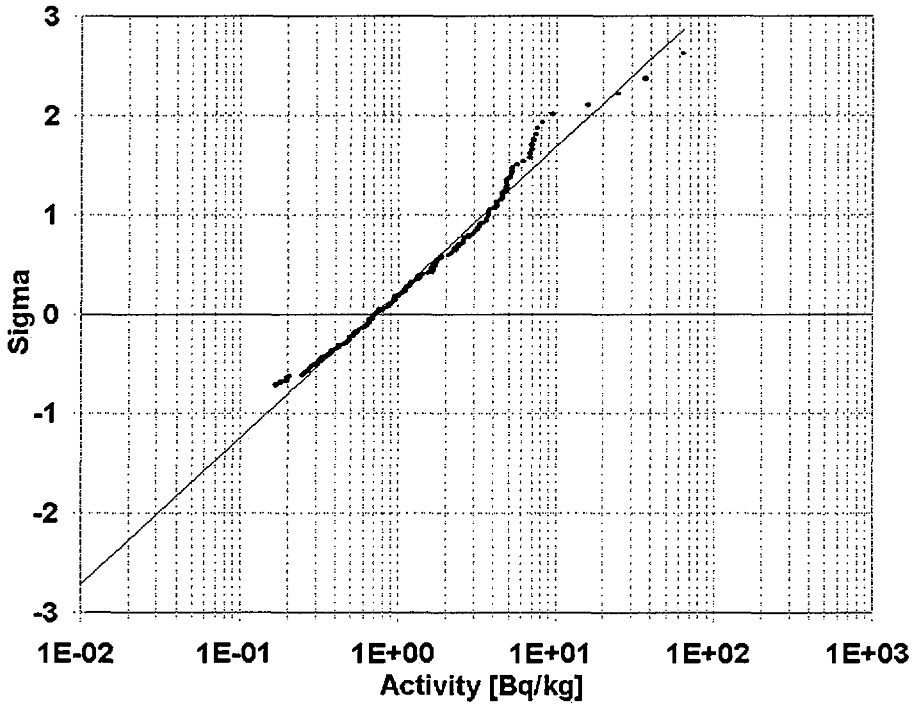

Fig. 14: Overall (steel-plant No.5)

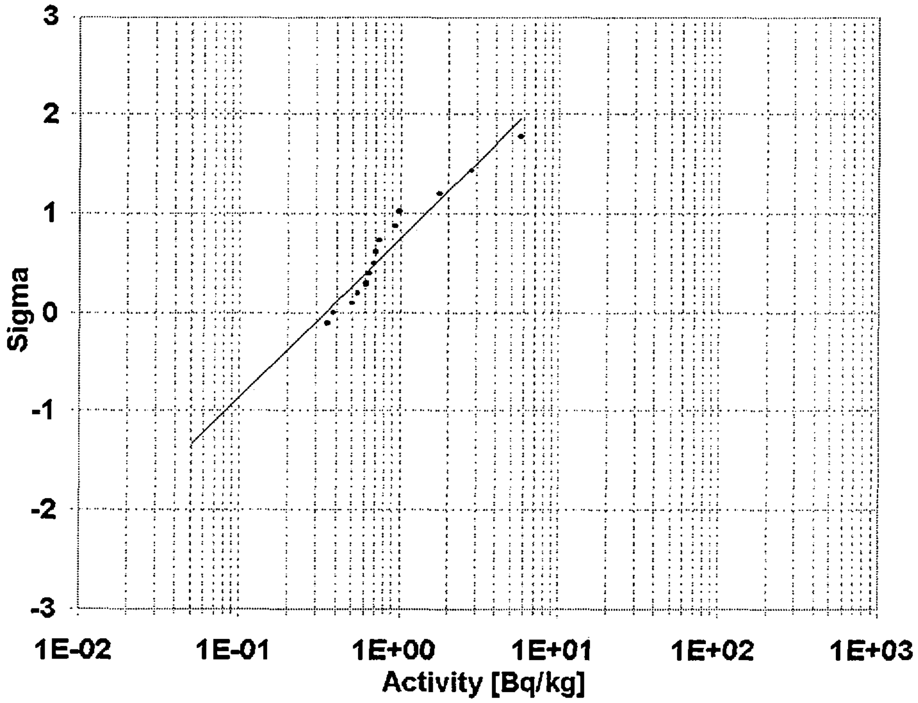

Fig. 1-15: Cumulative log.-norm. distribution of mass activity of ^{60}Co

Fig. 15: Overall (steel-plant No.6)