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Title:	**TECHNICAL GUIDE FOR LABORATORIES PERFORMING RADIOACTIVITY ANALYSIS OF WATER INTENDED FOR HUMAN CONSUMPTION**

Summary:	This guide describes the procedures laboratories must respect when executing radioactivity analysis of water intended for human consumption. It covers the requirements, conditions and modalities to be met by the laboratories carrying out the radioactivity analysis: compliance with the decision tree, calculating the ID and reporting of the measurement data via the imposed reporting protocol (Excel spreadsheet template).

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Document approval

Review	Author	Verification	Approval
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Distribution

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Document History Log

Review	Review date	Modification description	By
0	2017-01-09	Initial version in EN	Jurgen Claes Lionel Sombré
1	2020-04-01	Some corrections relative to the Annexes	Jurgen Claes

1. Objective

The purpose of this guide is to present and explain the various procedures to be observed by laboratories analysing the radioactivity of water for human consumption as defined in the Royal Decree of 31 May 2016 on Protection of Water for Human Consumption from Contamination by Radioactive Substances.

Article 9.1 of the Royal Decree describes the specifications that FANC may impose with regard to services provided by a supplier of water to a laboratory to comply with the conditions stipulated by FANC pursuant to Article 10.

The FANC Decree of 24.11.2016 specifies the rules and methods for monitoring radioactive substances in water intended for human consumption.

This guidance provides insight into the expectations and demands of the FANC regarding the radioactivity measurements that are performed on water samples which are taken by suppliers and submitted to the labs.

The (ISO 17025 accredited) laboratories who should take the radioactivity analyzes water samples must adhere to the rules laid down in the instruction sheets in Annex 1 to the guidelines for the water suppliers

2. Scope

Implementation of the Royal Decree of 31 May 2016 regarding the protection of public health from radioactive substances in water intended for human consumption of 31 May 2016.

3. Protocols and methods for the analysis of radioactivity in water

3.1. Laboratory requirements

The laboratories responsible for carrying out radioactivity measurements (accredited in compliance with ISO/IEC 17025) must be able to perform the following analyses depending on their level (1 or 2):

- **Level 1 laboratory:**
  Screening measurements: total alpha (α_T) reference plutonium-239, total beta (β_T) reference strontium-ytrium-90, tritium (^3H), free radon Rn-222 and potassium-40 in a water matrix;

- **Level 2 laboratory:**
  Screening measurements and full isotopic vector measurements by gamma spectrometry, beta (and total beta (β_T) reference strontium-ytrium-90), alpha (and total alpha (α_T) reference plutonium-239), potassium-40[1], tritium (^3H), free radon Rn-222 in a water matrix

[1] Potassium-40 can be determined by establishing stable potassium using an ISO 17025 accredited method.

3.2. Subcontracting analysis

If a Level 1 or 2 laboratory is not accredited to perform certain analyses, it may subcontract this analysis or analyses to a different laboratory which is accredited for this kind of analysis. The subcontracting laboratory remains responsible for the radioactivity measurements whether it performs them itself or subcontracts them.

3.3. Radiological analysis strategy for determining the indicative dose (ID)

Laboratories must use the decision tree included in Annex 1 of this Guide. There are two types of laboratories: Level 1 laboratories and Level 2 laboratories.

Level 1 laboratories carry out quick analyses to sort the water samples and perform an initial radiological assessment: first investigation or screening level (Class 1), whereas Level 2 laboratories carry out more in-depth analyses to calculate the total indicative dose if one of the screening parameters recorded in the first level is exceeded (Class 2).

The residual beta value is calculated by subtracting the figure for potassium-40 (K-40) from the total beta value. The concentration of K-40 is assessed with a detection limit of at least 0.04 Bq/L in order to calculate the residual beta value using an ISO 17025 accredited method.

Determination by weight and the associated radioactivity calculation can be performed on the basis of a specific activity of 27.9 ± 0.7 Bq/g natural K ([2]) using an ISO 17025 accredited method.

If one or more screening indicators are exceeded, the Level 1 laboratory must notify the supplier of this fact. The Supplier must then take a new water sample and send this to the Level 2 laboratory. This laboratory will check the indicator(s) exceeded during the screening process performed by the Level 1 laboratory and will continue the analysis procedure by following the branch of the decision tree (Annex 1 – Class 2) corresponding to the indicator(s) exceeded in the Level 1 test and will then determine the corresponding ID.

The part of the decision tree reserved for Level 2 laboratories (Class 2) allows to determine uranium concentrations in two different ways:

1. alpha spectrometry to determine U-234, U-238 and U-235:
2. determination by weight and calculation of the associated radioactivity based on 4 µg/l for ≈ 0.1 Bq/L.

In both cases, the methods must be ISO 17025 accredited.

