# The Measurement of Released Radionuclides during TIG-Welding and Grinding

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## INTRODUCTION

One of the methods used in industry for the specific improvement of particular properties of tungsten electrodes is the addition of oxides . In this respect, radioactive thorium oxide ($ThO_2$) is used very often. The most extensive area of application of these thoriated electrodes is the Tungsten Inert Gas (TIG) Welding.

The properties of the tungsten rods are improved through the addition of radioactive thorium.

Depending on the way of use, the electrodes are produced with different $ThO_2$ shares. For a better differentiation, the electrodes are marked with different colours. Table 1 shows the codification, the corresponding colour codes and the oxide additive.

Table 1. Codification, colour code and oxide additive of tungsten electrodes (according to EN 26848)

| **Codification** | **Colour code** | **Oxide additive m/m [%] material** |
|---|---|---|
| WP | green | - |
| WT- 4 | blue | 0,35 ... 0,55 $ThO_2$ |
| WT-10 | yellow | 0,80 ... 1,20 $ThO_2$ |
| WT- 20 | red | 1,70 ... 2,20 $ThO_2$ |
| WT- 30 | violet | 2,80 ... 3,20 $ThO_2$ |
| WT- 40 | orange | 3,80 ... 4,20 $ThO_2$ |
| WZ-3 | brown | 0,15 ... 0,50 $ZrO_2$ |
| WZ-8 | white | 0,70 ... 0,90 $ZrO_2$ |
| WL-10 | black | 0,90 ... 1,20 $LaO_2$ |
| WC-20 | grey | 1,80 ... 2,20 $CeO_2$ |

In Figure 1 the market share of the most important types of electrodes are presented.

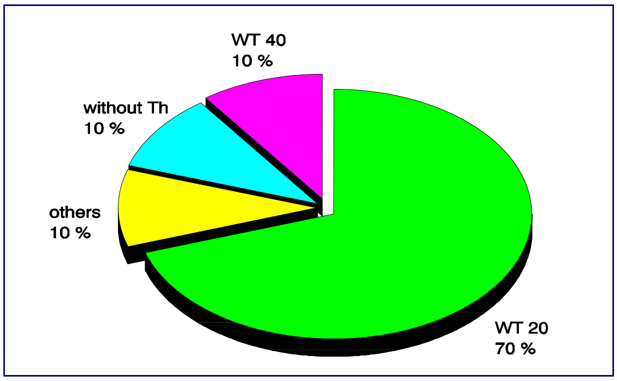


Figure 1. Market share of different electrodes

The radiological relevance of the TIG welding using thoriated tungsten electrodes has recently been proved by means of different studies (e. G. (1, 2, 3, 4, 5)). As a result of this the TÜV Süddeutschland and the

University of Göttingen have carried out special investigations concerning the release of radionuclides during TIG welding. The main emphasis of these investigations has been the representativity of various sampling techniques, the influence of various parameters during welding as well as the determination of activity size distributions related to the aerodynamic diameter of the inhaled aerosols.

By carrying out surveys with the users, we have determined the exposure pathways for the individual exposed persons: TIG-"hand-welders", TIG "machine-welders", labourers, other persons.

We have determined the specific activity depending on the different types of welding rods. We have measured the activity concentration of the breathing air during welding, during grinding the electrodes and by staying in the rooms where usually it is welded. The size distribution of the aerosol-attached activity was determined with several kinds of impactors. The main emphasis has been the comparison of the different sampling systems at the measuring of the activity concentration of the inhaled air.

## EXPERIMENTAL

Following sampling systems have mainly been used for experimental investigations.

Selective sampling by impactors:

- Berner-impactor, stationary
- Sierra-impactor, stationary
- Anderson-impactor, stationary
- Marple-impactor, personal sampler

Aerosol sampling by air samplers

- 5 personal air sampler
- 2 stationary sampler, ring face
- 2 stationary sampler, open face

Rn-220-Measuerements

- Thoron-monitor

Determination of activitys on measuring filters

- alpha spectrometry
- low-level-gamma-spectrometry

In Figure 2 the Sierra-impactor, the Berner-impactor as well as stationary sampler with ring face can be seen during sampling.

