

DIN 25457-1:2014-12 (E)

Activity measurement methods for the clearance of radioactive substances and nuclear facility components - Part 1: Fundamentals

| Contents | Page |
|--|-------------|
| Foreword | 5 |
| 1 Scope | 6 |
| 2 Normative references | 6 |
| 3 Terms, definitions and symbols | 7 |
| 3.1 Terms and definitions..... | 7 |
| 3.2 Symbols | 9 |
| 4 Measurement methods..... | 13 |
| 4.1 Basic model and characteristic variables of the activity measurement methods with consideration of type A and type B measuring uncertainties..... | 13 |
| 4.1.1 General information..... | 13 |
| 4.1.2 Description of the model in general form | 14 |
| 4.1.3 Special model approach for activity measurement method..... | 15 |
| 4.1.4 Procedure for conservative and realistic approaches | 17 |
| 4.2 Direct surface-total-activity measurement..... | 18 |
| 4.2.1 General | 18 |
| 4.2.2 Relevant type B measurement uncertainties..... | 19 |
| 4.2.3 Requirements for the measurement devices | 20 |
| 4.2.4 Requirements for the calibration sources | 20 |
| 4.2.5 State of the surface of the measured material | 21 |
| 4.2.6 Dependency of the count rate of the detector on the geometric conditions | 21 |
| 4.2.7 Determination of an alarm value | 21 |
| 4.2.8 Measurement procedure | 23 |
| 4.2.9 Quality assurance..... | 25 |
| 4.3 Indirect surface total-activity measurement | 26 |
| 4.3.1 General | 26 |
| 4.3.2 Relevant type B measurement uncertainties..... | 26 |
| 4.3.3 Requirements for the measurement setup..... | 27 |
| 4.3.4 Requirements for the calibration source | 27 |
| 4.3.5 Calibration..... | 27 |
| 4.3.6 Background effect determination..... | 27 |
| 4.3.7 Performing the measurement..... | 27 |
| 4.3.8 Quality assurance..... | 28 |
| 4.4 Spectrometric measurement methods..... | 29 |
| 4.4.1 Gamma spectrometry on material samples..... | 29 |
| 4.4.2 In-situ gamma spectrometry | 36 |
| 4.4.3 Alpha spectrometry on material samples | 42 |
| 4.4.4 Determination of the activity of alpha-emitting radionuclides using gamma spectrometry on material samples..... | 47 |
| 4.5 Total gamma activity measurement | 47 |
| 4.5.1 General | 47 |
| 4.5.2 Relevant measurement uncertainties | 48 |
| 4.5.3 Requirements for measurement equipment..... | 48 |
| 4.5.4 Property of the measured material..... | 48 |
| 4.5.5 Requirements for the calibration | 48 |
| 4.5.6 Performing the measurement..... | 49 |
| 4.5.7 Detection limit, decision threshold and confidence interval..... | 49 |
| 4.5.8 Quality assurance..... | 50 |

| | |
|---|------------|
| Annex A (normative) Determination of the surface response | 52 |
| Annex B (informative) Energies and range of alpha particles | 57 |
| Annex C (informative) Determination of the activity of alpha-emitting radionuclides using gamma spectrometry on material specimens..... | 59 |
| C.1 General..... | 59 |
| C.2 Thorium decay series and Th-230 | 59 |
| C.3 Uranium..... | 59 |
| C.4 Plutonium | 60 |
| Annex D (informative) Explanations for the calculation of the decision thresholds and detection limits for the pulse counting with time preselection..... | 64 |
| Annex E (informative) Explanations for the calculation of the detection limit and decision threshold for stationary pulse rate measurements | 69 |
| Annex F (informative) Explanations for the calculation of the detection limit and decision threshold for dynamic pulse rate measurement..... | 79 |
| Annex G (informative) Explanations for the calculation of the decision thresholds and detection limits for the pulse counting with time preselection at small pulse numbers, e.g. alpha surface activity measurement..... | 82 |
| Annex H (informative) Calculation of the detection limit and decision threshold, the upper limit of the confidence interval and the expected value for measurements using contamination monitors with consideration of type B measurement uncertainties..... | 84 |
| H.1 Basic measurement model | 84 |
| H.2 Measurement task and measurement parameters | 85 |
| H.3 Calculation of the characteristic variables..... | 86 |
| H.4 Interpretation of the results in respect of the decision measurement for the clearance..... | 87 |
| H.5 Integration of uncertainties in respect of the clearance level of the area-specific total activity | 88 |
| Annex I (informative) Calculation of the detection limit and decision threshold for measurements with wipe test measurement setups (indirect total surface activity measurement) | 89 |
| Annex J (informative) Calculation of the detection limit and decision threshold, the upper limit of the confidence interval and the expected value for gamma spectrometry and in-situ gamma spectrometry | 92 |
| J.1 Preliminary remarks..... | 92 |
| J.2 Measurement of site grounds according to DIN 25457-7: Determination of the area- specific activity as well as the nuclide-specific dose rate of Cs-137..... | 92 |
| J.2.1 General..... | 92 |
| J.2.2 Calibration factor and its standard uncertainty..... | 93 |
| J.2.3 Calculation of the nuclide-specific ambient dose equivalent rate..... | 93 |
| J.2.4 Example for the calculation of the characteristic limits as well as the best estimator and its standard uncertainty (non-collimated measurement, area-specific activity and nuclide-specific dose rate) | 94 |
| J.2.5 Summary | 96 |
| J.3 Determination of the mass-specific activity if a disturbance is present due to an interfering line as well as a line in the background effect spectrum..... | 96 |
| J.4 Determination of the Co-60 activity from very small net peak areas..... | 98 |
| Annex K (informative) Calculation of the detection limit and the decision threshold, the upper limit of the confidence interval and the expected value for total gamma activity measurements..... | 104 |
| K.1 Preliminary remarks..... | 104 |
| K.2 Essential input variables for the conservative calibration | 105 |
| K.3 Realistic calculation of decision threshold and detection limit | 108 |
| K.3.1 General | 108 |
| K.3.2 Determination of the realistic calibration factor w..... | 108 |
| K.3.3 Consideration of the reduction of the background effect due to measured material..... | 108 |
| K.3.4 Consideration of the non-counting statistical variance of the background effect | 108 |
| K.4 Best estimated values, upper limit of the confidence interval | 111 |
| K.5 Summary | 114 |
| Bibliography | 116 |