If Po-210 and Pb-210 need to be determined, a new water sample must be taken by the supplier and submitted within 48 hours of sampling to the Level 2 laboratory performing the rest of the necessary analyses.

The ID will be calculated on the basis of the results obtained from the radioactivity measurements. Any result less than or equal to the detection limits will be regarded as zero when calculating the ID.

[2] Technical report: IRSN EEI/STEME No. 2008-04 – Calculation of ^{40}K contribution to gross beta.

4. Derived concentrations and screening values

Annex 2 shows the derived (reference)concentrations for which the total indicative dose is reached. The table also shows the control values of the 1st level of which further analyses of the 2nd level and calculation of the ID must be carried out if these are exceeded.

5. Analysis methods and performance

Annex 3 shows the detection limits that must be reached in order to measure radionuclide activity concentrations and the necessary parameters to determine the ID.

6. Registration and reporting of radioactive measurements

FANC imposes that the reporting of the radioactivity measurements is performed by using the reporting protocol it provides (Excel spreadsheet). This protocol identifies the required information and provides additional explanatory notes of the data.

The results of any radioactivity measurement and calculation of indicative dose (ID) must be delivered by the laboratory to the supplier and to the FANC. The easiest way to do that is by registering on the data exchange web platform of the FANC. The laboratory can upload the data by using the available spreadsheet template. Suppliers and FANC can consult the measurements into the database of the web platform.

The template can be downloaded from the web platform or from the informative website of the FANC for radioactivity in water intended for human consumption. More clarification regarding this spreadsheet for measurements (Annex 4) is also reflected in the technical guides:

- Technical guide for water suppliers and laboratories, sampling methods and procedures for water intended for human consumption;
- Technical guide for suppliers of drinking water, modalities for the choice of compliance points and the creation of an auto-control programme.

The supplier can - at the registration of the auto-control programme and more specific at the identification of the laboratories which will carry out the analysis of radioactivity in water - authorize the laboratories to upload their measurement data directly into the data exchange web platform. In this case, both the supplier and the Agency receive a notification that new results are available which can be accessed after login.

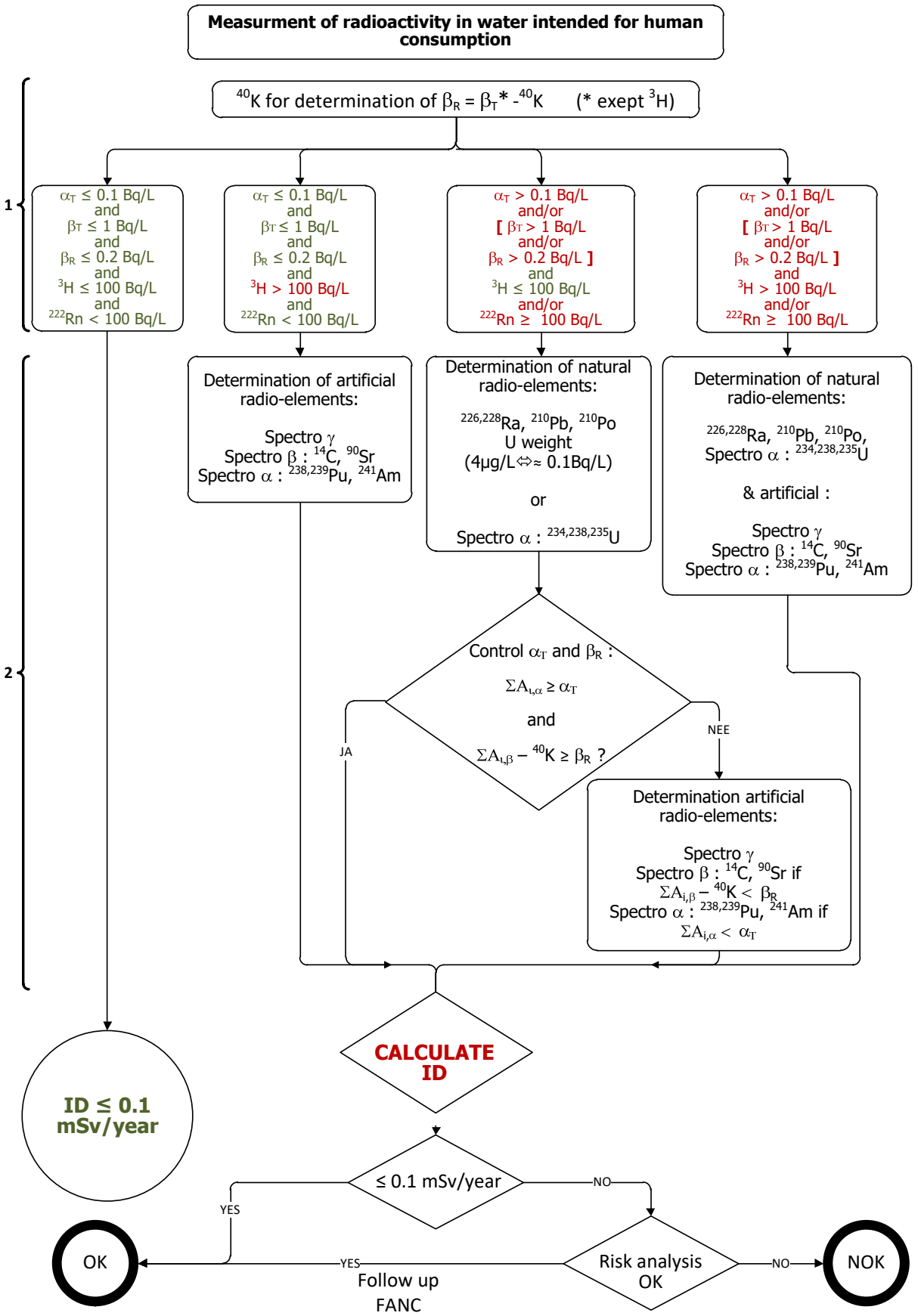
The laboratory can upload the data when registered on the data exchange web platform.