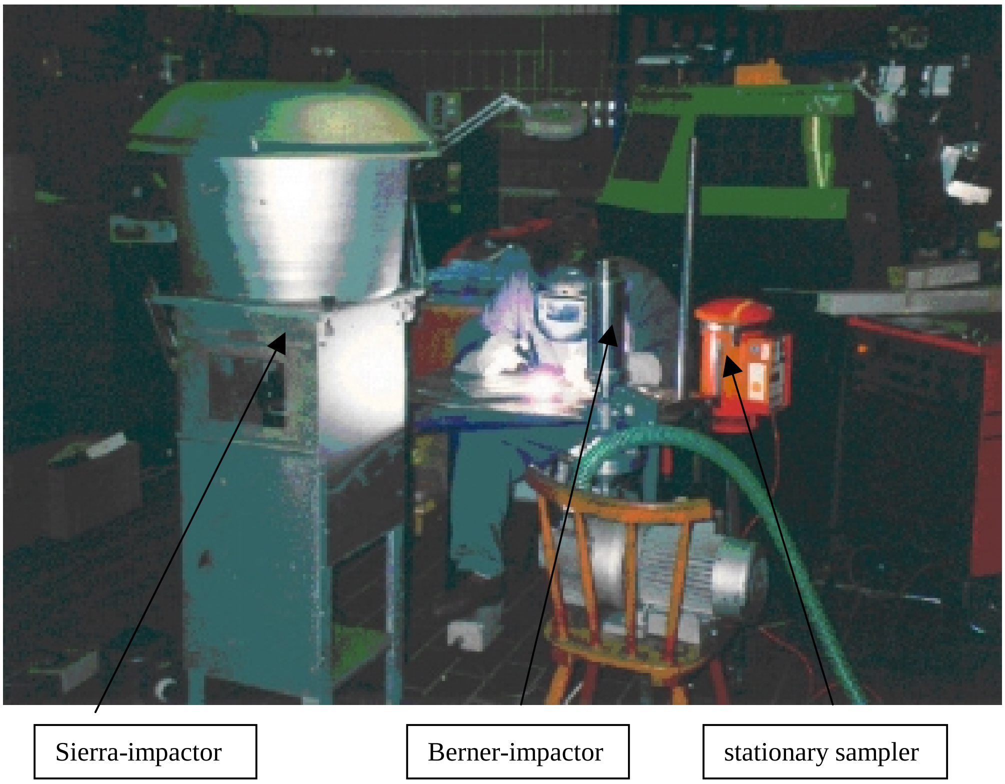


Figure 2. Sampling techniques for aerosol measurement during welding (activity size distribution and total activity concentration of inhaled air)

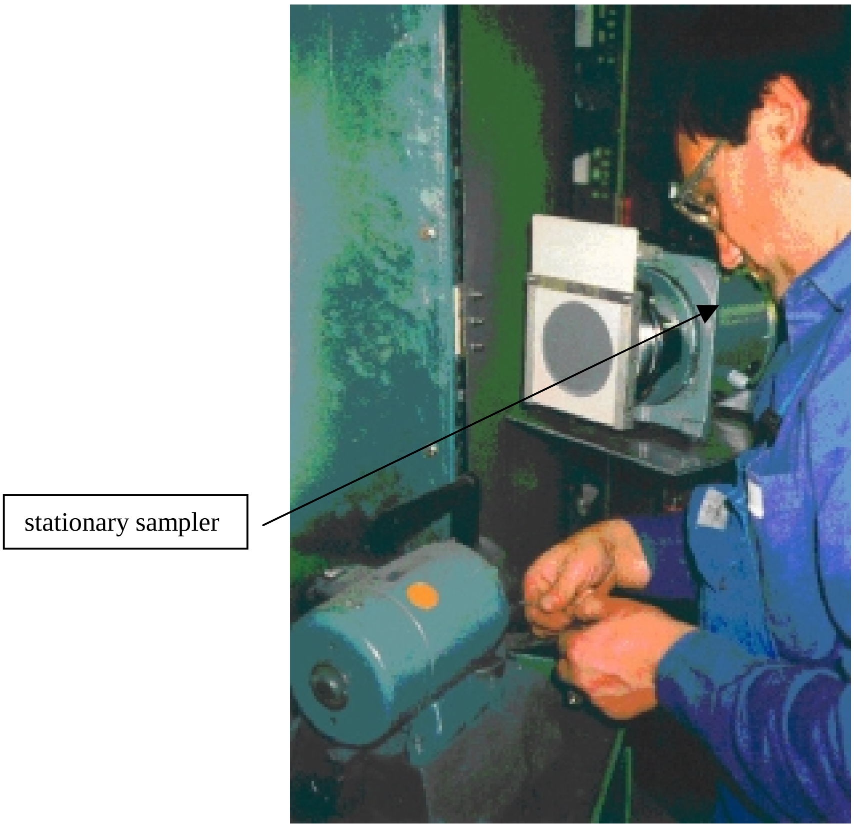


Figure 3. Sampling techniques for aerosol measurement during grinding (total activity concentration of inhaled air)

## RESULTS

Before showing the results of the new investigations, we are presenting in summary some results according to (1):

Table 2 shows activities related to the mass of different electrode types calculated by means of $ThO_2$ contents as well as measured activities. Figure 4 shows measured activities of several radionuclides of Th decay chain for WT-40 electrodes. Table 3 shows the measurement results of released activity and activity concentration during welding and grinding.

Table 2. Calculated and measured Th-232 activity of tungsten electrodes (1)

| Codification | Th-232 activity [Bq/g] - calculated | Th-232 activity [Bq/g] - measured |
|---|---|---|
| WT-10 | 29 - 43 | 27 |
| WT-20 | 61 - 78 | 69 |
| WT-30 | 100 - 114 | 110 |
| WT-40 | 136 - 150 | 149 |

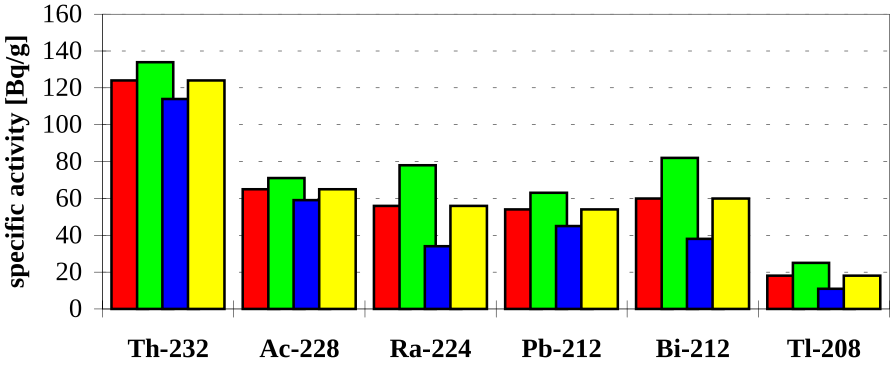


Figure 4. Measured specific activity of WT-40 electrodes (1)

Table 3. Relased activity and activity concentration by welding and grinding (1)

| **Measured activity rate of releasd Th-232 by TIG welding** | | | | | |
|---|---|---|---|---|---|
| **Type of electrode** | **Type of current** | **Current [A]** | **Activity rate of releasd Th-232 [Bq/h]*** | | |
| WT-40 | AC | 150 | 8,1 | | |
| WT-40 | DC | 200 | 0,4 | | |
| WT-20 | AC | 110 | 3,0 | | |
| **Measured activity concentration of breathing air during welding** | | | | | |
| **Type of electrode** | **Inert gas** | **Current** | **Activity concentration of breathing air [Bq/m³]*** | | |
| | | | **Th-232** | **Th-228** | **Ra-228** |
| WT-40/2,4 mm | Ar, 9 l/min | AC, 150 A | 0,142 | 0,055 | 0,030 |
| WT-40/2,4 mm | Ar, 9 l/min | AC, 150 A | 0,061 | 0,027 | 0,015 |
| WT-40/2,4 mm | Ar/He, 9 l/min | AC, 150 A | 0,047 | 0,022 | 0,017 |
| **Measured activity concentration of breathing air during grinding of thoriated tungsten electrodes** | | | | | |
| **Exhaustion** | **Type of electrode** | | **Activity concentration of breathing air [Bq/m³]** | | |
| | | | **Th-232** | **Th-228** | **Ra-228** |
| without exhauster | WT-40/2,4 mm | | 0,27 | 0,12 | 0,05 |
| with exhauster | WT-40/2,4 mm | | 0,07 | 0,03 | 0,02 |

* the activity rate (activity concentration) is only connected with phases of welding; stops are not included

For the various exposed persons, at the extern irradiation with gamma- and beta-radiation and the inhalation of radioactive aerosols, the radiation exposure has been calculated by means of experimental determined data. In this way, a dose about 5 - 20 mSv per year has been estimated when using the inhalation dose coefficients according to ICRP 30 (1).