7. Questions and Support

For questions or support regarding the required analysis and reporting procedures, please contact surveillance.dw@fanc.fgov.be.

8. Appendixes or forms to be used

ANNEX 1



1 : laboratory Of 1st Level – **2** : laboratory 2nd Level

NOK => Corrective actions

ANNEX 2

Derived concentrations and screening values[3]

Source	Nuclide	Reference concentration (Bq/L)	Screening values (20% of RC) Bq/L
Natural	U-238[4]	3.0	0.6
	U-234[3]	2.8	0.56
	Ra-226	0.5	0.1
	Ra-228	0.2	0.04
	Pb-210	0.2	0.04
	Po-210	0.1	0.02
Artificial	C-14	240	48
	Sr-90	4.9	0.98
	Pu-239/Pu-240	0.6	0.12
	Am-241	0.7	0.14
	Co-60	40	8
	Cs-134	7.2	1.44
	Cs-137	11	2.2
	I-131	6.2	1.24
	Total beta Residual beta Total alpha H-3 Rn-222		1 0.2 0.1 100 100

The reference concentration (RC) of a given radioelement leads to a total indicative dose of 0.1 mSv/year (assuming 730 litres ingested by an adult) for this radioelement alone.

[3] This table includes values for the most common natural and artificial radionuclides. These are accurate values, calculated for a dose of 0.1 mSv and assuming an annual ingestion figure of 730 L, given the dose coefficients specified in Annex III, Table A of Directive 96/29/Euratom; the derived concentrations for other radionuclides may be calculated on the same basis and values can be updated in the light of the most recent information recognised by the competent authorities in the Member State in question.

[4] This table only considers the radiological properties of uranium, not its chemical toxicity. 1 milligram (mg) of natural uranium contains 12.3 Bq of U-238 and 13 Bq of U-234.

ANNEX 3

Analysis methods and performance

The analysis method used for the following parameters and radionuclides must at the very least make it possible to measure activity concentrations with the detection limit specified below:

Parameters	Detection limit (DL) Bq/L (Notes 1 and 2)	Notes	% of the screening value
H-3	10	3	10
Rn-222	10	3	10
Total beta Total alpha	0.4 0.04	4 4	40 40
U-238	0.02	6	3.3
U-234	0.02	6	3.6
Ra-226	0.04		40
Ra-228	0.08 0.02	5	200 50 (Note 5)
Pb-210	0.02		50
Po-210	0.01		50
C-14	20		~ 40
Sr-90	0.4		~ 40
Pu-239/Pu-240	0.04		~ 33
Am-241	0.06		~ 40
Co-60	0.5		6
Cs-134	0.5		35
Cs-137	0.5		23
I-131	0.5		40

Note 1: the detection limit is calculated in accordance with ISO 11929. Determination of characteristic limits (decision threshold, detection limit and confidence interval limits) for measuring ionising radiation – Fundamental principles and applications, with 1st and 2nd category error probabilities of 0.05 each.

Note 2: measurement uncertainties are calculated and reported in the form of combined standard uncertainties or expanded standard uncertainties with an expansion factor of 1.96 in accordance with the ISO guide on expressing measurement uncertainty.

Note 3: the detection limit for tritium and radon is 10% of their parametric value of 100 Bq/L.

Note 4: the detection limit for overall alpha activity and overall beta activity is 40% of their monitoring thresholds, i.e. 0.1 and 1.0 Bq/L respectively.