In Table 1 the results of the activity concentration in working rooms during the grinding of electrodes and during welding are shown. The sampling of aerosols has been carried out under conditions which are similar to the human inhalation. The measured Rn-220 activities have not to be in a causal connection with the TIG welding, as a natural origin of these concentrations can not be excluded. The Rn-222 concentrations in the working rooms have been 20 – 50 Bq/m³.

Table. 4: Activity concentration of the room air during the grinding of electrodes and during welding

| Work | $c_{Th-228}$ [mBq/m³] | $c_{Rn-220}$ [Bq/m³] |
|---|---|---|
| Grinding of electrodes[1] | 298 | 3 |
| AC-welding[2] | 8 | < 3 |
| AC-welding[3] | 1 | < 3 |
| AC-welding[4] | 3 | 3 |

[1] Average value of several grindings; WT-40; 2,4 mm; grinding wheel: diamond; distance from the source of emission: about 1 m
[2] Daily mean value; 1 welder in the workshop; WT-40; 3,2 mm; 250 A; distance from the source of emission: about 2 m
[3] Daily mean value; 4 welders in the production hall; WT-20, WT-40; 2,4, 3,2, 4,8 mm; 200 - 310 A; middle of the room
[4] Daily mean value; 1 welder in the workshop; WT-40; 2,4 mm; 200 A; distance from the source of emission: about 3 m

Figure 5 shows the release rates measured in connection with different welding parameters. By means of the WT-40-electrodes example, the visible tendency of increase of the release rate together with the strength of current is shown. Figure 6 includes release rates for Pb-212, which has been analysed shortly after sampling because of its very short half-life.

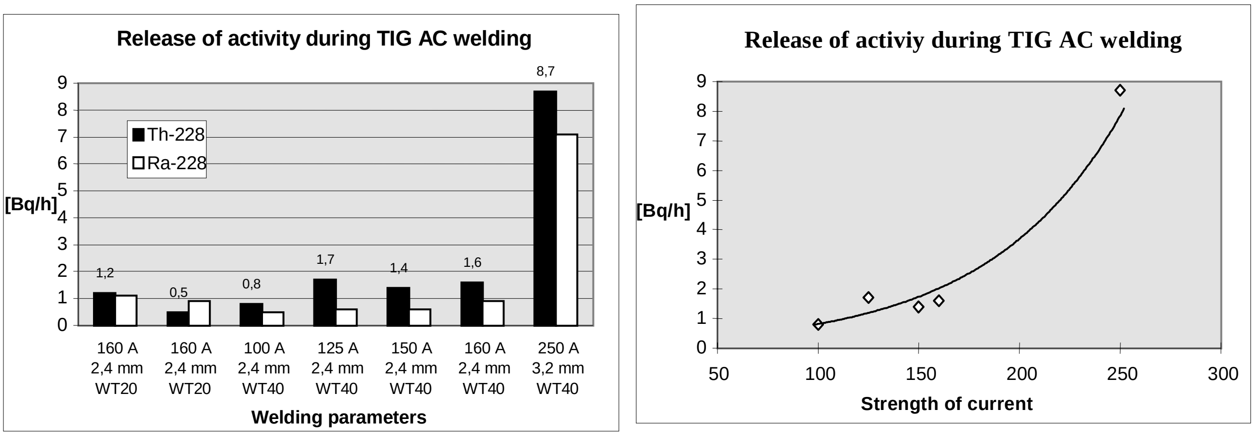


Figure 5: Release of dose relevant long-lived radionuclides during TIG welding; Dependence of the release rate on the strength of the electric current (WT-40 electrodes)

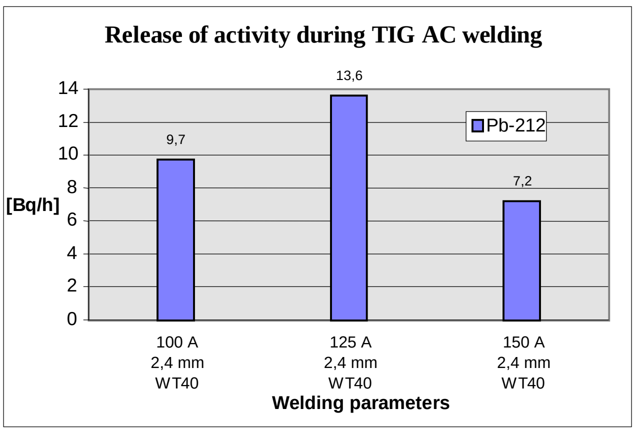


Figure 6. Release of short-lived radionuclides during TIG welding

Figure 7, 8 and 9 show the measured distributions of the activities attached on the smoke and dust particles depending on the aerodynamic diameter. Based on logarithmic normal distribution, the respective activity medians (AMAD) have been calculated. The distribution differences between welding (AMAD < 1µm) and grinding (AMAD > 1 µm) can be clearly recognised.

The result shown in Figure 8 (Marple-impactor as personal air sampler) represents an average value during four measurement days and at four different working places.

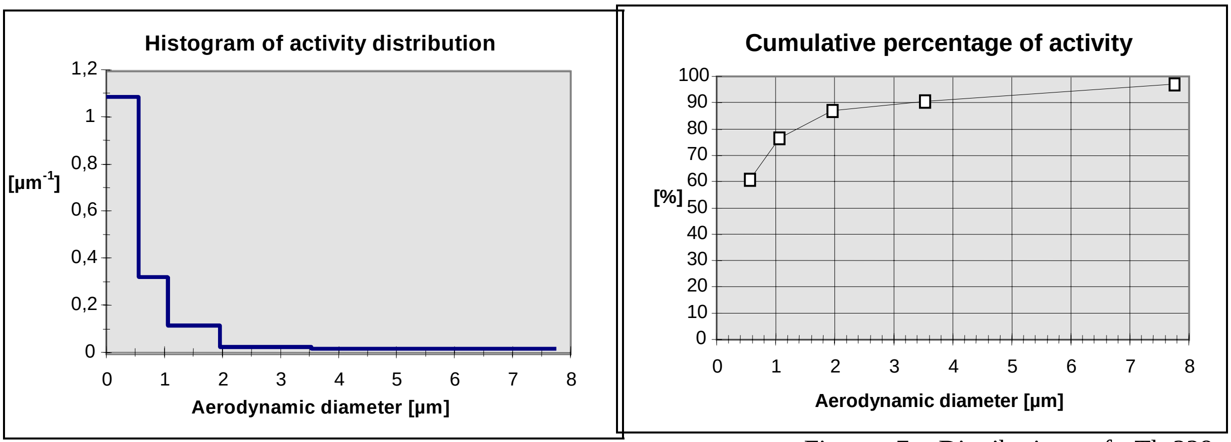


Figure 7. Distribution of Th-228 activity in air during TIG-welding with thoriated electrodes;
AMAD = 370 nm (Sierra-impactor)