Note 5: this detection limit applies solely to initial monitoring of the TID for a new water source; if the initial test indicates that it is unlikely that Ra-228 will exceed 20% of the derived concentration, the detection limit may be changed to 0.08 Bq/L for specific routine measurements of Ra-228 until a new test is required.

Note 6: the lowest value for the uranium detection limit takes its chemical toxicity into account. (Note: according to the WHO, uranium is regarded as posing a chemical toxicity hazard at 15 µg/L. This corresponds to 0.37 Bq U-238+U-234, which in turn corresponds to 0.184 Bq for each uranium isotope. If this is rounded up to 0.2 Bq/L, the detection limit can be set at 10% or 0.02 Bq/L).

ANNEX 4

The template for registration and reporting of the radioactivity measurements can be downloaded from the data exchange web platform of the Agency (https://dxp.fanc.be) or from the informative website of the FANC.

The spreadsheet for the measurements contains following information:

- PDC Sample ID = unique ID (identification) of the Point of Compliance
- LIMS ID = supplier column where measurements can be linked to the laboratory information management system ID for the laboratory/laboratories carrying out the measurement
- Locality Name = place/town and region where the PDC-point is located (drop-down list)
- NUTS Code = Geographical code (provinces) where the PDC-point is located (drop-down list)
- Catchment = description of the catchment area and water source (drop-down list)
- Latitude / Longitude = geographical coordinates of the PDC-point in decimal degrees (DD.DDDD)
- Accuracy Type = precise sampling point (drop-down list)
- Sample Type = type of sample / sample description (drop-down list)
- Sample treatment = method used to treat / prepare the sample (drop-down list)
- Nuclides = nuclide or calculated ID (drop-down list)
- Apparatus Type = type of measuring equipment used to determine the radioactivity (drop-down list)
- Begin Date = date on which sampling commenced (YYYY/MM/DD)
- Begin Time = time sampling commenced (HH:MM)
- End Date = date on which sampling ended (YYYY/MM/DD)
- End Time = time sampling ended (HH:MM)
- Less Than = if the measurement is less than the DL (detection limit), the "<" symbol is inserted and the DL is mentioned in the Activity Value column. The Uncertainty Value column stays in this case empty
- Activity Value = measured value
- Value Type = mathematical description of the measured value (drop-down list)
- Measuring Unit = measured value unit (drop-down list)
- Uncertainty Value = error associated with the measured value
- Uncertainty Type = mathematical method used to determine the measurement error (drop-down list)
- Uncertainty Unit = measurement error unit (drop-down list)
- Laboratory = abbreviation of the laboratory carrying out the measurement
- Supplier = abbreviation of the supplier from where the sample was taken
- Comment = empty field for adding comments or specifications such as the geographical coordinates of the sampling point if this location is not identical to the corresponding PDC-point location

Further details on the data to be entered:

- Locality Name, NUTS Code, Catchment: these cells may not be left empty and may only contain one value from the drop-down list.
  REMARK: The cells may be empty if the measurements are uploaded to the EDWD web platform of the Agency. In that case, the cells are automatically filled in by the system with the information that is linked to the corresponding PDC-point of the proposed auto-control programme.
- Latitude, Longitude: degrees expressed as decimal figures – cells may not be left empty.
  REMARK: The cells may be empty if the measurements are uploaded to the EDWD web platform of the Agency. In that case, the cells are automatically filled in by the system with the information that is linked to the corresponding PDC-point of the proposed auto-control programme.
- Accuracy Type, Sample type, Sample treatment, Nuclides, Apparatus Type: these cells may not be left empty and must contain a value from the drop-down list
- Begin Date and End Date: may not be left empty, format: YYYY/MM/DD. The end date is always later than or the same as the begin date (in case of a grab sample both dates are equal).
- Begin Time and End Time: may not be left empty, format: HH:MM. The end time is always later than or the same as the begin time if the begin and end dates are identical.
- Less Than: if < appears in this column, the Uncertainty Value column must remain empty and the Activity value column must contain the detection limit (DL).
- Value Type and Uncertainty Type: these cells may not be left empty and must contain a value from the drop-down list
- Measuring Unit and Uncertainty Unit: this cell may not be left empty and must contain a value from the drop-down list
- Activity Value and Uncertainty Value: decimal numbers
- Laboratory, Supplier: these cells may not be left empty and must contain their respective abbreviation or name
- Comment: when this cell should contain different or multiple items, values or text parts are separated by a semicolon.

Additional tabs on the spreadsheet itself clarify the various fields and how they should be completed.

The supplier can - at the registration of the auto-control programme and more specific at the identification of the laboratories which will carry out the analysis of radioactivity in water - authorize the laboratories to upload their measurement data directly into the data exchange web platform. In this case, both the supplier and the Agency receive a notification that new results are available which can be accessed after login. The laboratory can upload the data when registered on the data exchange web platform.