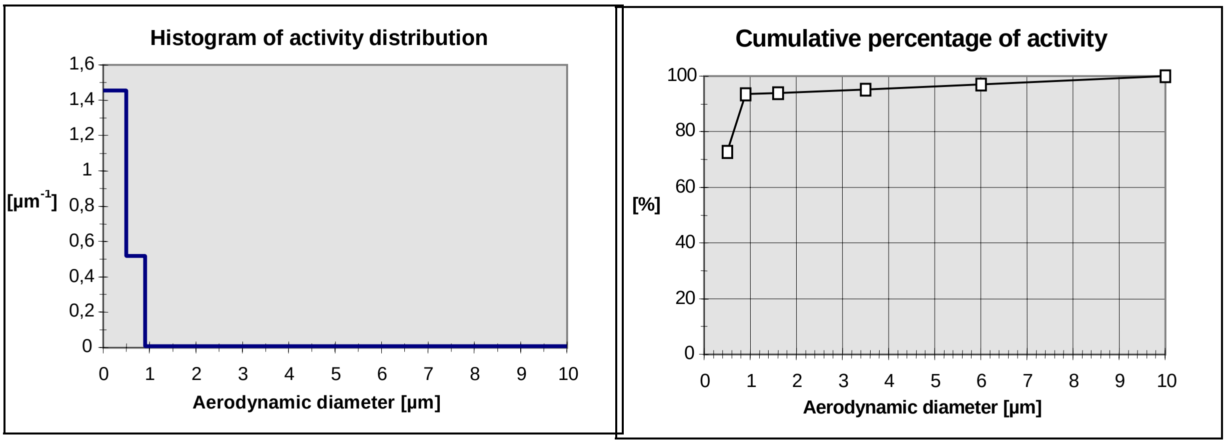


Figure 8. Distribution of Th-228 activity in air during TIG-welding with thoriated electrodes;
AMAD = 200 nm (Marple-impactor)

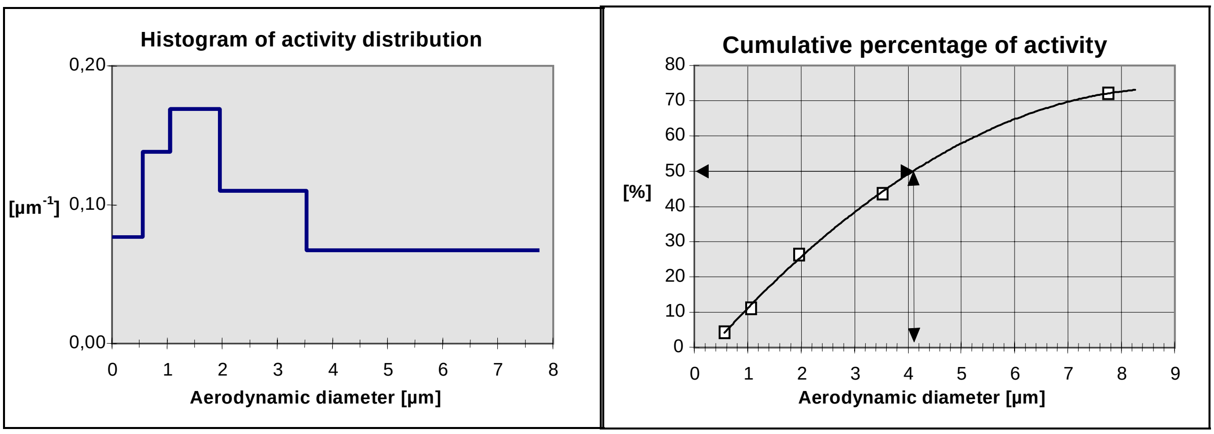


Figure 9. Distribution of Th-228 activity in air during grinding with thoriated electrodes;
AMAD =4100 nm (Sierra-impactor)

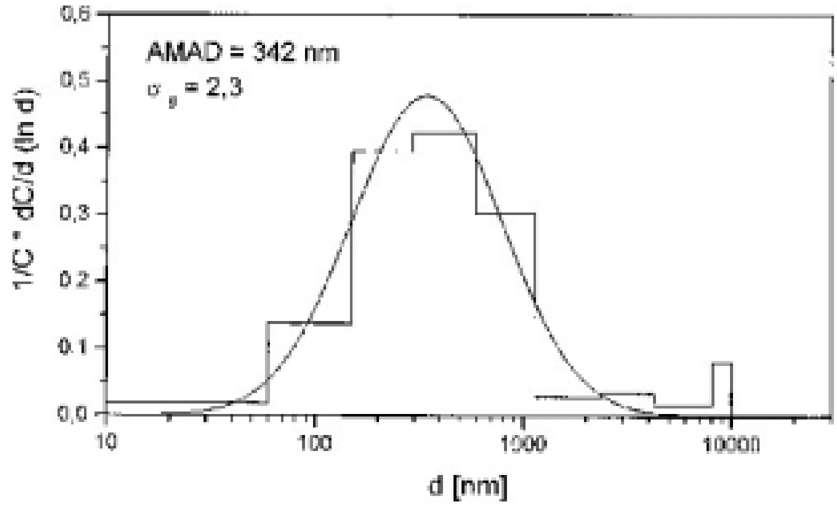


Figure 10. Relative size distribution of Th-228 activity measured during TIG welding (Berner-impactor)

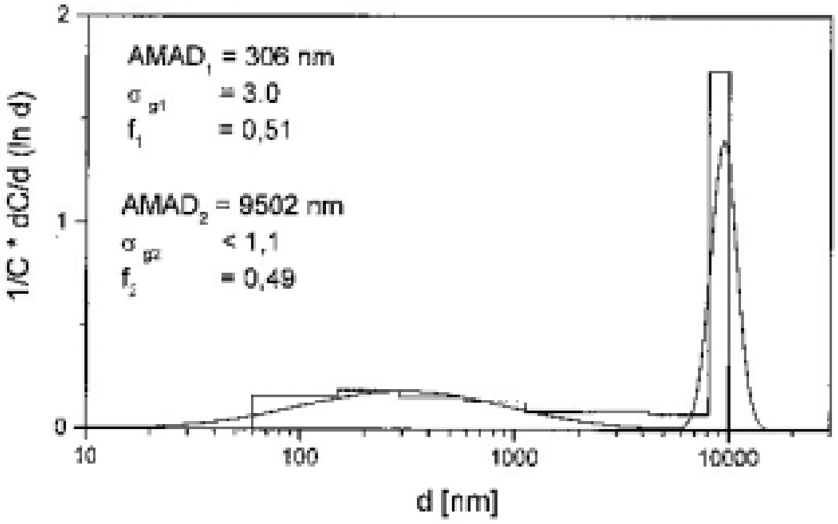


Figure 11. Relative size distribution of Th-228 activity measured during TIG welding (Berner-impactor)

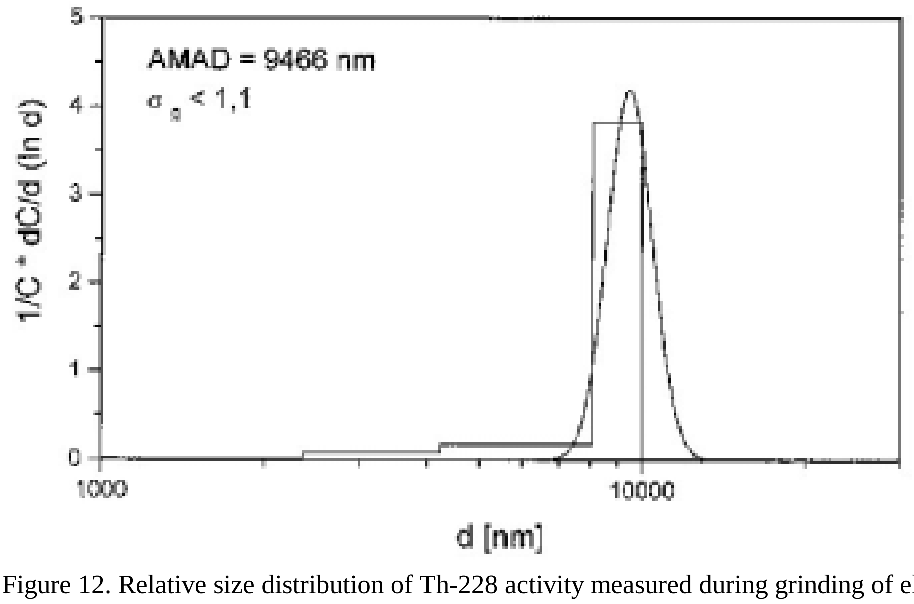


Figure 12. Relative size distribution of Th-228 activity measured during grinding of electrodes (Berner-impactor)

The Figures 10 and 11 show the size distribution during TIG welding. In Figure 11 an activity fraction on big aerodynamic diameters (AMAD = 9502 nm) can be seen. The reason is possibly the dust in the workrooms. Further evaluations of the measurements will show more detailed information on this fraction.

Figure 12 shows size distribution of Th-228 activity measured during grinding of electrodes. The AMAD = 9466 nm is greater than the AMAD in Figure 9. The reasons are probably different grinding techniques.

## ACKNOWLEDGEMENT

We would like to thank the Government of Bavaria, State Ministry for State Development and Environmental Affairs for providing financial resources for the investigations.

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